
Massachusetts Institute of Technology



Reports to the President

For the Year Ended
June 30, 1996



Reports to the President

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For the Year Ended
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PRESIDENT

In this age, in this country, there is an opportunity for the development of [humankind's] intellectual, cultural, and spiritual potentialities that has never existed before in the history of our species. I mean not simply an opportunity for greatness for a few, but an opportunity for greatness for the many.

– Edwin H. Land

In 1957, nearly 40 years ago, Edwin Land, the founder of Polaroid, gave the Arthur Dehon Little Memorial Lecture at MIT.¹ His address was entitled *Generation of Greatness: The Idea of a University in an Age of Science*. In it, he set forth his conviction that everyone is born with the potential for greatness and that we must be far bolder in our vision and commitment to develop the full creative powers of our young.

His proposal for how universities might meet this challenge was to create within each university small communities of faculty and students who would work together as colleagues in scholarship and research...where learning would become, once again, an exciting adventure. This proposal led to the establishment in the 1960s of the Undergraduate Research Opportunities Program at MIT – still one of the strongest features of an MIT education.

But the point here is not that Land had a major influence on education at MIT, but that he had a vision of greatness and a boldness of spirit that were embraced by others. Certainly his influence can be attributed to the power of his intellect and his dream. But perhaps it also had something to do with the times, the dawn of the 1960s, when the country was ready to dream of greatness and to take bold action, and did so in many domains – in science and technology, in education, in civil rights.

IS BOLDNESS A THING OF THE PAST?

Today – in 1996 – we live in an age that seems to reject bold thought and bold action. This is true in America, and it is true in Europe. Why is this? Does boldness come with a price tag we can no longer afford? Does it imply excess or waste or impracticality? Are we too cynical to embrace visionary new ideas? Have we turned from boldness because such vision and action usually call for shared commitment...and we only care for what affects us personally and immediately? Is this a natural outcome of our maturation as a nation and as a society? Perhaps all of the above. Or perhaps, at century's end, we have become so concerned with eliminating the budget deficit in order to protect future generations from economic grief that we are blind to the equal importance of making the investments necessary to assure the vitality and quality of their lives.

I do not believe, however, that for most Americans, or for most people around the world for that matter, such limited vision is a conscious choice. We have slipped into complacency and self-interest, but we need not, and cannot, remain there. As a society we must once again believe that we can envision and generate greatness in our time, and build the foundation for future generations of greatness.

SCIENCE AND TECHNOLOGY – GREAT EXPECTATIONS?

I am not alone in this belief or desire. Take science and technology, for example.

A new national survey² finds that the vast majority of Americans want this country to be the world leader in scientific and technological progress as we enter the next century. They believe that public policy and federal investment should encourage education, research, and careers in science and technology – in order to build a better future for the nation as a whole and for the everyday lives of individual citizens.

And yet, we do not seem to have the will to stay on this course.

One major scientific project illustrates the point. A decade ago the United States committed itself to constructing the *Superconducting Supercollider* (SSC), a huge new particle accelerator that would have helped us to answer critical questions in particle physics and perhaps discover another force of nature. The frontier technology required to build this project also could have led to important technological innovations of practical benefit to the general society. We

invested over \$2 billion and got construction well underway. Then we simply changed our mind, walked away, and left a rusting hulk in the arid Texas desert – too expensive.

But more than just expense was involved. We – the science community and the federal government – knew that this was an expensive undertaking when it was conceived and given the go-ahead. It could have been a truly international project, but it was supported in part in order to do it all ourselves, in a nationalistic spirit. Yes, the Japanese were invited to help fund it, but only after the concepts and designs were completed and construction was underway – hardly a true international undertaking.

Then there was the matter of location. The SSC was vigorously supported by the Congress and by the public in several parts of the country – until it was sited. Not surprisingly, it is more attractive to support an activity in one's state or district than if it is located thousands of miles away. Yet, in reality, facilities like the SSC would be shared by researchers – faculty and graduate students from all around the nation and the world.

My purpose here is not to argue that the SSC should have been built; many good people disagreed about that. My point is to ask why we cannot conceive and carry through such bold ventures – why our commitments have no staying power.

Other science and technology programs also illustrate the point. Take, for example, our nation's *magnetic fusion program*. As the trauma of the 1970s' oil embargo and other "wakeup calls" regarding worldwide energy needs have receded in our memories, we have ceased to think much about the future of energy supplies and utilization. The most conservative analyses indicate that we will need at least to double worldwide energy production by 2050 if nations around the world are going to have the opportunity to become industrialized and improve their standards of living. At the same time, doing this in a way that does not degrade the earth's atmosphere to an intolerable extent represents a major challenge. Just consider one country, China, with a population of 1.2 billion people, which is developing its industrial base and meeting its heating needs primarily by burning coal. Meeting the demand for energy throughout the world will require new technologies for large-scale generation of heat and electricity that are relatively environmentally benign and that utilize readily available fuels. It is difficult, if not impossible, to construct a scenario that does not involve substantial use of thermonuclear fusion reactors for this purpose. They offer the potential of using essentially inexhaustible fuel, producing very little radioactivity, and releasing no carbon dioxide into the atmosphere.

The problem is that fusion science and technology are very complex and the state of the art must be advanced considerably over the next few decades. A great deal has been learned, but much remains to be done. In 1995, the US magnetic fusion program was funded at a level of \$375 million and scheduled to increase substantially in the years ahead, in large part to meet our obligations to the International Thermonuclear Experimental Reactor (ITER) project. ITER is a large joint undertaking of the United States, Europe, Russia, and Japan. In 1996, however, funding for the US magnetic fusion program has been cut to \$244 million – and is headed toward a still lower level in 1997. In order to maintain a viable program in the most essential basic fusion science and technology, the US will likely need to drop its commitment to ITER. Reducing our overall fusion program to such levels decreases the probability that our companies will be major players in the provision of power generation plants in the expanding world markets as we approach the middle of the next century. Furthermore, we greatly increase the risk that no acceptable means of meeting world energy needs will be available.

Now let us turn to two bold ventures that, in fact, appear to be moving toward realization: The Space Station and the Human Genome Project.

The *Space Station* is primarily a technology, rather than a science, project. To a far greater extent, however, it is about humans in space. I believe that reaching beyond the boundaries of earth has an intrinsic value – it is as surely a part of the ongoing human adventure as Hillary and Norgay's ascent of Mount Everest, the Lewis and Clark expedition, the sixteenth-century explorations of Vasco da Gama, or the fifth-century Polynesian expeditions across 2,300 miles of open ocean to Hawaii.

Some of the most wondrous and important explorations of space have been made remotely, by spacecraft with no crews aboard: the Hubble Telescope's observations of the Shoemaker-Levy Comet collision with the planet Jupiter,

or the Galileo Space Probe's magnificent exploration of Europa, Ganymede, and other Jovian moons. Remote exploration through technology should continue to expand our understanding and sense of wonder about the universe.

Still, the human presence in space captures the imagination of most people. The realization that in the entire sweep of human history, my generation was the first to go beyond the bounds of the earth is both a marvel and an inspiration. Children, in particular, remain entranced by this adventure – always a sure sign that something is worthwhile.

Now, fundamentally, the Space Station can do only two things that cannot be done in other ways. It can put humans into a microgravity environment for very long periods of time, and it can put very massive objects into orbit for very long periods of time. Why should we want to do this? For one thing, we will be able to perform empirical medical studies that are necessary preludes to future interplanetary flights.

And while the Space Station is basically a technology project, the ability to place massive objects in orbit for sustained periods of time appears to be leading to an important, though initially unintended, role for the Station in fundamental science. The Alpha Magnetic Spectrometer, conceived by MIT/CERN physicist Samuel Ting, will be placed on the Station. There the device, which will weigh two tons and be about a meter high and a meter in diameter, will allow us to study the properties and origin of cosmic particles and nuclei, including antimatter and dark matter. Discovering the presence of either material will increase our understanding of the early universe and could potentially lead to a clearer understanding of the actual origin of the universe and to the discovery of antimatter stars and galaxies.

The Space Station, whose history and congressional support is checkered, to say the least, appears to be moving toward reality for two reasons. First, it is an international project that overtly became a tool of US foreign policy. Second, there is broad public enthusiasm for human space travel.

The *Human Genome Project* is the one bold, high-profile, large-scale science project that appears to be moving at a direct, determined pace toward its intended goal. The idea is to tap our newly discovered knowledge of the structure of genes and chromosomes in order to improve our understanding of the physical structure of human life, and, ultimately, to make possible dramatic advances in medical science and health care. Originally, it was thought that a map of the entire human genome could be completed by 1998. In fact, this program has been so successful that the mapping was completed in 1996, and work has now begun on the vastly larger task of sequencing the human genome.

The pace of success has been so rapid because project leaders such as Eric Lander and his team at MIT/Whitehead Institute recognized early on that this was not a task for thousands of biologists and technicians working ploddingly with micropipettes. Rather, it was a problem to be solved through the creative and careful application of combinatorial mathematics, computer science, and robotic automation. Technological innovation, combined with human imagination, made the difference.

In addition, this project has been able to proceed on course because Congress and the public understand that the medical advances so important to all of us spring from such basic biomedical research. They are willing to support the necessary investment in this area because they share the vision and can understand the potential for dramatic returns – in the form of better health and improved quality of life.

It is much more difficult, however, to generate such shared vision for basic research that does not hold such immediately recognizable benefits. We have a quandary. Most Americans, when asked, say that they expect science and technology to solve some or most of the problems faced by our society, and that in order for that to happen, we should invest in research and put more emphasis on science in our schools. But at the moment, at least as far as the long-term prospects for research funding go, we seem to be moving in the opposite direction.

Somehow, as a nation we are unable or unwilling to make the sustained investment or have the confidence that will ensure the kind of future we want – a future made brighter by cures for cancer and mental illness; by clean,

renewable energy; by sustainable industrial development; by broadly accessible transportation and information systems; by affordable food and shelter; and by expanded horizons.

There is legitimate concern about how much we can afford to do. We need to balance the national budget so that future generations will not be burdened with our debt. Fair enough. But we need to distinguish between spending for the moment and investing in the future. Just as we cannot saddle the coming generations with our financial debt, neither can we saddle them with our societal debt through lack of concern for the future. We must invest in that future – through education, through research, and through attaining common purpose.

EDUCATION – PASS, FAIL, OR EXCEL?

The American educational system certainly developed through a series of bold assertions and actions. It is an essential part of our national heritage. What assertion could have been more bold in the eighteenth and nineteenth centuries than the belief that for a democracy to function and a nation to thrive, education must be the universal right of our young? What action could have been more bold than the passage of the Morrill Act, providing a large grant of land to each state to enable the establishment of universities that would provide higher education to vast numbers of young men and women, mostly of modest means? And, in our own century, what step could have been more dramatic, or have better provided for our future, than the establishment of the GI Bill? This is the stuff of greatness, nation building, and empowerment.

Today, however, we have evolved into a truly paradoxical situation. We have, by a huge margin, the greatest and most effective system of higher education in the world – in terms of quality, accessibility, and creation of new knowledge. At the same time, we have a system of primary and secondary education that is a national shame, one that is a surefire determinant of national decline if it is not corrected.

Repeatedly we have set national goals to be met by our schools by the year 2000 – just four years hence: goals that call for our students to be first in the world in science and mathematics achievement, and for every school to be free of drugs and violence. But few seem serious about accomplishing such goals. Too ambitious.

Our schools, especially in large cities, have had thrust upon them social ills with which they are not prepared to deal – parental indifference, students with low expectations, outmoded and decaying infrastructure, political infighting, misplaced ideology, meaningless bureaucracies, and insufficient financial support. But these are symptoms. They are symptoms of a loss of national will and vision, uncertain or nonexistent values, and lack of respect for our most important profession – the profession of teaching our children.

I do not profess to know the answer to improving America's public schools, but it must begin with a bold reassertion that nothing is more important than preparing our young to face the future.

To do that, I suggest that we must give our students the ability to live, act, and contribute meaningfully in a world that is ever changing. This will require far more than simple mastery over a body of knowledge. We need to prepare our students with a solid foundation in the sciences, social sciences and the humanities to appreciate what they encounter, and we need to do so in ways that will provide them with the skills to negotiate the unknown. To be prepared for the future, our students must be intellectually adventurous.

This is not the place to lay out a set of educational goals for our schools, but I would suggest that there is much to be learned from a set of national standards for science education recently developed by the National Research Council.³ These standards are based on principles that could apply to many fields. They are based on studying the changing needs of our populace, the changing nature of science itself, and successful educational practices. The standards promote science as discovery, rather than science as a collection of facts to be memorized and accepted. Students are encouraged to develop skills of analysis and synthesis and perspective. Our educators should explore these standards as well as the associated pedagogical techniques. If they were to be adopted, we would see some fundamental changes in the way we assess the progress and preparation of our students. There is much to be learned that could inspire a whole new generation of students and teachers.

Setting ambitious educational goals is one thing. But we will not attain them unless there is broad societal recognition of the importance of the teaching profession. We must support our committed teachers, and we must

create a new generation of teachers who are well educated, future-oriented, technologically literate, willing to be accountable, and excited to explore new ways of teaching and learning.

This is only the necessary condition, however; it is far from sufficient. These teachers must be supported by our citizenry of all ages, by government at all levels, by the mass media and the entertainment industry, by sports figures, by the criminal justice system, and, above all, by the parents and guardians of the young. They must be provided with the tools, the resources, the financial rewards, and the respect to do the job that must be done.

There is progress on at least one of these fronts. There appears to be enthusiasm and action at both federal and state levels, and within the private sector, for connecting all of our schools to the Internet by the end of the decade. This is a bold move, and it is appropriate. But the technical and financial requirements and capabilities must be thought through with great care, though expeditiously. Then the real question must be addressed: How can this new technology enhance learning?

First, of course, teachers must have the necessary understanding of and access to computers and information systems. But beyond that, the community of educators must become a learning and sharing organization. Herein lies the promise: There must be ways of sharing and learning from each other's experiences. The theory and practice of *learning organizations* must be tapped for techniques applicable to our educational system in the large.

The use of the World Wide Web and related tools holds huge promise for sharing learning resources. In the hands of skilled educators networked across the country, one school can produce a small, effective video, text, or other segment on, say, basic cell biology. Another school can produce brief segments about elementary algebra, another can address instruction in Spanish, and yet another may develop an exciting history unit. Individual teachers can then pull different units together to form coherent learning tools for the use of each class or student. By making all of these units available through the World Wide Web, it will be possible to share expertise, and achieve savings, on an unprecedented scale. There is no reason that this kind of collaboration need be restricted to the United States. The opportunities to share and work in education across national boundaries should be seriously explored; they will serve future generations well.

ARE WE STILL A LAND OF OPPORTUNITY?

When we think of the future, scientific and technological innovations often come to mind. But the quality of our future will have even more to do with human relations than it does with science and technology. If this nation is to thrive – economically, socially, politically – we must do all we can to ensure that all of our citizens are able to reach their full potential. Only then will we realize the full benefits to be found in a society peopled with different cultures, races, and nationalities.

RACE AND SOCIETY – ONE NATION OR MANY?

In the 1950s and 1960s, we as a nation determined that we would build a racially integrated, nondiscriminatory society, and we recognized that various interim commitments and corrective actions would be required until we reached that goal. Full attainment of that goal has proved more elusive than most anticipated. We now seem to be backing off in many ways – too ideological; too uncomfortable; too difficult.

Educational institutions have had central roles in both the action and debate throughout this period. Fundamentally, this is because of our special responsibility to prepare young people to take their full place in our society. Indeed, America's course in these matters was largely set by the 1954 Supreme Court decision in *Brown v. Board of Education* that laid the foundation for the affirmative action initiatives of the 1960s by ordering racial integration of public schools with all deliberate speed.

Today, more than 40 years after *Brown v. Board of Education*, we still find ourselves at the center of discussion, evaluation, and legal decisions about race and diversity. Largely because of explicit actions to increase access to our colleges and universities, most have become much more diverse racially, culturally, and economically. The presence and role of women on our campuses have improved dramatically. Still, most campuses cannot be judged to be broadly representative of the makeup of contemporary America. Statistics regarding most measures of academic success and access of young people to career, professional, and leadership tracks tell us that the goals set in the 1950s and 1960s have not yet been achieved. My sense is that we are losing will, ignoring realities, falling

into political partisanship, and, not infrequently, introducing mean-spiritedness into the national debate on these matters.

Effectively addressing issues of race and diversity is too essential to the future of the United States to allow it to be dissipated in partisan rhetoric. Maintaining our momentum is too urgent to allow it to be defined away through narrow, technical judicial decisions. Reinvigorating a national commitment is too demanding to allow it to drown in a sea of red tape. We need both idealism and pragmatism, but we cannot, through what Father Theodore Hesburgh refers to as “combat fatigue,” enter the next century without making real progress toward broad equality.

It astounds me how frequently the issue of diversity is addressed as if it were an abstract concept. Racial diversity is a *reality* of American life in 1996, and we know with certainty that it will be an even more dominant reality in, say, 2015, when the children being born this year are of college age. In 2015, the college-age population of the US will be 16-percent African-American and 19-percent Hispanic-American, and the mix of new immigrants to our shores, especially from Asia and Southeast Asia, also will contribute more substantially to the makeup of our citizenry.

By the year 2015, the work force will be one-third white male, one-third white female, and one-third people of color. All these workers will be toiling to support not only themselves, but all of us who, as retirees, will be dependent upon them – and they will constitute a much smaller proportion of our population. (In 2015, there will be only half as many people working and supporting the retired population as there were in 1960.) If they do not form a cohesive, productive society, the future will indeed be bleak. This prognostication is truly daunting, especially when combined with the fact that we will need to compete in a marketplace and economy that will be even more globalized and integrated than today.

Thus, even if we are willing to ignore the historical imperative and noble goal of equality and true integration, we must be problem solvers and set a sound course for our rapidly changing nation.

It is sorely tempting to declare victory and turn our back on affirmative action and related processes in America. How pleased I would be if we could legitimately assume that all of our citizens have reached a sufficient state of actual equality of opportunity and access that we could adopt simple, race-blind approaches to all that we do. That, of course, is the goal. But is it an honest evaluation of the situation today? One need only peruse the extensive tabulations of national statistics regarding wages, crime, education, health, and many other parameters in Andrew Hacker’s book, *Two Nations: Black and White, Separate, Hostile, Unequal* to know that we have not achieved anything approaching equality across the racial boundaries of our society. If that is not convincing, read the front page of any urban newspaper on any given day.

Yet we are retreating. The federal district court ruling in *Hopwood v. University of Texas* has already had repercussions around the country – as organized efforts to end affirmative action continue to grow. The actions of the University of California’s Board of Regents are well known; and in Colorado, the governing board of the university system has cut back on affirmative action programs. Other efforts include legislative moves in Pennsylvania and Arizona to outlaw affirmative action, and more than a dozen campaigns to amend the constitutions of various states.

In this context, I use the term “affirmative action” rather broadly to refer to programs or actions that specifically foster access or participation of minority groups or women in educational programs or jobs. This breadth seems appropriate in discussing universities in light of recent court decisions. MIT’s admissions process is consistent with the Supreme Court’s 1978 *Bakke* decision that universities may consider race “as one factor among many” in making admissions decisions. We build our admitted class to bring together students from diverse geographic, economic, cultural, racial, and experiential backgrounds, all of whom have exhibited the intellectual capacity, achievement, and motivation that are needed to succeed and benefit from MIT. Furthermore, our undergraduate financial aid is awarded solely on the basis of demonstrated financial need.

Yet in 1996, in *Hopwood v. University of Texas*, the Fifth Circuit Court of Appeals effectively reversed the *Bakke* decision for public institutions in Texas, Mississippi, and Louisiana, by declaring that “any consideration of race or ethnicity by the law school for the purpose of achieving a diverse student body is not a compelling interest” and therefore is not permitted.

I do not wish to defend across the board all federal affirmative action laws and set-aside policies, with their attendant red tape, cumbersome bureaucracies, and often artificial metrics. But I do want to defend the core concept that determined, often race-specific consideration and effort are still essential to move us toward the integrated, cohesive society we will need in the years ahead. The society I believe we will need is one in which individuals can realize their potential, and in which we can draw effectively on the individual and collective strengths and talents of our citizens of all colors and ethnicities. We cannot command, decree, or wish into existence such a nation. Rather we must work proactively to build it through the environments and opportunities we create for learning and working.

The idea that affirmative action programs are unnecessary or even unconstitutional is gaining momentum just at a time when we in science, engineering, and higher education are beginning to see some real results from these programs.

Last summer, the American Council on Education released its study on minorities in higher education,⁴ and reported a record number of Ph.D.'s awarded to black graduate students in 1995. And over the past eight years, the National Science Foundation reports,⁵ there has been a 75-percent increase in the number of science and engineering doctorates awarded to black graduate students – from 319 in 1987 to 557 in 1995. The media and others have hailed this as a dramatic increase. It is, indeed, real progress; nonetheless, the absolute numbers are stunningly small. Last year, for example, the number of blacks receiving the doctorate in electrical engineering in the US rose 40 percent over the previous year – to 24. Yet this is out of a total of 966 doctorates awarded in that field.

And yet there are arguments over the reasons for this progress. Supporters of affirmative action claim the increase as evidence of the programs' effectiveness, while critics argue that it is the result of increased educational opportunities, and that any benefits of affirmative action are offset by the negative effects of what they regard as preferential treatment of minorities.

Did "affirmative action" play a role in this modest success? It should not be a difficult matter to assess how many of these new Ph.D. graduates were definitively encouraged or enabled to reach this high level of attainment by specific programs or support. It should not be a matter of guesswork; the data should be obtained and affirmative action and outreach programs should be objectively evaluated on the basis of outcomes over time. It should not be a matter of ideology of the left or of the right. We should assess where we are, demonstrate what does and doesn't work, and get on with the job.

In the current legal environment, attorneys are recommending to organizations that were established specifically to promote educational opportunity for minority students that they modify their eligibility criteria to indicate that they will review applications without regard to the applicant's ethnicity. Frankly, this strikes me as a strange and artificial approach.

My own view is that we must hold to our principles if our nation is to benefit from the full range of talent needed to meet the challenges of a changing world. Our journey is not over. Our goal is not attained.

I believe that the time will come when affirmative action programs will no longer be necessary, but for now, we still have a compelling need for proactive efforts, despite calls by some that what is needed instead is simply stronger enforcement of antidiscrimination laws. Indeed, as Tom Wicker put it in his recent book, *Tragic Failure*: "If enforcement of antidiscrimination laws is the alternative to affirmative action, race, sex, and ethnic discrimination will be with us for a long time."

AN OPEN SOCIETY – TO WHOM?

Race is not the only focus of the argument about how open our society should be. These are economically difficult times in America – at least relative to our aspirations and to the post-war boom years. And as times get tight, there is a natural tendency to turn inward. So once again, we hear concerns that we should not be educating so many foreign graduate students. We hear that immigrants are a major cause of our woes. And we keep pulling apart into homogeneous groupings of one sort or another. But just because these are natural or understandable tendencies does not make them right.

America has always been a nation of immigrants and we have always been a land of opportunity. These statements perhaps sound quaint or old fashioned, but they are true, and we must retain their spirit.

Each year, my wife Becky and I host a dinner in our home for the men and women who are retiring from the tenured faculty ranks of MIT. These are always extraordinary assemblages of talented and accomplished colleagues – people who have defined MIT, and who have defined their professional and scholarly fields. No lack of bold thought there!

Yet, as I survey that room each spring, I realize how much MIT and indeed America have benefited from our being open to those from other countries, and how wise has been our tradition of selecting and advancing people on the basis of their talent and accomplishment rather than their wealth or nationality. Now, some might say that this represents a passing era, that what I am observing has its origins in the intellectual migrations from Europe associated with the turmoil of the World War II era. Or it might even represent the vestiges of the times during which the leading universities in science and engineering were in Germany and England.

No, it is an ongoing fact that the excellence of our institutions is due in very large measure to our openness to international scholars. MIT faculty who have received the Nobel Prize include individuals who were born in Japan, India, Italy, and Mexico. Our provost was born in Israel. We have deans who were born in Canada and Australia. Almost all came to the US as graduate students.

In fact, about one-third of all Ph.D. degrees in science and engineering earned in US universities are awarded to foreign citizens. (In engineering alone, half of the Ph.D.'s are earned by foreign citizens.) Many of these doctoral recipients initially pursue their careers in the US, and about 40 percent of them appear to remain here permanently. What a magnificent resource for our industries, universities, and government laboratories. Openness and meritocracy are what have made our universities great, and we must continue that spirit and philosophy in our national endeavors.

At the same time, we should concentrate on improving both science education and general education in this country's K-12 system in order to increase the number of motivated, well-prepared students entering universities and colleges. We should value more highly intellectual pursuits and celebrate the accomplishments of those who contribute to our health and quality of life by advancing science and technology. This is the way to ensure that, in the long run, our graduate programs have a larger, more stable base of US students.

We must, however, continue to provide access, opportunity, and welcome to the brilliant immigrants who contribute so much to our society – people like Institute Professor Hermann Haus, who received the National Medal of Science this year. Recollecting the call from John Gibbons, the President's Science Advisor, Professor Haus said, "I did not trust my senses, at first. After the news sunk in, the thoughts that came to my mind were that I was grateful to my fate for having come to the US, a victim of the 1945 ethnic cleansing in Yugoslavia; for becoming a citizen; and for the recognition I received on account of work I thoroughly enjoyed and for the privilege of association with outstanding students and colleagues."

I can think of no more eloquent description of what it means for this country to be the land of opportunity. We must retain our commitment to this bold dream.

END NOTE

Boldness and openness are qualities that we as a nation must seek to preserve and advance. We in America's research universities have a particular duty to do so.

Boldness flows from a spirit of adventure and a "can do" attitude long associated with America. These characteristics must again be dominant. To be effective, however, we must remember that boldness must be accompanied by staying power. Staying power is waning. We increasingly are better at starting things than at carrying them through. Contemporary politics demands "change" and new vision at least every two to four years. Our budget cycles cause us to be unreliable international partners as we start and stop projects. Staying power does

not mean stagnation, it permits the fulfillment of bold ideas, with plenty of correction, evolution, and adaptation along the way.

Openness flows from a spirit of generosity that has long characterized America, but which today appears to be in peril under the stresses of change, slow economic growth, and increasing uncertainty of the future. We must not allow this to happen, for openness and generosity can only be replaced by narrow expectations and selfishness.

We must, instead, choose to be bold and to be generous of spirit. We must believe in the possibility of greatness, for our society today and for the generations to come.

Charles M. Vest
September 1996

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- 1 Edwin H. Land, *Generation of Greatness: The Idea of University in an Age of Science*, Ninth Annual Arthur Dehon Little Memorial Lecture, delivered at the Massachusetts Institute of Technology, Cambridge, Massachusetts, May 22, 1957.
 - 2 National survey on public opinion of science and technology, commissioned by the National Science and Technology Medals Foundation, and conducted in June 1996 by the Roper Center for Public Opinion Research at the University of Connecticut.
 - 3 *National Science Education Standards*, National Academy Press, 1996.
 - 4 Reginald Wilson and Deborah Carter, *Minorities in Higher Education 1995-96: 14th Annual Status Report*, American Council on Education, June 1996.
 - 5 *Selected Data on Science and Engineering Doctorate Awards, 1995*, Division of Science Resource Studies, Directorate for Social, Behavioral and Economic Sciences, National Science Foundation (NSF 96-303).

IN SPECIAL RECOGNITION

This eventful year saw a number of changes within the academic and administrative leadership of MIT.

While many of these changes were cause for celebration, one brought great sadness. James J. Culliton, Vice President for Administration, died on June 3, 1996, at the age of 58 after a difficult battle with a rare affliction, multiple myeloma. Mr. Culliton held major responsibilities in personnel, finance, and administration at MIT for more than 20 years. He brought great humanity to the management of MIT: not only did he foster the careers of the many people who reported to him over the years, he cared about each of them. An articulate advocate of the public value of scientific and technological research, his approach to resolving complicated issues between the research universities and the federal government was highly respected on both sides. Within MIT, his was consistently a voice of reason and wisdom.

Robert A. Brown, Warren K. Lewis Professor of Chemical Engineering and Head of Chemical Engineering since 1988, was appointed Dean of the School of Engineering. Dr. Brown fills the vacancy created when Joel Moses, Dugald C. Jackson Professor of Computer Science and Engineering, was appointed Provost in June 1995. John B. Vander Sande, Cecil and Ida Green Distinguished Professor in the Department of Materials Science and Engineering and Associate Dean of Engineering, had served as acting dean in the interim.

J. David Litster, Vice President and Dean for Research, assumed additional responsibility as Dean for Graduate Education. Professor Litster, a physicist recognized internationally for his pioneering experimental and theoretical studies of phase transitions in unusual states of matter, will hold the title of Vice President for Research and Dean for Graduate Education. Frank E. Perkins, Dean of the Graduate School since 1983, returned to the Department of Civil and Environmental Engineering.

Alan Brody, the noted playwright who has been Professor of Theater at MIT since 1988, was named Associate Provost for the Arts. Professor Brody, Class of 1960 Fellow for 1993-95, had been chair of the Music and Theater Arts Section in the School of Humanities and Social Science since 1990. He succeeds Ellen T. Harris, Professor of Music, who was the first person to hold the post at MIT. After spending six years as associate provost, Professor Harris decided to return to full-time scholarship and teaching, beginning with the writing of a long-planned book about the music of George Frideric Handel.

Ann J. Wolpert, executive director of library and information services at the Harvard Business School since 1993, was named Director of the MIT Libraries. The previous director, Jay K. Lucker, retired in September after 20 years at MIT. Ms. Wolpert brings 30 years of experience in library and information science to her new position. David Ferriero, Associate Director of Public Services in the Libraries, accepted the position of University Librarian and Vice Provost for Library Affairs at Duke University, beginning in the fall of 1996. The Libraries have initiated a search for Mr. Ferriero's replacement.

New department or academic program heads announced during the past year were: Robert C. Armstrong, Head of Chemical Engineering; Peter Child, Head of Music and Theater Arts; Edward F. Crawley, Head of Aeronautics and Astronautics; Suzanne Flynn, Head of Foreign Languages and Literatures; and David E. Hardt, Engineering Co-Director of the Leaders for Manufacturing Program.

Among other key changes in the administration were the appointments of David G. Woodbury, Sr., as Head of the Administrative Division at Lincoln Laboratory; J. Daniel Nyhart, as Acting Registrar for 1996-97, succeeding David S. Wiley who retired as Registrar in the spring of 1996; R. Bruce Journey as the first full-time publisher of *Technology Review*; and Margaret R. Bates as Dean for Student Life in the Office of Undergraduate Education and Student Affairs.

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

Mario J. Molina, Professor of Earth, Atmospheric, and Planetary Sciences, along with two of his scientific colleagues, was awarded the 1995 Nobel Prize in chemistry for identifying chemical reactions, initiated by

chlorofluorocarbons, that can damage the ozone layer that shields us from the ultraviolet radiation of the sun. This work led ultimately to a landmark international agreement to phase out this entire class of chemicals.

Three members of the MIT family were recipients of the National Medal of Science. Announced by President Clinton, these awards are the nation's highest science and technology honors. The recipients are: Institute Professor Hermann A. Haus, Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics; Alexander Rich, William Thompson Sedgwick Professor of Biophysics, Department of Biology; and Institute Professor Emeritus Paul A. Samuelson. Their selection for the honor brings to 20 the number of MIT faculty who have received the National Medals of Science or Technology.

Two faculty members were elected to the National Academy of Sciences (NAS): Richard O. Hynes, Professor of Biology, Howard Hughes Medical Institute Investigator, and Director of the Center for Cancer Research; and Robert T. Sauer, Whitehead Professor of Biochemistry and Associate Head of Biology. The NAS was established by Congress in 1863 to act as an official advisor to the federal government in matters of science and technology. Election to membership is one of the highest honors accorded to scientists. Their election brings to 104 the number of MIT faculty members in the NAS.

Professor Hynes also was elected to the Institute of Medicine in recognition of his major contributions to health and medicine. Established in 1970 as a unit of the NAS, the Institute is broadly based in the biomedical sciences and health professions, as well as related aspects of the behavioral and social sciences, administration, law, the physical sciences, and engineering. Of the 519 active members of the Institute, 21 are from MIT.

David D. Clark, a Senior Research Scientist in the Laboratory for Computer Science, was elected to membership in the National Academy of Engineering (NAE). Election to the NAE is among the highest professional distinctions accorded to an engineer. His election brings to 94 the number of MIT faculty (active and emeriti) and staff who are members of NAE.

Six faculty members were inducted as Fellows of the American Academy of Arts and Sciences: Boris Altshuler, Professor of Physics; Thomas H. Jordan, Robert R. Shrock Professor of Earth and Planetary Sciences and Head of Earth, Atmospheric, and Planetary Sciences; Alan P. Lightman, John E. Burchard Professor of Science and Writing and Head of the Program in Writing and Humanistic Studies; James M. Poterba, Professor of Economics and Associate Head of Economics; Gerald J. Sussman, Matsushita Professor of Electrical Engineering in the Department of Electrical Engineering and Computer Science; and David A. Vogan, Professor of Mathematics.

Institute Professor Mildred S. Dresselhaus, an award-winning solid state physicist dedicated to improving career prospects for young scientists, was named president-elect of the American Association for the Advancement of Science (AAAS). The AAAS is the world's largest general science organization, with about 143,000 members and 300 affiliated science and engineering societies. It also publishes the weekly journal *Science*. Professor Dresselhaus is the ninth woman to be elected as AAAS president-elect. She will become president of AAAS in 1997, and then chairman of the Board of Directors in 1998.

Three members of the faculty were appointed MacVicar Faculty Fellows in recognition of their outstanding ability as teachers, their major innovations in education, and their dedication to helping others achieve teaching excellence. The new fellows are: Rick L. Danheiser, Professor of Chemistry and Associate Head of Chemistry; Michael F. Rubner, TDK Professor of Materials Science and Engineering; and Robert J. Silbey, Class of 1942 Professor of Chemistry.

Gian-Carlo Rota, Professor of Applied Mathematics and Philosophy, was selected as the 1996-97 recipient of the James R. Killian, Jr., Faculty Achievement Award, which recognizes extraordinary professional accomplishments and service to MIT. The selection committee's citation described Professor Rota as a "leading innovator and theorist in the transformation of combinatorics from a disparate collection of facts and techniques unworthy of serious mathematical consideration into an active, systematic and profound branch of modern pure and applied mathematics." Over the years, Professor Rota's services to the academic community, within MIT and beyond, have included the presidency of the Massachusetts chapter of Phi Beta Kappa, chair of the mathematics section of AAAS;

chair of the MIT Freshman Advisory Council, and a continuing enthusiasm for teaching undergraduate subjects in mathematics.

Anne E. C. McCants, Associate Professor of History and Class of 1957 Career Development Professor in the History Section, was named the 1996-97 recipient of the Harold E. Edgerton Faculty Achievement Award. This award is given annually to a junior faculty member in recognition of exceptional teaching, research, and scholarship. The selection committee described Professor McCants as “an energetic, creative and effective teacher.” During one three-year period, she created nine new history subjects, and has greatly invigorated teaching about the pre-industrial world. In addition to her significant research and teaching activities, Professor McCants has served the MIT community as the faculty resident at Green Hall, as an advisor to students, and as a member of many Institute committees.

The Gordon Y Billard Award, which recognizes individuals who have performed special service of outstanding merit to MIT, went to John M. Fresina, Director of the Safety Office, and Robert M. Randolph, Senior Associate Dean for Undergraduate Education and Student Affairs. For more than 30 years, Mr. Fresina has approached his mission as an educator rather than an enforcer and, in doing so, has been a teacher to us all. A wise counselor and advisor to students at all levels, Dean Randolph also has overseen the chaplaincy and the creation of the Religious Life Center.

Jonathan Gruber, Associate Professor of Economics, and seven MIT alumni and alumnae were selected as National Science Foundation Presidential Faculty Fellows. The awards program was introduced in 1992 to strengthen the relationship between research and teaching in science and engineering.

Vera Kistiakowsky, professor emeritus of physics, and Stephanie J. Bird, Special Assistant to the Provost, were among 25 persons elected to the first group of Fellows of the Association of Women in Science (AWIS). The new award of AWIS Fellow was created – on the 25th anniversary of the organization – to honor individuals who forward its goals through commitment to the AWIS mission, and support of women in science through scholarship, leadership, education, mentoring, or service. Professor Kistiakowsky and Dr. Bird were cited for their “demonstrated exemplary commitment to the achievement of equity for women in science and technology.”

The Institute was saddened this year by the deaths of several longtime friends and colleagues, including James J. Culliton, whose exceptional service to MIT is noted earlier in this report.

Warren Ambrose, professor emeritus of mathematics, died December 4, 1995, in Paris. Professor Ambrose, who was 81, retired in 1985 and had lived in Paris since 1989. He was recognized for his research in differential geometry, partial differential equations, and probability theory. He was also known for his commitment to political and social causes, particularly in Argentina and Chile when those countries were ruled by military regimes.

George Bekefi, professor emeritus of physics, died of leukemia on August 17, 1995. Professor Bekefi, who was 70, had retired in the summer of 1995, after 38 years on the faculty. He was widely known for his contributions in the field of plasma physics, particularly in the production of extremely high-powered microwave generators and in the development of free-electron lasers that are used as power sources in high-frequency bands. Dr. Bekefi also was highly regarded as a teacher, and was known for his enthusiasm and dedication to undergraduate and graduate students alike.

Professor George S. Boolos of the Department of Linguistics and Philosophy, president of the Association for Symbolic Logic, died May 27, 1996, at the age of 55 from pancreatic cancer. A prominent logician and philosopher, Professor Boolos was internationally known as one of the originators of provability logic. He had been awarded a Guggenheim Fellowship for 1996 to complete a book on Gottlob Frege, one of the founders of modern symbolic logic, and he had been recently appointed Rockefeller Professor of Philosophy at MIT.

Herbert S. Bridge, professor emeritus and an internationally known space scientist who played a key role in mapping the solar winds that flow through interplanetary space, died August 30, 1995, after a long illness. As associate director and later director of the MIT Center for Space Research, he was one of the pioneers in the exploration of the

solar system from unmanned spacecraft. Professor Bridge's combined interests in high-energy particles and mountaineering took him to high-altitude laboratories throughout the world.

Former Boston Mayor John F. Collins, who held visiting and consulting professorships at MIT for 13 years after he left office, died November 23, 1995, of pneumonia at the age of 76. Mayor Collins, widely regarded as one of the most successful and progressive mayors in the city's history, was appointed a visiting professor on January 2, 1968, the day after he completed his second term in office. Later in his tenure at MIT, Mr. Collins concentrated his efforts in the Sloan School, where he held the title of consulting professor.

Stuart H. Cowen, Vice President for Financial Operations at MIT at the time of his retirement in 1987, died on June 29, 1994, at the age of 72. In addition to his service as vice president, Mr. Cowen held several important posts in the financial operations area at MIT, including associate director for research contracts in the Division of Sponsored Research, director of fiscal planning, and comptroller.

Herbert H. Dow II, a Life Member of the Corporation, died suddenly on January 26, 1996, following heart surgery in Houston. Mr. Dow, who received the SB degree from MIT in 1952 in general engineering, spent his career with the Dow Chemical Company, retiring as vice president in 1992. He had been a director of the company since 1953. Long active in MIT affairs, Mr. Dow had been a member of the Corporation Development Committee since 1969. He was first elected to the Corporation in 1983 and had been a Life Member since 1993.

David Durand, a professor emeritus of management who was an early adherent of applying statistical methods – especially sampling – to problems in corporate finance and other fields, died February 26, 1996, at the MIT infirmary of aplastic anemia. Before coming to MIT in 1953, he was associated with the National Bureau of Economic Research and the Institute for Advanced Study at Princeton University. He also did consulting work for the Twentieth Century Fund and taught part-time at Columbia University.

Robley D. Evans, professor emeritus of physics, winner of the 1990 Enrico Fermi Award and a pioneer in studying the effects of radium on the human body, died of respiratory failure on December 31, 1995, in Paradise Valley, Arizona, where he lived in retirement. Professor Evans was a founder of the field of nuclear medicine and established the standard, used throughout the world, for the maximum permissible body burden of radium.

Thomas S. Kuhn, professor of philosophy and history of science from 1979 to 1983 and the Laurence S. Rockefeller Professor of Philosophy from 1983 until 1991, died on June 17, 1996. He had been ill with cancer in recent years. Professor Kuhn's theory of scientific revolution became a profoundly influential landmark of 20th-century intellectual history. He was the winner of the George Sarton Medal in the History of Science in 1982, and the holder of honorary degrees from many institutions.

Jerry McAfee, former chairman and CEO of Gulf Oil Corporation and Life Member Emeritus of the MIT Corporation, died of congestive heart failure at his home in Pittsburgh on October 14, 1995. Dr. McAfee was elected to the MIT Corporation in 1977. Previously he had been a member of the Corporation Visiting Committee on Chemical Engineering and a member of the national sponsoring committee for the chemical engineering building. He became a Life Member Emeritus in 1991.

Hajime Mitarai, the president of Canon, Inc., of Tokyo, who was elected to the MIT Corporation in June of 1995, died August 31, 1995, at the age of 56. His death was attributed to complications from pneumonia. After graduating from high school in Tokyo in 1957, Dr. Mitarai came to the United States for his education, something unusual for a Japanese citizen in those days. He actively supported MIT, having served as president of the MIT Association of Japan since 1990.

Carl F. J. Overhage, a physicist and electrical engineer who led a research group in the Airborne Division at the Radiation Laboratory during World War II and headed Lincoln Laboratory from 1957 to 1964, died August 7, 1995. Dr. Overhage's time at the Laboratory's helm was marked by several notable achievements, including the successful completion of work on the Semi-Automatic Ground Environment (SAGE) system of continental air defense; the establishment of the MITRE Corporation to operate the system for the government; and the reorientation of the

laboratory's technical programs toward research and development in new fields that included radar, radio physics and astronomy, space surveillance, and ballistic missile defense.

Institute Professor Emeritus Francis O. Schmitt, internationally recognized as a pioneer in modern biological research and in the study of the brain, died October 3, 1995, at the age of 91. As professor of biology, Dr. Schmitt headed MIT's department from 1942 to 1955, when he returned to teaching and research. It was at this time that he was appointed Institute Professor, in recognition of his exceptional contributions to the scholarly, educational, and general intellectual life of the Institute.

Prescott A. Smith, professor emeritus of mechanical engineering, died April 19, 1996, in Concord following a stroke. Professor Smith received the SB degree in mechanical engineering from MIT in 1935 and returned to the Institute in 1945 as an assistant professor and director of the Machine Tool Laboratory, now the Materials Processing Center. He was promoted to full professor in 1969 and retired in 1975. Professor Smith followed the footsteps of his father, the late professor Robert H. Smith, who joined the mechanical engineering faculty in 1882 and retired in 1932. Together, father and son served MIT for a total of 80 years.

Julian Szekely, Professor of Materials Engineering and widely known as an expert in the development of mathematical models in materials processing operations, including analysis of the economic, technological, and environmental factors involved in the production of various materials, died of cancer on December 7, 1995. As an example of his pioneering work in mathematical modeling, he developed the first comprehensive mathematical model of fluid-flow, electromagnetic and heat transfer phenomena for the refinement and solidification of metals, as well as the first quantitative analysis of plasma torches and innovative approaches to circuit board attachment problems.

Charles Fayette Taylor, Sr., professor emeritus of mechanical engineering, died June 22, 1996, at his home in Weston, of pneumonia and congestive heart failure. Professor Taylor, who was 101, joined MIT in 1926 after working with Orville Wright on the design of the "Whirlwind" engine that powered the historic flights of Charles Lindbergh and Robert Byrd. Founding Director of the Sloan Laboratory for Aircraft and Automotive Engines in 1933, he shaped the scientific framework for engine design and operation still in use today. During the years after World War II, he was active in efforts to encourage African-Americans in the Boston area to pursue higher education.

STATISTICS FOR THE YEAR

REGISTRATION

In 1995-96 student enrollment was 9,960, compared with 9,774 in 1994-95. There were 4,495 undergraduates (4,472 the previous year) and 5,465 graduate students (5,302 the previous year). The international student population was 2,138, representing 8 percent of the undergraduate and 33 percent of the graduate populations. These students were citizens of 104 countries. (Students with permanent residence status are included with US citizens.)

In 1995-96, there were 3,013 women students (1,705 undergraduate and 1,308 graduate) at the Institute, compared with 2,813 (1,604 undergraduate and 1,209 graduate) in 1994-95. In September 1995, 471 first-year women entered MIT, representing 42 percent of the freshman class of 1,122 students.

In 1995-96, there were, as self-reported by students, 2,630 minority students (1,980 undergraduate and 650 graduate) at the Institute, compared with 2,496 (1,944 undergraduate and 552 graduate) in 1994-95. Minority students included 363 African Americans (non-Hispanic), 37 Native Americans, 505 Hispanic Americans, and 1,725 Asian Americans. The first-year class entering in September 1995 included 493 minority students, representing 44 percent of the class.

DEGREES AWARDED

Degrees awarded by the Institute in 1995-96 included 1,223 bachelor's degrees, 1,350 master's degrees, 28 engineer's degrees, and 554 doctoral degrees – a total of 3,155 (compared with 2,839 in 1994-95).

STUDENT FINANCIAL AID

During the academic year 1995-96 the continuing healthy economy and a reduction in the number of needy students reduced the need for grant funds. At the same time, endowment income for scholarships increased by 10 percent. A total of 2,638 students who demonstrated need for assistance (59 percent of enrollment) received \$34,548,000 in grant aid and \$15,611,000 in student loans from all sources. The total, \$50,159,000, represents a 2-percent increase in aid compared to last year.

Grant assistance to undergraduates was provided by \$12,022,000 in income from the scholarship endowment, \$773,000 in current gifts, \$3,754,000 in federal grants (including ROTC scholarships), and \$3,315,000 in direct grants from non-federal outside sources to needy students. In addition, \$14,684,000 in scholarships from MIT's unrestricted funds was provided to undergraduates, inclusive of the special program of scholarship aid to needy minority group students that represented \$86,000 and the MIT Opportunity Awards that accounted for \$648,000. An additional 519 students received grants irrespective of need from outside agencies, totaling \$3,156,000. The undergraduate scholarship endowment was increased by the addition of \$23,867,234 in new funds. These new contributions increased the endowment for scholarships to \$128,000,126.

Loans totaling \$15,611,000 were made to undergraduates, a 9-percent increase from last year. Of the total loans made, \$1,911,000 came from the Technology Loan Fund, \$4,406,000 from the Federal Perkins Loan Program, and \$9,294,000 from the federal Direct Loan Program and other outside sources.

Graduate students obtained \$4,471,000 from the Technology Loan Fund, a 63-percent increase from last year's level. Most of this increase was a result of the increased enrollment in the master's program in the Sloan School of Management. Graduate students obtained \$9,204,000 from outside sources under the Federal Stafford Program, 19 percent more than last year. Graduate students also received \$172,000 in Perkins Loan funds and \$51,000 from other outside sources. The total, \$13,898,000, is an increase of 32 percent over last year.

The total of loans made to undergraduate and graduate students was \$29,509,000, a 12-percent increase over the last year.

The number of needy undergraduate students decreased by 2 percent to 2,639. The average need for this population increased by 2 percent to \$20,085. In the aggregate, the financial aid program required \$25,110,000 from needy

students' family resources and provided \$53,004,000 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

The year saw a bull market for MIT talent. Unlike the bull market on Wall Street, which showed signs of faltering in the spring, employers were eagerly soliciting resumes up to graduation. Over 600 employers (including individual divisions of companies making their own recruiting arrangements) used the facilities of the office to interview candidates. This compares with 442 in 1994-95 and 393 in 1993-94. It is doubtful that the office has ever seen more traffic in its 70-year history.

Buoying the market was a voracious demand from employers for graduates with software skills. It came from every corner of the economy – from the computer industry, from software firms and firms engaged in information systems consulting, and from firms of all sorts in manufacturing and the service sector using computers in their business. Approximately 5 out of 6 employers interviewing on campus listed “computer science” as a desired discipline. Many were also looking for students with other skills, but a large number wanted only students with a computer science background. Over a quarter of all the firms recruiting were either software developers or information systems consultants.

While the market was strongest for students with software skills, it was also strong for students with other interests. There was a welcome jump in recruiting, for example, by firms building mechanical and electro-mechanical equipment. The electronics industry was well represented, as were manufacturers of biomedical devices. In spite of continuing downsizing in the defense industry, firms engaged in work for the Department of Defense were active recruiters. Recruiting by firms in the oil, chemicals, materials, and food industries lagged only by comparison with the active recruiting by other companies. Salary offers to technical students were up 7 to 8 percent at the bachelor's level, about 4 percent at the master's level. Salary offers at the doctoral level ranged widely, but \$70,000 was roughly the median for Ph.D.'s in engineering.

MIT continued to participate in the nationwide surge in the number of applicants to medical school. A total of 254 candidates used the services of the office, up from 201 in 1995 and 187 in 1994. They included 153 undergraduates, 29 graduate students, and 72 alumni. It is not known at this writing how many were accepted. Last year the MIT acceptance rate was 59 percent, compared with 35 percent in the nation at large.

Gifts

Gifts, grants, and bequests to MIT from private donors in 1995-96 total \$130.9 million. This amount includes cash, securities, and real estate gifts totaling \$123.6 million, and \$7.3 million in support through the Industrial Liaison Program. In addition, gifts in kind, mostly of equipment, totaled \$8.8 million. The gifts reported by the Alumni Fund were \$24.8 million, a new record.

The pace of new gifts and new pledge commitments increased substantially over the past year. New commitments totaled \$137.1 million for the year, representing an increase of 37 percent over the previous year and a combined increase of 76 percent in the last two years. 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 \$1.3 billion, an increase of 6.3 percent from 1994-95. Education and general expenses, excluding the direct expenses of departmental and interdepartmental research and the Lincoln Laboratory, amounted to \$669.3 million during 1995-96 compared with \$598.8 million during 1994-95. The direct expenses of departmental and interdepartmental sponsored research on campus increased from \$271.2 million to \$275.7 million, while direct expenses of the Lincoln Laboratory sponsored research increased slightly from \$318.2 million to \$318.4 million. Current revenues used to meet the Institute's operating expenses totaled \$1,247.5 million, augmented by \$7.3 million in current gifts, \$1.6 million of other fund balances, and \$6.9 million of funds functioning as endowment.

At the end of the 1996 fiscal year, the Institute's investments, excluding retirement funds, student notes receivable, and amounts due from educational plant, had a book value of \$2.18 billion, and a market value of \$2.92 billion compared to last year's book value of \$1.94 billion and market value of \$2.50 billion.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

Change once again seemed to dominate the campus this year – both physical change and change in the way we do business. As the reengineering effort continued, many processes were reviewed and redesigned. Some of these changes involved custodial services, repair and maintenance procedures, and mail services in Physical Plant; copy and printing services in Graphic Arts; and the Office of Laboratory Supplies, which closed its operations entirely.

Physical improvements to the campus took place as well. After several years of design and construction, the Cogeneration Plant commenced operation. This project included the reconfiguration of the electrical distribution system, which has allowed us to phase out three old incoming substations and consolidate our service entrance requirements at the Central Utility Plant. However, within weeks of the start of operation, the Massachusetts Department of Public Utilities ordered the Institute to pay the local utility company a customer transition charge of \$1.3 million per year for leaving their system. The Institute has appealed this order as contrary to federal energy policy and continues legal action in what is being considered a landmark case.

Many new construction and renovation projects were undertaken this year, including the final phase of work on Senior House. With an aggressive schedule, this work should be completed in time for students to occupy the building for the fall term. The Tang Center, a 32,000-square-foot classroom building, was completed this year, and renovation work on the Whitaker Building (56) commenced with an expected completion date next winter. Other miscellaneous projects included major security upgrades in two parking garages, a continuation of the high-rise sprinkler program, and several landscape projects.

Work in conjunction with the Americans with Disabilities Act (ADA) also progressed. Campus elevator upgrades continued throughout the year in order to ensure compliance with current elevator and ADA regulations. Many projects upgrading the path of travel to and within our buildings were completed, and a study was begun of possible ways to improve access to the Kresge Auditorium, Kresge Little Theater, and the surrounding plaza.

The Institute purchased 480 Commonwealth Avenue in Boston for the purpose of housing a sorority.

The safety of students, faculty, and staff members remains an important issue. Additional lighting and improved walks in Killian Court were completed and a new Campus Police Motorcycle Unit was implemented this year, lending higher visibility to patrols. In addition, motor vehicle thefts decreased dramatically as the result of improved parking access control and security systems.

PERSONNEL CHANGES

CORPORATION

DEATHS

Herbert H. Dow
Life Member, Emeritus

Jerry McAfee
Life Member, Emeritus

Hajime Mitarai
Life Member, Emeritus

CHANGES OF APPOINTMENT

Joseph G. Gavin, Jr.
Life Member, Emeritus

Edward O. Vetter
Life Member, Emeritus

T. A. Wilson
Life Member, Emeritus

ELECTIONS

Alexander W. Dreyfoos, Jr.
Life Member

Josephine S. Jimenez
Member

L. Robert Johnson
Member

Michael M. Koerner
Member

Claudine B. Malone
Member

Christian J. Matthew
Life Member

Dana G. Mead
Member

Paul Rudovsky
Member

Theresa M. Stone
Member

Morris Tanenbaum
Life Member

William J. Weisz
Life Member

R. Robert Wickham
Member

Elliot K. Wolk
Member

MEMBER EX-OFFICIO

DuWayne J. Peterson, Jr.
President, Association of Alumni and Alumnae

TERMS EXPIRED

Karen W. Arenson
Member

William R. Brody
Member

DuWayne J. Peterson, Jr.
Member

Reginald D. Tucker
Member

FACULTY

DEATHS

Warren A. Ambrose
Professor
Department of Mathematics

George Bekefi
Professor
Department of Physics

George S. Boolos
Professor
Department of Linguistics and Philosophy

Herbert S. Bridge
Professor
Department of Physics

David Durand
Professor
Sloan School of Management

Robley D. Evans
Professor
Department of Physics

Thomas S. Kuhn
Professor
Department of Linguistics and Philosophy

Elting E. Morison
Professor
School of Humanities and Social Science

Carl F. J. Overhage
Professor
School of Engineering

Francis O. Schmitt
Institute Professor
Institute Professors

Prescott A. Smith
Professor
Department of Mechanical Engineering

Julian Szekely
Professor
Department of Materials Science and Engineering

RETIREMENTS

Robert W. Balluffi
Professor
Department of Materials Science and Engineering

E. Jane Betts
Associate Professor
Athletic Department

Klaus Biemann
Professor
Department of Chemistry

Harold Brown, Jr.
Assistant Professor
Athletic Department

Eugene E. Covert
Professor
Department of Aeronautics and Astronautics

Richard S. Eckaus
Professor
Department of Economics

Shaoul Ezekiel
Professor
Department of Aeronautics and Astronautics

Ralph A. Gakenheimer
Professor
Department of Urban Studies and Planning

Leon B. Groisser
Professor
Department of Architecture

Albert R. Gurney, Jr.
Professor
Literature Section

James W. Harris
Professor
Department of Linguistics and Philosophy

Hermann A. Haus
Institute Professor
Institute Professors

Kenneth M. Hoffman
Professor
Department of Mathematics

Keith H. Johnson
Professor
Department of Materials Science and Engineering

Arthur Kaledin
Professor
History Section

Jack L. Kerrebrock
Professor
Department of Aeronautics and Astronautics

John G. King
Professor
Department of Physics

Robert D. Logcher
Professor
Department of Civil and Environmental Engineering

Willem Van R. Malkus
Professor
Department of Mathematics

Gary T. Marx
Professor
Department of Urban Studies and Planning

James E. Mc Cune
Professor
Department of Aeronautics and Astronautics

Robert B. Mc Kersie
Professor
Sloan School of Management

Pasquale E. Melaragno
Assistant Professor
Athletic Department

David Michael
Associate Professor
Athletic Department

Marvin L. Minsky
Professor
Department of Electrical Engineering and Computer Science

Francis C. O'Brien, Jr.
Associate Professor
Athletic Department

Irwin Oppenheim
Professor
Department of Chemistry

Seymour A. Papert
Professor
Program in Media Arts and Sciences

David B. Ralston
Professor
History Section

George W. Rathjens
Professor
Department of Political Science

Phillips W. Robbins
Professor
Department of Biology

Jerome H. Saltzer
Professor
Department of Electrical Engineering and Computer Science

Robert W. Simpson
Professor
Department of Aeronautics and Astronautics

Harold Y. Wachman
Professor
Department of Aeronautics and Astronautics

Charles Weiner
Professor
Program in Science, Technology, and Society

RESIGNATIONS

Professor

Boris Altshuler
Department of Physics

Ned J. Block
Department of Linguistics and Philosophy

Susan Carey
Department of Brain and Cognitive Sciences

Richard C. Mulligan
Department of Biology

Marc H. Raibert
Department of Electrical Engineering and Computer Science

Associate Professor

Anantaram Balakrishnan
Sloan School of
Management

S. Lael Brainard
Sloan School of
Management

Roger K. Brooks
Department of Physics

Chris F. Kemerer
Sloan School of
Management

Peter T. Lansbury
Department of Chemistry

Ruth Lehmann
Department of Biology

Karl T. Ulrich
Sloan School of
Management

William E. Weihl
Department of Electrical
Engineering and Computer
Science

Assistant Professor

Ella Edmondson Bell
Sloan School of
Management

John Core
Sloan School of
Management

J. Robert Fricke
Department of Ocean
Engineering

David A. Gonzales
Department of Aeronautics
and Astronautics

Mauro F. Guillen
Sloan School of
Management

Mauricio Karchmer
Department of Mathematics

Mark Matthews
Department of Mathematics

Leonard J. Morse-Fortier
Department of Architecture

Paul J. Resnick
Sloan School of
Management

PROMOTIONS**To Professor**

Rohan Abeyaratne
Department of Mechanical
Engineering

Dimitris J. Bertsimas
Sloan School of
Management

Ricardo J. Caballero
Department of Economics

Michael J. Cima
Department of Materials
Science and Engineering

President

Lorna J. Gibson
Department of Civil and
Environmental Engineering

David K. Gifford
Department of Electrical
Engineering and Computer
Science

W. Eric L. Grimson
Department of Electrical
Engineering and Computer
Science

R. John Hansman, Jr.
Department of Aeronautics
and Astronautics

Peter S. Kim
Department of Biology

Andreas Mortensen
Department of Materials
Science and Engineering

Nicholas M. Patrikalakis
Department of Ocean
Engineering

Carl R. Peterson
Department of Mechanical
Engineering

Nancy L. Rose
Sloan School of
Management

D. Eleanor Westney
Sloan School of
Management

PROMOTIONS**To Associate Professor**

Cynthia Barnhart
Department of Civil and
Environmental Engineering

Moungi G. Bawendi
Department of Chemistry

S. Lael Brainard
Sloan School of
Management

Roger K. Brooks
Department of Physics

Erik Brynjolfsson
Sloan School of
Management

Gerbrand Ceder
Department of Materials
Science and Engineering

James E. Chung
Department of Electrical
Engineering and Computer
Science

Dara Entekhabi
Department of Civil and
Environmental Engineering

Jonathan Gruber
Department of Economics

Nesbitt W. Hagood
Department of Aeronautics
and Astronautics

Jonathan Golden Harris
Department of Chemical
Engineering

Qing Hu
Department of Electrical
Engineering and Computer
Science

Kirk D. Kolenbrander
Department of Materials
Science and Engineering

Jon E. Lendon
History Section

Patricia Maes
Program in Media Arts and
Sciences

Anne E. C. Mc Cants
History Section

Uday Bhanu Pal
Department of Materials
Science and Engineering

Rosalind Picard
Program in Media Arts and
Sciences

Nasser Omar Rabbat
Department of Architecture

Lisa J. Randall
Department of Physics

Gregory Rutledge
Department of Chemical
Engineering

Paul Smoke
Department of Urban
Studies and Planning

Paraskevas Sphicas
Department of Physics

Ritsuko Taho
Department of Architecture

Lawrence Vale
Department of Urban
Studies and Planning

Stephen W. Van Evera
Department of Political
Science

Xiao-Gang Wen
Department of Physics

Bernd Widdig
Foreign Languages and
Literatures Section

James R. Williamson
Department of Chemistry

CHANGES OF APPOINTMENT

Robert C. Armstrong
Department Head, and
Chevron Professor of
Chemical Engineering
Department of Chemical
Engineering

Arthur B. Baggeroer
Ford Professor of
Engineering
Department of Ocean
Engineering

David Baltimore
Institute Professor
Institute Professors

Aaron F. Bobick
LG Career Development
Assistant Professor
Program in Media Arts and
Sciences

V. Michael Bove
Alex W. Dreyfoos, Jr.
(1954) Career Development
Associate Professor
Program in Media Arts and
Sciences

Rafael L. Bras
Department Head and
Bacardi-Stockholm Water
Foundations Chair
Department of Civil and
Environmental Engineering

Alan Brody
Associate Provost
Music and Theater Arts
Section

Robert A. Brown
Dean of the School of
Engineering And Warren K.
Lewis Professor of Chemical
Engineering

Erik Brynjolfsson
Douglas Drane Career
Development Associate
Professor
Sloan School of
Management

Robert E. Cohen
Raymond A. and Helen M.
St. Laurent Professor
Department of Chemical
Engineering

Elfatih A. B. Eltahir
Gilbert T. Winslow Career
Development Assistant
Professor
Department of Civil and
Environmental Engineering

Lynn W. Gelhar
William E. Leonhard
Professor
Department of Civil and
Environmental Engineering

Stephen C. Graves
Abraham J. Siegel Chair
Professor of Management
Science
Sloan School of
Management

John H. Harbison
Institute Professor
Institute Professors

David E. Hardt
Co-director of Leaders for
Manufacturing Program and
Professor of Mechanical
Engineering

Ellen T. Harris
Professor
Office of the Provost

Michael J. Hawley
Alex W. Dreyfoos, Jr. 1954
Career Development
Assistant Professor
Program in Media Arts and
Sciences

James Howe
Head And Professor of the
Anthropology And
Archaeology Program

William Q. Hubbard, Jr.
Visiting Associate Professor
Department of Architecture

Jean E. Jackson
Professor
Anthropology Program

M. Frans Kaashoek
Jamieson Career
Development Assistant
Professor of Computer
Science and Engineering
Department of Electrical
Engineering and Computer
Science

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

Steven R. Lerman
Professor
Office of the Provost

Donald R. Lessard
Epoch Foundation Professor
of Management
Sloan School of
Management

Paul F. Levy
Adjunct Professor
Department of Urban
Studies and Planning

Alan P. Lightman
Department Head Professor
and John E. Burchard
Professor of Science and
Writing
Program in Writing and
Humanistic Studies

Stephen J. Lippard
Department Head and
Professor
Department of Chemistry

J. David Litster
Vice President for Research
and Dean for Graduate
Education and Professor of
Physics

Seth Lloyd
Finmeccanica Career
Development Assistant
Professor Of Engineering
Department of Mechanical
Engineering

Patricia Maes
Sony Corporation Career
Associate Professor
Program in Media Arts and
Sciences

Don O. May
Nanyang Technological
University Career
Development Assistant
Professor
Sloan School of
Management

Anne M. Mayes
Class of 1948 Professor of
Polymer Physics
Department of Materials
Science and Engineering

Gregory J. Mc Rae
Bayer Professor
Department of Chemical
Engineering

Marcia K. McNutt
Director of the MIT/Woods
Hole Joint Program in
Oceanography and Ocean
Engineering and Earle A.
Griswold Professor

Shigeru Miyagawa
Kochi Prefecture - John
Manjiro Professor of
Japanese
Language and Culture
Foreign Languages and
Literatures Section

James D. Paduano
Carl Richard Soderberg
Professor of Power
Engineering
Department of Aeronautics
and Astronautics

Frank E. Perkins
Professor
Office of the Provost

Rafael L. Reif
Director of Microsystems
Technology Laboratory and
Professor of Electrical
Engineering and Computer
Science

Mitchel J. Resnick
Fukutake Career
Development Assistant
Professor of Research in
Education
Program in Media Arts and
Sciences

Harriet Ritvo
Arthur J. Connor Professor
of History and Writing
History Section

Stephen D. Senturia
Barton L. Weller Professor
of Electrical Engineering
Department of Electrical
Engineering and Computer
Science

Joanne Stubbe
Ceiba-Geigy Professor
Department of Chemistry

Laurence E. Susskind
Ford Professor of Urban and
Environmental Planning
Department of Urban
Studies and Planning

Steven R. Tannenbaum
Professor and Director
Division of Toxicology

Marcus A. Thompson
Acting Section Head and
Professor of Music and
Theater Arts

John B. Vander Sande
Associate Dean and Cecil
and Ida Green Professor
School of Engineering

Daniel I. C. Wang
Institute Professor
Institute Professors

Jiang Wang
Ford Foundation Internation
Career Development
Associate Professor
Sloan School of
Management

Rosalind H. Williams
Dean, Undergraduate
Education and Metcalfe
Professor of Writing
Undergraduate Education
and Student Affairs

Shi-Chang Wooh
Esther And Harold E.
Edgerton Assistant Professor
Department of Civil and
Environmental Engineering

Mark S. Wrighton
Visiting Professor
Department of Chemistry

Jacquelyn Ciel Yanch
W. M. Keck Career
Development Professor in
Biomedical Engineering
Department of Chemical
Engineering

Jackie Y. Ying
Raymond A. and Helen E St.
Laurent Career
Development Assistant
Professor
Department of Chemical
Engineering

Lawrence R. Young
Apollo Program Professor of
Astronautics
Department of Aeronautics
and Astronautics

NEW APPOINTMENT

PROFESSOR

George Apostolakis
Professor
Department of Nuclear
Engineering

George N. Stiny
Professor
Department of Architecture

Gang Tian
Professor
Department of Mathematics

Maria Zuber
Professor
Department of Earth,
Atmospheric, and Planetary
Sciences

Associate Professor

Alexander B. Goncharov
Associate Professor
Department of Mathematics

Hiroshi Ishii
Associate Professor
Program in Media Arts and
Sciences

Michael Leja
Associate Professor
Department of Architecture

Mark S. Welsh
Associate Professor
Department of Ocean
Engineering

Assistant Professor

Barton L. Anderson
Assistant Professor
Department of Brain and
Cognitive Sciences

Larry Anderson
Assistant Professor
Athletic Department

Susan Athey
Assistant Professor
Department of Economics

Michael P. Brenner
Assistant Professor
Department of Mathematics

Alexander Bryne
Assistant Professor
Department of Linguistics
and Philosophy

Ismail Chabini
Assistant Professor
Department of Civil and
Environmental Engineering

John Core
Assistant Professor
Sloan School of
Management

Elizabeth A. Eccher
Assistant Professor
Sloan School of
Management

Dennis M. Freeman
Assistant Professor
Department of Electrical
Engineering and Computer
Science

Denis Gromb
Assistant Professor
Sloan School of
Management

Sandy D. Jap
Assistant Professor
Sloan School of
Management

James K. Kuchar
Charles Stark Draper
Assistant Professor
Department of Aeronautics
and Astronautics

Amos Lapidot
Assistant Professor
Department of Electrical
Engineering and Computer
Science

Earl K. Miller
Assistant Professor of Visual
Neuroscience
Department of Brain and
Cognitive Sciences

John B. Miller
Assistant Professor
Department of Civil and
Environmental Engineering

Shankar Raman
Assistant Professor
Literature Section

Frederic Rasio
Assistant Professor
Department of Physics

Omar M. Razzaz
Assistant Professor
Department of Urban
Studies
and Planning

Sanjay E. Sarma
Assistant Professor
Department of Mechanical
Engineering

Frederic C. Schaffer
Assistant Professor
Department of Political
Science

Kai-Yeung Siu
Assistant Professor
Department of Mechanical
Engineering

Sarah Slaughter
Assistant Professor
Department of Civil and
Environmental Engineering

Scott Stern
Assistant Professor
Sloan School of
Management

Andras Szenes
Assistant Professor
Department of Mathematics

Nader Tavassoli
Assistant Professor
Sloan School of
Management

Anna Thornton
Assistant Professor
Department of Mechanical
Engineering

Robert van der Hilst
Assistant Professor
Department of Earth,
Atmospheric, and Planetary
Sciences

Jaume Ventura
Assistant Professor
Department of Economics

Paul A. Viola
Assistant Professor
Department of Electrical
Engineering and Computer
Science

Ralph Nicholas Wedgwood
Assistant Professor
Department of Linguistics
and Philosophy

Kelin Whipple
Assistant Professor
Department of Earth,
Atmospheric, and Planetary
Sciences

Visiting Professor

James Ackerman
Assistant Professor
Department of Architecture

John A. Armstrong
Visiting Professor
Department of Physics

Eduard Arzt
Visiting Professor
Department of Materials
Science and Engineering

Charles Berg
Visiting Professor
Department of Mechanical
Engineering

Robert S. Berg
Visiting Professor
Program in Media Arts and
Sciences

Atilio Alberto Boron
Visiting Professor
Department of Political
Science

Edward H. Bowman
Visiting Professor
Sloan School of
Management

Anirudh Dhebar
Visiting Professor
Sloan School of
Management

Rudolf Dolzer
Visiting Professor
Department of Political
Science

Stephen R. Forrest
Visiting Professor
Department of Electrical
Engineering and Computer
Science

John Geanakoplos
Visiting Professor
Department of Economics

Robert Gooding
Visiting Professor
Department of Physics

Isaac Greber
Visiting Professor
Department of Aeronautics
and Astronautics

Wesley L. Harris
Martin Luther King, Jr.
Visiting Professor
Department of Aeronautics
and Astronautics

Toshihisa Honma
Visiting Professor
Department of Aeronautics
and Astronautics

Richard Joseph
Visiting Professor
Department of Political
Science

John Kao
Visiting Professor
Program in Media Arts and
Sciences

Theodoulos Z. Kattamis
Visiting Professor
Department of Materials
Science and Engineering

Bruce Lehmann
Visiting Professor
Sloan School of
Management

Marsha Lester
Visiting Professor
Department of Chemistry

Geoffrey R. Loftus
Visiting Professor
Department of Brain and
Cognitive Sciences

Donlyn Lyndon
Visiting Professor
Department of Chemistry

Shlomo Maital
Visiting Professor
Sloan School of
Management

Alan J. Marcus
Visiting Professor
Sloan School of
Management

James M. Mc Innes
Visiting Professor
Sloan School of
Management

Paul Milgrom
Visiting Professor
Department of Economics

James W. Modestino
Visiting Professor
Department of Electrical
Engineering and Computer
Science

Tomasz S. Mrowka
Visiting Professor
Department of Mathematics

Finn G. Nielsen
Visiting Professor
Department of Ocean
Engineering

Kenji Nishibori
Visiting Professor
Laboratory for
Manufacturing and
Productivity

Philip M. Parker
Visiting Professor of
Marketing
Sloan School of
Management

Paul Platero
Visiting Professor
Department of Linguistics
and Philosophy

Jay Ritter
Visiting Professor
Sloan School of
Management

Charles F. Sabel
Visiting Professor
Department of Political
Science

Bruce Schmeiser
Visiting Professor
Sloan School of
Management

Michael L. Tushman
Visiting Professor
Sloan School of
Management

Robert Verrecchia
Visiting Professor
Sloan School of
Management

Terrence A. Weisshaar
Jerome C. Hunsaker Visiting
Professor
Department of Aeronautics
and Astronautics

Kenneth L. Williamson
Visiting Professor
Department of Chemistry

**Visiting Associate
Professor**

Yannis Bakos
Visiting Associate Professor
Sloan School of
Management

Arup Kumar Chakraborty
Visiting Associate Professor
Department of Chemical
Engineering

Suzanne DeTreville
Visiting Associate Professor
Sloan School of
Management

Paul Donnelly
Visiting Associate Professor
Department of Architecture

Meir Feder
Visiting Associate Professor
Department of Electrical
Engineering and Computer
Science

President

Harold J. Frost
Visiting Associate Professor
Department of Materials
Science and Engineering

Manuela Hidalgo
Visiting Associate Professor
Department of Civil and
Environmental Engineering

William Q. Hubbard, Jr.
Visiting Associate Professor
Department of Architecture

Mark Jarzombek
Visiting Associate Professor
Department of Architecture

Sharon A. Johnson
Visiting Associate Professor
Leaders for Manufacturing
Program

Hiroshi Kagemoto
Visiting Associate Professor
Department of Ocean
Engineering

Terry W. Knight
Visiting Associate Professor
Department of Architecture

Arthur D. Lander
Visiting Associate Professor
Department of Brain and
Cognitive Sciences

Su-Jien Lin
Visiting Associate Professor
Department of Materials
Science and Engineering

Oliver G. Mc Gee
Visiting Associate Professor
Department of Aeronautics
and Astronautics

Joyce S. Mehring
Visiting Associate Professor
Center for Transportation
Studies

Takayuki Morikawa
Visiting Associate Professor
Department of Civil and
Environmental Engineering

Daniel Richards
Visiting Associate Professor
Sloan School of
Management

James R. Richardson
Visiting Associate Professor
Department of Urban
Studies
and Planning

Kevin Rock
Visiting Associate Professor
Sloan School of
Management

Jean-Jacques Salomon
Visiting Associate Professor
Department of Political
Science

Rakesh V. Vohra
Visiting Associate Professor
Sloan School of
Management

**Visiting Assistant
Professor**

John Dinardo
Visiting Assistant Professor
Department of Economics

Charalabos Doumanidis
Visiting Assistant Professor
Department of Mechanical
Engineering

Sara Fisher Ellison
Visiting Assistant Professor
Department of Economics

Alan Hajek
Visiting Assistant Professor
Department of Linguistics
and Philosophy

Diana Henderson
Visiting Assistant Professor
Literature Section

Barbara F. Hyams
Visiting Assistant Professor
Foreign Languages and
Literatures Section

Steven Lee
Visiting Assistant Professor
Department of Mathematics

Dekang Lin
Visiting Assistant Professor
Department of Electrical
Engineering and Computer
Science

Gita Martohardjono
Visiting Assistant Professor
Foreign Languages and
Literatures Section

Arthur G. O. Mutambara
Visiting Assistant Professor
Department of Aeronautics
and Astronautics

Kate Okikiolu
Visiting Assistant Professor
Department of Mathematics

Ronitt Rubinfeld
Visiting Assistant Professor
Department of Electrical
Engineering and Computer
Science

Panajiotis Sakkalis
Visiting Assistant Professor
Department of Ocean
Engineering

Ilya Segal
Visiting Assistant Professor
Department of Economics

Sarah Stroud
Visiting Assistant Professor
Department of Linguistics
and Philosophy

T. Kelly Wilson
Visiting Assistant Professor
Department of Architecture

Kenneth Yip
Visiting Assistant Professor
Department of Electrical
Engineering and Computer
Science

ADMINISTRATION

DEATHS

John J. Barbato
Project and Construction
Engineer
Physical Plant

Weston J. Burner
Director, Information
Processing Services
Vice President for
Information Systems

Richard J. Caloggero
Administrative Officer II
Department of Electrical
Engineering and Computer
Science

James J. Culliton
Vice President
Vice President for
Administration

Maryrose Eramo
Assistant to the Director for
Administration
Admissions Office

Peter D. Gellatly
Associate Publisher,
Technology Review
Alumni Association

Ben H. Inouye
Assistant Director, I L P and
Director of M I T - I L P
Toyko
Industrial Liaison Program

J. Samuel Jones
Associate Director, Student
Financial Aid Office
Student Financial Aid Office

Edward L. Mc Cormack
Institute Auditor
Audit Division

Shawn F. Mc Kay
Applications Development
Programmer I I I
Department of Electrical
Engineering and Computer
Science

George K. Sankey
Special Assistant to the Vice
President
Resource Development
Vice President

C. Fayette Taylor
Administrative Staff
Department of Mechanical
Engineering

George L. Wallace
Purchasing Agent
Purchasing and Stores

RETIREMENTS

Morton Berlan
Director of
Telecommunications
Systems
Vice President for
Information Systems

Lee C. Birks
House Manager
Housing

Paul E. Brown
Director, Advanced Study
Program
Center for Advanced
Educational Services

Ronald J. Byrnes
Supervisor, Mechanical
Services
Physical Plant

William A. Caiewski
Production Analyst
Service Process

Josephine E. Calareso
Supervisor, Media and
Glassware Preparation
Department of Biology

George E. Carney
Shift Supervisor, Building
Services
Physical Plant

James B. Coffin, Jr.
Engineering Assistant
Physical Plant

Richard M. Collis
Supervisor,
Quick Copy Center
Graphic Arts

John A. Currie
Director of Finance
Vice President for Financial
Operations

Robert C. Di Iorio
Associate Director, News
Office
Public Relations Services

Raymond M. Diffley, Jr.
Associate Director of Safety
Office
Safety Office

Norman Doelling
Executive Officer/ Assistant
Director for Advisory
Services and Education
Sea Grant College Program

George H. Dummer
Director, Office of
Sponsored Programs
Vice President for
Administration

Margaret E. Fahey
Accounting Officer
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Industrial Liaison Program

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Libraries

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Advising
Vice President for
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Lauri B. Hugentobler Senior Analyst Programmer Registrar's Office	Keith Morgan Librarian Libraries	Joel D. Risberg Analyst Programmer Physical Plant	Bonny Claire Marie Wilbur Associate Director, Counseling Career Services and Preprofessional Advising
Gregory A. Jackson Director, Academic Computing Services Vice President for Information Systems	David W. Murphy Supervisor, Technical Processing Services Libraries	David B. Robbins Systems Programmer Service Process	Jamie E. Young Administrative Officer Department of Linguistics and Philosophy
M. Susan Jones Consultant Support Process	Juliet S. Murphy Research Analyst Office of Development Research and Systems	Peter Roden Senior Project Manager The Network Business	Chao-Yang Zhang Associate Liaison Officer Industrial Liaison Program
Jeffrey T. Kalin Designer MIT Press	Lillian Lee Neiswender Assistant to the Director, Communications and Donor Relations Office of Individual Giving	James F. Rudd, Jr. Systems Analyst Sloan School of Management	NEW APPOINTMENTS
Thomas F. Krall Consultant Academic Computing Services	Lisa S. Newfield Manager of Special Projects Medical Department	Christopher D. Seebeck Computer Network Administrator Graphic Arts	Rebecca J. Aaronson Supervisor, Technical Processing Services Libraries
W. Kevin Larkin Assistant Treasurer/ Assistant Director Capital Gifts and Legal Affairs Treasurer's Office	Junco N. Norton Financial Administrator Department of Earth, Atmospheric and Planetary Sciences	Brittany Leigh Sherer Analyst Programmer Office of Facilities Management Systems	Alicia L. Allen Consultant The Network Business
Joanne W. Larrabee Senior Consultant Support Process	Lisa J. Oliveira Assistant Director of Admissions Admissions Office	Ann Sochi Assistant Editor MIT Press	Roslyn M. Allen Benefits Counselor Personnel Office
Jeannet Leendertse Senior Designer MIT Press		David Mark Sprague Systems Programmer Service Process	Bruce N. Anderson Industrial Liaison Officer Industrial Liaison Program
Barbara A. Luby Coordinator of Parent and Student Programs Alumni Association		Mallory Stark Librarian Libraries	Mark A. Angel Auditor Audit Division

Elizabeth D. Ankers Analyst Programmer Controller's Accounting Office	Jennifer L. Edwards Librarian Libraries	William F. Hogue Director, I / T Support Vice President for Information Systems	Jeff Martin Systems Programmer Foreign Languages and Literatures Section
Alemayehu Awoke Auditor Audit Division	Robin C. Elices Administrative Officer Department of Earth, Atmospheric, and Planetary Sciences	Greg Hudson Systems Programmer The Network Business	Patricia A. McCosco Administrative Officer Department of Mechanical Engineering
Margaret R. Bates Dean for Student Life Undergraduate Education and Student Affairs	Lisa J. Feltner Financial Administrator Department of Earth, Atmospheric and Planetary Sciences	Gerald I. Isaacson Manager of Data Security Vice President for Information Systems	James E. Mc Wethy Designer MIT Press
Lisa M. Berard Analyst Programmer Physical Plant	Sharon D. Francis Assistant to the Vice President for Finance and Treasurer Reengineering-Management Reporting	Imee M. Jackson Industrial Liaison Officer Industrial Liaison Program	Stacy E. McGeever Admissions Counselor Admissions Office
Joseph C. Brady Benefits Counselor Personnel Office	Kenia Franco Personnel Officer Personnel Office	R. Bruce Journey Publisher, Technology Review Alumni Association	Kimberly G. McGlothlin Assistant Dean, Counseling and Support Services Undergraduate Education and Student Affairs
Leslie E. Byrne Administrative Assistant Medical Department	Joan M. Frank Assistant Circulation Manager, Technology Review Alumni Association	Jaclyn B. Kalb Supervisor, Quick Copy Center Graphic Arts	Paul A. Michelman Director of Publications Sloan School of Management
Kathleen Cahill Consultant Support Process	Susan A. Funke Manager, Corporate Resource Center, Career Development Office Sloan School of Management	Cynthia W. Kam Senior Compensation Consultant Personnel Office	Alexander Midler Analyst Programmer Office of Development Research and Systems
Huey S. Chan Analyst Programmer Office of the Bursar	Jessica A. Goldhirsch Director of Health Education Service Medical Department	Elisabeth Kaplan Archival / Manuscript Specialist Libraries	Thomas Mullins Assistant Director for Administration and Finance, Information Systems Vice President for Information Systems
John H. Christel Senior Research Analyst, Resource Development Office of School Development Services	Christina M. Gonzalez Analyst Programmer Lincoln Fiscal Office	Joanne M. Katz Manager, Campus Activities Complex Campus Activities Complex	David J. Mycue System Manager / System Programmer Center for Advanced Educational Services
Michael P. Corcoran Contract Administrator Office of Sponsored Programs	Margaret Gonzalez Manager of Corporate Relations Industrial Liaison Program	Ori Kometani Designer MIT Press	Stephanie D. Neal-Johnson Assistant to the Vice President For Human Resources Personnel Office
Nathaniel L. Crosswhite Applications Development Programmer Office of Facilities Management Systems	Louis W. Graham, Jr. Manager, Audio Visual Graphic Arts	Walter J. Kullas Maintenance Supervisor Physical Plant	Eileen Ng Financial Administrator Department of Mechanical Engineering
Michele E. Desautels Facility Administrator, Learning Center Vice President for Information Systems	Karen Harnett Gribbell Assistant Director, Master's Program Sloan School of Management	M. S. Vijay Kumar Director, Academic Computing Services Vice President for Information Systems	William J. O'Connor Systems Coordinator Whitaker College of Health Sciences Technology
Patrice M. Diaz-Migoyo Systems Analyst Sloan School of Management	Lori Gross Director, Museum Loan Network Office of the Arts	Thomas J. Lane, Jr. Consultant The Network Business	Katherine G. O'Dair Assistant Dean, R.C.A Undergraduate Education and Student Affairs
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		Peter J. Maloof Systems Programmer Department of Chemical Engineering	

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Joseph W. Pinciario Safety Officer Safety Office	Paul L. Sweeney Assistant Intellectual Property Counsel Office of Sponsored Programs	Peggy Berkovitz Educational Administrator Department of Physics	William H. Connelly, Jr. Senior Staff Accountant Controller's Accounting Office
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Scott L. Runkle Benefits Counselor Personnel Office	Heahyun Yoo Librarian Libraries	Carolyn A. Bunker Bursar Vice President for Administration	Hillary H. Debaun Associate Director of Undergraduate Programs and Interdepartmental Advising Sloan School of Management
Arthur Russell Administrative Coordinator of Equipment Rooms Athletic Department	Thomas L. Yu Systems Programmer Delivery Process	David Albert Carlson Captain Campus Police	Diane M. Devlin Director, Office Computing Vice President for Information Systems
Linda J. Scatamacchia Auditor Audit Division	CHANGES OF APPOINTMENT	Robert P. Casey Accounting Officer Reengineering-Management Reporting	Cathi A. Di Iulio Assistant Coordinator of Conference Services Public Relations Services
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Office of the Bursar

David A. Woodruff
Director, Institutional
Advancement, Western
Region of U. S. and The
Pacific Rim
Office of Individual Giving

Imelda Zepf
Senior Staff Accountant
Controller's Accounting
Office

Elena Zhitnikov
Senior Analyst Programmer
Student Information Systems

PUBLIC RELATIONS SERVICES

This past year saw a number of changes and new developments in the Public Relations Services, whose mission is to help enhance public understanding and support of MIT, and of higher education and research more generally, and to enhance the community life of the Institute through communications and special events.

As forecast in last year's report, Miss Mary L. Morrissey, Director of Special Events and the Information Center, retired in the fall after 45 years at MIT. While her personal flair is unique, and her wit and wisdom will be missed, the transfer of responsibility to her successor, Gayle M. Fitzgerald, has gone smoothly. Ms. Fitzgerald adds to her long experience in the office the invaluable personal qualities of poise, unlimited energy, and good humor.

Many members of the PRS staff continued to participate both in reengineering project design and in the associated communications efforts, while individual offices continued to enhance their effectiveness and efficiency through more intensive use of information technology. One reengineering project was expected to have a profound impact on PRS and on communications efforts throughout MIT. As the year came to an end, plans were being made for major changes in the way the Institute works with outside providers of publishing services, from designers to printers. These changes, the product of an intensive evaluation of the Institute's publishing process, were expected to result in the creation of a new Publishing Services Bureau. This Bureau, which would report jointly to the Director of Public Relations Services and to the Senior Vice President, would assist departments in the planning of both print and electronic publications, match Institute publishers with appropriate outside vendors, and act as the purchasing agent for all MIT publications-related purchases. While details of the proposed Bureau were in discussion at the end of the academic year, it was anticipated that design and production services currently offered in-house through Design Services would in the future be provided by outside vendors under agreements coordinated by the Bureau.

The Public Relations Working Group, which brings together a small group of people from throughout MIT who have responsibility for public affairs, continued to develop plans for dealing with specific issues as well as for raising the profile and concerns of MIT and research universities in general. In addition, the monthly meetings of the Information Group continued to offer a forum for news and the exchange of ideas for a larger group of communications specialists from across the Institute.

The Office of the Director congratulated Susan Browne Aylward, Administrative Assistant, on her success in a graduate program in museum administration at Harvard University; she left MIT to take up new challenges in her chosen field at the Davis Museum at Wellesley College. Gina S. Kent has assumed her responsibilities with aplomb.

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.

Last year, the Communications Office provided significant support to the Institute's reengineering efforts in two ways: (1) the manager continued to participate on the teams charged with redesigning MIT's publishing services, nearly full-time; and (2) remaining staff maintained the routine flow of work, introducing key innovations in an intense year of change.

The Communications Office plunged into the brave new world of publishing on the World Wide Web (WWW) by designing a modest homepage to list the publications produced by the office and how to obtain them. By publishing additional information such as MIT's Nondiscrimination Policy on the WWW and updating on an ongoing basis, the Office improves access to information for the MIT community.

The Office achieved other "firsts" in electronic publishing. Chief among them was publishing the *Reports to the President* in print and electronic formats. This required rethinking how the Office collects reports from dozens of

information providers across the Institute and training those contacts in new procedures; shaping unique files to ensure adherence to style guidelines; and rethinking the organization and design of electronic files to accommodate publishing in different print formats and on the World Wide Web. The CWIS facilitator in Information Systems worked closely with the Office to refine these new production processes.

Working closely with the Registrar's Office, the Office rethought the *Summer Session Issue* of the *MIT Bulletin*. Focusing more clearly on the purpose and audiences served by the publication, the Office decided to publish this issue on the World Wide Web, making print copies by request only. This was an opportunity to provide electronic links to other Institute summer programs, improving access to information for customers inside and outside the Institute.

The Office published MIT's organization chart in the Faculty and Staff Directory. This two page chart illustrates reporting relationships for academic and administrative areas as well as the centers, labs, and programs reporting to the provost and academic deans.

For next year, the Office plans to (1) reevaluate its role in relationship to the anticipated Publishing Services Bureau, as it is established and begins its work; and (2) evaluate priorities for publishing additional reference information electronically.

Personnel

Editor and production manager Ruth T. Davis, and administrative assistant Marianne Charny continue to sustain the Communications Office in an exemplary fashion, supporting the Office's publishing efforts with their hard work, clear thinking, and close eye to improving business processes.

Barrie Gleason

CONFERENCE SERVICES, EVENTS, AND INFORMATION CENTER

The mission of Conference Services, Events, and Information Center is to meet the informational needs of the MIT community, visitors to the campus, and the public; to promote a sense of community within MIT; and to support conferences and events that enhance MIT's role in the broader academic community.

EVENTS AND INFORMATION CENTER

During the past year, the Center served as a clearinghouse for mail addressed to MIT; answered and directed to other offices telephone and office inquiries from the public and MIT community; and distributed over 41,200 pamphlets, brochures, maps, guides, and catalogues. Heather Reed, '96 (Department of Aeronautics and Astronautics), assumed the role as head guide. Ms. Reed handled the scheduling of the tours while Terri Priest, staff associate in the Center, trained 23 active tour guides who conducted tours for 10,963 visitors of whom 3,795 were prospective students, 1,478 international visitors, and the remaining guests visiting MIT. Assisting during the summer as a full-time guide was John Modzelewski, '98 (Department of Chemical Engineering). Ms. Priest arranged programs for 422 short-term visitors.

The Center also handled the arrangements for more than 200 recruitment presentations by companies and other organizations that visit MIT under the auspices of the Office of Career Services and Preprofessional Advising.

The Center also assisted in the logistics of the Lemelson-MIT Prize Ceremony in Washington, DC on April 11, which was quickly followed by the dedication of the Jack C. Tang Center for Management Education on April 19. This year's Killian Award Lecture, "Views from a Garden of Worldly Delights," was given on March 13 by Daniel Kleppner, Lester Wolfe Professor of Physics and Associate Director of the Research Laboratory for Electronics. The special event of the season was held on October 17 in Walker Memorial – the Commencement of Miss Mary L. Morrissey, who retired last fall after 45 years of extraordinary service to the Institute. We certainly miss her sense of humor, style, grace, and unique sense of MIT.

The Hooding Ceremony for 400 doctoral degree recipients, held in Rockwell Cage the afternoon before Commencement, was once again a success. Over 70 faculty members proudly marched and applauded as a faculty

representative from each of the departments assisted J. David Litster, Vice President for Research and Dean for Graduate Education, in the hooding and showing of the colors of each candidate.

The 130th Commencement Exercises were held on June 7, a day that included alumni and alumnae returning for reunions and Technology Day. The Honorable Albert Gore, Vice President of the United States, was the guest speaker, and President Vest gave the charge to the candidates. Killian Court was sunlit and the day extraordinary for 2,009 seniors and graduate students.

CONFERENCES SERVICES

The mission of Conference Services is to manage the logistical arrangements of conferences and meetings, ranging in size from 10 to 2,000, sponsored by MIT faculty and staff. This past year, the Office coordinated 20 such events, which brought more than 10,000 visitors from all over the world to the campus, including the Computers, Freedom and Privacy Conference, American Computer Experience Summer Camp, Oxford Study Program, Regent Language Training Program, English/Japanese Exchange Program, National Coalition for Education Activists Conference, Career Connection Fair, New England Conference on Technology and Education, Massachusetts Future Problem Solving Bowl, Massachusetts Biotechnology Council Symposium and Exposition, Homer Associates Metric America Meeting, the second annual City Year National Conference, and the CASE Workshop on Information Systems.

In addition, the staff worked with MIT's Program in Technology, Management, and Policy on the arrangements for two summer courses. The Conference Services staff also assumed responsibility for the events registration process for non-student events this year; 163 applications were approved this year.

PERSONNEL

This year marked not only the retirement of Miss Morrissey as Director of Special Events and the Information Center and Executive Officer for Commencement, but also the realignment of the Center as a cohesive unit to continue the mission of events management and guest services. The International Scholars Office, which had been part of the Center, transferred to the Office of the Provost, under the supervision of Associate Provost Phillip L. Clay., effective July 1, 1995.

The new Center, under the direction of Gayle M. Fitzgerald, was delighted to welcome Cathi A. Di Iulio as Conference Coordinator in July. Ms. Di Iulio had been the Assistant Secretary of the Corporation and associated with that office since 1991. She joined Marie Seamon, also Conference Coordinator, and both welcomed Tara Osborn as Senior Staff Assistant in November. These three staff members have primary responsibility for the operation of the conference activities. Kathleen Barrett and Terri Priest continued as Staff Associates for information dissemination, tour operations, and short-term visits, and Donald Ferland continued as Administrative Secretary to the Director. Mr. Ferland assumed responsibility for the recruitment presentation logistics previously handled by Ms. Seamon.

Gayle M. Fitzgerald

OFFICE OF DESIGN SERVICES

The Office of Design Services has long brought the highest standards of graphic design and production management into the creation of visual material that will enhance their effectiveness, and to provide high-quality electronic publishing services for the MIT community.

During the year, the Office continued to improve the quality of publications and explore new publishing technologies that created more efficient methods for design, production management, electronic pre-press conversion, and printing, and established stronger communication links between internal offices, and evaluated customer needs in developing new publications plans for first-time clients.

Among the publication highlights of the year were the creation of materials for the Jack C. Tang Center for Management Education dedication, the Media Laboratory 10th Anniversary celebration package for the event "10/10," the Civil and Environmental Engineering Open House poster and brochure, the Center for Biomedical Engineering identity program, the Conference Services "How to Get Around Commencement" booklet and

Commencement Program cover redesign, the Media Laboratory “Things That Think” symposium program, the MIT Museum Hacks poster, and the Mary L. Morrissey Farewell invitation.

Other publications that were designed by our office for the first time this year were the MIT Sea Grant Program booklet cover, the Department of Aeronautics and Astronautics Graduate Program posters, the Mathematics Department Rotafest Conference poster, the Women’s League Calendar of Events, the Emma Rogers Society newsletter and letterhead, the Department of Earth, Atmospheric, and Planetary Sciences Master’s Degree Program publications and website, the Center for Biomedical Engineering Introductory brochure, the International Motor Vehicle Program posters, the Sloan School Student Handbook, and the MIT Hillel newsletter.

Design Services won a Bronze Medal in the 1996 CASE Competition for the Media Laboratory newsletter “Frames”; a four-color printing award from the New England Craftsmen Association for the book “MIT Lincoln Laboratory: Technology in the National Interest”; and a second place award from the New England Museum Association for the catalogue “Images of Boston.”

PERSONNEL

Design Services staff for the year included Lee Corbett, Elizabeth Chimento, Elizabeth Ferry, and Anne Hubbard. Elizabeth Ferry, who came to MIT in 1968 as the office Production Manager, left this past spring to embark on a new career at Lifeline Systems in Cambridge. Her organizational proficiency, imagination, skill, and good humor will be missed by all of our clients who had the opportunity to work with her.

Celia Metcalf

NEWS OFFICE

During the past year, the News Office publicized the achievements of MIT in 34 issues and 308 pages of *MIT Tech Talk*, ten issues of the *MIT Research Digest*, 133 news releases, more than 100 editions of the MIT Newsclips, and countless telephone conversations, interviews, and e-mails. A key objective of the News Office is to support the Institute’s mission and priorities. This Report highlights stories from news releases, *Tech Talk* articles, and other developments aided by the News Office that furthered the following objectives, frequently articulated by President Vest:

- Rebuilding Understanding of Higher Education and Research
- Emphasizing Teaching at MIT
- Identifying Critical Emerging Directions in Education and Research
- Providing a Strong Financial Base for MIT Programs
- Enhancing Racial and Cultural Diversity within MIT

REBUILDING UNDERSTANDING OF HIGHER EDUCATION AND RESEARCH

A number of developments involving MIT occurred this past year that furthered the public understanding of higher education and scientific research. Dr. Vest’s speech before the National Press Club on July 18, 1995, was the first in a series of speeches by him warning that budget cuts in basic research imperiled the nation’s future. He followed that speech with an op-ed the News Office placed in *The Washington Times*, “Have we lost the will to excel?” Dr. Vest’s annual report in November captured the imagination of editors and the public by surveying the MIT faculty and reporting what researchers have yet to discover. The report was widely reprinted, particularly after an op-ed article appeared in *The Washington Post*, prompting publication in Tokyo, Paris, and elsewhere.

The Nobel Prize in Chemistry was awarded to Professor Mario Molina and colleagues in October for their work in showing that chlorofluorocarbons in spray cans and air conditioners could imperil the ozone layer and in convincing the world that this was a problem. This first Nobel Prize for work in the environment was one of the most commonly understood Nobel prizes in science in recent history, and Professor Molina devoted many days to interviews, particularly to Latin America, where he was celebrated as the first Hispanic scientist to win a Nobel Prize.

Staff of the MIT Technology Licensing Office published a study saying that even before manufacturing begins, at least \$2 billion to \$5 billion is invested into the economy each year, generating 20,000 to 40,000 jobs from licensing

alone. Another report, "MIT, the Federal Government and the Biotechnology Industry: A Successful Partnership," noted that five MIT professors have won the Nobel Prize in medicine or physiology for government-funded research discoveries fundamental to biotechnology, and that nine of the top 10 selling drugs in 1994 were made by firms founded or co-founded by MIT alumni or faculty.

Highlighting the excellence of MIT also advances public understanding of science. In the first peer rankings by the respected National Research Council since 1983, MIT had the highest totals of top-three rankings of any university, even though MIT offers doctoral programs in only 23 of the 41 subjects examined. MIT faculty scholarship and teaching were ranked 1, 2, or 3 in 34 out of 46 categories, the News Office analysis showed. *US News & World Report*, in September, ranked MIT as the fourth best buy among universities. In March, the *US News & World Report* Survey of Graduate Schools again gave MIT excellent ratings to the Schools of Engineering and Science and the Sloan School of Management.

EMPHAZING TEACHING AT MIT

The celebration of great teachers at MIT continued with the appointment of three more professors as recipients of the 10-year Margaret MacVicar Faculty Fellows award. The MIT Teaching Resource network offered its Better Teaching at MIT course for the eighth year, giving faculty and teaching assistants the chance to polish their skills.

IDENTIFYING CRITICAL EMERGING DIRECTIONS IN EDUCATION AND RESEARCH

A major initiative in identifying the critical areas for new developments in education and research was made by Provost Joel Moses, who in April named four Institute-wide councils on the environment, educational technology, industrial relationships, and international relationships to help MIT set its course for the future. Below are some news stories and events related to these areas:

The Society of Environmental Journalists held their national conference at MIT. The News Office prepared a media guide to environmental experts at MIT and found a breadth of activity that surprised leading faculty involved in the environment – more than 100 faculty and researchers are working on environmental concerns. Vice President Gore addressed the conference, reviewing the environmental record of the current Congress. Some of the research stories on the environment this year included findings that environmental metals hasten damage to trees and a hazardous metal detector devised by engineers at the Plasma Fusion Laboratory.

The World Wide Web dominated discussions of new educational technology. The study group evaluating advance technology (EVAT) found that the Web offers opportunities and risks for MIT. The MIT Press did its first simultaneous publication of a book in paper and on the Web, *City of Bits* by Dean William Mitchell of the School of Architecture and Planning. The News Office found that its home page, which started in January, 1995, significantly increased inquiries from national and international journalists; responses are usually by e-mail rather than by phone.

The Whitehead Institute/MIT Center for Genome Research received a \$26-million, three-year grant from the NIH to begin sequencing specific proteins on the human genome, following their success in creating a map of the human genome that will allow them to fill in the entire sequence of DNA letters. Research into Parkinson's disease, attention deficit disorder, and depression among the elderly may be aided by a compound that, with a specialized scan, allows doctors to see the brain's transport of dopamine, a chemical involved in these disorders. MIT researchers have developed a "smart needle" embedded with microchips that could offer aid in probing tumors.

The Sloan School combined new educational technology and industrial relationships in seeking donated equipment for their Wall Street Trading Room, a state-of-the-art trading room for teaching and research. The School of Engineering and the Sloan School joined with industry also in creating a graduate program in system design and management (SDM), in which students can complete most course requirements at their job sites using new, interactive, distance-learning techniques. A metallurgical team at MIT is developing an environmentally friendlier technology for steel production that does not use carbon and has oxygen as the principal by-product.

The Alliance for Global Sustainability, announced at the Society of Environmental Journalists Conference, is an alliance among MIT and leading technological universities in Switzerland and Japan that seeks to encourage economic development while protecting the environment. The News Office assisted the MIT faculty in the Alliance

by arranging coverage from Cambridge for an environmental conference in China, resulting in front-page photo and story coverage in the *South China Morning Post* while the MIT delegation was meeting with officials.

PROVIDING A STRONG FINANCIAL BASE FOR MIT PROGRAMS

MIT was recognized as one of the 19 strongest financial organizations in the nation when Standard & Poor's raised MIT bonds to the top rating, Triple A. Only MIT, 12 companies, and six other universities have a Triple A rating. Record gifts and a strong stock market have brought MIT's endowment above the \$2 billion level, although MIT trails other schools in endowment per student.

ENHANCING RACIAL AND CULTURAL DIVERSITY WITHIN MIT

Four Martin Luther King, Jr., Fellows were at MIT this year in the first implementation of a program to bring to MIT professors or researchers from other institutions. Women's presence continues to grow at MIT; more than 40 percent of the freshman class are women. The Sloan School's MBA Class of 1997 includes 28 percent women and 16 percent minorities, both School records. Faculty members had a profound debate over the Reserve Officers Training Corps' (ROTC) "don't ask, don't tell" policy against gays and lesbians. The Faculty approved a proposal to develop a modified ROTC program that would be open to all MIT students.

PERSONNEL

The News Office has a staff of 11: Charles H. Ball, senior assistant director; Kenneth D. Campbell, director; Donna M. Coveney, assistant director/photojournalist; Myles P. Crowley, administrative assistant; Lisa Damtoft, editorial and design assistant; Robert C. Di Iorio, associate director; Mary Anne Hansen, office assistant; Joanne Miller, assistant director and editor of *MIT Tech Talk*; Kathleen M. Rowe, assistant director, media relations; Elizabeth Thomson, assistant director for science and engineering news; and Alice C. Waugh, assistant editor of *MIT Tech Talk* and staff writer. We also thank Stephanie Gellar for her part-time work this year, particularly on the database development for the environmental experts guide and the forthcoming guide on experts in medicine and physiology. Special thanks are due to Charlie Ball, Bob Di Iorio, and Joanne Miller for their combined 85 years of service to MIT; all three will be retiring in 1996 under the Institute's Early Retirement Program.

Kenneth D. Campbell

PROVOST

This is my first Report to the President as Provost. It is a privilege to serve as Provost for MIT. I wish to thank President Vest for his confidence in appointing me and for his great support during this past year.

ACADEMIC COUNCIL CHANGES

There were numerous changes in the past year in the Academic Council members who report to the Provost. The first change was made during Mark Wrighton's last days as Provost. It was the appointment of Professor Rosalind H. Williams, Metcalfe Professor of Writing, as Dean of Undergraduate Education and Student Affairs. Rosalind replaced Professor Arthur C. Smith with whom I had previously worked for many years in the Department of Electrical Engineering and Computer Science headquarters. I strongly supported this appointment, in part because of my previous work relationship with Rosalind as Dean of Engineering. Roz is also the granddaughter of Doc Lewis, author of "The Lewis Commission Report."

Ann Wolpert, Director of the Library in the Harvard Graduate School of Business, was appointed the new Director of the MIT Libraries, replacing Jay Lucker. Ann took her post in December of 1995. In the four months between Jay's retirement and Ann's start, the two Associate Directors of the Libraries, Carol Fleishauer and David Ferriero were acting Director and Acting Co-Director, respectively. They held the fort very well and developed a good budget and Five Year Plan for the Libraries. I believe that Ann will do an excellent job in bringing the Libraries to the next level in both technology and organization.

Professor of Music and Theater Arts, Alan Brody, was appointed Associate Provost for the Arts replacing Professor Ellen Harris who was the first person to occupy that post. Alan took office in January, 1996. Alan has broad experience in the theater and I am certain he will continue in the grand tradition set by Ellen Harris in furthering the role of the Arts at MIT.

Professor J. David Litster, Dean and Vice President for Research, took on the additional responsibility of Dean of Graduate Education. We had considered continuing with a part-time Dean of the Graduate School, but decided to combine the Research and Graduate Education functions as is done at many other institutions. Dave replaces Professor Frank E. Perkins who returned to teaching and research in the Department of Civil and Environmental Engineering. Associate Dean of the Graduate School, Isaac L. Colbert, was promoted to Senior Associate Dean of Graduate Education. Ike is expected to deal with most of the day-to-day issues in the Graduate Education Office.

Head of the Department of Chemical Engineering, Robert A. Brown, was appointed Dean of Engineering in the middle of the year. He replaced me as Dean. In the interim, Associate Dean John Vander Sande was acting Dean of Engineering and did his usual excellent job in the Dean's Office. I have known Bob for many years in the role of Department Head. I am confident that he will be an outstanding Dean of Engineering.

EARLY RETIREMENT INCENTIVE IN THE ACADEMIC UNITS

In the Fall of 1995, MIT announced an early retirement incentive for MIT staff age 55 and above with ten or more years of service. In conjunction with that announcement we also announced an early retirement incentive for tenured faculty. Faculty age 60 and above who qualify for the staff incentive could receive a one time payment of 150% of their salary if they elected to retire during the window (March and April of 1996) senior faculty could not be rehired and would be replaced by junior faculty. In addition, faculty age 65 or older could choose to obtain a one time payment of 100% of their salary, but could then stay at MIT for up to five years at up to 49% of their pay. These faculty would be replaced with junior faculty when their appointment period ended.

Our goals in the Faculty Program was to rejuvenate the faculty as well as save money. We were pleased that 73 faculty chose the incentive program (approximately six years worth of retirements at recent rates). In addition, six athletic coaches who are considered faculty as well, also chose to accept the incentive. At this point, we believe that this faculty program will save approximately \$2 million a year, when the cost of the incentive is taken into account.

The academic departments also had significant departures of teaching, administrative, support, and research staff. It is too early to estimate the level of savings arising from this incentive program for these categories of non-faculty staff members.

One side effect of the faculty retirement incentive is the hardening of the faculty salaries. This goal was met in several different ways. Certain departments in the School of Engineering gave up faculty positions in order to use some of the funds to reduce the needed research support for other faculty during the academic year. Some of the retired faculty members had significant research support for their academic year salaries. Others had chairs that will be given in part to faculty who currently support some of their academic year salaries on research. We do not yet know who will be receiving the chairs. Thus we can only estimate the reduction of research support for the academic year salaries of the faculty. Our estimate is that it will be over one million dollars a year.

ACADEMIC FACILITIES

The major activity of CRSP (Committee for Review of Space Planning) in the past year has been planning for the demolishing of Building 20 in early 1998. Major renovations are being made in Buildings 16 and 56, with Building 56 stated to be reoccupied in early 1997, and Building 16 in early 1998. Plans are nearly complete for housing for the remaining occupants of Building 20, especially the Department of Linguistics and Philosophy.

The Jack C. Tang Center for Management Education was dedicated in April of 1996. It is an impressive facility which is similar to the EG&G Building in that it is devoted entirely to education. The dedication was both a moving and festive occasion, and the Tang Building is being very well utilized by the Sloan School at this time. A third stage of renovation of Architecture Department Space is proceeding. This renovation will permit several faculty now in Building N51/N52 to come back to the main complex.

The close cooperation of CAES and CECI has led to the forthcoming move of CECI from E40 to Building 9. The Knight Fellows will leave Building 9 and take over space of the Technology Licensing Office. TLO is moving to rental space off campus. The CECI space in E40 will be given to the Industrial Performance Center directed by Professor Richard Lester. The current IPC space will be given to the CTPID.

MIT recently had an opportunity to join a major consortium that is building a pair of telescopes in Chile. We decided to purchase 8-10% of one of these telescopes, to be partially funded from funds controlled by the Provost. We anticipate the overall expenditures to be between \$5.4 M and \$7.0 M.

FOUR NEW COUNCILS

We formed four councils during the year in order to pursue important directions for the Institute. The Council on the Environment is a restructuring of the Provost's Council on the Global Environment created by Mark Wrighton in 1991. The new Council has approximately thirty members from throughout the Institute. The Executive Committee of the Council meets monthly to discuss new opportunities for education and research in areas related to the environment. Its deliberations are then reported to the larger Council membership. This Council is chaired by the Provost and co-chaired by Professor David H. Marks.

A major activity related to the Council on the Environment has been the formation of the Alliance for Global Sustainability, a partnership of MIT, the Swiss ETH and Tokyo University. The Alliance was also initiated by Mark Wrighton. It is anticipated that a private donor will give the AGS a \$10 million matching gift in the coming year.

The Council on Technology and Education deals with the uses of computer and communication technologies in education, both on and off campus. On campus, we need to re-examine our Athena system to determine whether it shall meet our needs in the coming years. We also need to determine how MIT can use modern technologies to educate students who reside off campus. Of course, technologies used in remote education should be available to our on-campus students, and our extensive computer system should be available to remote students.

At this time, remote education is likely to be of greatest interest to professional students in the Schools of Architecture and Planning Engineering and the Sloan School of Management. The System Design and Management Program that is joint between Engineering and Sloan, relies on such technologies. The Center for Advanced Educational Services.

The Council on International Relationships has a goal that is similar to that of the Council on Industrial Relationships. That is, the pursuit and analysis of new relationships with organizations in foreign nations. Several

such relationships have begun in recent years. For example, the Sloan School has major educational programs in Singapore, Taiwan and most recently China. The School of Engineering has initiatives in Argentina and Italy, largely in the Department of Civil and Environmental Engineering. In late June of 1996, chairman Paul E. Gray will lead a delegation to Thailand to sign a major agreement with the institute in Thailand in research and education.

The Council on International Relationships should over see them and other potential relationships and determine their situations in the MIT contest. The Council is chaired by Associate Provost Philip L. Clay and co-chaired by Professor Suzanne Berger and Fred Moavenzadeh.

CAES RENAMED

In conjunction with the formation of a Council on Technology and Education, we felt the need to make a major move at MIT in remote education. We thus moved the Center for Advanced Engineering Education (CAES) from the School of Engineering to the Provost's office and renamed it the Center for Advanced Educational Services. We also appointed Professor Richard C. Larson as the Director of the CAES. The summer session that used to report to the Dean of the Graduate School will now report to the Director of CAES. This will help coordinate our various activities for professional students whose main employment is off campus. The Center for Educational Computing Initiatives, directed by Professor Steven R. Lerman, will also coordinate its activities with CAES in the future. It is our expectation that this new focus of activities will further research in new modes of education, as well as help deliver MIT education to remote sites.

EFFORTS TO DIVERSIFY THE FACULTY

We have continued the efforts of the past few years to diversify the MIT faculty. This year we appointed the first group of four Martin Luther King Jr. Visiting Professors. One of them, Dr. Wesley Harris, was later appointed Professor of Aeronautics and Astronautics.

A new board on women and minority issues, chaired by Professor Gretchen Kalonji of the University of Washington, met for several times during the year. A goal of this board is to suggest programs at MIT and elsewhere that will increase the funding of women and minorities who obtain Ph.D.'s and enter the professoriate in science and engineering.

Programs to appoint minority faculty as well as senior women by creating new positions have been continued. They have led to 5 new minority hires and 9 appointments of women (including one senior woman).

MODELING THE BUDGET

Given the many changes in the Institute budget expected in the coming years, we decided that greater effort should be made to model the budget for the coming decade. One approach is to create a system dynamics model. Two Sloan faculty members and a consultant are working with the Provost to develop such a model. Data about the Institute since 1940 have been stored in the model. It is expected that the model will provide insight regarding the impacts of certain future actions by the Institute.

A spread sheet model is also being developed, and various studies by staff in the Controller's Accounting Office and the Budget Office are creating inputs to this model. Since a number of senior staff in these offices are retiring this year, we hope that their replacements can continue these studies.

BUDGET ISSUES

There are continuing concerns over the research funding levels permitted at the Lincoln Laboratory. Lincoln is an FFRDC- a Federally Funded Research and Development Center. In the FY 96 Federal budget there was a cap of \$1.2 Billion for all FFRDC's, and Lincoln's portion of it was \$250 million. In spite of this, Lincoln's DOD sponsors were prepared to expend over \$310M during the Federal FY 96 year. Our efforts to deal with Lincoln's cap were not successful in FY 96. It is our hope that the FY 97 budget will have a manpower cap, rather than a dollar cap. Lincoln has operated successfully for many years with a manpower cap.

Another continuing issue involving Lincoln is the so-called line. A line in the Federal budget provides Lincoln with an annual support for R&D that is relatively unrestricted, and thus permits the type of research that rejuvenates the laboratory. Maintaining the funding level in the Lincoln line requires the continuing vigilance and support of the MIT President and the Washington Office staff.

A major concern for the coming year involves overhead recovery and the overhead rate. The Institute has under recovered overhead in recent years because of earlier over-estimates of the growth in research volume. This has meant artificially low overhead rates. As a result the overhead rate will increase in the coming year. Other factors leading to an increase in the rate are: the major renovations in Building 16 and 56, lack of growth in research volume relative to inflationary growth in the budget, and the shift in the method of paying for research and teaching assistants in FY 99. Recent changes in A-21 will not permit us to recover significant costs for student services and library use. This will dampen the growth in the overhead rate, but increase the annual deficit by several million dollars each year.

The RA/TA change has the advantage of lowering the employee benefit rate by about 10 points. We are considering other mechanisms for lowering the EB rate. Thus, the overall effect of forthcoming changes in indirect costs and employee benefit costs may be positive for many research contracts at the Institute.

NEW EDUCATION PROGRAMS

The Nuclear Engineering Department has proposed a new Masters of Engineering Program, and obtained the approval by the faculty and Corporation. This brings to five the number of departments in the School of Engineering that will offer a Master of Engineering Program. We understand that the Earth, Atmospheric and Planetary Science Department is considering a professional masters program similar in character to the Master of Engineering Program. Such professionally oriented education is the area of greatest growth in the Institute.

A new Masters' level program, System Design and Management, was proposed jointly by the Schools of Engineering and Management. It is intended to teach how to design and manage the development of large scale technical systems, such as cars, planes, software or telecommunications systems. The founding Co-Directors of SDM are Professors Edward Crawley and Thomas Magnanti. Professor Magnanti was the founding Co-Director of the Leaders for Manufacturing Program. SDM is intended to be available in both a full on-campus version and a version that can be partially taken remotely.

Joel Moses

CENTER FOR ADVANCED EDUCATIONAL SERVICES

On September 1, 1995 the Center for Advanced Engineering Study was renamed and dramatically reorganized. The mission of the new Center for Advanced Educational Services (CAES) is to create and distribute educational services world-wide. The off-campus offerings leverage the growing capabilities of computer and telecommunication technologies, including interactive multimedia, the Internet, the World Wide Web (WWW), videoconferencing (or "compressed video"), satellite TV, MIT Cable, as well as more mature delivery mechanisms such as videotapes and books. CAES provides facilities, equipment and expertise to the MIT community for the educational, research, and creative uses of video and multimedia. In support of its primary goal and as a service to participating organizations, the Center has traditionally supported short term (non-degree) programs having both on-campus and off-campus components. All with MIT faculty as teachers, the *three* thrusts include non-credit, MIT for-credit courses, and courses with academic credit to other universities. The on-campus offerings, particularly the Advanced Study Program (now in its thirty-third year) and the Professional Institute's Summer Session Office (in its forty-sixth year) are the major programs which provide educational experiences for professional women and men who wish to keep pace with developments in their fields.

As part of its mission to facilitate the use of the new technologies for educational purposes, CAES includes an applied "research arm," the Center for Educational Computing Initiatives (CECI). The mission of CECI is to carry out research linking the emerging technologies to education, facilitating both the creation and the distribution of educational products and services towards the goal of improving the effectiveness and productivity of learning and education. 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.

Together under the CAES umbrella, these organizations assist in the creation of Institute-wide policies, procedures and operations related to MIT's "virtual campus," i.e., MIT's implementation of "distance learning" offerings. Policy/procedure topics to be addressed include electronic cross registration of subjects (by students at other universities registering for MIT subjects and by MIT students registering for subjects elsewhere), distance degree programs, policies regarding public as well as tuition-based distribution of MIT subjects, and guidelines for the presence of onscene teaching support. Operational topics are more complex, involving virtually all MIT schools and

several MIT support functions. The educational offerings created by our collective efforts are built upon MIT's leadership in science and engineering, management, economics, humanities, and architecture and planning. The audiences for our products and services is broadly distributed, by age, geographical location and educational interest. We stand prepared to assist in the development of both the physical and intellectual infrastructure required to build MIT's distance learning capabilities to world class standards.

MAJOR HIGHLIGHTS

CENTER FOR EDUCATIONAL COMPUTING INITIATIVES

This year the Center for Educational Computing Initiatives (CECI) was part of the winning consortium competing for one of the three awards under the new, Army Research Federated Laboratory program. The ATIRP Consortium includes Lockheed-Martin, Motorola, GTE, Bellcore, the University of Maryland, the University of Delaware, Howard University and Morgan State University. The five year, \$50 million research project will explore advanced telecommunications and multimedia technologies.

CECI was funded by Electricite de France to develop an extension to the AthenaMuse 2 authoring system that will support the storage and retrieval of both application components and multimedia content from an object oriented database. In addition, CECI won a research contract with France Telecom to undertake a three year project to develop innovative, multimedia computer-human interfaces.

We also were funded by the US. Environmental Protection Agency to develop a Windows version of XFLOW, a simulation game about ground water pollution. This project, originated by Prof. Dennis McLaughlin of the Department of Civil and Environmental Engineering, is funded for two years and should lead to a publishable, multimedia software application.

CECI has provided the technical staff for the MIT Shakespeare Archive project under the direction of Prof. Peter Donaldson, the Head of the Literature Section of the Department of Humanities. All the software that will be developed in this project will be created by CECI staff and students.

ADVANCED STUDY PROGRAM

The ASP continues to be CAES's primary on-campus mid-career educational program. Under new leadership, we plan to grow the ASP substantially via advanced technologies to distant learners in North America and overseas. During the 1995-1996 academic year the Advanced Study Program hosted 33 foreign and 22 US professionals who attended graduate and undergraduate courses throughout the Schools within MIT. A number of them pursued individual studies of interest to them and their sponsors. This brings the cumulative number of ASP alumni/alumnae to over 1,700.

During the 1996 Spring term, ASP offered the course on Management of Technological Change (13.651) taught by Professor Ernst Frankel by video conference to 20 students from a major oil company in Argentina. All 20 students received the course live, interactive, in real time while seven students received the course live on-campus.

SUMMER SESSION OFFICE

Effective January 1, 1996, the Summer Session Office moved under the CAES umbrella. This program, which in the future will be known as the MIT Professional Institute, 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. A comparison of the last two year's registration follows:

Summer 1994: 1252 registrations	51 special programs	by 1199 registrants
Summer 1995: 1274 registrations	53 special programs	by 1222 registrants

Foreign students comprised approximately 13 percent of this registration.

In April, 1996 at the Industrial Liaison Program's Research Director's Conference, the first distance learning initiative since the CAES reorganization was implemented. Eight week long special programs chosen from the Summer 1996 course offerings were announced under pre-paid annual educational site licenses. (See Product Development and Strategic Marketing below for specifics.)

MIT VIDEO PRODUCTIONS

MVP has been expanded to include working more closely with MIT faculty in the utilization of advanced technologies for the delivery of MIT courses. Institute awareness and utilization of the valuable services provided by MVP continues to grow as we delivered services this past year to every Institute academic department. CAES provided student and administrative space for Systems Design and Management Program and MVP provided technical assistance and equipment in launching of MIT's first distance dual graduate degree initiative. A combination of delivery methods were utilized including live multi-point videoconferencing from the Tang Center, and the periodic delivery of classes on videotape. CAES video conferencing systems have served an expanding range of campus requirements this year. We launched two distance learning initiatives between MIT and an oil company in Argentina and between MIT and the University of California at Berkeley. During this past year MVP installed a digital non-linear editing system. This system delivers BetaSP quality images and can easily import and export a variety of digital file formats. This system provides the Institute with reasonably priced digitization/compression capability.

CAES and the Industrial Liaison Program (ILP) launched a Distinguished Lecture Series with invited presentations by Professors Hawley, Thurrow, Dresselhaus, Bose, and Mitchell. These live lectures were simulcast over MIT Cable and ILP member companies received videotaped copies of each lecture.

PRODUCT DEVELOPMENT AND STRATEGIC MARKETING

This academic year marks the first time CAES has halted large-scale video course production and refocused its attention to the initial entrants in a series of new international distance learning offerings which have been developed, tested, and successfully launched by CAES within nine months. The new programs contain some key features:

- Professors live via video-conferencing
- Key learning objectives reinforced through videotapes or CD-ROM
- Customized topics based on "learner" specific needs/interests
- MIT course materials delivered to PC and Mac platforms.
- MIT's Virtual Campus Learning System™ student -to-student as well as student-to-professor research and discussion access.

Many corporations, educational institutions, and government organization are currently in site license negotiations. Executive Economics for Industrial Engineers, Design and Analysis of Experiments, and Programming Content on the World-Wide Web were recently produced and comprise the first educational products under this initial offering.

HONORS AND AWARDS

CECI's Director, Prof. Steven R. Lerman, was reappointed for three years as the Class of 1922 Distinguished Professor. He also won a Mitsui Award for research in multimedia research done at CECI.

PROGRAM HIGHLIGHTS

Since this is the *first* Report to the President that the reorganized CAES has prepared and the amount of change and new initiatives is formidable, it's extremely difficult to differentiate between what should be distinguished as *Highlights of the Year* and those which can be attributed to Program Highlights. Indeed, this first year has been simultaneously exciting and very demanding for each and every individual in the CAES family. The launch of distance learning initiatives has consumed much of the talent, time and resources of CAES this year. Key feedback from parties interested in all of our initiatives has focused on the need for customization, strategic alliances, and academic credit. Although we expected interest in our efforts from large domestic and international corporations who have large training and development programs; an unexpected result has been shown by our sister US and foreign colleges and universities in acquiring MIT experience in technology and management. We are working closely with several of these institutions of higher education to develop credit and non-credit graduate-level offerings. (Please see Highlights of the Year above for specifics.)

RESEARCH ACHIEVEMENTS

CECI continues to focus on the development and application of emerging technologies that can be applied to enhance the quality of education at all levels. During the past year, we have completed a major new release of the AthenaMUSE authoring system that provides a wide range of capabilities, including: the ability to store and retrieve both applications and multimedia content from diverse databases; the ability to fetch and display documents in the World Wide Web; support for Internet messaging between AthenaMUSE applications and with other, networked

software systems; tools for extending the capabilities of the authoring system; a sophisticated, object oriented scripting language that supports multiple inheritance.

CECI and CAES have jointly staffed the Networked Multimedia Information Services project supported by ARPA and the NSF. As one of its major sub projects, this effort digitizes, segments, stores, indexes and makes accessible over the Internet thirty minutes of broadcast content daily provided by Turner Broadcasting. This service is made available to secondary schools connected to the Internet.

CECI have recently completed our work on a CD-ROM about the life and work of Prof. Harold Edgerton. This CD-ROM is scheduled to be released by a major publisher early in 1997.

MVP productions range from a software demonstration videotape for Lincoln Lab's Speech Cognition Group to a semester long documentation of a new subject, Archaeological Science, team taught by 15 faculty members from seven Boston-area institutions.

MVP also produced a variety of scripted video programs ranging from a Student Services Reengineering overview to a series of Lemelson/MIT Prize recipient profiles. During the past year MVP produced reports on research, including human resources training tapes, documentation of an arts installation, and video news releases in support of waste vitrification research programs.

PERSONNEL

CAES wishes to thank and acknowledge the many years of guidance and leadership of Professor Shaoul Ezekiel who stepped down as CAES Director on September 1, 1995. His enthusiasm and dedication guided the directions of the Center for many years and we wish to acknowledge and applaud his outstanding service to CAES and MIT. At the time this report is being written, the CAES family has not dramatically increased in personnel. CECI's staff consists of seven full time research staff and seven visiting scientists and engineers. In addition, CECI supported seven graduate research assistants last academic year and had approximately 15 UROP students working on various projects. The MIT Professional Institute has three full-time administrative staff. The remaining CAES personnel number 17 full-time and two part-time administrative staff. We expect our staff to grow over the next two years.

The Advanced Study Program has had the great fortune of having outstanding leadership by one individual, Dr. Paul E., Brown MIT'61 who retired after 32 years of service to the program. Ms. Diana Garcia-Martínez, MIT '78, joined CAES in April from ILP to spearhead the domestic and international development of both on-campus full-time and distance part-time ASP Fellows Programs. Internal staff changes: Tracy Pierce to Sr. Multimedia Producer, this past year she completed the Physical Measurement video course series; Edward Moriarty to Sr. Multimedia Producer and Technical Producer of the MIT Shakespeare electronic archive.

FUTURE PLANS

The most significant new direction for CAES is developing many more discreet distance learning educational opportunities for the MIT community, alumni, corporate affiliates and our government sponsors. CECI's future plans involve developing a closer working relationship with its new parent organization, CAES. The merger of the two organizations is well underway, but we see the potential of much greater synergy in the future.

This coming year CECI will move from Building E40 to Building 9, where CAES is currently housed. This will facilitate collaboration between the CECI and CAES staff on a wide range of current and planned projects and eliminate the need for staff working on some of our projects to travel between the two sites. CAES and CECI have developed a major proposal to create a network-based course in the area of project management that could be taken by employees of a world-wide organization in these areas.

CECI also plans to continue developing new software development tools that are suited to the needs of educators and non-profits. The technology base for this work will continue to evolve, reflecting the growth of the World Wide Web, new software tools such as VRML, and the emergence of new languages suited to network use such as Java. CECI expects to be working on a set of software templates that would make it easy for faculty and other teachers to organize and deliver digital information to support teaching and learning. CAES will offer workshops and one-on-one instruction for MIT faculty and instructors to use these new tools and methods.

The ASP and the MIT Professional Institute will undergo reorganization to incorporate MIT's desire to offer the broadest range of educational opportunities throughout the year. An analysis and exploration of what corporations and industries needs will be comprehensively explored.

CAES will continue to pursue possible new affiliations with other MIT entities that share its vision. Three such entities currently in negotiations with CAES are TILT (The Institute for Teaching and Learning), LATH (Laboratory for Advanced Technologies in the Humanities) and the Hypermedia Teaching Laboratory (of Mechanical Engineering). Professors Lerman and Larson also plan to convene this fall a group of "CAES-affiliated faculty" to act as an advisory board and broad-based constituency for CAES and CECI going forward.

CAES has embarked on an aggressive program in plant and equipment modernization to bring MIT into the forefront as a showcase facility for commercial and educational video-conferencing systems. We hope to have CECI moved into Bldg. 9 in early 1997 and have both the largest single video-conferencing learning hall in 9-150, as well as the largest selection of services and conference room sizes at MIT. This new technology will be integrated with CAES software via strategic alliances with major international technology suppliers. New alliances already in place are with PictureTel Corporation and ADCOM Communications. Others are in negotiations.

Pockets of effort in the area of distance learning efforts in the five schools will be further consolidated under the CAES umbrella, as an example; administration and registration of off-campus registrants in various industrial programs including the General Motors Technical Education Program, will take place this Fall. Since there is continued interest in receiving by video conference live courses offered at MIT, we are presently planning our course offerings in the 1996 Fall term. Further marketing activities will be pursued in order to increase the numbers of both the on-campus as well as the off-campus participants in all CAES programs.

CAES will hold two special Fall, 1996 conferences. The first featuring Dr. Timothy Berners-Lee and the W³ consortia will take place at Endicott House this Fall. Also scheduled for this Fall is a joint CAES/CECI/ILP Conference and Trade Show on the state-of-the art in Distance Learning: Corporate Strategies for Professional Development and Employee Education. The latter event will be held simultaneously at three sites in North and South America while proceedings will be transmitted via satellite and the Internet.

Richard C. Larson

CENTER FOR ARCHAEOLOGICAL MATERIALS/CENTER FOR MATERIALS RESEARCH IN ARCHAEOLOGY AND ETHNOLOGY

With the goal of establishing at MIT an undergraduate major in Archaeology and Archaeological Science, the Center for Archaeological Materials (CAM) offered a new subject, Archaeology and Archaeological Science, which will become a core subject in the new curriculum. Designed by the curriculum committee of the Center for Materials Research in Archaeology and Ethnology (CMRAE), the subject was taught by 15 faculty members from six CMRAE institutions: MIT, Harvard, Boston University, the University of Massachusetts, Wellesley College, and the Museum of Fine Arts, Boston. Each faculty participant is a specialist in the area of archaeological science/engineering presented. Thirty-two students enrolled: 21 from MIT, seven from Harvard, and the others from Boston University, Brandeis University, the University of Massachusetts, and Wellesley. Next year this subject will be jointly offered by CAM/Department of Materials Science and Engineering, and the Chemistry Department at MIT. All sessions were videotaped to encourage dissemination of an unusual approach to archaeology and to capture the expertise of an uncommon roster of scholars.

For the first time in its 19-year history, CMRAE issued a 25-page brochure describing the consortium's philosophy and mission and its educational programs. The Center's broad research activities are provided in brief biographies of its 25 faculty members who represent all eight consortium institutions. The CMRAE brochure will be entered on our WEB site so that it can be internationally available.

Professor Dorothy Hosler received a grant from the American Smelting and Refining Company (ASARCO), Southern Peru Copper Corporation, and Industrial Minera Mexico S.A. to support her ongoing field work and laboratory studies of the metallic ore mining, processing, and extractive metallurgy technologies carried out in ancient Mexico. Her lead isotope analysis of Mexican copper ores and ancient copper and bronze artifacts to establish the natural resources exploited in the production of those artifacts is the first use of this technique in the archaeology of Latin America. Professor Heather Lechtman received a grant from the American Philosophical Society which supported a three-month summer of field work in Peru and Bolivia to determine when prehistoric bronze metallurgy was developed in the Andean culture areas. In examining and analyzing metal artifacts from the ancient city of Tiwanaku in the Bolivian altiplano, she determined the presence of a ternary copper-arsenic-nickel alloy that has not previously been reported. This bronze alloy, rarely seen in either the New or the Old Worlds, was

widely used by the Tiwanaku polity and by peoples with whom the state interacted. It is distinct from the copper-arsenic bronzes typically produced by northern Andean peoples during the same period.

Heather Lechtman

COUNCIL ON PRIMARY AND SECONDARY EDUCATION

The Council on Primary and Secondary Education (CPSE) develops and oversees programs that bring the strengths of MIT to the American K-12 educational system.

HIGHLIGHTS

CPSE has entered a transitional phase during the past year. While it has created high-quality programs, CPSE is now faced with the challenge of finding financial and organizational support to sustain them. Council members are looking at ways to conduct programs through a fee-for-service format and/or using advanced communication technologies to reach a larger audience nationally, perhaps even globally. Plans are underway for some programs, such as The Institute for Learning and Teaching (TILT), to move under the umbrella of the Center for Advanced Educational Services (CAES). The CAES emphasis on distance learning dovetails nicely with TILT's new emphasis on reaching more people at a lower cost.

CPSE is pleased to acknowledge a generous gift from Beymon ('50CH) and Phyliss Blanchard in 1995. Funds from the Bey and Phil Blanchard Fund are being used to help sustain K-12 efforts at MIT, including support for a large team of educators from Ashtabula County, OH, the Blanchard's home county as well as the location of Plasticolors, Inc., where Bey Blanchard is Chairman.

PROFESSIONAL GROWTH OF EDUCATORS

TILT provides professional development for educators that uses a project centered around a common technology, such as water delivery systems, as a vehicle for developing skills in team building, group dynamics, effective communication, negotiation, grant writing, brainstorming, mind mapping, working with different learning styles, group reflection and debriefing, and computer use. The traditional TILT model is a community-based team of teachers, school administrators, and their champions in the community (parents, school board members, university representatives, or industrialists) that spends three-weeks in July in residence on MIT's campus followed by a year of planning how to implement and integrate TILT ideas back in the team's home community.

The TILT Design Team is now looking at ways to provide this professional development using different models, ranging from changing the composition of the team attending TILT to using advanced communication technologies to interact with teams. For example, TILT has been asked by the community college system in Massachusetts to redesign the TILT model for use by the Commonwealth's 15 community colleges. TILT personnel are also negotiating with the University of Natal in South Africa to adjust the TILT model to their need for professional development that links schools of education with businesses in that country. In addition, TILT's model of professional development has been adopted by the seven universities that make up the Coalition of Schools for Excellence in Education and Leadership (ECSEL), which is supported by the National Science Foundation (NSF).

In 1995, TILT's summer residential component ran from July 10-28 and teams attending came from Lynn, MA; Pittsfield, MA; Springfield, MA; Worcester, MA; New Bedford, MA; Shiprock, NM; Middlebury, VT; and the School-to-Work Program in Massachusetts. Each year, TILT chooses two different technologies to investigate, in the past looking at water treatment and delivery, construction, mass transportation, telecommunications power generation, and health care. In 1995 teams explored either air transportation or fish processing. Each team was linked to a site (a business or facility engaged in the technology) and explored in detail one technical aspect of the technology, determining who it serves and how it serves them. Teams examined how the sciences, mathematics, and the social sciences intertwine to produce the technology, how it might be changing, and how it compares with trends in education. All teams returned to their communities in August with the charge to share their experiences with colleagues in their home community and to promote school improvement. To help them maintain communication with TILT, MIT, and other community groups, each team was given seed money and was loaned a laptop computer with a subscription to America Online for one year.

TILT'95 was funded by the Alden Trust, James A. Daley Fund, General Telecom, author Tony Hillerman, the Robert M. Noyce Foundation, the Pew Charitable Trusts, ComEnergy Service Corporation, Polaroid Corporation, National Science Foundation's Engineering Coalition of Schools for Excellence in Education and Leadership, Raytheon Corporation, Plan for Social Excellence, the Bey and Phyliss Blanchard Fund, Vermont Institute for Science, Math & Technology, Commonwealth of Massachusetts School-to-Work Office, Lynn Public Schools, Massachusetts Department of Education Goals 2000 Grant, Pittsfield Public Schools, and Springfield Public Schools. Support for the UROP students was provided by the MIT Class of 1992.

In 1996, TILT will begin with its three-week residential workshop running July 8-26 and will focus on power co-generation, MIT's ID card system, and ATM machines. Teams attending will represent Ashtabula County, OH; the ECSEL program; and Boston Public Schools. An impact study, funded by the Noyce Foundation, is being developed to evaluate TILT's impact on education.

TILT has a World Wide Web page at <http://web.mit.edu/tilt/www/>.

MIT/WELLESLEY TEACHER CERTIFICATION PROGRAM

To foster the growth of a cadre of new teachers who meet MIT's standards of excellence in science and mathematics, yet appreciate the value of different ways of approaching and understanding a problem, MIT has created a joint program with Wellesley College, the Teacher Education Program (TEP). It prepares undergraduates for Massachusetts State Certification in mathematics and science at the middle and high school levels. This program, started in the fall 1993, has now been integrated into MIT's Department of Urban Studies and Planning. Enrollment in TEP's introductory Course 11.124 has steadily increased, from 8 students the first year it was offered, to 14 the second, to 25 in 1995's fall semester. In 1996, six students in the program completed the certification process, while 12 students are applying to graduate schools of education or to Wellesley's Fifth Year Program to complete their teacher certification. Four students will be teacher in private high schools.

Undergraduates in the program must complete a major in the subject area in which they wish to teach. In addition, they must complete three courses at MIT and two at Wellesley; one of the latter is a seminar taken in conjunction with the required 150 hours of supervised practice teaching. Students must also complete 75 hours of supervised classroom observations; these observations often take place in the classrooms of teachers participating in the MIT Teacher Fellows Program at Cambridge Rindge and Latin High School.

TEP is currently funded by the National Science Foundation through a collaborative called TEAMS-BC (Teacher Education Addressing Math and Science in Boston and Cambridge), which consists of MIT, Harvard, UMASS Boston, Wheelock College, and the Boston and Cambridge school systems. NSF has awarded TEAMS-BC a grant of \$5,000,000 over five years. TEP is supervised by Professor Jeanne Bamberger.

The Noyce Prize, a \$10,000 prize provided by the Noyce Foundation, is awarded each year to an outstanding graduating senior who has chosen a career in teaching and who has completed (or will complete) certification requirements to teach math or science in a public school. This June, the award was given to Catherine Lavelle, a graduating senior in mathematics. The first recipient of the prize, Sally Buta (Course 3, 1994) is now teaching physics at Cambridge Rindge and Latin High School, in Cambridge, MA. The second recipient, Ricardo J. Campbell (Course 10, 1995), is teaching 8th grade science at the Longfellow School in Cambridge while completing his certification in the Wellesley Fifth Year Program.

TEACHER FELLOWS

The Teacher Fellows Program in 1995 focused on six master teachers at Cambridge Rindge and Latin High School, four in mathematics, two in science. With the enthusiastic support of their school administration, they were released from 20% of their teaching responsibilities; they continued to teach their regular classes in the remaining time. During their released time, they visited one another's classrooms, discussed, discovered, clarified, and documented as a group the practice and the strategies that they find are most effective in encouraging students to learn, understand, and practice mathematical reasoning. Periodically, the teachers led meetings of the school's mathematics staff and disseminate their insights to these teachers.

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

FORUM ON PUBLIC EDUCATION

In the spring of 1996, CPSE launched a continuing series of seminars, the Forum on Public Education. Paul Reville from the Massachusetts Business Alliance for Education kicked off the series on March 11 with "Education Reform in Massachusetts and the Nation: How Are We Doing?" Bruce Alberts, President of the National Academy of Sciences, delivered the second seminar entitled "Science Education: A Wedge Revitalizing Our Nation's Schools," on May 31. The next in the series is tentatively scheduled for early September. The Forum on Public Education is sponsored jointly by MIT's Council on Primary and Secondary Education and the Boston Museum of Science. The purpose of the seminar series is to foster conversation between leaders in the educational reform movement and the public at-large.

UPDATE ON JOINT VENTURE

ScienceMedia, Inc., is a toy company created by MIT alumna Joan Roth that promotes science literacy through toys and TV, the goal being to attract children usually turned off by science. The company produces science kits that contain all necessary equipment for an experiment, full instructions, and science trading cards. The first product line focused on Better Sports Through Science, and is in its second production run. A new product line focusing on earth science is in development. MIT's name and logo appear on the kit box, and royalties from sales are shared with CPSE.

PROGRAMS BY THE CPSE CHAIRMAN

Connecting to Statewide Educational Reform

Professor Ron Latanision, Chairman of CPSE, is also a co-principal investigator for the NSF-supported statewide systemic initiative in Massachusetts, PALMS (Partnerships Advancing the Learning of Mathematics and Science). As such, his primary areas of responsibility are outreach to the community and enhancing educational technology. Professor Latanision and PALMS personnel have established the Massachusetts Software Partnership Task Force as part of the statewide technology initiative Mass Ed Online. The task force is establishing partnerships between school members and software developers that will enable them to work together to design/develop curriculum software that will provide students with high quality, hands-on learning experiences. The task force has set up criteria for software developers and school districts to participate in this partnership, and will evaluate its effectiveness.

Through the efforts of another PALMS co-principal investigator, Dr. Pendred Noyce, the Noyce Foundation has lent support to the Council's TILT program for the past three years, most recently supporting teams from Pittsfield, Springfield, and Lynn, MA. Dr. Noyce is the daughter of MIT alumnus Robert Noyce, founder of Intel.

Linda Breisch, Communications Manager for CPSE, also assists PALMS by acting as a regional coordinator for the central part of Massachusetts. In this capacity, she provides a working link between PALMS, TILT, and other groups at MIT.

Role of Universities in K-12 Education

The white paper *Role Of Universities In K-12 Education*, written by Professor Latanision in conjunction with the Association of American Universities, considers the potential roles of the academies and of research universities in confronting the national challenge posed by K-12 education. In the upcoming year, Professor Latanision will go on sabbatical to implement the recommendations presented in the paper. During this time, he will also work with the federal School-to-Work (STW) Office to bring it together with the business community and business schools around the school-to-work theme.

Professor Latanision is also a member of an ad hoc admissions committee at MIT which includes Michael Behnke, Director of Admissions; Professor Robert Birgeneau, Dean of the School of Science; and Professor Rosalind Williams, Dean for Undergraduate Education, that is looking at how education reform and the changing K-12 experience for students in Massachusetts and the nation at large will impact their admissions credentials. In addition, the committee is considering both MIT's position on the new education standards developed by the National Research Council and the potential for modifying MIT's undergraduate science core to reflect K-12 educational reform and include more experiential learning like that found in Course 8.01X.

New England Science Teachers

Professor Latanision directs the Science and Engineering Program for Middle and High School Teachers, which shares the Council's goal of science literacy for all students. Key to a good education is an enthusiastic, knowledgeable teacher. Since 1989, this program has endeavored to give educators a unique perspective of how the basic sciences, mathematics, and engineering are integrated to meet the technological challenges and needs of commerce and society. In 1996, the program ran from June 24-28 and had 65 participants from across the United States.

The alumni of this program, now totaling approximately 400, become members of the New England Science Teachers (NEST). This year, NEST members came to MIT's campus on June 28th for a two-day meeting to assess the program and determine future directions for the organization. NEST now has its own World Wide Web page at <http://web.mit.edu/nest/www/>. NEST will be supported by a grant from Raytheon through 1998.

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 Mary Callahan, Assistant Registrar, Schedules; Nancy Cavanaugh, Administrative Officer, Music and Theater Arts; Gayle Fitzgerald, Director Conference Services, Events and Information Center, Public Relations Services; Michael Foley, Assistant Director, Campus Activities Complex; Elizabeth Garvin, Director, Class Programs, Alumni Association; Anne Glavin, Chief, Campus Police; Margaret Jablonski, Associate Dean, and Section Head, Residence and Campus Activities; Sandra Lett, Administrative Assistant, Facilities and Scheduling, Athletics; Paul Parravano, Assistant for Community Relations, Office of the President; Mary Tobin, Supervisor, Operations Center, Physical Plant; Susan Tomases, Program Director, Alumni Association; Tina Trager, Event Coordinator, Campus Activities Complex; and Phil Walsh, Director, Campus Activities Complex.

A few changes in committee membership occurred this year. Eliza Dame, and Susan Allen both left the Institute to pursue other opportunities. Susan Tomases and Margaret Jablonski joined the committee to fill these vacancies.

In reaction to re-engineering activities and event safety concerns the committee was kept informed on a range of issues including introduction of metal detectors at large student events, moratorium and subsequent changes to student party policies, privatization of campus parking as it related to guest parking, and ongoing discussion of scheduling and event planning processes. The Committee also reviewed plans for the merger of Alumni Reunion activities and Commencement.

During the 1995-96 year, in addition to a number of smaller meetings, the Institute hosted the Massachusetts State Science Fair, the American Computer Express, Pre MBA Summer Institute, Massachusetts Biotechnology Council, National Coalition of Education Activities, Career Connection Job Fair, Society for Environmental Journalists, City Year National Conference, Special Olympic Games, and a fund-raiser for The Cambridge Hospice.

Stephen D. Immerman

OFFICE OF EDUCATIONAL OPPORTUNITY PROGRAMS

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 and Somerville.

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 interventions.

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 5th 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 29 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 and Somerville 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 675 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, weekend, and school holiday activities.

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 6:00 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.

The Program offers workshops to supplement the instructional support provided to participants. The workshops are offered to provide more specific support or to address special interests (e.g., SAT preparation, Word Processing, Time Management, Peer Pressure, Computer Skills, etc.) and are offered on a regular and as needed basis.

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.

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 and eleven student information nights, took participants to four local College Fairs and sponsored fifteen college visits. The Program also visited

Middlesex Juvenile Court, Cambridge Police Headquarters, SEA Engineering Consultants, as part of its career exploration effort.

The Program provided five 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, New England Aquarium and Butternut Basin Ski Area. In addition, the Program regularly visits several points of interest, i.e., libraries, museums and laboratories, on the MIT campus.

Summer Program

The summer program provides both academic instruction to 65 (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 Reading. 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 various points of interest.

Since many of the participants in grades 9-12 hold summer jobs, the Program provides continuing support through dissemination of information about area college fairs, hosted a weekly 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 29th 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, Science or Foreign Language). Science electives include; physical science, biology, chemistry, physics and computers while Social Studies address United States, African-American and World Histories. The Foreign Language electives are Spanish I and II as well as French I and II. 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:

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.

The Program offers classes, specifically for the 9th grade students, in Mathematics and Language Arts to supplement the instruction received at the target school. Also, workshops are offered to address more specialized participant needs (e.g., SAT Preparation, Computers, Study Skills Development, Time Management, Job Readiness Skills, etc.).

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. The college advising component includes campus visits to many of the local colleges and universities, while the career advising component offers exposure to career options through our Speaker Series and Job Site Visitation Program.

The Program provides numerous field trips which have as their purpose, the intellectual, social and cultural development of the participants. Such trips included; the Museum of Science, the New England Sports Museum, skiing, bowling, and roller-skating.

College Report: Class of 1996

Ninety-four percent of the Program's graduating seniors have enrolled in the following institutions: Bentley College, Boston University, Burdett School, Bunker Hill Community College, Lasell College, Massachusetts Maritime Academy, Mount Holyoke College, Mount Ida College, Suffolk University, University of Massachusetts at Amherst, and Wentworth Institute of Technology.

Ronald S. Crichlow
Evette M. Layne

ASSOCIATE PROVOST

The mission of the Office of the Associate Provost is to assist the Provost in carrying out a variety of academic and program support functions. In the past year the Office of the Associate Provost has focused on four major areas of activity.

APPOINTMENT PROMOTION AND TENURE

We revised portions of Policies and Procedures related to Appointment, Promotion, and Tenure procedures. The aim of this rewrite was to clarify procedures relating to faculty and academic staff and to update existing policies and procedures. The changes were made after extensive consultations with Department Heads, Deans, the Faculty Policy Committee, and after approval by the Academic Council.

Some of the revisions include:

- A change to allow retiring Professors to retain the rank in post-retirement academic staff appointments.
- Changes and clarifications in faculty leave policy to conform to the Family Medical Leave Act of 1993 and to authorize schools to make special arrangements to further accommodate faculty.
- Changes in the Notice Requirement for Academic Staff.
- Clarification of personal and professional leaves and their relation to the calculation of years of service for tenure.

These changes are incorporated in the new version of Policies and Procedures to be published in Fall 1996.

JACOBY COMMITTEE REPORT ON GRIEVANCE INVESTIGATION PROCEDURES

The second area of activity was following up recommendations of the Jacoby Committee with respect to investigations relating to charges of harassment and other matters. In March 1996, the Jacoby Committee recommended that the Institute establish a special independent procedure to investigate charges of harassment against faculty and staff that cannot be handled under normal procedures within departments and offices. The committee also recommended training and other support for those officers and staff who routinely handle grievances or for faculty and senior staff selected to investigate them.

The recommendations of the committee were discussed at the Faculty Policy Committee and at the Faculty Committee on Administration. Academic Council approved an independent procedure. Under the procedure a committee composed of Officers of the Faculty (and headed by the Chair of the Faculty) will review grievances and determine whether an independent procedure is required and if necessary, put a procedure in place to investigate selected cases. The committee carries out its work in consultation with the Associate Provost.

In the coming months, general guidelines will be available for how investigations are to be carried out. The guidelines will be provided to investigators on a just-in-time basis. A description of the investigation procedure will be published in Policies and Procedures.

INTERNATIONAL COUNCIL

In February 1996, the Provost appointed the Associate Provost to chair the International Council. The purpose of the International Council is to advise and support the development of an institute strategy for international research and education initiatives. The responsibility for these initiatives rests with individual faculty and with academic and research units. However, the council's responsibility will be to make sure that major programs and the overall approach to major international efforts support the institute's academic goals.

Members of the Council include Professors Alice Amsden, Suzanne Berger (Co-chair), Joel Clark, Daniel Hastings, Don Lessard, Greg McRae, Fred Moavenzadeh (Co-chair), Mario Molina, Ken Oye, Peter Perdue, Richard Samuels, Judith Tandler, Lester Thurow, Bob Weinberg, and Mr. Karl Koster.

During the Spring term the Council held three meetings. These meetings were for the purpose of generating an agenda and beginning to explore various topics. These topics include the nature of past international initiatives and the lessons learned from those experiences and the relationship between international initiatives and resource

development activities. In addition, the Council held discussions on several pending initiatives, including proposed activities in Thailand.

There were other international highlights of the year. Among these were more than a dozen visits from international delegations, a highly successful meeting of international alumni attending the Habitat II in Istanbul, participation in the first ILP meeting of European member companies, and participation in the Catalunya project Conference in Barcelona, Spain. The Associate Provost also held meetings with faculty members to explore issues associated with developing international components for educational programs for graduates and undergraduates.

INTERNATIONAL SCHOLARS OFFICE

On July 1, 1995, the International Scholars Office was assigned to the Office of the Associate Provost. The International Scholars Office (ISO) assists MIT faculty and staff in bringing international researchers and professors to campus for a variety of purposes. The ISO advises on immigration matters, issues visa documents, and provides guidance, information booklets and flyers on a wide range of issues relevant to the international scholar population. Weekly orientations are held for incoming scholars and family members.

The ISO served a total of 1,296 international scholars who were affiliated with MIT during the period 7/1/95 to 6/30/96. These scholars represented 75 different countries and 75 departments, laboratories, and centers. During some or all of that period there were 907 scholars sponsored under MIT's J-1 exchange visitor program, and 144 scholars sponsored by MIT on the H-1B visa. Sixteen petitions for permanent residence were submitted on behalf of MIT faculty members and upper-level researchers.

Immigration-related matters have been in the political and media spotlights, with major House and Senate bills at various stages of the legislative process throughout the year. A major focus for the ISO has been advocacy to prevent draconian changes in the non-immigrant and immigrant visa regulations which are important to the MIT community. The ISO director joined the American Association of Universities Immigration Advisory Group, which has played a key role in representing the interests of international educational exchange. Jack Crowley, director of MIT's Washington office, has once again provided invaluable support. The result of this advocacy is that the most damaging legislative changes have so far been averted.

The ISO remains active in the professional organization NAFSA: Association of International Educators, with some staff members participating in monthly meetings, presenting at regional conferences, attending the national conference, and serving on working groups pertaining to J-1 and H-1B visa issues. These gatherings provide MIT and other institutions with opportunities to clarify regulations and discuss policies of mutual concern, and often enable ISO staff members to address MIT's questions and concerns directly with officials from the Immigration and Naturalization Service, the United States Information Agency (USIA), the State Department, and the Department of Labor (DOL). This year has also been an important one for regulatory change. The USIA published substantial and problematic changes to the J-1 regulations in both April and June, and the DOL published a welcome proposed rule in April, finally recognizing the importance of distinguishing academic and industry salaries when determining prevailing wage for the H-1B and permanent resident visas. MIT has been proactive in each case, and has also actively responded with comment letters and follow-up. Among other significant staff activities were the following:

- Continued participation in the Appointment Process System reengineering team devoted to revising and computerizing the academic appointment process for the Institute.
- Preparation of customized annual reports for the United States Information Agency, the Institute for International Education, and MIT.
- Sponsorship of two campus-wide sessions for Administrative Officers, addressing the role and procedures of the ISO and the basics of relevant immigration regulations, and organization and hosting of the annual workshop on taxes for international scholars.
- Continued communication with the International Students Office and the MIT community to help people distinguish between the new Visiting Student category, administered by the International Students Office, and the scholar activity served by the International Scholars Office.
- On-going revision of informational booklets and flyers that give up-to-date information to international scholars and the MIT faculty and staff who host them.

PERSONNEL

Frances Helmstadter retired on June 30, 1995, and is very much missed. Fortunately, the International Scholars Office continues to benefit from an energetic and capable staff. Dana Bresee Keeth was promoted to Director, Penny Sundberg was promoted to Advisor to International Scholars, Diana Faust LeLacheur was hired as Advisor to International Scholars, part-time. Jennifer Wellman was hired as Administrative Assistant, and Heather McConley ably continued as Senior Staff Assistant.

Phillip L. Clay

ASSOCIATE PROVOST FOR THE ARTS

As Adam said to Eve, "We live in an age of transition." 1995-96 was a year of transition for the Office of the Associate Provost for the Arts.

After a national search, Professor of Theater Arts Alan Brody succeeded Professor of Music Ellen T. Harris in the position of Associate Provost for the Arts. Professor Harris remained in the position until January when Professor Brody returned from sabbatical leave as a Visiting Scholar at Oxford University. Other significant transitional events included the retirement of Warren Seamans as Director of the MIT Museum and the appointment of Mary Leen as Acting Director; the appointment of Susan Cohen to replace Mark Palmgren as Director of the Council for the Arts; the retirement of Joan Loria as Director of Exhibitions for the MIT Museum; the retirement of John Oliver, Senior Lecturer in Music and Director of the MIT Concert Choir; and the departure of Ron Platt, Assistant Curator of the List Visual Arts Center for a curatorship at the Southeast Center for Contemporary Art in Winston-Salem, NC.

It was also a time of academic and professional achievement. Peter Child gained promotion to Full Professor and the position of Chair of Music and Theater Arts beginning in the academic year 1996-97; Dennis Adams won tenure as Associate Professor of Visual Arts; Pamela Wood became Senior Lecturer in Music assuring her continued inspiration to all the students she serves.

PROFESSIONAL ACHIEVEMENTS

Professor John Harbison received his final commission from the Metropolitan Opera to complete his adaptation of *The Great Gatsby*; Associate Professor Tod Machover prepared his *Brain Opera* for its July opening at Lincoln Center; Director of the Center for Advanced Visual Studies Krzysztof Wodiczko's *Xenophobia* opened at Gallery LeLong in New York City to unanimous acclaim; Professor of Theater Arts Janet Sonenberg published her provocative book, *The Actor Speaks*; Associate Professor of Music Evan Ziporyn was featured in the most recent CD release of the music of "Bang on a Can" and toured his music from Düsseldorf to Auckland; Alan Brody's play, *The Housewives of Mannheim* was cited as Best Play of 1995 by the Live Oak Theater of Austin, TX and a reading was scheduled for the Berkshire Theater Festival; Pamela Wood premiered two settings of spirituals set by Choral Instructor William Cutter for Tech Night at the Boston Pops; and Laura Harrington, Instructor in Theater Arts, won the coveted Clauder Competition for her play, *Mercy*, which will be produced by Shakespeare and Company this summer. In Writing and Humanistic Studies, Professor Anita Desai released her new novel, *Journey to Ithaca*, and Professor Alan Lightman saw the publication of a splendid collection of essays, *Dance for Two*. List Visual Arts Center Director Katy Kline was the recipient of the 1996 Gyorgy Kepes Award. The List Visual Arts Center also received the largest single Museum grant awarded by the still breathing National Endowment for the Arts for its forthcoming exhibition, *Women and Surrealism*.

STUDENT ACHIEVEMENTS

Student achievements in the arts were no less extraordinary. The MIT Brass Ensemble, under the direction of Affiliated Artist Larry Isaacson toured France, performing in Toulouse, Lyon, and Paris. Alan Pierson '96 and Marivi Acuña '96 won the Laya and Jerome B. Wiesner Student Art Awards for Music and Theater respectively. Jeff Morrow '96 won the Louis Sudler Prize for Music. The first endowed Arnold and Helen Schnitzer Awards in the Visual Arts went to Chris Moore (G), Brant Chamberlain '97, and Eto Otitigbe '99. Two alumni in the arts were heard from this year, as well. Ryan Yu '93 completed his post-graduate training at the Royal Academy of Dramatic Art and was invited to join the London company of *Miss Saigon*. Jose Elizondo '95 saw performances of his symphony, *Estampas Mexicanas* with its MIT Symphony debut and future performances booked for the San Jose Symphony as part of the America Festival, the Jalisco Philharmonic Orchestra of Mexico, the Nuevo Leon Symphony Orchestra, the Santa Cruz Youth Symphony Orchestra, the Pan-American Symphony Orchestra, the University of Guadalajara Symphony Orchestra, and the Keio University Eine Kleine Orchester in Japan.

ACQUISITIONS AND SPACE

1995-96 saw significant additions to the Institute's permanent collection of contemporary art including David Bakalar's (Class of '51) *Television Man* sited between Kresge Auditorium and the Johnson Athletic Center, Frank Stella's *Loohooloo* on the walls of a conference room in the Department of Architecture, and Stella's *Head or Tails*

in the Wolk Lobby of the Tang Center. Discussions began for the commissioning, by alumnus Elliot Wolk '57, of a major work by Bernarr Venet to be sited on the Plaza of the Sloan School of Management early in the fall. Plans were made for the renovation of the Music Library as the newly-designed Rosalind Denny Lewis Music Library, as well as for work on the Jacques and Yulla Lipschitz Courtyard in the Humanities Building. Space was allotted to establish a World Music Center in N52 to house Associate Professor Evan Ziporyn's Gamelan Galak Tika, Lecturer George Ruckert's collection of Indian instruments, and newly-appointed Assistant Professor James Makayuba's African drums.

PROGRAM HIGHLIGHTS

1995-96 was the first year of operation for the Museum Loan Network. Supported entirely by funds from the Pew Charitable Trust and the James L. Knight Foundation and under the skillful leadership of Director Lori Gross, the Network awarded 33 grants totaling \$300,000 to museums throughout America and developed a national database to realize its mission to encourage and support collection sharing.

With three major retirements, the Associate Provost for the Arts engaged a consultant to review the organization and procedures of the MIT Museum, while Harvey Steinberg '54 and Chairman of the Museum Advisory Board commissioned architectural drawings at his own expense for a contemplated future move from N52 to the Metropolitan Warehouse.

Director of Arts Communication Mary Haller's work to gain national visibility for the arts at MIT took a major step forward with an eight minute feature on National Public Radio's *Morning Edition*.

In its continuing commitment to the integration of science and the arts, the Special Programs section of the Office of the Arts sponsored the residencies of photographer Felice Frankel at the Edgerton Center and sculptor Arthur Ganson in the Department of Mechanical Engineering. The List Visual Arts Center's Education Program hosted a lecture by primatologist Jane Goodall in conjunction with the exhibition, *Next of Kin*.

The Office of the Arts' focus on diversity and community outreach expanded even further — producing, in collaboration with the Campus Committee on Race Relations, the advanced screening of *W.E.B. DuBois: Biography in Four Voices* by filmmaker Louis Massiah '82. Additional collaborations with IBA Arte y Cultura, Next Stage, Inc., and the Cambridge Multicultural Arts Center resulted in the production of *Son Corazon: Heartstrung For Myrna Vasquez* written and directed by former Artist-in-Residence Professor Rosa Luisa Marquez and Assistant Professor of Theater Arts Brenda Cotto-Escalera; and three public multicultural productions: *Kenembu Mestizo: An Evening of Brazilian Music and Dance*, *Three Divas—Three Storyweavers: The 20th Anniversary of Black Music*, and *Dreamfields: Three Evenings of Intergenerational Dance Theater*.

FUTURE PLANS

The Associate Provost for the Arts and the Office of the Arts remain committed to the advocacy of arts programs at MIT, the strengthening of interdisciplinary work and research, and the development of ever greater consciousness of the presence of the arts at MIT within the community, in the Boston and Cambridge regions, and nationally. In the coming year the Office of the Arts will expand the current program of placing artists in the Departments of Science and Engineering, multicultural outreach and education programs, and the support and encouragement of ongoing creative work in all areas of campus life. In addition the Office of the Arts will initiate a series of Arts Colloquia to bring all the artists on campus into dialogue, begin a search for a new Director of the MIT Museum, and initiate action in response to the recommendations of the consultant.

Alan Brody

OFFICE OF THE ARTS

ARTS COMMUNICATION

In the seventh year of the Office of the Arts, Arts Communication published and disseminated up-to-date information on MIT's arts programs and events while successfully promoting and cultivating awareness of the arts at MIT, both within and outside the Institute. Significant accomplishments included the broadcast of a feature story on National Public Radio about MIT's commitment to the arts; the first inclusion of arts information postcards in the MIT admission applications and the distribution of Student's Guides to the Arts to prospective students who responded; and the creation of a World Wide Web site for the arts at MIT.

INTERNAL (MIT)

For the first time, MIT's admission application included tear-out postcards for prospective students to request information on the arts at MIT and indicate specific arts interests. A total of 60,000 applications were printed. Postcards were returned from 2,300 individuals, and a copy of the Student's Guide to the Arts was sent to each with a letter from Associate Provost for the Arts Alan Brody. Students who were eventually admitted and who had indicated interests in theater were sent congratulatory letters from Professor Brody giving specific information on opportunities in theater at MIT.

For the seventh year, Arts Communication provided text and images for the weekly Arts Page in Tech Talk. Material for 22 feature Arts Pages and eight Month-at-a-Glance Arts Pages were compiled and written by Lynn Heinemann, edited by Mary Haller. The layout of this material was handled by the News Office instead of the Office of the Arts; this arrangement proved very successful and helped improve the look of the page and better-integrate it with the rest of the paper. The director of arts communication attended weekly News Office meetings and developed closer working relationships with its staff. Arts Page stories and arts information were made available on-line through Tech Info and the World Wide Web. Copies of the Month-at-a-Glance arts page (including two two-pagers) were mailed monthly to 745 individuals at their request.

There were 26 feature arts-related stories and 12 arts-related photos-with-captions in Tech Talk's general spaces, including five stories and two arts photos on the front page. Authors included Mary Haller and Lynn Heinemann of the Office of the Arts, members of the News Office staff, and members of the MIT arts community.

A World Wide Web site for the arts at MIT was created, maintained, publicized, and linked to numerous other Web pages and sites.

The arts at MIT were the focus of the Winter 1996 issue of MIT Spectrum, a newsletter produced by MIT's Office of Resource Development. The issue began with an introduction by President Charles M. Vest on the "Importance of Art" which proclaimed that "Not only are the arts healthy here, but they are thriving, a great testimony to the talent, dedication, an enthusiasm of so many of our faculty and students." The publication featured articles on architect I.M. Pei '40, sculptor David Bakalar '51, Institute Professor John Harbison, *Alma Mater* (the mural in Walker Memorial's Morss Hall), Associate Provost for the Arts Alan Brody, and art patron Margaret McDermott.

The director of arts communication represented the Office of the Arts and gave presentations on the arts at MIT during Parent's Weekend and Campus Preview Weekend (for prospective women and minority students)

The Director of Arts Communication, with assistance from List Visual Arts Center Director Katy Kline, nominated arts patron Vera List for the 1996 National Medal for the Arts.

Arts Communication continued to oversee ArtsNet, which consists of about 90 campus arts representatives, the "Arts at MIT" bulletin board in Lobby Seven, and the weekly "Arts Hotline" (253-ARTS).

IAP activities included 90 arts-related programs, workshops, and performances. Separate listings of arts events occurring during IAP were prepared by Arts Communication and distributed throughout the Institute.

LOCAL AND NATIONAL ATTENTION

A National Public Radio (NPR) feature story about the arts at MIT ran on the January 16, 1996 broadcast of "Morning Edition." The eight-minute-long story featured comments from former Associate Provost for the Arts Ellen T. Harris, Artist-in-Residence Felice Frankel, Professors John Harbison, Tod Machover and Jerome Friedman and several MIT students. Reporter Phyllis Joffe cited MIT's commitment to the arts at a time when most programs face challenges. "No one questions that most students come to the Institute to pursue science and technology, usually with a passion. But once they get to MIT, many venture to the arts with the same earnest intensity," she announced. Following the broadcast, NPR received nearly 200 requests for copies of tapes and transcripts; the Office of the Arts received numerous requests for information on MIT's arts programs and philosophies from arts administrators, teachers, and parents, many of whom expressed their appreciation of MIT as an educational "role model" in maintaining its commitment to the arts. Cassette tapes of the broadcast were mailed out to members of the Council for the Arts at MIT.

Arts Communication assisted in the announcement of the new Museum Loan Network Program, the announcement of its first grants, and the creation of its brochure. The program, hosted at MIT, generated great interest in the media, including announcements/stories about the program in the Boston Globe, the Boston Herald, Artnews, and The New York Times, among others.

Other MIT-related arts "news" announcements covered in the local media included naming of Alan Brody to the position of Associate Provost for the Arts; MIT Heritage of the Arts of South Asia (MITHAS), a new, pan-ethnic society formed for the preservation and presentation of the classical performing arts of South Asia, and its first concerts; the advancing of the MIT Chorallaries to the national championship of College A Capella in New York City's Avery Fisher Hall (their fellow a capella ensemble, The Logarhythms, were also mentioned in a New York Times Education article on the popularity of a capella on campuses); next year's artist residency by Shakespeare and Company (leading the Boston Globe's "Backstage" column, with quotes by Tina Packer and Associate Provost for the Arts Alan Brody).

Exhibitions at the List Visual Arts Center earned positive reviews from the Boston Globe, Cambridge Chronicle, Harvard Crimson, and others. *Face to Face: Recent Abstract Painting*, prompted the Tab to write that "the curators [Helaine Posner and Katy Kline] have succeeded. There is as much to look at as there is to think about at the List." Helaine Posner, List curator, was featured as one of "five Boston-area women who have forged successful careers in the visual arts" in a story that ran in the Sunday Boston Globe on Sunday, Jan. 28, 1996. Referring to the List Center as "arguably the Boston area's most adventurous presenter of the visual arts" the article noted Ms. Posner's work with such themes as "the body, psychological insights and feminist revisionist theory."

An August, 1995 article headlined "You gotta have Art" in the Boston Business Journal featured The Dean's Gallery in the Sloan School of Management and an interview with Dean Glen Urban on the importance of creativity in management training. "Urban ... sees art as the best way to open students to new ways of thinking. Working in art ranging from watercolors to sculpture—Urban's own passion—teaches numerous lessons, he said. Managers need to realize that immediate success isn't everything."

The installation of Frank Stella's *Looooloo* on the walls of a specially-constructed conference room at the Department of Architecture rated a large photograph in the Boston Globe's "Names and Faces" column. The work, along with Stella's *Heads or Tails*, which was installed in the new Tang Center, was mentioned in various MIT publications.

A photograph of graduate student Scott Schiamberg's Council for the Arts-sponsored project, *The Garden in the Machine* — consisting of a wheat field and panel texts in Lobby Seven — was taken by Associated Press and picked up by press nation-wide. The project was also documented with a color photo in the Boston Globe and by a television news crew for Channel Seven.

Photographs by artist-in-residence Felice Frankel were featured on the covers of Science (Aug 4) and Nature (Aug 17). A feature story in the Boston Globe (Oct. 23) titled "Scientific exposure: MIT photographer captures the beauty of research," referred to her as an artist-in-residence who is "out to create a whole new profession: science photographer." Her work was featured in a photo essay in the May/June issue of Technology Review.

Former artist-in-residence Arthur Ganson was featured in the January 1996 issue of Smithsonian Magazine. "The sculptor has found a visual language that seems to have universal appeal," the article reported, noting the popularity of Mr. Ganson's MIT residency and Compton Gallery exhibition.

Local media attention given to other MIT artists-in-residence and guest artists sponsored or co-sponsored by the Office of the Arts included enthusiastic reviews of a performance by Brazilian choreographer Marlene Silva and her 24-person dance company (Kenembu: Brazil Mestizo), and of a performance by Conjunto Folklórico Nacional de Cuba, which noted that "...they turned the concert into a free-form and full-spirited celebration." Steve Reich's March 1995 residency at MIT was ranked in the number eight slot for Performing Arts in the "Best of..." listings for 1995 by the Tab's T.J. Medrek Jr.

The MIT Club of Boston's 50th Anniversary Gala Celebration at the Museum of Fine Arts focused on the arts at MIT and featured MIT alumni/ae who have achieved recognition in the arts. The event was covered by the Boston Globe's Partylines, and arts brochures were distributed to the attendees.

Other media attention for MIT artists and programs included a story on Roadkill Buffet (MIT's improvisation troupe) in the Boston Globe's City Weekly section; an item on the MIT Shakespeare Ensemble's spring production of *The Tempest* with MIT's Gamelan Galak Tika; a feature-length story on Gamelan Galak Tika in the Cambridge Chronicle's Entertainment Line; a Globe feature story that referred to the MIT Museum as one of eight Boston-area "urban outposts for the truly techno-hip."

Arts Media Calendars were produced and mailed monthly to 261 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.

The "The Arts at MIT" brochure was chosen as one of four winners in the Confetti/Circa Designer Competition held by Fox River Paper Company.

MIT ARTISTS OFF-CAMPUS -- SELECTED MEDIA ATTENTION

The debut performance by Sonos, a new chamber ensemble comprised of MIT faculty members Marcus Thompson, viola and David Deveau, piano and Boston University faculty members Bayla Keyes, violin and Andres Diaz received a glowing review by the Boston Globe's Richard Buell ("Make a note of them"); Professor Anita Desai's new novel, *Journey to Ithaca*, received positive comments by the Boston Globe and India Currents Magazine, among others; the world premieres of *Recordare* and San Antonio Sonata by Professor John Harbison, received positive reviews from the Boston Globe; The Boston Phoenix listed MIT lecturer Kermit Dunkelberg's performance in *Letters from Sarajevo* at the Boston Center for the Arts as one of the year's best in their year-end round-up, and the February 1996 edition of NEED (New England Entertainment Digest) awarded Mr. Dunkelberg an honorable mention as one of 1995's best performers; Wellington ("Duke") Reiter, assistant professor of architecture, garnered excellent reviews for *Island Culture: A Sculptural Investigation of Isolation and Containment*, an exhibition at the Massachusetts College of Art in February, 1996, including one by the Boston Globe's Christine Temin; *Xenology: Immigrant Instruments*, an exhibition on view at the Galerie Lelong in New York City by Krzysztof Wodiczko, director of the Center for Advanced Visual Studies, received positive reviews, including one from Time Out New York; Robert Campbell of the Boston Globe offered critical praise for *Open Strings for e: Search on the Journey*, an exhibit of the works of Professor Jan Wampler of the School of Architecture and Planning on view at the MIT Museum; Arts Communication began working with Professor Tod Machover to promote his upcoming *Brain Opera*, whose initial press attention included stories in the New York Times and the Boston Herald.

Mary L. Haller

SPECIAL PROGRAMS

In its sixth year, Special Programs expanded the Artist-in-Residence Program within the School of Humanities and Social Science, continued a major long term initiative to integrate artists and develop the model for the program in

the Schools of Science and Engineering, and strengthened its role as a collaborative producer of significant and diverse programs with local cultural agencies. Planning for the Artist-in-Residence Program Advisory Board began.

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

In collaboration with the Campus Committee on Race Relations, the Office of the Arts produced the advanced screening of *W.E.B. DuBois: Biography in Four Voices*. The filmmaker, Louis Massiah '82, along with composer Dwight Andrews and narrator Thulani Davis participated in a panel discussion and related Residency activities in Film and Media Studies, "Music for Film," and other Humanities courses in the Media Lab Interactive Cinema Program. At the time of submission of this report, Mr. Massiah has received a MacArthur Award.

The third and final year of a three year Music Residency with Balinese artists I Nyoman Catra and Desak Made Suarti Laksmi ended and was marked by well-attended, indoor and outdoor concerts performed by MIT's ensemble, Gamelan Galak Tika. After three years of coaching in Balinese music and dance, the student orchestra is off to a very promising start as evidenced by their expanding concert appearances at many New England universities. Additional support for a second phase of the Balinese Residency — bringing Balinese composers and the Kronos String Quartet to work with Gamelan Galak Tika — has been requested from the Asian Cultural Council.

A return Residency by the ROVA Saxophone Quartet proved very successful and spurred the Music Residency Committee toward longer range planning for the continuation of successful residencies such as ROVA and Endellion String Quartet.

The Theater Section began a Residency Committee and set a new programmatic and financial planning standard with the development of a three year Artist-in-Residence Program Plan.

The Asian American Exhibit at the List Visual Arts Center provided a substantial opportunity for resuming work with the Asian and Asian-American communities in and outside of MIT. Curator Margo Machida worked with the Women's Studies Program and the Office of the Arts on panel discussions and in classes which raised and examined the question of mixed identity among Asians.

The Community Fellows Program initiated a Residency with Nicaraguan primitive painter and activist Miriam Guevarra who participated in Fellows Program classes, and — through technique classes — worked with Foreign Language and Literature teachers to encourage Spanish-English bilingual students in the English as a Second Language (ESL) Program, and provided theater students with Nicaraguan scenarios for improvisation.

SCIENCE AND ENGINEERING INITIATIVES

Images by science photographer Felice Frankel, who is based in the Edgerton Center, appeared on the cover of both *Science* and *Nature* last August. Her images of MIT research graced prominent publications from the School of Science, the Center for Material Science and Engineering, and the 1996 MIT Facts brochure. Sculptor Arthur Ganson offered discussions on the creative process. Long-term Residency Partnerships with each of these artists, who live locally, have been formed, and plans for three future residencies were developed.

COMMUNITY COLLABORATIONS

Collaborations with many local agencies continued. The fifth year of working with IBA Arte Y Cultura and the first year with Next Stage, Inc. (a producer of women's theater), together gave birth to *Son Corazon: Heartstrung For Myrna Vazquez* written by a former Artist-in-Residence, Rosa Luisa Marquez, and current MIT Theater faculty member Brenda Cotto-Escalera. The script has subsequently been optioned for production at the New World Theater Summer Play Lab at University of Massachusetts–Amherst, with substantial regional funding support.

Additional community collaborations resulted in the three public multicultural productions: *Kenembu Mestizo: An Evening of Brazilian Music and Dance*, *Three Divas—Three Storyweavers: The 20th Anniversary of Black Music and Dance* and *Dreamfields: Three Evenings of Intergenerational Dance Theater*. These programs were co-produced by the Cambridge Multicultural Art Center. First Expressions Gallery for University Student Art planned an MIT exhibition program for the Fall of 1996.

Maureen Costello

COUNCIL FOR THE ARTS AT MIT

The Council for the Arts at MIT completed a year of change and renewal, all the while continuing in the refinement of its work in standing and prize committees, and the development of new initiatives to foster student engagement with the arts. The year saw the succession of Alan Brody to the position of Associate Provost for the Arts, held until August 1995 by Ellen T. Harris. Mark Palmgren, Director of the Council for the Arts, also stepped down, finishing his stay in July 1995; Susan Cohen assumed the title in February 1996.

COUNCIL STANDING COMMITTEES

Annual Meeting (Catherine N. Stratton, Chair)

Led by Catherine N. Stratton, the Annual Meeting committee presented an entertaining and informative event, the 23rd Annual meeting, on October 19 and 20, 1995. One hundred twenty-three Council Members and guests attended. The meeting was organized to highlight the Visual Arts, one of the six curricular arts disciplines at MIT. President Charles M. Vest and Provost Joel E. Moses addressed the Council on MIT affairs, and Associate Provost for the Arts Ellen T. Harris delivered her final "State of the Arts" address at the Friday morning business meeting in Bartos Theater.

Also at the Friday morning session Cheryl Morse and Glorianna Davenport presented excerpts from "A Random Walk Through the 21st Century: A CD-ROM Portrait of Jerome B. Wiesner," which featured an interview with our own Kay Stratton. Also, as an additional tribute to Dr. Wiesner, Ida Ely Rubin announced the gift, by Yulla Lipchitz, of three Jacques Lipchitz sculptures to MIT's permanent collection in Dr. Wiesner's memory.

The Eugene McDermott Award and the Gyorgy Kepes Fellowship Prize were presented, respectively, to Jeff Wall, a photographer from Vancouver, BC who works in large-format cibachrome prints, and Katy Kline, the Director of the world-renowned List Visual Arts Center (see Special Programs below).

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

Sixty-two Council members provided unrestricted contributions averaging \$3,076. Sixteen non-member donors contributed unrestricted gifts averaging \$469. The total raised was \$198,255. In addition to unrestricted gifts, 19 members provided designated contributions totaling \$266,237 to other MIT arts programs. These include support for the renovation of the Music Library, architecture exhibitions at the MIT Museum, and the "Student Playwrights in Performance" series developed by the Theater Arts faculty.

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

Under the leadership of Chairman Bradford M. Endicott '49, \$64,470 in the form of 29 grants were awarded to projects such as the recreation of a Rain Forest in holographic form at the MIT Museum to the overnight installation of a Texas wheatfield in Lobby Seven as a comment on the pastoral in the technological.

Membership (Bernard G. Palitz '47, Chair)

At the writing of this report (7/96), Council membership stands at 83, excluding five *ex officio* members and two Life members. Eight individuals accepted appointment to the Council upon the invitation of President Vest: Ellen Berman, Anne and Bruce '59 Blomstrom, Lawrence Erdmann '63, Alan Fetzer, Marian Marill, and Ruth and Daniel '45 Vershbow. With deep sadness this report must note the passing of two beloved members of the Council: Mr. James S. Plaut and Mrs. Peggy Lamson. The Grants Committee, upon which both served, will be sadly lacking without their informed presence.

List Visual Arts Center (LVAC) Advisory Committee (Kitty Glantz, Chair)

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

Both committees were spun off as "affiliated Committees" this year. The chairs of the committees still sit on the Executive Committee of the Council, which annually allocates funding to both to be used at their respective directors' discretion. The List Visual Arts Center received \$15,000 and the MIT Museum \$22,500.

SPECIAL PROGRAMS

Museum Membership Program

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.

Boston Symphony Orchestra Program

The free-ticket program with the Boston Symphony Orchestra continued this year. MIT students can obtain, with their student ID, free admittance to Open Rehearsals, Tuesday evening and Friday afternoon concerts on a day-of-show, stand-by basis. The success of this unique program continues unabated.

Performing Arts Excursions

The successful Student Performing Arts Excursions Series continued, with each event enjoying full attendance, with an average of 50 students per event. The Council sponsored the following: *Hamlet*, *Letters from Sarajevo*, *The Tempest*, *Dancers and Musicians of Bali*, Charlie Chaplin's *The Circus*, *Ballets Africains*, *Porgy and Bess*, *Seven Guitars*, and the *Alvin Ailey Dance Theater of America*.

Endowed Prizes and Awards

The Gyorgy Kepes Fellowship Prize was presented to Katy Kline, Director of MIT's List Visual Arts Center, at the Annual Meeting. Longtime LVAC supporter and Council member Dorothy Lavine offered remarks about Katy to the assembly. Also at the Annual Meeting, the *Eugene McDermott Award* was presented by Ida Ely Rubin (McDermott Award Committee chair) to Jeff Wall, a contemporary photographer from Vancouver, BC. Tom Sokolowski, Director of the Grey Art Gallery at New York University, offered remarks on Wall's work at the award presentation.

At the Institute Awards Convocation on Monday, May 13, Associate Provost for the Arts Alan Brody presented the *Laya and Jerome B. Wiesner Student Art Awards* to Alan Pierson '96 and Ivi Acuña '96. The *Louis Sudler Prize* was presented to Jeffrey Morrow '96 for his achievement as a composer.

Susan R. Cohen

MUSEUM LOAN NETWORK

The Museum Loan Network (MLN), a program funded by the John S. and James L. Knight Foundation and The Pew Charitable Trusts, was launched in October 1995 to promote collection sharing among museums in the United States. The program, administered by the Office of the Arts, was created to encourage museums across the country to tap the potential of one of their most valuable but underutilized resources: artworks currently in storage. By making grants available to both borrowing and lending institutions for long-term loans, the MLN is helping these organizations bring to light thousands of artworks that lie hidden in storage rooms across the country and simultaneously broadening collections of borrowing museums.

HISTORY

The program got its start in 1993 when the Knight Foundation commissioned a feasibility study to determine the amount of interest in a national collection-sharing initiative. The enthusiastic response to the study by potential borrowing and lending institutions convinced the Knight Foundation to proceed and encouraged The Pew Charitable Trusts to become full partners in the new program. In October 1995, MIT was chosen as the administrative site for the program because of its dynamic arts community and excellence in science and technology. Its expertise in information science is of particular value as the MLN develops a computerized directory of objects and collections available for loan, a strategic component of the program.

PRIORITIES

In the first year of the program, the MLN selected an Advisory Committee drawn from members of the national museum community, completed the design of the program, established a database, identified a universe of participant organizations and finally awarded grants. In addition, an important facet of this first year was to actively promote the program to the museum community and to encourage and assist museums in participating.

After the selection of MIT as the host institution, the first priority of the MLN was to formalize the mission, goals, eligibility requirements and guidelines. By May 1996, approximately 400 sets of guidelines were sent out to institutions throughout the United States.

MLN DIRECTORY

Development began in 1996 on a key element of the Museum Loan Network: the MLN Directory. Its primary goal is to create a practical means of identifying art objects available for long-term loan. The MLN will utilize standards already developed in the field to promote compatibility. Both the Categories for the Description of Works of Art, a combined initiative of the Getty Art History Information Project and the College Art Association, and the Art and Architecture Thesaurus will play a major role. The technological components of the data base are being developed at MIT's Center for Educational Computing Initiatives.

By bringing to the public information about objects that have been lying in collection storage, the directory will not only help bring these objects into public view, but will provide important new information about collections that will aid in their research.

PROGRAM PROMOTION

The first press packet was sent out by the Knight Foundation in early October 1995 to over 500 museums and museum organizations and another 200 copies to the press. Following the first grant awards in February 1996, approximately 500 press releases were distributed to museums, museum organizations and press. An informational brochure was produced in May 1996, just prior to the American Association of Museums (AAM) Conference. This brochure was distributed at AAM and regional meetings and will be the focus of a mailing during the summer of 1996.

Press attention in the first year was extremely favorable and helped considerably in the promotion of the program. Besides articles appearing in specialized journals (i.e., Museum News, Art News, The Art Newspaper) and regional museum newsletters, articles appeared in national and local newspapers throughout the United States, including, The New York Times, The Boston Globe, and The Miami Herald.

Since October 1, 1995, the MLN director attended the Director's Forum in NY, the New England Museum Association's annual meeting in Springfield, MA, and the Association of Art Museum Directors in Ottawa. In addition, the director was invited to give lectures on the program at the New England Consortium of Community Art Museums, the College Art Association in Boston, the Texas Museums Association in Dallas, and the American Association of Museums in Minneapolis.

GRANTS

The Museum Loan Network awards two types of grants to eligible non-profit institutions in the United States: planning grants and implementation grants. Planning grants consist of two types: travel grants which are available to museums interested in borrowing art objects to support travel of personnel to prospective lending institutions to research possible loans and initiate loan negotiations; and surveying grants available to lending institutions to enable them to identify objects for future loans that can be included in the MLN Directory. Implementation grants are made available to support costs associated with actual loans of objects.

In the February 1996 Advisory Committee meeting in Miami and June 1996 Advisory Committee at MIT, 33 grants totaling nearly \$300,000 were recommended, to be approved by MIT to be awarded to museums throughout the country, including survey grants to such prestigious institutions as the Museum of Fine Arts, Boston; the Philadelphia Museum of Art; The Brooklyn Museum and The Saint Louis Art Museum. Travel grants were awarded to, among others, the Phoenix Art Museum, the Stanford University Museum of Art, and Williams College Museum of Art. The first implementation grants were awarded to such geographically disperse institutions as the Mobile Museum of Art in Alabama, The Old Jail Art Center in Texas, and the University of Missouri-Columbia Museum of Art and Archaeology.

Lori Gross

Office of the Arts

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LIST VISUAL ARTS CENTER

The List Visual Arts Center's (LVAC) mission is to present, through changing exhibitions as well as the publicly sited Permanent Collection, the highest quality, most challenging art and design by professionals practicing in diverse media today and to provide additional educational programs which promote a broader appreciation of the ideas within contemporary visual expression.

The Center's Advisory Board, chaired again by Kitty Glantz, met three times, and welcomed new member David Wallace from the School of Engineering. The Board urged the staff to continue to connect itself more tightly with MIT and to expand educational outreach to the entire greater Boston community. The Board strongly recommended keeping LVAC galleries open on Friday evenings and encouraging student groups to use the spaces, as appropriate, for their social or programmatic activities.

HIGHLIGHTS OF THE YEAR

- The Center celebrated its 10th anniversary on October 19, 1995. Festivities included the chronicling of exhibitions through a slide program and on a special T-shirt; and the surprise presentation of several works of art to the Permanent Collection.
- Through the generosity of Council for the Arts at MIT (CAMIT) members Herb and Kitty Glantz a 16-foot programmable LED sign was acquired for the Hayden Gallery window, dramatically identifying the LVAC's location and program offerings.
- *19 Projects*, a 224-page book documenting the 19 artists-in-residence projects sponsored by the LVAC since 1985, was published.
- LVAC Website was established with help of an Undergraduate Research Opportunities Program (UROP) student.
- LVAC contracted with MIT Press to publish a hardbound book in conjunction with 1998 exhibition *Mirror Images*.

EXHIBITIONS

Muntadas: Between the Frames: The Forum. (Hayden Gallery, October 7 - December 10, 1995). A provocative video installation by the Spanish-born artist which offered a collective portrait of the people and institutions which come between the artist and the audience: dealers, collectors, galleries, museums, docents, critics, and the media. (48-page catalog published, together with interview transcription brochure.)

Next of Kin: Looking at the Great Apes (Reference Gallery, October 7 - December 10, 1995). Work by six contemporary US artists (Walton Ford, Daisy Youngblood, Sean Landers, Richard Ross, James Balog and Jean Lowe) who examine the charged and often contradictory relationships between humans and the great apes. (48-page catalog published)

Glenn Ligon: Skin Tight (Bakalar Gallery, October 7 - December 10, 1995). An investigation of boxing as an arena of conflicted black masculinity, through a series of punching bags bearing images and texts by fighters and rap singers, together with an editioned series of works on paper relating to Muhammed Ali. Two punching bags were hung publicly, in the Humanities Library and in a tree outside the East Campus Houses.

Asia/America: Identities in Contemporary Asian American Art (Hayden and Reference Galleries, January 13 - March 24, 1996). Work wrestling with cultural identity by 20 foreign-born artists representing China, India, Japan, Korea, Laos, the Philippines, Thailand, and Vietnam who emigrated after 1965. Exhibition organized by Asia Society, New York.

Kim Yasuda: Unquiet (Bakalar Gallery, January 13 - March 24, 1996). An installation commissioned by the LVAC by this west coast artist of mixed Asian descent, which investigated identity through images, text, sound, film, video, and light projection.

Face To Face: Recent Abstract Painting (Hayden, Reference and Bakalar Galleries, April 13 - June 30, 1996). An investigation of the variety of strategies employed to keep abstraction, 20th century art's most radical invention, fresh

and fertile. The ten artists were: April Hankins, David Ortins, and Jo Ann Rothschild (MA); Sandy Walker and Fandra Chang (CA); and Shirley Kaneda, Fabian Marcaccio, Dona Nelson, Byron Kim and Prudencio Irazabal (NYC). (32-page catalog published.)

EDUCATION PROGRAM HIGHLIGHTS

- Lecture by noted primatologist Jane Goodall in conjunction with *Next of Kin* to overflow audience in Room 10-250.
- *Memory, Tradition, Displacement: Asian American Identities in Recent Film*. Three Friday evenings comprising 11 films (organized in collaboration with Media Studies and Women's Studies; partial support from MIT Committee on Race Relations).
- One day workshop for local Asian American artists with Margo Machida, curator of *Asia America*; co-sponsored by Asian American Artists Association and Asian American Resource Workshop.
- Appearance by Helaine Posner on WHDH-TV's "Urban Update" to discuss *Asia America*.

COLLECTIONS

Through MIT's One Percent for Art policy, a geometric tile floor piece by Jackie Ferrara was installed in the Tang Center for Management Education. A Ferrara wood sculpture was purchased and installed in Rotch Library. Twenty-four works were added by gift, including three sculptures by Jacques Lipchitz, a painting by Sandy Walker and prints by Leon Golub, Nancy Spero and Elizabeth Murray. Fifteen additional works were acquired by purchase; Major conservation initiatives involved repainting the Calder and Tony Smith sculptures.

HONORS AND AWARDS

- Grant of \$35,500 received from National Endowment for the Arts to support upcoming exhibition *Women and Surrealism*.
- Received design excellence award from American Association of Museums for 1995-96 season calendar.

STAFF NEWS

Ron Platt, Assistant Curator, resigned after nearly seven years to become Curator at the Southeast Center for Contemporary Art in Winston-Salem, NC.

Katy Kline, Director, received the Kepes Award from the Council for the Arts. She served on the Challenge and Advancement panel at the National Endowment for the Arts the Mid-Atlantic Regional Fellowships Panel, and as an accreditation reviewer for the American Association of Museums.

Katy Kline

MIT MUSEUM

The MIT Museum accomplished two important goals toward building a stronger base for current and future operations. The Museum's Advisory Board was expanded from 18 to 34 members, with greater and more diverse representation by alumni and members of the MIT community. With generous support from the Provost and the Associate Provost for the Arts, the Museum extended its internal and external computing and communications capabilities by acquiring computers and software for staff members with administrative and collections management responsibilities.

The Museum enhanced its visibility through increased media coverage in FY96. Featured in stories on radio, television and in local and national magazines, the MIT Museum was dubbed an "urban outpost for the truly techno-hip" in *The Boston Globe Calendar*. The Museum also tested a new method of outreach: placemats distributed for use at local restaurants drew crowds of new visitors to the main exhibition center.

One of the Museum's most popular programs this year was "Larry Gonick Week." With funding from the DeFlorez Fund for Humor, the Museum brought internationally renowned cartoonist Larry Gonick to the Institute for a one-week class on communicating difficult technical subjects with cartoons.

COLLECTIONS

Through the generosity of 32 donors, a number of notable items were added to the Historical Collections including: 16 mm films from the Educational Council representing early MIT/WGBH collaboration and period admissions pieces; a LINC computer used by the Massachusetts Eye and Ear Infirmary's Eaton-Peabody Laboratory from 1964-92; a glass tube from the laboratory of Louis Pasteur given to MIT in 1932 and passed to the Biology Department; a braille embosser and hip simulator representing the work of Professor Robert Mann in Mechanical Engineering's Newman Lab for human rehabilitation engineering; the W. B. Elmer '22 collection of *Voo Doo* magazine; a class ring replica, representing MIT, flown on the NASA space shuttle *Atlantis* in November 1995; oil portraits of Professor Ellen Harris, MIT's first Associate Provost for the Arts and Rosalind Denny Lewis (wife of Professor Warren K. Lewis), who inspired MIT students with her enthusiasm for music, and in whose honor MIT's new Music Library will be named; and the personal photograph collection of Professor Francis O. Schmitt of colleagues and students, along with other memorabilia documenting a significant era of biology education at MIT.

The Museum also officially acquired the Harold E. "Doc" Edgerton Collection through a generous donation from Mrs. Esther M. Edgerton, the Harold E. Edgerton 1992 Trust, and the Harold E. and Esther M. Edgerton Family Foundation. The collection is comprised of original negatives, motion picture films, videotapes and memorabilia belonging to the late MIT Professor who developed multiple applications of the strobe light during his long career and is famous for his stop-action photographs that changed the way we see the world. Through a grant from the Edgerton Foundation, the Museum has digitized all of the still images in the collection onto Kodak PhotoCD.

Use of Historical Collections materials continued to be constant, with an average of 100 reference inquiries received per month, and frequent reference assistance provided to the Alumni Association, News Office, and Office of the President. Materials were also loaned to several museums, professional societies, and cultural organizations for exhibitions.

COLLECTIONS MANAGEMENT AND INFORMATION SYSTEMS

The Collections staff undertook a major revision of the Collections Management Policy as the first step in the production of a comprehensive Collections Management Manual for the Museum. Work was also begun on two other components of the manual: a section on procedures consisting of step-by-step details on performing various collections management functions, and a guidelines section to provide staff with current information on collections management-related topics ranging from the tax deductibility of charitable donations to the US Copyright Law and its relationship to Museum acquisitions, loans, and reference services.

The Museum's World Wide Web site (<http://web.mit.edu/museum/www/museum.html>) continued to expand, bringing in approximately 350 virtual visitors to the Museum every week. New features introduced include the

"TechTest," an on-line quiz on MIT's history, illustrated with images from the Museum's Historical Collections. In addition, the MIT Museum Shop took its catalog to the Web, providing customers with the ability to order merchandise on-line. Development of the Museum's Web site was one of the topics of discussion at a session on World Wide Web technology at the Fall 1995 New England Archivists meeting held at Clark University.

The Museum continued its relationship with the Museum Computer Network (MCN) in FY96, serving as the Office of the Program Director and working with both MCN and the Smithsonian Institution to implement an archival program for the organization. MCN, a nonprofit organization of professionals dedicated to fostering the cultural aims of museums through the use of computer technologies, serves individuals and institutions wishing to improve their means of developing, managing, and conveying museum information through the use of automation, and supports cooperative efforts that enable museums to be more effective at creating and disseminating cultural and scientific knowledge as represented by their collections and related documentation. The Museum was represented at MCN's annual conference in San Diego, California and also at a joint spring meeting of the New England Chapter of the Museum Computer Network and New England Archivists.

ARCHITECTURAL COLLECTIONS

The addition of a major collection occurred in FY96 when the Museum, with the support of the Dean of the School of Architecture and Planning, acquired the archives of The Architects Collaborative (TAC), founded by Walter Gropius in Cambridge in 1946, and one of the most influential firms in recent American architectural history, with important associations with MIT and Harvard. Another recent acquisition were the drawings of Horace E. Stowe from 1872, which are key pieces to the understanding of the teaching of architecture at MIT during that early period.

The processing of collections continued with intern and volunteer support provided by Lestra Litchfield, Kimberly Mims (an M.A. candidate at the Architectural Association, London), Kate Matison (a Ph.D. candidate at Boston University) and Hua-chu Yen (an M.A. candidate at Tufts University), who completed work on a project funded by the Institute of Museum Services to survey and rehouse 15,000 drawings in new flat files. Kate Matison also began work on an inventory of the Eduardo Catalano Collection.

Kimberly Shiland, Curator, and Kimberly Mims organized the exhibition *Samuel Chamberlain '18: A Centennial Celebration* at the Museum, and three exhibitions at the Wolk Gallery at the School of Architecture and Planning (with the assistance of the above mentioned interns and volunteers).

Several donors provided important support to the Architectural Collections, including Martin E. Zimmerman '59, who continued to help fund the curator's position; Robert C. Dean '26 and Narcisse Chamberlain, who made gifts in support of the Chamberlain exhibition; and TRO/The Ritchie Organization, which established a fund in memory of Lawrence Partridge '60.

HART NAUTICAL COLLECTIONS

The Haffenreffer-Herreshoff retrospective cataloging and microfilming project continues to be the primary collections management activity within the Hart Nautical Collections and the project will be completed in August 1996. The Curator will present a copy of the microfilm record to Halsey Herreshoff '60 for the Herreshoff Marine Museum on the occasion of their 25th founders dinner in August.

With income from annual general contributions and plan sale fees, the Hart hired Ocean Engineering senior (now a graduate student in OE) Jacqueline Brener in February to assist the curator ten hours per week. She is working at the Museum part-time this summer and intends to continue working while pursuing her studies. The Hart received partial funding from the Department of Ocean Engineering for a summer Undergraduate Research Opportunities Program (UROP) student, Amanda Underwood, Course XIII, who is working on a half-hull model measuring project using a digital three-dimensional coordinate measuring machine. This project is the result of a Mystic Seaport Museum grant from the National Center for Preservation Technology and Training. The MIT Museum and the Smithsonian Institution are partners in the grant.

One new exhibit, *Schooners and Whalers: Watercolors by Benjamin Russell*, was mounted at the MIT Museum.

John A. Lednicky '44 was again a generous donor in FY96. A friend of the Hart Nautical Collections, Michael McMenemy of Palo Alto, CA, made a gift toward the purchase of an engineering copier and a plan cataloging/microfilming project involving the Davis-Hand Collection. We are currently seeking additional funds for these projects. John K. Dema of the US Virgin Islands commissioned a scale model of the 1903 Herreshoff America's Cup yacht *Reliance* for the Hart Nautical Collections in October 1995. This model is under construction and will be delivered and donated to MIT in 1999.

HOLOGRAPHY

The Museum embarked on an innovative holography project in September 1995 with a challenge grant from the AT&T Foundation's *New Experiments in Art and Technology* initiative. The grant and additional gifts from the Council for the Arts at MIT, Mrs. E. Rudge Allen '48, A.R. Arulpragasam '77, and the Lowell Institute will help fund *Light Forest*, a new, permanent work for the Holography Collection, and a related education program. *Light Forest*, the creation of Betsy Connors, an artist who teaches in the Spatial Imaging Group of the Media Lab, will be a large-scale holographic rain forest installation that uses sophisticated technology to create visual and audio effects. The education program to be offered in conjunction with it will examine holography as an artistic and scientific medium and teach how a hologram is made, as well as provoke inquiry and discussion about environmental issues related to the rain forest. *Light Forest* will be installed in October 1996, and the education program will be available to teachers and K-12 students then.

NEW EXHIBITIONS

GALLERIES AT THE MAIN FACILITY

Schooners and Whalers: Watercolors by Benjamin Russell, October 1995-July 1996. These rare watercolors of majestic whaling vessels by Benjamin Russell (1804-1885) are among the most accurate representations of whaling ships produced by 19th century artists.

Samuel V. Chamberlain '18: A Centennial Celebration, October 29, 1995-June 9, 1996. Organized by Joan Loria, Kimberly Shilland and Kimberly Mims, this exhibition featured more than 75 Chamberlain drawings from the Museum's collection.

Open Strings for e: Search on the Journey, March 22-September 30, 1996. This collage of poetry, journal entries, photographs, drawings, models and stained glass chronicles the 25 year career of MIT Professor Jan Wampler as architect, teacher and activist.

Renewal and Metamorphosis: Russian Photography from the Late Soviet Era to the 1990s, June 25-October 29, 1996. This collection of photographs on loan from The Navigator Foundation includes the work of 68 artists active from the 1940s to the present.

COMPTON GALLERY

The Image of Boston: Perception and Change in the Modern City, September 21-December 29, 1995. Curated by Lois Craig, former Associate Dean of the School of Architecture and Planning, this exhibition examined changes that occurred in Boston's central city over a 40-year span. Images captured by Nishan Bichajian in the 1950s, which documented a study directed by Gyorgy Kepes and Kevin Lynch, were juxtaposed with contemporary photographs of the same sites by architectural photographer Peter Vanderwarker.

Richard Bertman: Sculptor, January 25-May 3, 1996. This exhibition featured whimsical sheet metal, steel rod and carved wood sculptures created by noted Boston architect and MIT alumnus Richard Bertman.

Glass: Linking Art and Science, June 3-August 2, 1996. Mounted in conjunction with the 26th annual Glass Arts Society conference in Boston, this juried exhibition features the work of nine contemporary glass artists whose youth, technical expertise and aesthetic investigation of the medium have placed them at the forefront of the glass art genre.

FACILITIES

The MIT Museum was the setting for 45 functions that drew 2,979 guests in FY96. These events included receptions and dinners hosted by a number of academic departments, Resource Development, other MIT offices, and outside corporate clients.

MUSEUM SHOP

The MIT Museum Shop introduced the successful Stochastic Discount to the MIT community this year, establishing its reputation as "the best deal on campus." At the Shop's two stores at 84 and 265 Massachusetts Avenue, MIT ID-holders may roll the numbered dodecahedron and deduct the percentage shown from the purchase price of everything they buy. Sales in both stores exceeded annual projections.

STAFF CHANGES

Three long-time members of the Museum staff retired in June 1996: Warren Seamans, the founder and Director, who served in that position for 25 years; Joan Loria, Director of Exhibitions, who joined the staff in 1974; and Barbara Linden, Functions Manager, a member of the staff for 23 years. The Museum staff greatly appreciates the contributions, loyalty, and dedication of these three colleagues.

MIT Museum Staff

DEAN FOR UNDERGRADUATE EDUCATION AND STUDENT AFFAIRS

In the Fall of 1994, Dean Arthur Smith announced his intention to resign as Dean for Undergraduate Education and Student Affairs. Then-Provost Mark Wrighton assembled a committee, chaired by Professor Linn Hobbs, and gave it two charges: to assemble a list of candidates to fill the position, and also to recommend how the position of dean, and more generally the office of Undergraduate Education and Student Affairs, might be redefined and reorganized to better serve the Institute's educational mission.

As one result of the deliberations of the Hobbs Committee, I was asked to serve as Dean Smith's successor. Since becoming Dean in September 1995, I have worked to bring about the changes in scope and organization recommended by the Hobbs Committee. In its report, that committee proposed that the two major elements of the office – one concerned with student residential life and campus activities, the other with academic affairs – should be more clearly separated, and that each should be strengthened with more authority and resources. The committee therefore advised that MIT hire a Dean for Student Life who would report to the Dean for Undergraduate Education. With this organization the two offices would work in a coordinated fashion, while assuring a primary focus on academic issues.

Accordingly, in December 1995 Margaret R. Bates was hired as Dean for Student Life. In very little time she has developed a broad knowledge of MIT and a deep understanding of its culture, and she has been an enormous help in running the office and in interacting with the rest of the Institute. Because the process of defining our respective roles has gone smoothly, I am finding more time to devote to academic issues. Most notably, I have been able to help organize the Task Force on Student Life and Learning, which President Vest has charged with undertaking a comprehensive review of MIT's educational mission.

What will take more time is the strengthening of the authority and resources of both the Dean for Student Life and the Dean for Undergraduate Education. This can be done only by developing closer relationships with other administrative units concerned with educational issues. The creation of these relationships is proceeding slowly – as it should – but it is proceeding, primarily through the creation of an array of student services reengineering teams during the past academic year. One team, under Margaret Bates, has been established to consider the reorganization of housing and residential life; another has been established, under student leadership, to design better administrative procedures in the area of co-curricular life. Although the boundaries of a more integrated organization for residential and campus activities are not yet clear, they should begin to be defined in the coming year.

On the Undergraduate Academic Affairs side of the office, administrative boundaries are also being re-examined in a collaborative spirit. One of the student services reengineering teams, the FAST team, has so far focused on routine financial and registration transactions, but it is also involved in areas such as curricular information and academic advising. In the fall, two other teams will propose redesigns in areas that have direct relation to academic affairs: career services and educational support services. Finally, in the spring of 1997 a reengineering team focused on student orientation will be started.

Therefore, on the academic side as well as on the student life side, the scope of this office will be changing. As we move forward, I will miss the comradeship and wisdom of Dean for Undergraduate Academic Affairs Travis Merritt, who has just announced his decision to retire on October 1, 1996. Dean Merritt has contributed extraordinary creativity and energy to the improvement of undergraduate education at MIT. He has done wonders with very limited resources, and one of the challenges that confronts me in the coming year is how to respond to the retirement of this truly irreplaceable person.

Another challenge I face is to serve effectively as sponsor of student services reengineering now that it is entering a phase of intensive, multifaceted activity. When I began as Dean, I looked forward to working as co-sponsor with Vice President James Culliton. The relationship that began so enjoyably and compatibly ended far too soon with his illness and death. No doubt other ways will be found to share oversight of the reengineering process, but the loss of his experience and guidance in this role is profound.

Yet another challenge for me during the coming year is to develop a clearer sense of common mission within the dean's office. During the past year we held a number of all-office meetings to discuss this and to begin to set some priorities. As a result of these meetings, communications throughout the office have improved, and during the coming year we will continue to improve them. We will also be working to develop administrative mechanisms and financial structures necessary to carry out our core mission: to provide coherence, leadership, and historical vision in defining, articulating, and supporting MIT's educational mission in the academic and residential lives of our extraordinary undergraduates.

Rosalind H. Williams

DEAN FOR STUDENT LIFE

When I was appointed to the newly created position of Dean for Student Life, beginning December 1, 1995, my charge was a wide-ranging one: to serve as an advocate for students, and to seek to improve the living and learning environment at MIT. Despite the inevitable difficulties associated with organizational change, to say nothing of the literal dislocations occasioned by my arrival, I have found a warm welcome indeed. Moreover, I have already had occasion to work cooperatively with a wide range of colleagues and offices, within UESA and beyond, as well as with both undergraduate and graduate students. The issues we have addressed have ranged at least as widely, from the pilot program for large student social events, to voter registration for students, to overcrowding in the residence halls, to the feasibility of a preorientation program for freshmen, to name only a few.

One of my first meetings was with the Student Services Reengineering Team, and that involvement continues, most directly as team captain for the Housing and Residential Life Implementation team, but also more generally with the many other groups addressing the quality of student life. I have also been privileged to join the MIT Museum Advisory Board, to participate in the deliberations of the Committee on Student Affairs, to moderate a guest panel at Leadershape, to introduce myself to the IACME group of industrial sponsors, to serve on the selection committee for the Compton and Stewart awards, and even to observe the heretofore mysterious rites of broomball. The experience has been an exhilarating one for me personally, but I also hope to foster such opportunities and connections for others in future, with the kind of support and encouragement that Dean Rosalind Williams has so generously provided me in my introduction to MIT.

Margaret R. Bates

CENTRAL ADMINISTRATION/SENIOR ASSOCIATE DEAN

Discipline and Conflict Resolution

During the 1995-1996 school year we completed and put into place the new Discipline and Conflict Resolution System. This new system had been several years in the making and a decade in the talking. The new system preserves the opportunity for students to resolve conflicts informally and at the lowest level. To that end, Residence and Campus Activities (RCA) continued to handle most cases informally, a process that draws on RCA's expertise in mediation. For the first time, however, students are involved in matters of discipline not heard by the Committee on Discipline (COD), since panel participants are chosen from a pool of trained staff and students. By including students, the system is now parallel with COD, and the perception that justice is dispensed fairly has been enhanced accordingly. The new procedures were piloted in the Spring of 1996 and a revised system will be in place for the year.

Chaplaincy and Religious Activities on Campus

W11, the Religious Activities Center, has continued to be one of the most active pieces of property on the campus. During the year the Lutheran Chaplaincy appointed The Reverend Constance Parvey to fill the void left last year when The Reverend Susan Thomas departed. David Thom, director of Campus Crusade for Christ, left after seven years to take a position with Athletes in Action at the University of Massachusetts in Amherst. A replacement has not been appointed. The Reverend Nick Fatato left during the year and has been replaced by The Reverend Mike Olejarz who will be an Associate Chaplain.

Over the course of the year the regular gatherings of the Religious Life Council brought student organizations together to further their understanding of one another and to keep our office aware of their general needs. Interfaith conversation occurred each time we gathered, but for the Institute at large these conversations across creed and history largely went unnoticed. This may change in the year ahead as the Jewish, Islamic and Christian communities begin a series of seminars on the views of science in the three traditions. The idea informing the creation of W11 was that by bringing these communities together we would be improving communication between them. This seminar series will turn this idea into a public reality.

Resource Development

The resource development efforts on behalf of programs housed in W11 has proceeded well. The Technology and Culture series is on sound footing for the immediate future and a September 10th program and dinner with President Vest will kick off the series for 1996-97. The efforts of Ms. Diane Goldin in Resource Development have aided not only Technology and Culture, but also MIT Hillel and hold potential for other programs as well.

Still needed, however, are resources to underwrite the operation of W11. The building is an important naming opportunity; efforts thus far to elicit the donation needed to endow its operation have not been successful, but should not be abandoned.

The Student Life Now designation for the Parent's Fund generated nearly \$10,000 to be used by the Dean in support of immediate student needs. The Alumni Fund will offer this option this year and increased resources should result.

The Yannis Krikelis Memorial Scholarship fund was set up in the months after Mr. Krikelis' untimely death. The fund grew so rapidly that the first scholarship was given this spring to a continuing MIT student. Plans now call for a major effort in the early fall to raise additional funds for the scholarship from the Greek community and others who knew and valued Yannis.

Student Deaths

This past year three undergraduate students died. Yannis Krikelis was killed in September in a motorcycle accident. Melissa Ronge took her own life in February, and John Selormey died in April. Each death was a tragedy in its own right and the Institute responded effectively to the needs of the moment. Our willingness to respond with compassion conveys the proper impression of the kind of community we are. We know that in a community as large as this one that the odds are that we will continue to deal with sudden death; on average it happens at least once each year. While we have the people to respond, it is important that other resources for responding appropriately be reserved, identified, and available.

New Year

In terms of community, the uncertainties that go with reengineering and with the early retirement of so many individuals in the Institute, combined with the greater uncertainties of the times, have contributed to a malaise that is clear to all. One way to address present anxieties and to focus attention on future opportunities is to understand and honor MIT's past. Efforts to capture the threads of history are underway that will have implications for how we bring new students, faculty and staff into this community and orient them to it. How important and successful these initiatives are will depend on interest and funding. The new year dazzles with opportunity – so much so that some fear we will stumble off a cliff. Our ability to sharpen our vision of the future is the appropriate answer to dazzling opportunities, and a sharpened vision can keep you sure footed.

Robert M. Randolph
Betty H. Sultan

CENTRAL ADMINISTRATION AND FINANCE

The Central Section assists the staff and students affiliated with Undergraduate Education and Student Affairs with decisions and support in the areas of Personnel, Space, Finance and Information Systems. The year was marked by the departure of Art Smith as Dean for Undergraduate Education and Student Affairs, and the arrival of Rosalind Williams, Dean for Undergraduate Education and Margaret Bates, Dean for Student Life. The introduction of new leadership has produced implications around office space and organizational structure which continue to affect the

department. With the exception of the leadership change, the department enjoyed a low turnover of administrative staff with only one departure and two new hires. Reengineering efforts in the areas of mail services and the hiring of temporary help affected the business practices of the office. Central personnel were actively involved in smoothing the temporary hiring process. The central office was and continues to be actively involved in the assessment and design of the student activities accounting process. In the area of Information Systems UESA introduced its web site at the start of the academic year. Additionally we coordinated the development of a new database architecture for the Undergraduate Research Opportunities Program and installed additional hardware and software for the research function of UESA. Support provided to major initiatives inside the department such as the Writing Requirement Discovery Team and outside the department such as the FAST team have implications for the gathering and distribution of information in future years.

AFFIRMATIVE ACTION SUCCESSES AND OBJECTIVES

Affirmative Action successes in UESA consisted of the appointment of four females to administrative staff positions, two of whom are in senior leadership positions. As a result the UESA staff is now 65% female. Over all classifications the UESA staff is 23% minority and 74% female. The table below displays the ethnic and gender profile of the 57 full- and part-time UESA staff as of June 1, 1996.

	Minorities	Non-Minorities	Total
Administrative & Academic Staff			
Male	5	9	14
Female	5	21	26
Subtotal	10	30	40
Support Staff			
Male	0	1	1
Female	3	13	16
Subtotal	3	14	17
TOTAL	13	44	57

Seven of the 40 administrative staff are African American (4 men and 3 women). The remaining minority members of the staff are an Mexican male, an Asian American female, and a Native American female. The 3 minority support staff are all female, one Asian American and two African American. UESA will continue its commitment to Affirmative Action in Fiscal Year 1997 by actively recruiting and hiring minorities, particularly Asian and Hispanic administrative staff and African American and Asian support staff.

Richard L. Brewer
Steven M. Burke

COUNSELING AND SUPPORT SERVICES

This office continues to dedicate itself to the personal support of all MIT students. In CSS, personal support is defined broadly to include a student's academic, psychological, interpersonal, and even career and financial well-being. Services are designed to address this combination of issues, with an emphasis on the student's ability to cope – and, we hope, flourish – within the learning environment at MIT. The mission of Counseling and Support Services is to provide personal counseling to all students in a highly competitive and stressful environment. Such counseling will seek to dignify each individual student in his or her efforts to learn within both academic and personal contexts.

The goals of the office are:

- To counsel and advise undergraduate and graduate students on a wide range of personal, academic, and career matters.
- To consult with Institute faculty, staff, family and friends on a variety of personal issues; on the necessity for intervention and the provision of support; and on the potential impact of personal difficulties on academic life.

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- To respond to personal student crises and emergencies, assessing risk, offering advice and assistance to the MIT community as needed, and making appropriate referrals to medical personnel and others.
 - To provide special support services for women, minority, and gay/lesbian/bisexual students, and for students with learning disabilities.
 - To promote and support the concept of peer counseling through training, supervision, and the administration of peer services at MIT.

HIGHLIGHTS OF THE YEAR

1995-1996 was a difficult year regarding student mental health at MIT, with a student suicide, several other student deaths, and a large number of particularly extreme psychiatric crises to respond to. As is true every year, the counseling deans teamed with the psychiatric service to handle numerous psychiatric hospitalizations, working with families, hospital staff, MIT faculty, housemasters and other students around these situations. Both our personal counseling and academic support counseling (involving discussion and advocacy around classroom academic difficulties or CAP review) were in great demand: four counseling deans often had to scramble to cover student requests for help. The addition of a learning disability consultant to our staff enhanced our services, but created new challenges in terms of community education, clarification of legal compliance issues, and the integration of services into existing structures. MIT's two peer hotlines, Nightline and Contact Line, continued receiving supervision and support from several staff members in this office. Finally, CSS offered an array of trainings, workshops, discussions, and small group meetings described below, designed to address a variety of student and staff needs.

These areas of responsibility, including the granting of leaves of absence and excused absences from final exams, place CSS in the midst of students' academic struggles. The counseling deans also help students when illness or serious circumstances interfere with the timely completion of their academic work. These responsibilities continue to provide an excellent means of drawing counseling-shy students into the office, and put the counseling deans in close touch with faculty around a wide array of student problems. Such work also acknowledges the potent interaction between academic and personal well-being at MIT.

This year CSS continued to strengthen its readmission process. Decisions are made by the counseling deans in a group format; standards for readmission have become more uniform and clear. Input on readmission decisions is routinely solicited from academic departments, since many students have been required to withdraw by the CAP due to poor performance. Work with the CAP this year has required clarification of several issues, including the impact of learning disabilities on student performance and on the Committee's process, and the role of MIT Medical and CSS in the Committee's decision-making. Such discussions within this complex Committee can be challenging at times but often serve to enhance understanding of the difficult student circumstances CSS brings to the CAP.

TRAINING/PROGRAMMING/SUPPORT

Students of Color (Ayida Mthembu, Arnold Henderson)

Assistance with Kwanzaa, Hispanic Month, Black History Month, Puerto Rican Week, Cinco De Mayo, The Minority Awards Banquet and the Minority Graduates Luncheon; support to the Black Theatre Guild; study skills trainings with SHIPE and minority students in New House; Committee on Campus Race Relations; Martin Luther King, Jr. Committee.

Women Students (Lynn Roberson, Kim McGlothlin, Ayida Mthembu)

Freshmen women's discussion group; graduate women's lunches (networking and programs); advising for women student groups of African-American, Asian-American and Latina background; workshops and presentations on relationships, communication, self-esteem, rape, harassment and violence prevention; participation in international women's conference at Harvard; MIT's Women's Advisory Group and Nutrition Resource Group.

Students with Disabilities (Rich Goldhammer, Arnold Henderson, Jackie Simonis)

Student screenings to determine need for Learning Disabilities evaluations; tutoring and coaching support; arrangement of Learning Disabilities accommodations with faculty; meetings and trainings with key faculty, departments and committees concerning learning disabled students at MIT; development of faculty advisory committee to set policy; frequent collaboration with MIT's Disabilities Coordinator on behalf of students; disabilities support for commencement.

Gay, Lesbian and Bisexual Students (Arnold Henderson, Lynn Roberson)
Contact Line peer hotline supervision and group facilitation; lesbigay R/O reception.

Institute Trainings, Inter-Office Programs, and Other Activities (Arnold Henderson, Kim McGlothin, Ayida Mthembu, Lynn Roberson, Jackie Simonis)
Admissions work; support to MITES and Interphase; training group with Undergraduate Academic Affairs Staff; R/O appearances and programs, Parents Weekend; discipline advisor panel training; MedLinks training.

CONCLUSION

The addition of Kim McGlothin to the counseling staff has helped CSS to cope with the intense work load created by the counseling demands of MIT's student population. Rich Goldhammer's work as a learning disability consultant has enhanced our work with students, providing us with more insight into learning problems, and giving students an essential resource for their difficulties. However, certain issues remain problematic and unresolved in CSS. Although we have an excellent and dedicated staff, four counseling deans may truly be an inadequate number to serve 10,000 students at a highly stressful institution like MIT. Our office's broad charge to engage both the emotional and academic well-being of students, the related processes administered through this office (such as readmission and leaves) and the programmatic support offered to special student groups, create an excellent, low-barrier, and multiple-entry atmosphere for student support. However, the breadth of our charge greatly taxes the work days of a minuscule staff. In addition to all the direct service we provide, other CSS responsibilities – programming support for special student groups, readmission, CAP advocacy, etc., – are time-intensive as well, adding more pressure to a very stressful work setting. As a result, talented staff members are recruited but become depleted; commitment and enthusiasm clash with serious battle fatigue. My hope for the coming year is that we can work as an office to consider ways to replenish staff and provide essential “down” and reflective time so that individuals can continue to bring kindness, creativity, and energy to the students they serve.

Space remains an unresolved issue for CSS as well. Although July 1 will see an administrative change as the International Students Office begins to report to the Office for Graduate Education, we are still crowded into one work space. Issues of staff supervision, student privacy, and autonomy for offices with very different missions have become difficult to manage. Moreover, the CSS staff who are not housed in 5-106 have suffered from the lack of collegial and supervisory connection, as have the students they serve. It is my sincere hope that the next President's Report does not reprise this lament.

Jacqueline R. Simonis
Arnold R. Henderson, Jr.
Ayida Mthembu

Lynn A. Roberson
Brima A. Wurie

INTERNATIONAL STUDENTS OFFICE

The purpose and mission of the International Students Office (ISO) is to provide services and support programs which meet the special needs of international students and help them to fulfill their academic goals.

When an international student is admitted to MIT, a legal component is added to the normal process of admission. Federal laws regulate the procedures that institutions and students must follow in order for students to come to the U.S. to study and maintain their legal non-immigrant student visa status for the duration of their program of study while in the US. The International Students Office issues the required legal forms and provides programs aimed at introducing the students to their new environment.

During the past year, the ISO issued the initial immigration documents for approximately 1000 students; 800 of them eventually enrolled at MIT. As in the past, the ISO, in cooperation with the International Residence Orientation Committee, provided an Orientation Program for new international undergraduate students. In addition, the ISO held daily information sessions on immigration regulations, life at MIT and in the U.S., and cross-cultural issues for all incoming international graduate students throughout the summer period as well as during the month of January. During the month of August the office sponsored weekly Coffee Hours where new students could meet current students and other members of the MIT Community. The Orientation Program also included presentations

on banking in the U.S., Social Security, Campus Safety Issues, tours of the Medical Department and MIT Libraries, and a Welcome Party co-sponsored by the Alumni Association. Finally, a few days before the beginning of the academic year, the ISO together with the Medical Department sponsored the International Open House for incoming students.

During the academic year and annual vacation periods, the ISO continued to provide legal documents and advice on immigration regulations for students who wished to travel, to have some work experience in this country, change educational level, transfer to and from other institutions, change visa status, or extend current visa status. In addition, the office provided letters certifying enrollment at MIT required by foreign countries to transfer money to the U.S., postpone military service, or to invite spouses, siblings or parents for a visit to the U.S. The office has provided personal advice when students encountered difficulties in adjusting to their new environment, in meeting their financial obligations, or any other problem they might have encountered on or off campus. Approximately 70% of the current international student population at MIT visited the ISO during this past year, and many of them came more than once.

The ISO-sponsored Hosts to International Students Program has continued to be very successful, with a large number of students having the opportunity to get to know and interact with American families on an on-going basis. The office has also worked closely with the Coordinator of the Wives' Group, a program sponsored by the Medical Department, which provides a social network for spouses of international students.

This past year has also seen the implementation of the first Student Exchange Program—between the Department of Aeronautics and Astronautics and European institutions—and the Visiting Students Program—which has brought to MIT a larger number of non-degree short-term students.

While the ISO has continued to carry out its most important functions and programs in an apparently routine fashion, there have been a series of external and internal events that have affected the Office. The Government shut-downs made it very difficult for a number of students who had gone home for the Winter Break to receive visas to return to the US. The Social Security Office and the Massachusetts Motor Vehicles Department implemented contradictory regulations that have made the process of obtaining a driver's license very frustrating for international students. Internally, the office has had to cope with a high turn-over of support staff and many organizational changes. Actually, what has made this past year different from the others has been the high level of uncertainty—uncertainty about the reporting structure, space, and staff. Finally, the staff and the students have had to cope with the unexpected death of two well known and well liked international students—one in a car accident and the other after a long-term illness.

Looking at the future, the ISO, now under the auspices of the Graduate Education Office, hopes that all the recommended changes in personnel and location will be implemented and that next year will bring a renewed commitment to the mission of the office.

Milena M. Levak, Maria Brennan, Danielle Guichard-Ashbrook, Brima A. Wurie

OFFICE OF MINORITY EDUCATION

Under the new leadership of Leo Osgood, Associate Dean for Undergraduate Education and Director of the Office of Minority Education (OME), the OME has strengthened its present programmatic efforts, increased awareness of the Office of Minority Education services, and further extended efforts on behalf of underrepresented minority students. With the growth of the underrepresented minority student population at MIT over the last eight years, the OME staff remained diligent in its visibility, accessibility, and increased quality of services offered to the underrepresented students. The OME staff continued to be involved in an array of Institute committees, programs, and reengineering initiatives.

The mission of the Office of Minority Education is to provide effective academic enrichment programs, to enhance matriculation, to promote higher retention and greater excellence in underrepresented minority (African American, Mexican American, Native American, and Puerto Rican/Hispanic) students' academic and general educational

achievements, and to encourage their pursuits of higher degrees and professional careers. OME's mission will embrace a strategy to address academic and graduation gaps between underrepresented minority and non-minority students on MIT campus.

The goals of the office are:

- To offer an introduction and orientation to MIT which will aid in the adjustment of minority students to the academic environment at MIT.
- To strengthen ties and relationships with academic and other support offices in order to increase the visibility and use of OME resources.
- To re-establish an effective freshmen advising program for underrepresented minority students that will focus on academic and social transitions to the rigors of MIT.
- To design and implement an infrastructure to support academic advising in the Schools of Engineering, Science, and Humanities and Social Sciences to encourage and actualize higher academic performance from underrepresented minority students.
- To determine what variables or conditions influence underrepresented minority students' achievement and retention.
- To develop and implement a Minority Student Leadership Institute with particular focus on leadership development for underrepresented minority students in engineering.

To address the educational and graduation gaps, the OME plans to request an additional professional staff to focus on developing academic and support programs for underrepresented minority students in their sophomore, junior, and senior years.

PROGRAMS

This section highlights an intensive and productive year of programs sponsored and operated by the OME during 1995-1996. Additional activities will be emphasized in this section.

Project Interphase

Project Interphase is one of the major efforts in providing academic enhancement to minority students. The program enrolls one-third of the admitted underrepresented minority students who decide to attend MIT. The curriculum covers Physics, Calculus, Writing, Physical Education and a myriad of co-curricular activities during a seven-week period prior to their first year at MIT.

Tenured faculty, with the assistance of graduate and undergraduate tutors, make up the teaching core for Project Interphase. Faculty and tutors' efforts remain one of the strongest academic buttresses in preparing underrepresented minority students to face the rigors of an MIT curriculum.

Ethnic and Gender Profile

Sixty students were accepted into Project Interphase 1995. Two students did not complete the seven-week program due to medical and extenuating circumstances. There was a slight change in the ethnic and gender profiles in the program: African American representation increased from 43% in 1994 to 45% in 1995. The participation of Latino and Hispanic origin (Mexican-American, Puerto Rican and other) remained constant at 53% during Project Interphase '95. The figure of 40% women was consistent with the number admitted in the Class of 1999.

Academic Outcomes

This year's Project Interphase '95 saw continued improvement in the area of academic outcomes. At the conclusion of the program, students were referred to the Writing Center and encouraged to complete Phase I of MIT's Writing Requirement. The following highlight should be noted: 38% of the 58 participants of Project Interphase passed the first phase of the Institute's Writing Requirement. Another strikingly positive outcome of the program was in the area of Calculus—thirty-one participants, 53% of 58 students, received advance placement credit for 18.01.

Program XL

This year, XL (EXCEL) continued to be an effective academic enrichment program for first-year underrepresented minority and non-minority students. Participants who enroll in the program are divided into small study groups that focus on Calculus, Physics, Chemistry and other courses associated with the core curriculum. The groups meet

twice a week for one and a half hours during the semester. All study groups are coordinated by XL Facilitators, who are usually graduate students. However, in some situations this year, the program has utilized upperclassmen who have demonstrated a high level of academic achievement in the subject. Facilitators oversee the interactive discussion of materials covered in the subjects. Eighteen facilitators/tutors were utilized in the Fall term and ten were utilized in the Spring term.

At the beginning of the 1995-96 academic year, the participation level in Program XL exceeded previous years by approximately 40 students. In the Fall term, Program XL established twenty-seven study groups to respond to the high level of Calculus, Physics, Chemistry and other courses. There was a decline in participants during the Spring term, which was consistent with previous years. During the academic year, the Director of the OME was approached by several upperclass minority students to establish a pilot Program XL for upperclass core courses in Science and Engineering.

The following are Program XL statistics for 1995-96:

	<u>Enrolled</u>	<u>Completed</u>	<u>Ethnicity Completed</u>
Fall 1995	71	58 (82%)	Asian 7, African American 26, Hispanic 20, Caucasian 5
Spring 1996	30	25 (82%)	Asian 2, African American 6, Hispanic 12, Caucasian 5

The major users of Program XL are underrepresented minority freshmen students. The program continues to attract and enroll Asian and non-minority freshmen.

Tutorial Services Room

The Office of Minority Education's Tutorial Services continue to provide effective academic support to a significant number of underrepresented minority students. The TSR also experienced a growth of tutorial hours by non-minority students over the 1994-95 academic year. This year the OME hired approximately 100 graduate and undergraduate tutors. All tutors were interviewed by the Assistant Director of the OME, who is responsible for coordinating, hiring and training tutors for the program. Grades of the tutors were verified to ensure quality control within the program. The TSR employed tutors who represented an array of ethnic backgrounds and academic discipline.

As the result of stronger fiscal management and a renewed focus on the primary clientele of the TSR, there was a slight reduction in the overall use of the TSR (see chart) as compared to previous years.

	Fall 92	Spr 93	Fall 93	Spr 94	Fall 94	Spr 95	Fall 95	Spr 96
Users	296	375	398	385	427	326	249	208
Tutoring Hours	904	1293	1654	2361	2109	1963	1190	1030
Independent Study Hours	269	371	226	566	228	277	190	149
Athena Use Hours	162	133	102	281	256	223	209	115

Freshmen and sophomores represent the majority users of the TSR. Last year, the TSR provided academic and tutorial support services to 457 student-clients. In recent years, members of the TSR staff have observed an increase in the number of women students utilizing the services offered by the program, while there has been a decline in the use of the TSR by male students. The total number of service hours received during the 1994-95 academic year was 2,882 hours (service hours include the tutorial, Independent Study and Athena Use hours.)

Below is the Tutorial Services Room Annual Report for the 1995-96 academic year. The report provides key information on the total number of Service Hours, Service Hours by Class Year, Service Hours by type of Service, and students' ethnicity and gender.

Total Number Of Student-Clients:	457 (Fall + Spring Totals. Some repeats included)
Total Number Of Visits:	2410 (Repetitive of students)
Total Number Of Service Hours:	2882 (Repetitive of students)

SERVICE HOURS BY CLASS

Class	Hours	Percentage
1	1551.25	53.86
2	626.00	21.72
3	380.50	13.20
4	192.00	6.66
5	85.75	2.98
Undetermined	46.75	1.62
TOTAL	2882.25	100.00

SERVICE HOURS BY TYPE OF SERVICE AND BY STUDENTS' ETHNICITY AND GENDER

Ethnicity	Tutorial		Independent		Athena	
	Hours	Percentage	Study Hours*	Percentage	Use Hours*	Percentage
Asian	440.00	19.82	21.50	6.36	28.75	8.88
Black	648.50	29.21	193.25	57.13	167.50	51.74
Hispanic/Latino	502.75	22.64	110.25	32.59	104.75	32.36
Native American	39.00	1.76	0.50	0.02	0.00	0.00
White	247.50	11.15	1.75	0.08	4.25	0.19
Other	78.25	3.52	0.00	0.00	3.25	1.00
Unspecified	264.25	11.90	11.00	3.25	15.25	4.71
TOTAL	2220.25	100.00	338.25	100.00	323.75	100.00

Gender	Tutorial Hours	Tutorial Percentage	Independent Study Hours*	Independent Percentage	Athena Use Hours*	Athena Percentage
Male	664.50	29.93	173.00	51.15	163.00	50.35
Female	1555.75	70.07	165.25	48.85	160.75	49.65
TOTAL	2220.25	100.00	338.25	100.00	323.75	100.00

* "Athena Use" are sometimes hidden as "Independent Study", and vice versa.

Second Summer Program/Industrial Advisory Council For Minority Education

For over twenty-five years, the Second Summer Program has complemented MIT's academic experience in an array of professional disciplines. SSP is an academic program that enriches and supports students' intellectual growth while assisting them to develop a keen sense of their professional possibilities. Program interns explore possible fields of interest, while making real contributions in their assigned workplace. Participants in the program return to their classrooms in the fall with a depth of knowledge and experience that greatly enhances their learning.

This year, forty-three students qualified to participate in the Second Summer Program by passing the academic requirement of the program. During the 1995-96 Independent Activity Period (IAP), these students participated in the Program's Engineering Design Workshop that covered a two-week period. There were 20 African Americans, 21 Latinos, 1 Native American, and 1 Other. The gender breakdown consisted of 21 men and 22 women.

SSP participants were divided into teams and each team was required to design and build a device/product for an urban school playground. At the end of the two-week period, each team competed in the program's engineering design competition. Through the support and direction of Professor Alex Slocum of Mechanical Engineering, the program academic officer, the winning team secured a patent for the product they produced during their SSP experience.

After completing the SSP Engineering Design Workshop, participants entered an intensive interviewing process with the OME's Industrial Advisory Council for Minority Education (IACME) companies participating in the Second Summer Program. Twenty-nine students were placed with 17 companies in engineering intern positions. MIT faculty continue to strengthen its partnership with the OME/SSP by volunteering to visit interns on-sight and to report on the students' experiences.

Beyond the collaborative effort of the SSP, members of IACME provide financial support to enhance the OME's ability to organize effective academic and professional development programs to assist our professional student organization: AISES (American Indian Science and Engineering Society), NSBE (National Society of Black Engineers) and SHPE (Society of Hispanic Professional Engineers). During the course of this academic year, the OME contributed over \$9,000 to support an array of underrepresented minority students' organizations and activities.

Secrets and Strategies for Academic Success

SSAS has been a part of the OME's core of support programs offered to underrepresented minority students for over twenty years. The primary aim of the SSAS program is to expose underrepresented minority students to the Institute's network of academic and support services available to all students. This year, coordinators of the SSAS Program observed a significant increase in participation by underrepresented minority students in sessions held in both terms on topics such as "Time Management," "Ways to Develop Effective Study Skills," and "How to Choose a Major."

Coordinators also held a session that provided an opportunity for minority students to network with minority faculty and administrators.

Office of Minority Education Student Advisory Council

OMESAC was created to provide a mechanism for minority students to bring their concerns and issues to the Associate Dean for Undergraduate Education and Director of the OME. OMESAC's membership consists of a cross section of underrepresented minority student professional and social organizations.

The 1995-96 academic year found OMESAC increasing its presence in both the minority and the non-minority communities. As a result of the Council's efforts, there was increased participation in activities and programs offered to minority students. The Council was instrumental in providing critical recommendations to the Metal Detector Policy Committee during MIT's moratorium on parties and special events.

Minority Scholarships

The OME continues to be a repository for information for internships and scholarships that target underrepresented minority students. Minority students receive scholarships from public, private, and corporate organizations. This year, the OME facilitated partial and full scholarship support for over thirty minority students, with amounts ranging from \$1,000 to \$26,000 to be applied to tuition, room and board, fees, and books.

Minority Awards Banquet

The Office of Minority Education held its Twentieth Annual Minority Awards Banquet at the end of 1995-96 academic year, in cooperation with the Counseling and Support Services, the Office of Career Services and Preprofessional Advising, the Office of the Dean for the Graduate School, the Office of the President, and Residence and Campus Activities. Over three hundred faculty, administrators, staff, and students attended the event. Graduate and undergraduate students received academic and community service awards for their contributions for improving the quality of life for minority students at MIT.

The Spirit

The "*Spirit*" newsletter maintained its circulation of 2,000 readers consisting of faculty, staff, students, members of the IACME and parents.

Leo Osgood, Jr.
Ruben Morfín-Ramírez
Gail-Lenora Staton

RESIDENCE AND CAMPUS ACTIVITIES

The Residence and Campus Activities (RCA) section coordinates the activities related to residence life, student activities, independent living groups, crisis management, conflict resolution and mediation, student governments, and public service. These functions provide students with opportunities to develop important skills outside the classroom: leadership, communications, group dynamics, understanding differences, teamwork, and conflict management. The staff in RCA provide direct service to students and their organizations through one-to-one interaction and by working with the approximately 300 student organizations and residence halls.

The programs and services of RCA, for both undergraduate and graduate students, are connected to the educational mission of MIT, and to the development of a sense of community at MIT. For example, this past year three staff members served on the Steering Committee for Leadershape, a leadership development program that helps 60 student leaders develop their skills and design solutions to problems at MIT. By providing the staffing for the informal resolution of most complaints by students against other students, RCA educates the individuals involved, as well as the general community about resolving conflict. As part of the team that plans and implements R/O, the RCA staff contributes expertise in program planning that enables a balanced residence selection and academic orientation schedule. By providing opportunities for public service and grants for fellowships in the Cambridge Public schools, we work with students to develop citizenship, leadership, and community involvement. In working with the planning and design of student events at MIT (including the event registration process and response to crises at events), our staff works directly with students in a collaborative way to foster involvement in campus life.

Another area of support for students involves being available for individual students and groups with special needs. Our staff works with students around issues of race, gender, ethnicity, and sexuality. We advise individual students who have concerns, as well as working with student groups representing a larger constituency, i.e., GAMIT or the Asian Caucus. Although this work often occurs behind the scenes, the time given to direct support translates into students feeling that they are part of the community at MIT and that they have someone who understands them. A related area of our work happens when a crisis occurs such as a student death. In addition, we work directly with the Housemasters and Tutors on a daily basis to address both major and minor issues of concern in the residence community.

DISCIPLINE AND CONFLICT RESOLUTION

RCA staff dealt with a significant number of disciplinary cases, such as damage to property, theft, arson, and assault and battery with a deadly weapon. They also dealt with harassment cases including inappropriate attention, unwanted touching and comments, and harassment via Athena. The sanctions imposed were verbal warnings, restitution for damages, community service, agreement to stop the behavior, and probation. For more information, please refer to the report to the Faculty, which was presented in February.

MEDIATION

This year, approximately 30 staff, students, and faculty have been certified through mediation@mit. The number of formal mediations is small, but the option of formal mediation for students will continue to be available.

UNDERGRADUATE HOUSING

This past year, undergraduates were again able to indicate their house preferences and receive their assignments using Athena. Over 90% of the 745 students who participated received one of their top three choices of residence halls. For the first time, temporary assignments were completed electronically, eliminating the approximately 60-80 work hours required to assign temporary housing manually.

Crowding for first year students was comparable to that in previous years, with 154 crowds at the beginning of the year, compared with 132 the previous year.

For the first time, students were able to submit on-campus housing requests, housing change requests, housing cancellations, and summer housing requests electronically over the World Wide Web at the Residence and Campus Activities web site.

FACULTY AND GRADUATE RESIDENTS

The strength, initiative, and energy of the new Housemaster couples have been a welcome addition to the residence hall system. The GRT training program was very well received, not only in the August Orientation Training, but also throughout the year. Particularly popular were the Listening Skills Seminars. Five ongoing listening skills classes were established, all led or assisted by experienced Tutors. Some of the recommendations developed from the previous year were implemented, particularly in the area of hiring, orientation, training, and evaluation processes for GRTs.

Housemasters, Graduate Resident Tutors, and RCA staff have been engaged in a significant effort this year to examine the residence program with the goal of improving services to and quality of life for our students. Recommendations have been developed in the areas of roles and responsibilities, information flow, and hiring, orientation, training, and evaluation.

In addition, a group of representatives from areas across the campus began to discuss program issues that affect students. For the first time in several years, *all* Housemasters chose to continue in their positions.

FRATERNITIES, SORORITIES AND INDEPENDENT LIVING GROUPS

Approximately 390 freshmen took residence in one of the Institute's 36 Independent Living Groups. This was a slight drop from 1994 but still well over the ten year average of around 370.

Sigma Nu Fraternity became the Institute's thirty-sixth Independent Living Group last Fall with their purchase and renovation of a three-story building located at 523 Newbury Street in Boston. Renovations, funded through MIT's Independent Residence Development Fund, increased its capacity to 20 occupants.

In June, MIT completed the purchase of a property at 480 Commonwealth Ave. After renovations are completed, will house 24 members of Sigma Kappa Sorority beginning in Fall 1997. This will be MIT's third housed sorority.

In October the MIT colony of Alpha Epsilon Phi sorority received its charter, and became the Institute's fifth national sorority.

HOUSE FELLOWS PROGRAM

The House Fellows Program, now in its eighth year, promotes greater interaction and sense of community between students in Institute Houses and MIT faculty members. This past year, over 30 Fellows were associated with five undergraduate and one graduate house and seven Independent Living Groups.

STUDENT ACTIVITIES OFFICE

The second annual Event Planning and Student Leadership Workshops were held with the distribution of the Planning Events guidebook. A manual of policies and procedures for students accessing and depositing funds into their Student Activities and their Undergraduate Association Accounts was completed. Check-writing for both the Student Activities and Undergraduate Association is now done by computer to expedite students' ability to access their funds. In addition, several staff are engaged in examining the student activity funding process and the possibility of moving to outside bank accounts.

UNDERGRADUATE ASSOCIATION

The Undergraduate Association (UA) reinstated the Free Airport Shuttle Program, available to all MIT students for major holidays. The UA sponsored the MIT Medical College Admissions Test (MCAT) classes for the second year. This program's student enrollment has increased and now has scholarships available. The UA, with coordination by the Association of Student Activities (ASA) and financial support by Residence and Campus Activities, printed the 1996/97 Student Activities Directories including all currently ASA-recognized student organizations. Additional copies will be made available to other departments.

ASSOCIATION OF STUDENT ACTIVITIES

This year, the Association of Student Activities (ASA) began to service student organizations which were seeking room allocation and ASA recognition. ASA now handles applications for Campus Activities Complex's (CAC)

programming board. In addition, ASA went on-line this year; all electronic Bulletin Board space information and Activity Midway programs are now conveniently located at the student's fingertips.

GRADUATE STUDENT COUNCIL

In addition to its committees listed below, the Graduate Student Council (GSC) tries to represent graduate student interests to the administration by providing a channel of communication. Nominations for institute and presidential committees are made through the GSC.

The Academic Project and Policy Committee (APPC) dealt mainly with academic issues.

- A panel discussion on the Rights and Responsibilities in Advisor-Graduate Student Relationships was held with panelists Dean Ike Colbert, Professor Patricia Culligan-Hensley (Civil/Environmental Engineering), Professor Doug Lauffenburger (Chemical Engineering, Director of the new Center for Biomedical Engineering), and Professor David Pritchard (Physics).
- A new award, the Perkins Award for Excellence in Graduate Advising was presented to two students in honor of Frank E. Perkins' many contributions to graduate students during his twelve years as dean for the Graduate School.
- An anonymous exit survey was distributed to six departments to gather information about graduate student life in order to plan events tailored to graduate student needs in a more educated manner.
- The second annual leadership workshop with Professor Jon Carroll of the Sloan School workshop for student and post-doctoral advisees on acquiring tools for working with your advisor was conducted with Lynn Roberson.

The Activities Committee organized over 20 subsidized events this past year, 95 percent of which were sold out. These events included the GSC annual weekend trip to the Montreal Jazz Festival, a Fall Foliage Weekend at Talbot House, and the second annual Formal Ball held at Morss Hall. Regular favorites such as ski trips, hiking trips, Red Sox Games, performances at the Wang Center, Tanglewood, and a Christmas shopping trip to Kittery, Maine, were also big hits.

The Graduate Newsletter was revived in August, produced quarterly and mailed to every graduate student with an on-campus address (office, lab or housing). It appears to be an effective way to communicate with graduate students, informing them of activities at the GSC and in the administration. It also provides an assortment of funding and fellowship information and even information on what is happening in Washington with the help of the National Association of Graduate Professionals (NAGPS).

The Housing and Community Affairs Committee (HCA) has the large responsibility of trying to improve graduate student life at MIT. The members are always busy and involved with departments around the Institute in an effort to make life more equitable.

- Josten's 25 percent discount continued this past year. A licensing fee scheduled to go into effect last November (but not for undergraduates) was postponed due to the efforts of the HCA co-chairs and letters of support from individual deans.
- The GSC's 11 percent student T-pass discount continued this past year, with the cashier's office taking over the responsibility of dealing with the large sums of money involved.
- The Grocery Shuttle stopped running with the closing of LaVerde's Medford Star Market. The grocery shuttle was resurrected with the heavy involvement of a graduate student's spouse, who negotiated with another local (more convenient) Star Market to provide shuttle service for the MIT community (undergraduates are heavy users as well). As a result the Grocery shuttle jumped from two trips a week on Saturday mornings to adding three additional trips on a weeknight!
- HCA became heavily involved with the parking committee to suggest the unfairness of increasing the parking permit in January to on campus residents (mainly graduate students) with leases. The increase was postponed until Fall 1996.

The Orientation Committee organized a fall orientation jam-packed with events. The Lobby 10 information booth provided information on MIT departments, local area bus schedules, tenant/landlord responsibilities, and brochures

on local sights, museums, and sports team schedules. The committee enlisted the help of the other GSC committees (APPC, Activities, HCA) to focus on workshops and off-campus events ranging from trolley tours around Boston, and Night on the Town, Red Sox Game for 200 and Harbor Cruise for 400. The annual picnic at Killian Hall was open to all 1100+ incoming graduate students.

HARASSMENT ADVOCACY AND RESOURCE GROUP

HARG's planning group went through changes as its leaders are transitioning on to other things. Understanding that student involvement in this project will ebb and flow, Dan Goldner, one of HARG's founders, wrote up the HARG training curriculum manual which was distributed to various offices around the Institute as well as the RCA office. People who are interested in doing a training can refer to this manual, as well as the accompanying videotape.

ASIAN STUDENT CONCERNS

From last year's successful effort in planning an Asian student R/O, the Asian Student Caucus helped to initiate the implementation of an official Asian Student R/O this coming August. They received substantial backing from the RCA office. This year, an Asian Heritage summer intern has been hired, Peggy Chen. She will continue to give Asian R/O administrative support. With the departure of Mary Ni, the Institute loses a major source of support for Asian students.

MIT PUBLIC SERVICE CENTER

The year-long CityDays program, a unique partnership with the Cambridge Public Schools, was kicked off on Friday, September 1, in collaboration with the School Department of the City of Cambridge. On that date, 400 Cambridge public school children came to MIT where they were hosted by 600 MIT student volunteers who ran a variety of activity stations ranging from lab tours to sports and crafts. The CityDays component of R/O has become a tradition of freshman orientation at MIT.

LINKS

The CityDays Festival is a nice lead in to the LINKS component of the year-long program, which extends throughout the school year with the mission of improving the quality of science education in the Cambridge Public Schools. Each volunteer spends 1-2 hours per week at one of ten Cambridge elementary schools. The program had about 175 volunteers during the fall semester and 150 in the spring, with 15 ILG's and 8 Residence Halls participating. Training sessions and follow-up discussions were offered to student participants at the beginning of each semester.

KEYS TO EMPOWER YOUTH

KEYs is a student-run program sponsored by the PSC which holds one- and three-day science and technology workshops matching up MIT student mentors and 11-13 year old girls from the Greater Boston area. KEYs is dedicated to empowering adolescent girls by promoting self-confidence, increasing self-esteem, and unveiling opportunities for potential career paths. The students ran six one-day and two three-day programs this year which allowed 200 girls and 70 MIT students to take part in one or more programs during the year. KEYs, with the help of a grant from ECSEL, was also able to create a promotional video and manual for dissemination to other institutions and organizations who may wish to duplicate or expand on the KEYs model.

GIVING TREE

The PSC helped Panhellenic coordinate its annual Giving Tree program which solicited donations for over 1,000 gifts from students, faculty, and administrators from MIT this holiday season. The gifts were distributed to 15 local agencies and shelters.

PSC FELLOWSHIPS

Twenty-four PSC Fellowships of \$1,200 each were awarded over IAP this year. Sixteen of the Fellows were responsible for working with a 7-8 grade Science Teacher in one of the elementary schools, while the other eight worked with the Coordinator of Educational Technology in a number of schools. All of the Fellows were also responsible for encouraging and working with groups of Cambridge students on their Science Expo projects and most of the Fellows continued this work through the spring term.

SCIENCE EXPO

The fourth annual MIT/Cambridge Science Expo was held at MIT on May 1st, involving 150 fifth through eighth graders from twelve Cambridge schools who came to exhibit their science projects, participate in hands-on experiments, and tour Institute labs. Approximately 150 MIT student volunteers helped make this event possible.

COMMUNITY SERVICE DAY

On April 16, the second annual Community Service Day was co-sponsored by the PSC, Sigma Chi fraternity, the Race Relations Committee, and the Timberland Company. Fifty MIT undergraduates from ten different living and social groups on campus participated in this day-long event designed to enhance race relations on campus while providing needed help to the Cambridge community. The students were divided into diversified service groups and sent to one of six local agencies where they spent the day painting, doing yard work, working with children, and similar activities. Teams were composed of students from a mix of racial and cultural backgrounds in order to reflect the diverse nature of the MIT/Cambridge community.

FELLOWSHIPS

This summer, eight fellowships of \$4,000 each have been awarded to students who will work a minimum of 400 hours in community service. Three are assigned to work with the Science Coordinator for the Cambridge public schools on curriculum development and teacher training. In addition, three agencies have been chosen as recipients of a fellow: Shelter Inc., Tutoring Plus, and Summerbridge/Cambridge, which are all located in the surrounding community of MIT. The eighth Fellowship was awarded to a student who developed an independent proposal to work in the Edgerton Center on their Outreach Program.

PUBLICATIONS

Copies of *OUTREACH: A Resource Guide for Volunteering in Cambridge and the Greater Boston Area*, with a listing of over 100 local agencies, were sent out to interested undergraduates and other constituencies in the early fall. The PSC newsletter was published during both the fall and spring semesters, which listed upcoming projects and featured articles written by students about different public service efforts through the PSC. Volunteer opportunities have continued to be published weekly in Tech Talk and posted in the PSC display case.

FUNDING

The PSC is in the second year of a three-year grant from the Germeshausen Foundation which was specifically donated for IAP and summer fellowships. The Lord Foundation granted additional funding for the same purpose again this year. The PSC was also written into a grant awarded to the Cambridge Public School Science Department by the National Science Foundation, and it is in its second year (of three) for receiving support for the facilitation of the LINKS program. Approximately \$10,000 has also been donated to the Priscilla King Gray Endowment over the past year, and the PSC is in the process of seeking additional funding through Foundations and individual donors to support the KEYs program and other PSC activities.

LOOKING AHEAD

The process of reengineering and redesign of student services at MIT will have a major impact on the programs and services of RCA. We have been involved in several of the teams to date: Housing, Food Service, Co-curricular, and the Student Services Center. We foresee major involvement in the redesign of the student activities component of RCA and in the development of a plan to combine housing and RCA. We have offered our expertise in student affairs, our contacts in the field at other campuses, and our knowledge of other models to the re-design teams. Although we do not know what the final structure for student life at MIT will be, we envision a coordinated range of programs and activities that include RCA and several other departments. This will require working with staff to change their focus and help them develop the necessary skills and understanding necessary in a new environment.

In addition to the formal reengineering teams, efforts are underway to develop policy across departments and to coordinate the delivery of services to students. Some examples of this include the pilot program for events that took place last spring and will be implemented this fall, the opening of tutor training to staff in housing, the development of an Outside Bank Account Policy, and the hiring processes for staff vacancies. In all of these cases, RCA has worked with representatives from various departments and with students to create programs that meet the needs of the groups affected.

STAFF CHANGES

Susan Allen, Assistant Dean for Student Activities, left in December and was replaced by Katherine O'Dair in June. Mary Ni, Assistant Dean, leaves MIT in July.

Margaret A. Jablonski
Philip M. Bernard
Eleanor P. Crawford
Neal H. Dorow

Andrew M. Eisenmann
Mary Ni
Katherine G. O'Dair
Emily B. Sandberg

ROTC

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 1996 was as follows:

	Freshmen	Sophomores	Juniors	Seniors	Total
MIT	19	14	6	14	53
Harvard	5	5	1	2	13
Tufts	1	1	1	0	3
Wellesley	0	0	0	0	0
Total	25	20	8	16	69

The assortment of special cadet activities continued unchanged from previous years and 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*.

HIGHLIGHTS

- In the fall term, Professor Meyer lectured and Colonel Borah and Mr. Seabolt led the recitations for 17.471, American National Security Policy, to 42 students (26 were non-AFROTC).
- In the spring, Detachment 365 sponsored a field day at MIT for Air Force ROTC cadets from six other detachments in the surrounding area.
- Eleven MIT cadets received commissions as 2nd lieutenants on 7 June 1996. Colonel Borah administered the oath of office. Two Harvard cadets were commissioned on 5 June 1996.
- The AFROTC program provided MIT cadets with over \$989,230.00 for tuition for AY 95/96.
- The cadre for AY 95/96 included Colonel Borah, Major Gerrig, Captain Eherenman, Captain Tagg, MSgt. Trevino, TSgt. Briggs, and Mrs. Cronin.

Colonel Steve B. Borah

ARMY ROTC

The purpose of the Army Reserve Officers' Training Corps (ROTC) is to provide instruction and training in military science subjects, to include a focus on leadership development. When coupled with the completion of a bachelor's degree, this training qualifies selected students for commissions as officers in the U.S. Army, U.S. Army Reserves, or U.S. Army National Guard.

HIGHLIGHTS

Our training, administrative, logistical, and recruiting operations remained very strong as exemplified by our commendable ratings during our First ROTC Region Command Inspection in October. Additionally, the establishment of a super-tiered scholarship will greatly enhance our future recruiting efforts. The MIT Army ROTC detachment has been allocated 15 of these scholarships annually which pay \$20,000 towards tuition, a book allowance of \$225 per semester, and \$1500 a year for living expenses.

ENROLLMENT

Over the academic year, a total of 66 students participated in our program. At year's end 55 students were enrolled. Of those 55 students 19 (35%) were minority and 10 (18%) were female.

	Freshmen	Sophomores	Juniors	Seniors	Total
MIT	4	6	7	2	19
Harvard	1	3	7	5	16
Wellesley	3	2	0	1	6
Tufts	7	3	3	1	14
Total	15	14	17	9	55

Of the 19 MIT students, 15 are currently on scholarship, while two of the four non-scholarship students won scholarships this year.

COMMISSIONS

This year the Army ROTC Department commissioned nine new second lieutenants, two of whom were from MIT. Of the nine, four are entering the Reserves, and five will be reporting to Active Duty.

STAFF AND FACULTY

Two faculty positions changed this year. Captain Lewis replaced Captain Campbell and will be assigned as the Recruiting Officer; Master Sergeant Holley applied for retirement from the service with no replacement named as yet.

EXTRACURRICULAR ACTIVITIES

Social highlights for this year included a Military Ball where cadre, cadets, and guests participated in a formal event that included dinner and dancing. Again the Army ROTC sponsored the Annual Tri-Service Awards Banquet with over 120 cadets receiving awards from 40 organizations. Army ROTC also participated in the Annual Tri-Service Ball as well as commissioning ceremonies at Tufts, Harvard, and at the *USS Constitution*.

On- and off-campus learning opportunities both continued to expand. Cadets trained voluntarily at Fort Benning, GA (Airborne), Ft. Campbell, KY (Air Assault), and other U.S. posts (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 tactical excellence and patriotism.

Lieutenant Colonel Buckner M. Creel IV, P.E.

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 1995-96 Academic Year, a total of 17 graduating men and women were commissioned. Program enrollment just prior to June commencement was as follows:

	Freshmen	Sophomores	Juniors	Seniors	Total
MIT	11	18	4	8	41
Harvard	8	7	5	8	28
Tufts	4	4	0	2	10
Total	23	29	9	18	79

The Navy's financial assistance totaled approximately \$1,562,000 for the year, including about \$903,000 for MIT students. Approximately 96% of all NROTC students receive full tuition, payment for books, and a monthly stipend. We are expecting total enrollment to rise in the fall with a higher number of freshmen entering the program than the number who are departing due to being commissioned.

ACTIVITIES

Annual activities included Freshman Orientation held in Newport, Rhode Island, and the Navy and Marine Corps Birthday Ball, where Lt.Col Phillip Shutler, USMC, was the honored speaker. The MIT NROTC Color Guard participated in the Boston Veteran's Day parade, as well as in several MIT football games. The midshipman battalion was also active in community service, working closely with the New England Shelter for Homeless Veterans. The MIT NROTC sailing team competed successfully this year. The team sailed to victory at Georgetown and Cornell Universities and hosted the Second Annual Beaver Regatta on the Charles River, where the team was again victorious. The spring semester included two military excellence competitions at Villanova and Holy Cross.

During the summer, all of the scholarship midshipmen participate in active duty training with deployed naval units. This summer, midshipmen are cruising aboard submarines, maritime patrol aircraft, aircraft carriers, amphibious assault ships, and other vessels.

VISITS

The MIT NROTC unit hosted the Vice Chief of Naval Education and Training, Rear Admiral Paul E. Tobin, in the spring semester. Admiral Tobin visited the unit and met with President Vest to discuss the importance of the Navy's relationship with MIT.

The culmination of four years of training was reached on June 7, 1996, as seven MIT students were commissioned as Ensigns in the United States Navy in a service alongside the *USS Constitution*. The guest speaker was Mr. Frank Kendall, the Vice President for Engineering at Raytheon Corporation.

Captain Michael L. McHugh

UNDERGRADUATE ACADEMIC AFFAIRS

1995-96 was an unusually challenging year for Undergraduate Academic Affairs (UAA). First-stage planning toward the reengineering of student services drew substantially on the time and energy of several senior staff members, requiring heightened contributions by their junior colleagues in some key programmatic areas.

At the same time, important changes in leadership and organizational structure for UESA as a whole necessarily brought with them an interval of adjusted expectations complicated by some uncertainty regarding priorities for the long term.

All in all, however, these challenges seem to have been stimulants, not impediments, to UAA achievement. The UAA continues its mission of insuring that undergraduates receive high-quality education and advising by working in collaboration with faculty, staff, and students to improve existing academic programs and initiate new ones as needed. As detailed in the sections that follow, this year has seen, among other developments:

- major expansion of the office's work to improve teaching at MIT

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- useful studies toward improvement of the first-year curriculum
 - clear signals that UROP has survived its funding crisis and is moving to even greater heights as a model for integrating education and research
 - significant progress toward a radically improved version of the Writing Requirement
 - a quickened system of early alerts to students headed for the academic shoals
 - increasingly solid establishment of Freshman Advisor Seminars as anchor of a nationally unrivaled mentoring experience for new undergraduates.

In addition, we have started to benefit from closer networking ties with the academic schools and departments, with other sections of the Deans' Office, with such allied offices as Admissions and Career Services, and with faculty and students in advisory groups and individually. We are quite justified in looking forward to increasing levels of such engagement.

It has been a year in which we can all take pride. For the Dean for Undergraduate Academic Affairs personally, completing a decade of work with this office, this report provides an apt occasion to express thanks, however succinctly, to all the members of the MIT community – and especially the entire UAA staff – who have helped make his time here so thoroughly satisfying.

ACADEMIC ADVISING AND SUPPORT TO UNDERGRADUATES

Freshman Advising

The Class of 1999 was advised primarily through the highly successful Freshman Advisor Seminar system. A record 1033 freshmen (94% of the class) elected Freshman Advisor Seminars, while 65 others received advising primarily from administrators in randomly-assigned clusters of three-to-five freshmen each. There were no residence-based clusters this year.

The Freshman Advisors comprised 106 faculty members, 16 non-faculty teaching staff, 7 researchers, 47 administrators (including 5 UESA deans), and 4 graduate students. Assisting them were 227 upper-class Associate Advisors, of whom 198 worked with seminar leaders and 29 with cluster advisors.

The number of Freshman Advisor Seminars remained stable at 133 for Fall '95, which allowed almost every student who wanted to be in a seminar to be placed in one. Although proud of the success of their efforts in recruiting FAS leaders thus far, UAA staff are concerned about their ability to continue intensive one-on-one recruitment and are working with the Schools and departments to find a more efficient, reliable way to ensure sufficient seminars to meet the continuing the needs of freshmen.

Prominent among the changes for this year's class was the new system for evaluating freshman academic performance during term-time. Instead of the multi-copy midterm report for all freshmen, freshmen performing at non-passing level, and their advisors, received Fifth Week Flags in the form of e-mail messages or letters from their instructors, informing them of their poor performance and encouraging the students to meet with their instructors.

In the spring, UAA conducted an informal survey of 179 recitation instructors who had freshmen in their subjects about the effectiveness of the new fifth week flag system. Of 47% who responded, 79% said the fifth week flag was effective in alerting freshmen to their poor performance and prompting the students to contact them. Open-ended comments consisted primarily of praise for the new system, including many remarks about its improvement over the old performance evaluation system.

Subsequent to the Fifth Week Flags, in Science Core subjects Freshman Watch letters were sent this year both to students who did not pass a test and to their advisors. (Previously the letters had been sent only to the students' advisors.) In addition to Fifth Week Flags and Science Core Freshman Watch Letters, freshmen received unofficial internal grades not just at the end of the spring term, but also at the end of the fall semester, as well as IAP.

This new component of our advising system, a contact group drawn from the ranks of experienced Freshman Advisors, has met several times this spring. Its work will focus on improving the quality of freshman advising and on providing a critically close perspective on the freshman year itself. In Academic Year 1996-97 the Council will expand to include liaison student members from the Associate Advising Steering Committee.

The Associate Advisor Steering Committee completed another successful year, having planned, organized, and implemented the following annual activities:

- Screening and training Associate Advisors, with twice-yearly follow-up meetings
- Assisting with UAA study skills workshops
- Presenting the "Choice of Majors" series, attended by more than 350 freshmen
- Recruiting "Choice of Majors Mentors," upperclassmen willing to talk to freshmen about their majors
- Overseeing the administration and tabulation of Freshman Advising Survey
- Presenting "How to Find a Job/UROP" workshops
- Helping with "Resume Writing" and "Job Interviewing" workshops
- Recognizing "Outstanding Associate Advisor(s)"
- Assisting with training of new Advisors
- Creating an "MIT Survival Guide" and disseminating it to all Freshmen

New this year, the Steering Committee added a "Sensible Schedules" workshop as a precursor to academic R/O. And, during IAP, the first annual "Choice of Majors Day" was pilot-tested, highlighted by a well-attended pre-med workshop and the student-to-student "Choice of Majors Fair."

Undesignated Sophomores

UAA has continued its policy of encouraging students to designate a Course at the end of their Freshman year, rather than to remain undesignated, since we feel students need the attention of a department, as well as the sense of belonging inherent in choosing a career path. Academic Year 1995-96 began with 56 sophomores remaining undesignated. That number decreased to 36 by the end of the Fall term and to 19 by the end of the Spring term.

TRANSFER STUDENTS

MIT's admission of transfer students continues to decrease, reaching an all-time low of 14 students accepting admission in the fall and 6 in the spring. Transfer students are offered the possibility of taking two or more Science Core subjects on Pass/No Record. Of the 14 students admitted in the Fall, five exercised that option, while none chose it in the Spring.

ALL UNDERGRADUATES

Over time UAA has increasingly evolved into an office that serves all undergraduates, offering academic advice and information to help students improve their academic performance through individual and group sessions on study skills and time management. UAA outreach includes the Study Skills portion of the Office of Minority Education's Project Interphase and "road show" sessions at independent living groups and campus organizations. With the help of the Associate Advisor Steering Committee, UAA leads monthly workshops on time management, handling academic crises, study techniques, and test preparation. This year, over 750 students attended one or another of these sessions. Approximately 125 students attended at least one of the study skills sessions offered during this year's IAP.

SUPPORT TO THE COMMITTEE ON ACADEMIC PERFORMANCE POLICY DELIBERATIONS

The Committee completed its proposal this year to reform the Institute's policy on the grade of Incomplete. The motion to change the current Incomplete policy was brought to the Faculty at its April meeting and approved at its May meeting. As a result of the new policy, an expired Incomplete grade ("R") may not remain on a student's transcript. The faculty member in charge of the subject must submit a final grade by the last day of the regular term during which the work was to have been completed. No grade of Incomplete can be assigned to any student in the semester in which he or she graduates, and all grades of Incomplete must be resolved prior to graduation.

Additional issues that the Committee discussed during the year were exceeding the IAP Credit Limit, Financial Holds (the Committee will be working with CUP, CUAFA and other Institute offices to form and implement a new policy during the next year), Students with Disabilities, and the Freshman Pass/No record grading system.

COMMITTEE ACTIONS

A total of 569 petitions were acted upon this academic year (approximately half of these petitions were acted upon administratively by the Chair and the remaining were brought to the Committee).

CAP actions voted at the end-of-term grades meetings resulted in a total of 51 Required Withdrawals (compared with 76 last year – a decrease of 33%) and 433 Warnings (compared with 429 last year), distributed as follows:

Class	Warnings	Required Withdrawals
1999	202	10
1998	91	16
1997	77	12
1996	63	13
Totals:	433	51

The pattern of total academic actions (ranging from mildly cautionary to official action) on Freshmen over the past five years shows a distinct recent increase.

Academic Year	Required Withdrawals	CAP/UAA Warnings	Total Letters	Academic Actions
1995-1996	10	202	110	222
1994-1995	17	171	64	252
1993-1994	13	154	99	264
1992-1993	15	148	105	268
1991-1992	17	148	111	282

CURRICULUM SUPPORT

For this area of UAA activity, 1995-96 was a year particularly affected by institutional upheaval and change. Because the new student services reengineering effort drew off so much energy, many curriculum support activities were carried at a maintenance level, particularly in the support we provide to the freshman year program.

This year UAA staff continued its responsibility for providing institutional support to the Faculty Committee on the Undergraduate Program. This activity is described in more detail in the report from the CUP under the Chair of the Faculty.

UAA continued to administer the yearly Pre-Calculus Math Diagnostic for entering freshmen, which has become a valuable tool in evaluating the high school mathematics background of our students and providing students and their advisors with guidance about physics and math subject selection.

Meetings among faculty undergraduate officers – representatives from all academic departments who share a common responsibility for overseeing the advising and educational programs – have been resumed after a several years' hiatus. This year, there were two such meetings; discussion topics included student services re-engineering, the three-year experiment with intermediate grades, and undergraduate advising. Monthly meetings among undergraduate program academic administrators were resumed in the spring, as well. These gatherings provide an opportunity for staff representatives from each academic department to meet on a regular basis, to hear about new policies or programs, and to share common concerns.

UAA worked with the Dean for Undergraduate Education to organize this year's awards process for the Class of '51 Fund for Excellence in Education and the Class of '55 Fund for Excellence in Teaching. As a result of better publicity, there was a large increase in the number of proposals submitted by faculty and other members of the teaching staff. Seven proposals were awarded a total of \$68K in funding for the coming year.

During the Spring Term, UAA was asked by the Associate Dean of the School of Engineering to look into the status of the student-run Course Evaluation Guide. In subsequent meetings with students, in discussions with individual

faculty and department representatives, and finally in a meeting with students and faculty to discuss the future of the Guide and subject evaluation, it was decided that options for a new system of subject evaluation should be investigated.

TEACHING RESOURCE NETWORK

This year the Teaching Resource Network (TRN) – a linked set of related activities sponsored by the offices of Undergraduate Academic Affairs and the Dean of the Graduate Education in conjunction with academic schools and departments – expanded its activities on a number of fronts.

The number of faculty and other teaching staff who take advantage of the Classroom Videotape Consultation Program continued to grow. The consultant for these sessions, who teaches communication in the Sloan School, has joined the UAA staff on a part-time basis. Over the year, 98 faculty or other teaching staff (principally graduate student TA's) were videotaped in their classrooms; 64 met with the consultant to review their tapes.

A record number of the Institute's top teachers (33 faculty and 7 TA's) participated in this Fall's Orientation Workshop for New Faculty and Graduate Teaching Staff. The event was sponsored by the UAA and the Graduate Education Office. The planning for next year's orientation began earlier than usual because of two major changes: (1) the Orientation for New Faculty will be expanded from one day to three and will include topics not directly related to teaching as well as more thorough coverage of teaching fundamentals, and (2) the TA Teaching Workshop will be held separately, one week later, to increase the attendance of TA's, many of whom receive their appointments during the first week of classes.

A new edition of MIT's popular guide to recitation section teaching, *The Torch or the Firehose*, completely re-written by Professor Arthur Mattuck, was issued in late August 1995, just in time to distribute to faculty and staff teaching in the Fall. We are pleased that the oversight and distribution responsibility for *The Torch or the Firehose* has returned to UAA.

The IAP Series "Better Teaching at MIT" continued for its third year. Eleven interactive presentations were offered to 360 faculty on topics ranging from broad overviews to more focused treatment of specific pedagogical issues.

The Department of Mechanical Engineering (Course 2) and UAA are in the process of establishing a Teaching Innovation Partnership (TIP) to explore and implement teaching innovations in the new Mechanical Engineering undergraduate curriculum. The first initiative will be the revision of "Mechanics and Materials II" (2.002) for next Fall and Spring to incorporate collaborative learning techniques. Other TIP initiatives will include the general improvement of teaching and learning in the core undergraduate Mechanical Engineering lecture/recitation subjects, an evaluation of the new Mechanical Engineering curriculum, and the dissemination of information on TIP's activities and programs.

EDUCATIONAL STUDIES AND RESEARCH

Expansion of ESWG Activities and Scope

The Educational Studies Working Group (ESWG), convened by UAA staff, is a group of administrators who share an interest in MIT-related educational studies and who collaborate on research projects. Membership has expanded this year and includes administrators from all parts of the Institute. ESWG is the process of compiling an educational research bibliography about past and present student-related MIT studies.

Specific Studies by UAA and ESWG

This survey of sophomores about their first-year experience was developed by ESWG and UAA staff under the sponsorship of the Dean for Undergraduate Education and the Provost. The response rate was 42%, the same as the response to the '94 Senior Survey. On the whole, sophomores had a more positive view of their freshman year academic experience than would have been predicted based on the findings from the '94 Senior Survey. Sophomores were somewhat less positive about their R/O experience than Seniors: a sizable number of Sophomores indicated that academic and residence orientation lacked sufficient depth. Student perceptions of improvement during their time at MIT were similar in both surveys with the majority indicating that their analytical and problem-solving skills had improved, while their academic self-confidence, knowledge of social and political issues, writing skills, and self-esteem had not improved (Senior Survey) and had, in fact, worsened (Freshman Year Survey).

Preliminary findings have been presented to CUP, to representatives from the freshman science core departments, and to faculty and administrative staff who assisted with the development of the survey. The final report will be available in the fall. Based on the interest engendered from the '95 survey of the freshman year, plans are currently underway to send a mini-version of last year's survey to all the sophomores immediately after they begin classes in the fall.

The ad hoc faculty committee on academic dishonesty, after having reviewed the findings of the '93 *Report on Academic Dishonesty*, made a number of recommendations which were brought before the FPC. Under FPC authorization, the recommendation regarding fuller reporting and centralized record-keeping on cases of proven academic dishonesty is now in the process of being implemented by UAA in conjunction with the academic departments and UESA Central. The UAA has also begun to explore with the Committee on Privacy means for publicizing proven cases of academic dishonesty in a way that ensures the anonymity of individuals.

This year the OME decided to conduct, with UAA assistance, a formal student assessment of XL, something that has not been done since 1989. The XL student assessment forms were mailed to students in the spring. Questionnaire analysis is currently being undertaken. The usual yearly survey on the effectiveness of Project Interphase was also carried out.

INDEPENDENT ACTIVITIES PERIOD

Despite a blizzard on the first day which closed the Institute and heavy snowfall throughout the period, IAP still showed an increase in the number of activities for credit and grades awarded. Eighty-one of the nearly 700 activities offered credit. Undergraduate registrations climbed to 1,495 while graduate student registrations dipped by a few to 819. The 1660 student registrations were still the second highest on record, surpassed only by last year's 1709.

For the first time two departments – Mechanical Engineering and Physics – required their majors to complete subjects during IAP. The IAP Policy Committee reiterated its support of the 12-unit credit limit during the period. It also began a discussion of ways in which to combine IAP credit offerings with semester subjects in order to make them more attractive teaching options for faculty.

The IAP Student Board, now one year old, has established itself as a recognized group on campus. It has added to the visibility of IAP by its presence at the Activities Midway and the Academic Expo. The Student Board is busy creating an interactive IAP Homepage as well as streamlining the IAP Guide on the Web.

The fourth annual Charm School was bigger and better than ever, featuring 24 different topics taught by 114 members of the MIT community. Special Charm School events included the Infrared Dating Game (organized by the Center for Advance Educational Services and broadcast on the television monitors in Lobbies 7 and 10), and Commencement, at which journalist and author Dan Zevin gave hilarious yet useful tips on real-life conduct. It is estimated that Charm School '96 was attended by 400-500 students; once again, it proved a media attraction, being featured on CNN, in the *Improper Bostonian*, and in *Boston Magazine*.

RESIDENCE/ORIENTATION

Residence/Orientation (R/O) was successfully implemented under the leadership of three student interns: Sanjay Chugh as Chair, John de Guzman as Personnel/Publicity Manager, and Arlene Frech as Logistics Manager. They were supported by 35 student volunteers who worked on various sub-committees.

The President's Convocation officially kicked-off R/O. President Vest invited biology Professor Eric Lander to address the class and inspire them for the academic challenges the next four years were sure to bring. Killian Kick-Off for the first time featured a student speaker, Catherine Conley, chosen through a competition run by the R/O interns during the spring semester. Academic Orientation was marked by a new event called "Core Blitz," a mandatory one-hour program which featured short presentations by faculty from the freshman core.

Parents Orientation offered parents a greater opportunity to interact with administrators than in years past. The traditional President's Reception was integrated with a continental breakfast at Walker Memorial where parents could visit tables staffed by personnel from Institute departments and offices.

SCHOLARSHIP RESOURCE CENTER

The Scholarship Resource Center (yet to be named formally), founded in February of 1995, enjoyed continued success as a first stop for students seeking information about scholarship, fellowships, grants, travel abroad, and other recognition opportunities. Over 500 students visited this Center, which houses a library of listings and resource books. As always, staff offered support through individual counseling sessions. Demand for information and counseling could not be fully met, as currently only one staff member oversees the Center on a part-time basis.

UNDERGRADUATE RESEARCH OPPORTUNITIES PROGRAM

UROP appears to be recovering from last year's abrupt decline in participation brought about by new federal regulations governing indirect costs published in OMB Circular A.21 in 1994. This year participation was up by 14% in the fall and 16% in the spring; paid UROP was up 15%. Compared with pre-1994 numbers, this year's numbers show a decline of only 7%.

The UROP hourly rate rose from \$6.90 to \$7.00 an hour in September 1995; this is once again below the Institute minimum student wage, which rose in June to \$7.25. A UROP rate increase for the fall semester is under consideration.

Discussions held by the CUP subcommittee headed by Professor John Southard led to general agreement that a fundraising campaign to bring endowment to \$10 million is the best way to ensure UROP's stability over the long term. A resolution to that effect was brought to the CUP and endorsed in the spring.

Data from the 1994 Senior Survey provided evidence of UROP's effect on students' educational experience that up to now had been only anecdotal. The most striking finding was that high UROP participation correlated with reported improvement in writing skills, public speaking, academic self-confidence, and intellectual curiosity.

In the Undergraduate Corporate Research Fellows Program (UCRF), five projects are now underway with six undergraduates, and four more are being negotiated. To date UCRF has contributed just under \$60,000 in corporate payments to MIT, including payment for UROP administrative costs.

The UROP office created an electronic web site which encompasses the entire *UROP Directory*, important deadline information, a project listings bulletin board, and all program handouts. A UCRF program page is also tied in. The annual hard copy of the *Directory* will become a bi-annual publication.

WRITING REQUIREMENT AND COMMUNICATIONS INITIATIVES

The Writing Requirement Office continues to administer and coordinate the two Phases of the current undergraduate Writing Requirement. At the same time, the office provided support for deliberations and subsequent actions by the Committee on the Writing Requirement to replace the current proficiency-based requirement with a more substantial experience-based curriculum.

FRESHMAN ESSAY EVALUATION

The Committee on the Writing Requirement decided to raise the level of proficiency necessary for a student to complete Phase One of the Writing Requirement through the Freshman Essay Evaluation: the Committee tightened its standards to express its conviction that writing skills are essential for success in any profession. As a consequence, only 17% of the Class of 1999 passed the evaluation, compared to 48% in 1994. The Committee's change in policy was reported internationally and elicited almost entirely positive responses from the MIT community, from MIT alumnae, and from other educators.

PHASE ONE

During academic year 1995-96, the Writing Requirement Office evaluated 311 Phase One papers, and 257 students completed Phase One through the paper option. Another 352 students completed Phase One through subjects offered by the Program in Writing and Humanistic Studies and the English as a Second Language Program in Foreign Languages and Literature.

PROGRESS OF THE CLASS OF 1996

Of the students receiving the S. B. Degree during the 1995-96 academic year, 71.6% completed Phase Two through the Undergraduate Technical Writing Cooperative, 7.5% by submitting a paper to their departmental writing coordinator, and 20.9% by receiving a grade of B or better in a Phase Two writing subject. Unfortunately, four seniors failed to graduate solely because they did not complete the Writing Requirement. All of these students are currently working on completing the Requirement for graduation on the September 1996 S.B. Degree list.

WRITING REQUIREMENT

The Writing Requirement Office provided support for the CUP subcommittee on the Writing Requirement and the Committee on the Writing Requirement in developing a proposal for a new undergraduate communications requirement. The subcommittee presented its final report to the CUP in the fall of 1995, recommending that the present proficiency-based Writing Requirement be replaced by an experience-based requirement that will integrate instruction in communication skills into the entire undergraduate program and provide students with a substantial experience each year in writing and speaking. In response to a charge from the CUP, the Committee on the Writing Requirement developed an implementation plan for a new requirement, which was accepted and endorsed by the CUP in May 1996.

REDESIGN OF WRITING REQUIREMENT DATABASES

The Writing Requirement Office collaborated with Information Systems in redesigning the Writing Requirement databases to support both current and long-term business and policy needs of the office. The Discovery Team, sponsored by Dean Leslie Perelman of UAA and Gregory Anderson, Director of Information Technology Discovery, and led by Timothy McGovern, Director of the Information Technology Competency Group, and Andrea Publow, Administrative Assistant of the Writing Requirement, developed the design for a new system that: 1) will reduce paper, manual processing, duplicate data entry; 2) integrate all current applications into one single user-friendly system; 3) make the exchange of data between the Writing Requirement and other offices easy and often automatic; 4) function in current UESA, MITSIS, and Campus Network environments; 5) adapt easily to the new MITSIS; and 6) anticipate major policy changes in the nature of the Writing Requirement.

POLICIES ON HANDLING STUDENT INFORMATION

After a hiatus of several semesters, the Institute's Committee on Privacy was reconstituted this year. At approximately the same time a new committee charged with examining problems raised by the new MIT Card began to meet. Both committees have a UAA member designated as a representative of the Dean for Undergraduate Education.

Policies relating to the handling of student information are central to the work of both of these committees as well as to the operation of many MIT offices, both central and department. Because these policies affect so many groups, members of UAA established a Working Group on Student Information Issues, which will develop overall guidelines regarding the using, sharing, preserving, and protecting of student information.

WELLESLEY/MIT EXCHANGE

UAA continues to provide registration support for Wellesley students taking MIT subjects. In the fall 76 Wellesley students enrolled at MIT; in the spring, 90. In addition the office publicizes the opportunity for MIT students to take subjects at Wellesley and provides information for those who do so. The academic year saw 81 MIT students taking Wellesley subjects. The office also organized an information session on the MIT/Wellesley teacher certification program. Interest was high, with seventy MIT students and seven staff members attending.

STAFF CHANGES

Dr. Lori Breslow, who teaches in the Sloan School, and who has been consulting for UAA on teaching performance, joined the UAA administrative staff part-time as Director of Teaching Initiatives.

Senior Office Assistant Rachel Jacobs moved to another MIT position. Her replacement on the UROP team is Michael Bergren, who has major responsibility for the January Mentor Program and a role in UCRF. Other departures included Toby Elliott, Administrative Assistant for IAP, and Justin Knight, Senior Office Assistant in the Advising Center. Three other Senior Office Assistants were added to the roster during the year: Madeline Brown, currently involved with Curriculum Support activities, including arrangements and notes for CUP; Margaret Ryan, Dean for Undergraduate Education and Student Affairs

working with financial administrative matters and in support of R/O; and Rosanne Swire, part of the team for Educational Studies and Research (and a key player in Charm School).

Travis R. Merritt
Mary Z. Enterline
Lori Breslow
Margaret E. Devine
Margaret S. Enders
Ida Faber
Donna L. Friedman
Marshall D. Hughes

Elizabeth Kowal
Alberta G. Lipson
Norma G. McGavern
Jeffrey A. Meldman
Leslie C. Perelman
Debbie H. Shoap
Bonnie J. Walters

GRADUATE EDUCATION OFFICE

REORGANIZATION OF GRADUATE EDUCATION

The past year witnessed significant change in the structure and operation of the Graduate School. Following twelve years of service as the Dean of the Graduate School, Professor Frank E. Perkins officially retired from the position at the end of August, 1995. His announcement in the prior academic year of his intention to step aside provided the Institute an opportunity to examine the existing administrative structure for undergraduate and graduate services in a coordinated manner. Accordingly, a faculty committee was established to undertake that review as a part of larger consideration of administrative services for all students. Deliberations were completed in May and the committee recommended that the Graduate School Office be retained as a separate operation and strengthened. The objective of this continuation was to establish a coherent structure representing the interests of graduate education at MIT.

During the following months, senior officials considered alternative ways in which to implement the committee's suggestions. In that period, Dr. Isaac M. Colbert was appointed as Acting Dean of the Graduate School and provided ongoing leadership for the work of the office.

As of January 1, 1996 the organization formerly known as "The Office of the Dean of the Graduate School" was renamed the "Graduate Education Office (GEO)." Several major personnel changes were also implemented, and the office was restructured to enhance its graduate mission:

- Prof. J. David Litster, Vice President for Research, was appointed Dean for Graduate Education;
- Acting Dean Dr. Isaac Colbert was named Sr. Associate Dean, with broad responsibilities for ongoing administration of GEO activities and programs;
- Ms. Margaret Daniels Tyler was appointed as Associate Dean for Graduate Education, with responsibility for daily administration of the GEO front-office and oversight of recruitment activities;
- The International Students Office and the Graduate Student Council were moved administratively into the Graduate Education Office, intact with existing staff and programs;
- Activities of the MIT Summer Session were moved into the Center for Advanced Educational Services (CAES);
- The MIT/Woods Hole Joint Program was moved into the Office of the Vice President for Research; and
- The Lowell Institute School was discontinued at MIT and moved to its new home at Northeastern University.

These changes have simplified the structure by administratively moving several organizations that came into the Graduate School Office with Professor Perkins when he was originally appointed as Dean. The new organization has brought greater coherence to the central administrative functions supporting graduate education at MIT.

STAFFING CHANGES

In addition to Professor Perkins' retirement, the office also said farewell to Jacqueline Sciacca, who retired at the end of September from her position as Fellowships Coordinator, and after more than thirty-five years of service. Ms. Sciacca's efforts established firm and trusting relationships between MIT and many Federal, foundation and corporate sources of financial support for graduate students. Mr. Brima Wurie is now serving on a part-time basis as the new Fellowships Coordinator, assisted by Mr. Edward Ballo and Ms. Julia Kent, both also on a part-time basis.

Also new to the office is Mr. George Brennan, who coordinates financial review and maintenance for the four hundred accounts overseen by the Graduate Education Office and its direct reports. Mr. Brennan came to the office with many years of experience in the private sector, as well as with significant experience in mainframe computing.

Finally, Mr. Daniel Langdale, formerly of the Financial Aid Office, was appointed as the new Assistant Dean for Recruitment, a significant staff addition to the human resources committed to the important task of recruiting women students and members of under-represented minority groups.

GRADUATE STUDENT SUPPORT AND ENROLLMENT

Several trends discussed in earlier Reports to the President have taken on added urgency during the past year. High among them is the continuing trend of funding agencies to replace full tuition payments with "cost-of-education allowances" that provide for far less than full tuition. This practice now appears to have become the general rule, placing a significant additional strain on internal financial resources because tuition shortfalls are typically subsidized via partial research assistantships.

Moreover, at least one major program, the AT&T Bell Labs Special Programs, has discontinued its fellowships while the parent company reorganizes into new configurations and then re-examines its corporate philanthropy programs. Additionally, Federal cost containment and deficit reduction concerns continue to place enormous pressure on programs supporting graduate education in non-science areas. A number of smaller programs administered through the Department of Education (i.e., Jacob Javits, Patricia Roberts Harris, and Grants in Areas of National Need), have highly uncertain funding for the coming year and may be eliminated outright in the anticipated budget authorization legislation. At best, we may hope for continuation of students who are currently funded through these programs but no new fellowships for the future. The impact on graduate education in humanities and social science areas at MIT may be devastating, unless new sources of revenue are developed.

While it remains too early to tell, these shortfalls may be offset in the long run by new revenues from a growing number of professional degree programs being designed and implemented throughout the Institute. It is not clear whether any of these developing new resources will be allocated to subsidies for research and teaching appointments, but that remains a possibility.

STUDENT INFORMATION SYSTEM

At the beginning of the past academic year, a reengineering team was established to undertake the training of graduate administrators and others in MITSIS functions. The team established an aggressive schedule, worked cooperatively with departments to implement training and quickly made appropriate program changes to improve MITSIS performance to produce the necessary functionality. By September, the team achieved a long awaited milestone, when each department and degree granting program became fully responsible for entry of graduate research and teaching appointments and of fellowship awards. During the past year of operation in this new mode, we observed the high degree of efficiency and accuracy with which departments have entered these actions. We have also confirmed our long-standing expectation that only a very few actions require intervention by Graduate Education Office staff. We remain delighted at this fundamental improvement in the administration of graduate fellowships and assistantships, and we have every indication that departments are similarly pleased.

COMMITTEE ON GRADUATE SCHOOL POLICY

With the change in leadership of the graduate education function, Dean Colbert chaired the CGSP for the academic year, while Dean Litster sought faculty input about ways to improve the committee's structure and operation. To assist in the operation of the committee, and to improve operations, Dean Colbert appointed an Executive Committee of the CGSP, comprised of three senior members. This group met as needed to discuss potential agenda items and achieve consensus on which items warranted discussion by the full CGSP and which could be acted on with power by the Acting Dean. The Executive Committee remained active throughout the academic year, provided valuable input, and reduced the amount of time that CGSP members needed to spend in meetings.

During the past year, the CGSP reviewed and recommended approval of five new Master's Degree programs. In addition, the School of Management, recognizing important market trends, received CGSP approval for students in its Master's program to opt for receiving the MBA Degree rather than the traditional MS in Management.

Having reviewed and commented during the previous Spring Term on an "informal" proposal from the Schools of Engineering and Management for a joint Master's program in System Design and Management (SDM), the CGSP formally considered and approved the program during the Fall Term. Approval was granted for an initial one-year

experiment, to begin with a pilot group in the Fall Term 1995 and follow with a full student compliment in the Spring Term 1996.

The CGSP also review and approved a proposal for a new Master's of Engineering program in Nuclear Engineering, which was also initially reviewed informally during the previous Spring Term and revised to address several issues and concerns.

The Department of Earth, Atmospheric, and Planetary Sciences proposed a very significant new Master's program, which represented the first professional program of its type offered within the School of Science. The CGSP reviewed and approved the Professional Master's Degree Program in Geosystems.

The CGSP reviewed and approved a Master's program in Medical Informatics within the Division of Health Sciences and Technology.

The CGSP reviewed and approved a Master's of Science program in Media Technology within the Program in Media Arts and Sciences.

As a part of its usual review of degree lists and end-of-term grades, the CGSP authorized a number of Dean's warnings and denials of further registration.

Finally, in an attempt to further adjust its operations in the direction of efficiency and greater effectiveness, members of the CGSP suggested a variety of ways to save time, make meetings more effective and identify key items that would engage the intellectual activity of the entire group. Deans Litster and Colbert hope to implement many of them during the coming academic year.

RECRUITMENT AND OUTREACH

With the addition of Daniel Langdale to the Graduate Education Office, we have been able to expand our outreach efforts and initiate some new activities. The GEO remains committed to developing and implementing strategies to increase the representation of African American, Mexican American, Native American, and Puerto Rican graduate students at MIT. Despite an anticipated leveling or decrease in MIT's graduate population beginning as soon as AY98, we plan to sustain efforts to achieve a full 6% representation of minority students. This goal reflects the recognized national need for universities to develop and demonstrate a capacity to produce scientists, engineers and faculty from under-represented groups. Given recently publicized efforts to dismantle affirmative action outreach and to scale back regional if not national commitments to full inclusion, achieving this goal seems even more imperative.

Information Technology

During the past year our project to develop an interactive, multi-media recruitment tool was completed, and the tool, Graduate World at MIT, underwent its first serious "road test." When used in an appropriate setting, the application has already proven to be effective in garnering attention and in showcasing graduate activities of interest to potential majority and minority graduate students. We are in the process of adding material to the multi-media resource to make it more complete, and expect that it will be used heavily for the AY98 recruitment season.

Also, we have nearly completed a new Graduate Education Office home page on the World Wide Web. The organizational and personell changes that occurred mid-year resulted in a complete re-design and expansion of our home page, to include the International Students Office and the Graduate Student Council.

With the multi-media application and a home page, the GEO now has two important tools with which to expand its electronic outreach. We plan to place electronic versions of the application for the Minority Summer Research Program (MSRP) on the web, are exploring the possibility of putting the Practical Planning Guide in that format, and have already linked our MSRP web page with a national network of similar programs already linked together.

In addition, group distribution lists for national student organizations (National Society of Black Engineers, Society of Hispanic Professional Engineers, American Indian Students in Science and Engineering, etc.) and campus nets (Black Student Unions at MIT, Berkeley, Stanford, Georgia Tech, etc.) are being used to widely disseminate

information. Our 1995 pilot of this approach proved it to be successful enough to use more extensively, if it is followed by an aggressive program of personal calls. It is now a standard part of recruitment outreach, although the lists are obtained at a significant cost to the GEO. These activities will all be coordinated with the GEO Homepage directory that will inform interested students about relevant departments and laboratories, so that they can explore on their own.

MIT Summer Research Program

The MSRP completed its eleventh summer of operation, with a cadre of nineteen interns working in many different laboratories throughout MIT. Using funds from the first year of a three-year grant from the Alfred P. Sloan Foundation, the program was successful in attracting students into a number of science departments. However, much of the funding for MSRP is earmarked for students in the chemical sciences, and more effort will be expended to expand the number of summer interns in those areas.

Student Involvement

Current Students participate in efforts to recruit new students. They are engaged in activities that capitalize on their intimate knowledge of the MIT experience and their ability to relate to and encourage those within their age cohort. Specifically, they are sponsored by the GEO to return to their alma maters for graduate school forums and seminars, attend national conferences as exhibitors or presenters, and participate in campus outreach activities including recruitment and yield telethons, graduate school forums, and undergraduate student mentorship.

We have recently installed additional telephone lines in the GEO main office specifically to support a new, year-long telephone outreach project. Current graduate student volunteers commit one or two hours at specified times in the evenings and on weekends to contact potential applicants and discuss their interest in MIT's graduate programs. Even in its pilot phase, this initiative appears to be highly successful in both reaching students and in motivating them to follow through with completed applications.

INTERNATIONAL STUDENTS OFFICE

The ISO continues to provide an expanding set of services to international students. A significant and growing use of the ISO is for counseling students on a wide range of problems, especially as rumors abound about possible changes to U.S. immigration policy. Maintaining cognizance of potential and emerging issues, and translating appropriate information to international students who are uncertain about their future status, keeps ISO staff occupied.

As in prior years, the ISO provided two tax workshops for students and served as a distribution and information point for relevant IRS forms. While the seasonal impact of this service is significant, students continue to appreciate the assistance they receive in complying with Federal regulations.

The Host to International Students Program, in cooperation with the Alumni Association, supported a number of parties to welcome new international students and to congratulate graduating students.

With the administrative reassignment to the Graduate Education Office, the ISO was able to update its technology base. The addition of new computers and related equipment has improved the efficiency and effectiveness of document production and access to necessary information. It has also increased the morale of staff. We hope to further improve ISO technical capacity with network installations and acquisition of new software to enhance the production of immigration forms.

Isaac M. Colbert

<u>ACADEMIC YEAR</u>	<u>NUMBER OF WOMEN</u>	<u>PERCENT WOMEN</u>	<u>NUMBER OF FOREIGN NAT.</u>	<u>PERCENT FOREIGN NAT.</u>	<u>NUMBER OF MINORITIES</u>	<u>PERCENT MINORITIES</u>	<u>TOTAL ENROLLMENT</u>
1973	304	9.1%	927	27.9%	108	3.2%	3,328
1974	318	9.5%	954	28.4%	121	3.6%	3,358
1975	405	11.7%	970	28.0%	151	4.4%	3,468
1976	487	13.5%	1,037	28.8%	155	4.3%	3,603
1977	546	14.5%	1,059	28.1%	178	4.7%	3,774
1978	559	14.6%	1,151	30.1%	157	4.1%	3,824
1979	606	15.4%	1,145	29.0%	147	3.7%	3,944
1980	684	16.5%	1,219	29.4%	150	3.6%	4,146
1981	779	17.8%	1,283	29.3%	174	4.0%	4,384
1982	828	18.2%	1,347	29.7%	140	3.1%	4,541
1983	856	19.1%	1,418	31.6%	145	3.2%	4,489
1984	914	19.7%	1,439	31.1%	143	3.1%	4,631
1985	981	20.6%	1,449	30.5%	141	3.0%	4,757
1986	981	19.9%	1,658	33.7%	139	2.8%	4,920
1987	987	19.8%	1,497	30.1%	144	2.9%	4,979
1988	929	19.2%	1,441	29.8%	154	3.2%	4,832
1989	963	20.0%	1,498	31.1%	159	3.3%	4,822
1990	1,064	21.7%	1,628	33.2%	168	3.4%	4,909
1991	1,092	22.0%	1,674	33.7%	155	3.1%	4,967
1992	1,155	23.0%	1,711	34.1%	190	3.8%	5,019
1993	1,177	23.4%	1,755	34.9%	215	4.3%	5,024
1994	1,154	22.7%	1,744	34.3%	193	3.8%	5,090
1995	1,308	24.0%	1,798	33.0%	229	4.0%	5,465
1996	1,222	22.1%	1,745	31.6%	743	13.5%	5,518
TOTALS	20,299	18.8%	33,547	31.1%	4,399	4.1%	107,792

TABLE I: WOMEN, FOREIGN NATIONAL AND MINORITY ENROLLMENT, AY1973 TO AY1996

1965-66		1971-72	
Canada	124	Canada	96
India	67	India	86
Taiwan	53	China	75
England	39	France	56
Japan	35	Japan	55
Greece	26	Hong Kong	47
France	22	England	46
Israel	19	Greece	34
Germany	18	Israel	31
Colombia	17	Brazil	28
Venezuela	17		
1991-92		1996-97	
China	203	China	206
Canada	157	Canada	160
India	148	India	97
Japan	136	Japan	115
Korea	89	Korea	93
Taiwan	80	Taiwan	56
France	59	France	49
Germany	56	Germany	51
Greece	52	Greece	43
Italy	42	Italy	48

Note: Data taken from Table VII of the annual Report of the Registrar,
1965-66 through 1996-97

**TABLE II: GEOGRAPHIC DISTRIBUTION OF
INTERNATIONAL GRADUATE STUDENTS**

Table III: Graduate Enrollment Fall 1996

	Internationals	Women	*Minority	**Non-Resident	Total MIT Enrollment
School of Architecture & Planning					
Architecture	166	182	38	28	515
Media Arts & Sciences	74	74	14	10	209
Urban Studies Planning	27	23	3	2	111
	65	85	21	16	195
School of Engineering	746	401	111	15	2337
Aeronautics & Astronautics	75	27	11	1	206
Chemical Engineering	66	57	12	1	227
Civil & Environmental Engineering	136	75	21	5	305
Electrical Engineering & Computer Science	176	128	26	2	792
Materials Science & Engineering	55	36	5	1	171
Mechanical Engineering	148	47	32	4	401
Nuclear Engineering	47	16	3	0	118
Ocean Engineering	43	15	1	1	117
Center for Advanced Educational Services	0	0	0	0	0
School of Humanities and Social Science	127	112	15	50	345
Economics	64	35	3	12	132
Linguistics & Philosophy	34	25	1	8	68
Political Science	25	42	9	26	119
Science, Technology & Society	4	10	2	4	26
School of Management (w/Operations Rsch)	372	234	60	5	895
School of Science	293	293	52	17	993
Applied Biological Sciences	0	0	0	0	1
Biology	18	95	8	6	222
Brain & Cognitive Science	17	21	4	0	50
Chemistry	46	72	16	6	207
Earth, Atmospheric & Planetary Sciences	60	62	7	1	169
Mathematics	53	19	1	2	93
Physics	99	24	16	2	251
Whitaker College	41	91	9	0	293
Toxicology	6	17	6	0	30
Health Sciences & Technology	35	74	3	0	263
Total Graduate Enrollment	1745	1313	285	115	5378
Category as % of Total	32%	24%	5%	2%	

* "Minority" refers to underrepresented groups: African Americans, Mexican Americans, Native Americans and Puerto Ricans.

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

WHITAKER COLLEGE

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 been 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. In the January of 1995, the Center for Biomedical Engineering was established under the direction of Professor Douglas Lauffenburger.

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 various materials both organic and inorganic.

The resources of the laboratory currently include seven SUN Microsystems workstations, two Silicon Graphics workstations, two PCs, and two Macintosh computers. Most 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 radiation therapy and modeling of a miniature X-ray source for use in interstitial radiotherapy of brain tumors.

One of the most exciting new research areas dealing with the design of radiation therapy has been the development of a new method of treating rheumatoid arthritis using neutrons and boron-loaded pharmaceuticals. This new method has been called "Boron Neutron Capture Synovectomy" by Professor Yanch. Her collaborators in this area include Dr. Alan Davison from the Department of Chemistry and researchers at the Harvard Medical School. Appropriate neutron beams, suitable for patient treatment, are currently being designed using the computation resources of WCBICL.

A second research thrust in the WCBICL is in the area of image analysis and image diagnosis. Areas of major interest over the past two years 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 development of a sophisticated simulation program to model the behavior of gamma photons in Nuclear Medicine imaging is able to link the two major research areas (imaging and radiation transport simulation) in the lab. This system is currently being used in the design of Nuclear Medicine imaging protocols which will allow early detection of arteriosclerosis. A parallel effort in this area has culminated in the design of a full, 3D human-like computer phantom which is used in the assessment of patient dose in various imaging modalities.

Current visitors to WCBICL include Dr. Ainat Rogel, from the Hebrew University of Jerusalem, who is working on automated neuroanatomical image acquisition and analysis. Also, Dr. Stefano Cagnoni (University of Florence, Italy), a 1994-1995 visitor to WCBICL, returned for an eight-week collaboration on new methods of contour identification using genetic algorithms. This visit was funded by the Italian government. Dr. Elizabeth Selcow from Brookhaven National Laboratory has joined WCBICL as a visiting scientist for 1996. Dr. Selcow will be involved

with both aspects of WCBICL research (radiation transport and images) and will work on both Nuclear Medicine simulation and radiation dosimetry.

A multi-layer page on the World Wide Web (WWW) in which all the research projects and personnel of the lab are listed has been installed and is currently being modified. 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 increasing important role in education, particularly with respect to the Department of Nuclear Engineering and 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 experiences in processing physiological data with examples from neurophysiology, cardiology, and two-dimensional imaging 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.

WCBICL also supports a number of undergraduates in their thesis or UROP research. A total of four UROP projects were carried out in the lab during the last year, two of which led to undergraduate theses.

Jacquelyn C. Yanch

CENTER FOR BIOMEDICAL ENGINEERING

CBE takes as its mission to coordinate and enhance MIT research and education at the interface of Engineering with Molecular & Cell Biology applied to innovations in health care technology.

HIGHLIGHTS OF THE YEAR

EDUCATION

The Interdepartmental Undergraduate Minor in Bioengineering was instituted, with 18 students enrolled from 6 different Departments (Biology, Chemistry, Chemical Engineering, Electrical Engineering & Computer Science, Mechanical Engineering, Nuclear Engineering). A new undergraduate/graduate course in Tissue Engineering was developed and offered for the first time by Professor Linda Griffith-Cima (Chemical Engineering). A Cell & Tissue Engineering Laboratory Module was developed by Professor Elazer Edelman (Health Sciences & Technology) and included in a sophomore-level core course in Materials Science & Engineering taught by Professor Anne Mayes.

A week-long Short Course in Molecular & Cell Biology for Engineering Faculty was organized, with financial support from the School of Engineering, and taught by Department of Biology Faculty (led by Professors Harvey Lodish and Richard Young) to 26 School of Engineering faculty in June 1996.

RESEARCH

Six Engineering/Biology Catalytic Research Seed Grants are being supported by CBE discretionary funds:

- "Laser Trapping Studies of Regulation of Gene Transcription" - Professor Paul Matsudaira (Biology) and Dr. Dan Ehrlich (Lincoln Laboratory)
- "Mechanical Properties of Self-Assembling Peptide Biomaterials" - Professor Roger Kamm (Mechanical Engineering) and Dr. Shuguang Zhang (Biology)
- "Polymeric Vehicles for Gene Delivery" - Professor Robert Langer (Chemical Engineering) and Professor Richard Mulligan (Biology)
- "Microrobotic Assessment of Growth Factor Therapy for Stroke Patients" - Professor Neville Hogan (Mechanical Engineering) and Dr. Seth Finkelstein (Massachusetts General Hospital)
- "Induced Neovascularization of Encapsulated Cell Implants by Genetically-Engineering Expression of Vascular Endothelial Growth Factor" - Professor Clark Colton (Chemical Engineering) and Dr. Gordon Weir (Joslin Diabetes Center)
- "Tissue-Engineering Liver Organoids for In Vitro Toxicology Studies" - Professor Linda Griffith-Cima (Chemical Engineering), Professor Robert Rubin (Health Sciences & Technology), and Dr. Joseph Vacanti (Children's Hospital)

A CBE/ILP Workshop on MIT/Industry Interactions in Biomedical Engineering was held in May 1996. Thirty-two companies from the health care industry, including biotechnology, pharmaceuticals, and medical devices, attended.

PERSONNEL

Professor Roger Kamm (Mechanical Engineering) is Associate Director for Programs, Professor Alan Grodzinsky (Electrical Engineering & Computer Science) is Associate Director for Facilities, and Professor Douglas Lauffenburger (Chemical Engineering) is Director. Other members of the Steering Committee include Professors Paul Matsudaira (Biology), Robert Langer (Chemical Engineering), Ian Hunter (Mechanical Engineering), Elazer Edelman (Health Sciences & Technology), Martha Gray (Health Sciences & Technology), Linda Griffith-Cima (Chemical Engineering), Robert Rubin (Health Sciences & Technology), and Fred Schoen (Brigham & Women's Hospital).

FUTURE PLANS

In the coming year CBE aims to update and expand the Undergraduate Minor and develop substantial research funding support for multi-disciplinary team projects from health care industry sources.

Douglas Lauffenburger

CENTER FOR ENVIRONMENTAL HEALTH SCIENCES

Faculty, students, and research staff are focused on discovery of the agents in our environment responsible for genetic changes in humans. Genetic disease causing severe physical or mental impairment of our newborns approaches 2%, and fills nearly half of the beds in our pediatric hospitals. Human cancers require several genetic changes (mutations) inherited or occurring within the organ from which the tumor arises. We hope to make substantial contributions to understanding basic mutational mechanisms, finding the causes of human mutations and defining the quantitative relationships that govern the lifetime occurrence of diseases which require multiple mutations in humans.

Among the efforts of the past year one in particular stands out that will affect research planning for years to come. Strangely enough, we discovered that biostatisticians in cancer and other disease areas had truncated their data sets for age-specific disease rates at 80 years of age. The National Cancer Institute had no data above this age level. We reasoned that the data from the extremely aged would allow testing of hypotheses about the fraction of a population really at lifetime risk of cancer, and perhaps other diseases of significant effect on human mortality such as atherosclerosis.

Despite distinct difficulty getting data from scientific bureaucrats, we now have the data giving the number of deaths for each kind of cancer per living individual in age-groups from 0-4 to 100-104 years in the United States, including males and females, majority and minority populations. The data reveal that the *rate* of death reaches a maximum at an age specific for each cancer type and subsequently declines toward zero. This maximum has been shifting as we compare populations born in 1860, 1870, etc., suggesting that subpopulations at risk of cancer death become extinct before subpopulations at lower or zero risk. The data point toward the value of studying the genotypes of the extremely aged, specifically with reference to their lifetime mutation rates.

To exploit this data and use it to guide direct studies of cell kinetics and mutation rates in humans, we have undertaken the development of a unified field hypothesis. This effort is in collaboration with the mathematician Professor Stephan Morgenthaler ETH (Lausanne) in Switzerland.

The development of technology to directly measure environmental chemicals and genetic change in humans continues to be our strongest area of contribution. We now need to invest in studies of cell turnover (the process of cellular renewal in all tissues), errors in the programming of which we believe are important in carcinogenesis.

We have developed technology which allows us to measure chemical reaction products with proteins and DNA in human tissue (NIEHS Biomarkers Program). We have developed means to measure the point mutational spectra arising in the human mitochondrial genome (NIEHS Superfund Program, DOE Human Cell Mutagenesis Grant). We have studied chemicals entering humans from the environment: food in the Biomarkers Program, air in the Mutagenic Effects of Air-borne Toxicants Program, and water in the Superfund Program.

Yet we have never assumed that environmental chemicals constitute the primary causes of human genetic change. Two major programs, Endogenous Nitrite Carcinogens in Man (NCI) and Genetics and Toxicology (NIEHS), have focused specifically on either one powerful endogenous mutagen, NO, or the endogenous process of DNA replication to determine responsibility for our genetic change rate. We have cast a net to discover if the patterns of spontaneous mutations in bacterial or human cell studies are recapitulated in human tissues. Recent data suggests that for human mitochondrial DNA, errors in DNA replication, not exogenous chemicals, are the primary causes of point mutation.

RESEARCH

The Air Quality Program has two components. The first is directed at identifying airborne chemicals which are mutagens for human lung cells, and relating these to their sources and atmospheric transformation processes. The second is to assess the potential human damage associated with the emissions from a variety of thermal processes proposed for remediation of Superfund sites.

The Water Quality Program focuses on the behavior of toxic chemicals in the natural environment with particular emphasis on processes that lead to human exposure. The studies also work to determine the effectiveness of

remediation technologies to attain high waste destruction efficiencies without the formation of mutagenic by-products.

Our Toxicology and Epidemiology Program focuses on discovering the causes of genetic change leading to human disease. We have developed technology which allows us to measure chemical reaction products with proteins and DNA in human tissue, and have also developed means to measure the point mutational spectra arising in the human mitochondrial genome. These twin technologies are now being used in parallel to try to discover the causes of mutations in people.

CORE LABORATORIES

ANALYTICAL CHEMISTRY

The Core Laboratory is a central resource in analytical chemistry for CEHS project participants, providing them with analytical expertise, training, and access to analytical instrumentation. A major goal of the CEHS is to foster collaborative research among combustion engineers, genetic toxicologists, analytical chemists, civil engineers and other investigators in order to solve important problems in human health effects research. The Core Lab is a centrally important resource in making this research collaboration come to fruition.

The chemical analysis protocol most important to our work is called bioassay-directed chemical analysis in which the analytical chemistry work is guided by feedback from human cell mutagenicity results. The bioassay work utilizes quantitative forward mutation assays based on a battery of metabolically-competent cell lines derived from diploid human B-lymphoblastoid cells.

GENETICS AND TOXICOLOGY: HUMAN CELLS AND TISSUES

Human tissues are being obtained and analyzed for mutational spectra in mitochondrial and nuclear genes. Tissues from specific organs are being analyzed for similarities and differences regarding mutations in order to determine a mechanism for mutation and disease on an organ by organ basis.

Human cell lines are being used to assess the mutagenicity of extracts and fractions of environmental samples provided by the Center investigators, as well as relevant pure compounds. A primary goal is a bioassay directed identification of the principal mutagens in environmental samples. Achieving this goal requires coordination with the individual investigator and the Core Laboratory in Analytical Chemistry.

The data obtained from the analysis of human tissues and compared to the principal mutagens found in environmental samples from human cell assays will be used to determine the significance of environmental mutagens in human disease.

MOST IMPORTANT PROGRESS IN 1996

AIR QUALITY PROGRAM

Our study of air samples from major US cities has confirmed that they contain chemicals which are potent mutagens in human cell assays. We have identified the specific chemicals accounting for one third of this activity in the form of four polycyclic aromatic hydrocarbons. We should soon know the identities of most of the remaining mutagenic compounds which appear to be semipolar derivatives of the polycyclic aromatic hydrocarbons.

These mutagenic air pollutants are among the higher molecular weight, less volatile air pollutants. We find that these are disproportionately represented on the smallest air-borne particles which are most likely to reach and reside in the human lung.

Our effort to use electron microscopy to characterize particles from various sources has brought gratifying results. It appears that the approach should allow accurate identification of environmental sources of the particles found in human lungs.

WATER QUALITY PROGRAM

In attempting to find a cause for the 1970-1986 Woburn, Massachusetts childhood leukemia cluster, we have used hydrogeologic methods to show that municipal wells would have drawn some 60% of their volume from the nearby

Aberjona River. Sediment core analysis showed that at or about the time of the wells' use, substantial quantities of arsenic and chromium were suspended or dissolved in the river. To discover if these or other metals reached the users of the municipal water supply, we have collected 109 hair samples cut from children from 1938 to 1994. Analysis by neutron activation of unwashed samples has shown marked elevation of a wide variety of toxic metals for the community relative to other US studies. Testing metals in washed hair should now allow us to discern any relationship to the use of municipal water from contaminated wells.

One key observation arising from the use of neutron activation analysis was the discovery of a recent sharp increase in the lanthanide elements in sediments. These highly reactive elements are being used in a wide and growing number of manufacturing processes and automobile catalytic converters. Their properties as strong redox catalysts would seem to make them strong persistent irritants. We will continue to follow this lead in both the Air and Water Quality Programs.

TOXICOLOGY AND EPIDEMIOLOGY PROGRAM

We have at long last observed point mutations as they occur in human tissues and compared them to those arising in human cells in culture. Curiously, the mutations observed (two hotspots in a 100bp mitochondrial sequence) appear to be the same in human cell cultures, human colon and human muscle samples. This may mean that such mutations in humans arise from endogenous chemical reactions or DNA replication error. It may also be that the first sequence studied is not representative of other mitochondrial or nuclear sequences. Reconstruction experiments seem to exclude the possibility of analytical artifact, but at the mutation fractions of about 2×10^{-5} and 2×10^{-6} , respectively, interpretive caution of these observations is justified.

Our ability to measure DNA adducts with the methionine ^{35}S post labeling approach, coupled to HPLC, has increased measurement sensitivity as well as allowed for a separation and isolation procedure which integrates with mass spectrometry. This, with continuing advances in the technology to measure certain polycyclic aromatic hydrocarbons adducted to proteins, has greatly advanced our ability to measure the actual amounts of many environmental chemicals which react with the chromatin (DNA and histones) of all human organs. The combination of analytical chemistry and analytical genetics in studying human populations opens new vistas for students and faculty alike.

We may now imagine studies of humans in which both exogenous and endogenous causes of genetic change are considered and analyzed. For instance, the finding that mismatched DNA repair defects were important in the early appearance of colon cancer in certain families followed our earlier discovery that human cell mutants existed with high spontaneous mutation rates which were deficient in this repair pathway. These "mutator" human cells mutate on their own so fast that the low levels of environmental chemicals in the human body are unlikely to contribute to mutations arising in such individuals.

EDUCATION AND OUTREACH

MIT EDUCATION

To give students a working understanding of environmental chemical problems, CEHS faculty several years ago created a series of four courses collectively called Chemicals in the Environment, CEHS faculty teach the first three: Sources and Controls (Sarofim), Fate and Transport (Hemond), and Toxicology (Thilly). Professor L. Susskind in the Department of Urban Planning teaches the fourth: Policy and Regulation. These courses continue to be a hit with students and we find both undergraduates and graduates enrolled. In 1991 we received the Sizer Award for Outstanding Contribution to Graduate Teaching at MIT for the series.

TOX 104J required of Civil Engineering IE students is now being revised to take advantage of the undergraduates' greater understanding of molecular biology resulting from the Institute biology requirement.

COMMUNITY OUTREACH

DISTANCE LEARNING FOR K-12 COMMUNITY

To promote broader public understanding of our methods and goals, CEHS has teamed up with the Massachusetts Corporation for Educational Telecommunications (MCET). MCET is a not-for-profit, distance-learning organization serving the needs of the K-12 community. It reaches an audience located in 47 states or approximately

1.3 million participants and every school district in Massachusetts. MCET has an annual budget of approximately \$9 million funded from various U.S. federal agencies, state agencies and corporations.

On May 3rd we aired a highly successful pilot program, for a five part program series for middle school teachers and students that will increase understanding of how hypothesized connections between the environment and health are explored. The series will highlight the scientific processes used by researchers to prove or disprove hypothetical connections between the environment and disease. We are preparing a proposal to be submitted (along with the pilot video) to the National Institute of Environmental Health Sciences for full funding of the five-part series.

PUBLIC MEETINGS ON LOCAL SUPERFUND SITE

We have been studying the chemical sources, fate and transport, and human exposure in the Aberjona River Watershed here in Massachusetts for eight years. When we began this work we knew we had a special obligation to the people in the several towns included in our work to communicate our aims, our findings and our limitations in interpreting these findings in terms of public health. To do this we regularly hold public meetings to discuss our progress and try to answer questions. Faculty and students present their work and hear what the public thinks soon thereafter.

Of course, since we have found that a local Superfund Site is "leaking" fair quantities of chemicals like arsenic into the Aberjona, our presence is regarded as a problem to those who wish to inexpensively develop the site for municipal and commercial use. In order that our observations are available to all in a timely manner, we have agreed with Congressman Edward Markey's staff to meet some weeks before our public presentations to discuss technical progress with representations of the federal EPA, Massachusetts Department of Public Health, Massachusetts Department of Environmental Protection, the custodial and remedial trusts responsible for the particular Superfund Site, as well as elected public officials or their representatives. In our first meeting of this group an assertion was made that the public could not understand our work as we present it and that it was causing undue distress when reported in newspaper articles. My answer was, and is, that our interactions with the public have impressed all of us with their basic understanding, interest, and support for a policy of openness as expressed through our public meetings. Let any one attend one of these open forums and hear the intelligent and informed questions from the audience before positing that the public cannot comprehend the essential elements of our research tasks or fails to differentiate between the testing of hypotheses and findings of fact.

Tangible assistance from the community has taken many forms, including site access, contribution of sample material (including human hair), recollections of historical events not otherwise recorded in the literature, and the identification of potential sources of contamination (repositories of tannery waste, etc.). We believe such outreach is both a responsibility of scientists who work in a community, and a policy that is in the long-term best interests of the research itself.

LEGISLATIVE EDUCATIONAL EFFORT

As we look into the future we see a real need to provide our elected representatives with knowledge about public health and hazardous waste issues as well as our need for basic research support. We know that in a real sense "all pollution is local," but who among us has the means to go into a community and discover the primary causes of mutations leading to cancer, birth defects, or other diseases requiring genetic change? To this end, we have coordinated an endeavor involving 23 Superfund Research Centers and 24 NIEHS centers nationwide. Faculty from these research centers have made presentations to members of Congress or their appropriate aides both in their home districts and in Washington, D.C.

OUTSIDE RESEARCH COLLABORATIONS

CEHS maintains a broad base of collaborations with researchers from other institutions including: Boston University, California Institute of Technology, Fred Hutchinson Cancer Research Center, Gentest Corp., Harvard School of Public Health, Ohio School of Medicine at Toledo, Tufts University, University of Rochester, University of Michigan. These researchers are directly involved with CEHS research projects and communicate with and share data on a frequent basis. In order to assist these collaborations the Center has actively promoted the use of information technology, including the following projects on the Web:

Dr. John S. Wisknok in collaboration with Hewlett Packard scientists adapted the operating system on the HP 5989B electrospray mass spectrometer to allow open-access operation. In this mode, the instrument can run continually and samples can be introduced and spectra obtained in less than five minutes by users with minimal training. They also have written custom software for: automatic calculation of molecular weights from oligonucleotide sequences and for calculating m/z values for multiple charge states; for controlling Harvard syringe pumps from the HP data system; and for data-dependent automated mode-switching on the TSQ 7000. These programs are available as freeware on the World Wide Web site (<http://web.mit.edu/toxms/www/index.htm>) that we recently constructed for the mass spectrometry laboratory.

A database has been established to catalogue tissues which have been collected for studies in the Center for Environmental Health Sciences. The database contains information such as: type of tissue, sex, ethnicity, age, pathology, distribution of tissues among CEHS researchers, experimental protocols, and results of experiments. The database has been placed on the World Wide Web for easy access at <http://web.mit.edu/cehs/ftp/>. The database downloads as a binhex Filemaker Pro file. This file, which is updated on a regular basis, requires a password to open which is available from Dr. John Hanekamp at (617) 253-8096 or hanekamp@mit.edu.

Plans are underway for a web site for all the labs worldwide working on problems involving mutational spectra and related technology. This includes point spectra such as we study and spectra of higher level events in the chromosomal hierarchy. It includes those who would attempt to see the set of human genetic polymorphisms by combining many separate human blood samples. This site would include a chat area to allow questions to be asked and answered interactively.

HIRING AND RECRUITMENT PRACTICES

The CEHS supports the affirmative action goals of the Massachusetts Institute of Technology while maintaining our commitment to hiring solely on qualification of the candidate for the position. This year two of our feasibility studies by female junior faculty members went on to receive direct support as projects in our grants. The majority of our staff, including research specialists, students, and support staff, are women.

The Center has continued to actively recruit graduate students from minority institutions. We, with NIEHS, support undergraduates in summer research internships which have yielded multiple top-notch recruits. In past years we hosted more than a dozen potential applicants from Cheyney College near Philadelphia; one of their number then served a summer internship and has entered our graduate program in toxicology. Our Director, Bill Thilly, along with Dean Ike Colbert, co-authored a grant request to the Sloan Foundation which now provides funds for entering minority graduate students to take the time to fill in their academic backgrounds if necessary before beginning the graduate curriculum.

William G. Thilly

DIVISION OF COMPARATIVE MEDICINE

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 comparative medicine. Total personnel in the Division now comprises 85 individuals.

FACILITY MANAGEMENT AND ANIMAL CARE

Major renovations and improvements in the animal facilities continued during FY96. The new, state-of-the-art 30,000 GSF animal resource in Building 68 has been occupied since November, 1994. Animals were moved back into the renovated E17/E18 facilities in March. Both 68 and E17/18 support transgenic and gene "knockout" *in vivo* experiments. Renovations are currently underway in Buildings 56 and 16. A new addition on the Whitehead facility has been completed and animals were moved there in February. The average daily census of laboratory animals increased approximately 5 percent during FY96. Mice remain the primary species used by MIT investigators and represent more than 98 percent of the animal population. The Division recently distributed to investigators the third edition of its comprehensive Laboratory Animal Users' Handbook.

RESEARCH ACTIVITIES

Current NIH-funded grants support *in vivo* study of nitrite carcinogenesis, *in vivo* study of *Helicobacter hepaticus* carcinogenesis, *in vivo* study of the etiology of lymphoma in ferrets and the effects of *Helicobacter felis* on gastric cancer. Recently NIH funded another RO1 grant to study *H. pylori* pathogenesis. Additionally, NCI funded for a third year a study of *Helicobacter hepaticus* which has been linked to liver cancer in mice. Private pharmaceutical firms have provided funding for research on the pathogenesis of *Helicobacter pylori* and vaccine development. FY96 was the eighth year of the Division's NIH postdoctoral training grant. There are currently six postdoctoral trainees, two of whom are enrolled in graduate programs in the Division of Toxicology. Two former postdoctoral trainees passed the board examinations of the American College of Laboratory Animal Medicine.

DCM faculty and staff published three chapters, 23 papers and 18 abstracts in FY96 and presented numerous research papers at national and international meetings.

ACADEMIC ACTIVITIES

The Division has recruited a number of new staff members. Charles Dangler, DVM, Ph.D and an ACVP boarded pathologist joined the Division as the Chief of the Comparative Pathology Laboratory to replace Dr. James Murphy who retired. Mark Whary, DVM, PhD and an ACLAM boarded diplomate joined the Division as the Associate Director. Dr. Karen McGovern has a PhD in molecular biology and was recruited from Harvard to be primarily involved in research. She has been appointed Assistant Director for Research. Dr. Robert Marini, Chief of Surgical Resources, was promoted to Assistant Director of DCM. DCM faculty and staff taught the graduate course Toxicology 201 and also sponsored UROP students.

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 continued to distribute to other institutions in the United States and abroad two instructional videos, one focusing on the role and responsibilities of Institutional Committees for the Care and Use of Animals and the other focusing on the use of anesthesia in laboratory animals. The Committee received external funding to make the videos. Both are available to MIT researchers at the Division or in the Schering-Plough Library.

James G. Fox, DVM

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, Ram Sasisekharan, David B. Schauer, William G. Thilly, and Gerald N. Wogan. 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. Professor Thilly also serves as Director, and other Toxicology faculty form the nucleus of the Center for Environmental Health Sciences in Whitaker College of Health Sciences and Technology.

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 and 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 pertinent to activities of 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 comprehensive written and oral examinations, usually administered in the fourth term of study, students must submit and defend a thesis proposal not later than three semesters later. 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 (MITSSRP). 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 MITSSRP since its inception; during the summer of 1995, four Toxicology faculty sponsored interns. 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. Three of seven students admitted for the 1995-96 academic year were members of under-represented minority groups, and two of the three were MITSSRP interns in the summer of 1994. The Summer Science Program interns receive advice and information about graduate study directly from their Faculty Sponsors, laboratory supervisors and the Division Academic Administrator.

Toxicology faculty are also involved in minority recruitment activities outside of MIT. 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. 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.

The following 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. Curtis Glover received his BS degree in chemistry and biology at Cheney University. J. Christopher Goodwin received his BS degree in biology at the University of Maryland Baltimore Campus. Ms. Kidd and Ms. Lawrence have passed the doctoral examinations and are nearing completion of their thesis research projects.

Several minority students received degrees in June, 1996. Donald Brunson was awarded the PhD degree, and has entered a postdoctoral fellowship at the Johns Hopkins University School of Public Health. Paula Lee was awarded the SM degree in Toxicology, and will enter the MD program at Baylor University. Esequiel Barrera received the SM degree and is employed as Assistant Biosafety Officer at MIT.

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, Senior Associate Dean and Margaret D. Tyler, Associate Dean of the Graduate School of MIT for minority student affairs.

FACULTY RECRUITMENT

Two new faculty members were identified through a national search as candidates for appointment as faculty members in the Division during the past year. Dr. Ram Sasisekharan was appointed Assistant Professor effective July 1, 1996, and Dr. Bevin Engelward was appointed Assistant Professor, to become effective September 1, 1997.

Dr. Ram Sasisekharan received his BS degree in physical sciences from Bangalore University, his MS degree in biophysics from Harvard University and his PhD in medical sciences from Harvard Medical School. After completion of his doctorate, he was Instructor in Biology at MIT, and Research Associate in the Division of Health Sciences and Technology. He is a well-rounded scientist with an excellent background in molecular pharmacology, cell biology, protein biochemistry, sustained release delivery together with a high level of sophistication in molecular modeling.

Dr. Sasisekharan's research accomplishments to date are outstanding. The objective of his doctoral thesis was the cloning, expression and regulation of the gene for heparinase, the enzyme that degrades heparin and inactivates its anticoagulant activity. He was the first to clone and expressing the gene in several systems, succeeding where many previous investigators failed to do so in other laboratories. More recently, he has shown that heparinase can be used to prevent neovascularization, leading to studies on its ability to release cytokines from the intercellular matrix. An outcome of this work was the elucidation of the molecular mechanism by which heparin and fibroblast growth factor interact to cause receptor binding and cell signaling. These are highly significant accomplishments, given the growing realization of the importance of heparin and heparin sulfate proteoglycan in biological processes, for example in growth factor action, matrix biology and smooth muscle proliferation. Sasisekharan's work makes

possible analysis of structural interactions of carbohydrates and proteins, as well as characterization of heparin-binding proteins, and thus has the potential to make major contributions to both basic and clinical research. Importantly, his program will provide a substantive and dynamic link with other programs in Whitaker College including HST, the Center for Biomedical Engineering and the Center for Experimental Therapeutics.

Dr. Bevin Engelward received her BA degree from Yale University. She conducted her doctoral thesis research in the laboratory of Prof. Leona D. Samson in the Department of Molecular and Cellular Toxicology at the Harvard School of Public Health, where she was awarded her PhD degree in June, 1996. As a graduate student, she received predoctoral fellowships from the Society of Toxicology and the Pharmaceutical Manufacturer's Association, both highly competitive, peer-reviewed awards. Her educational background has provided her with excellent backgrounds in biochemistry as well as molecular and cellular toxicology, and her area of research is of particular relevance to continued development of the programs of the Division of Toxicology.

Her research interests focus on responses of mammalian cells to the DNA damage induced by alkylating agents, many of which are mutagens, carcinogens and anticancer agents. Most of the compounds she studies are widely distributed in the environment and are also produced endogenously. Others are frequently used in patients being treated for cancers. The biological consequences of different types of alkylation lesions in DNA vary dependent on their specific structure. Some are innocuous, while others are potent mutagens or are lethal to cells if they are not repaired. Engelward's research concerns elucidation of DNA repair processes and their role in mutagenesis and lethality of alkylating agents. She identified a thesis topic that was both demanding and of great potential impact on the DNA repair field. The initial objective was to clone and characterize a mammalian 3-methyladenine DNA glycosylase cDNA (*Aag*), then to use the cloned gene for targeted homologous recombination in order to develop mutant mammalian cells deficient in DNA repair activity. No such cells had previously been developed, and their availability would provide powerful tools with which to characterize this aspect of DNA repair under *in vivo* conditions. She was spectacularly successful in accomplishing both objectives, the cloning being achieved using established methodology, and the targeted recombination using mouse embryonic stem cells and novel procedures that she developed independently. The mutant cells produced are currently being used to develop transgenic mice that will bear a homozygous null mutation in the *Aag* gene. If they are viable, they will provide a unique tool for exploring this repair activity in intact animals. The multidisciplinary strategy she employed in developing this project brings great strength to a field that has tended to be overcompartmentalized and represents a useful model for future work.

HONORS AND AWARDS

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

Prof. John M. Essigmann was the recipient of the 1996 School of Science Teaching Prize for Excellence in Undergraduate Teaching. Prof. Essigmann received this accolade on the basis of his outstanding teaching in 5.07, which he also developed as a new course offering in 1992.

Mr. William Kobertz, a doctoral candidate in Organic Chemistry conducting his thesis research in the laboratories of Prof. John Essigmann and Prof. Gerald Wogan received the American Chemical Society Division of Medicinal Chemistry Fellowship supported by the Abbott Corporation.

Mr. Jinghai Xu, a doctoral candidate in Toxicology working with Prof. Peter C. Dedon was awarded the *Whitaker Health Sciences Fellowship*, which is awarded to one doctoral student in Life Sciences or Bioengineering annually.

Mr. Curtis Glover, a doctoral candidate in Toxicology who is conducting his thesis research with Prof. William G. Thilly, was awarded a Sloan Fellowship for the 1995-1996 academic year. These fellowships are intended to provide support for minority students, and are competitively awarded by Dean Isaac Colbert, of the Graduate Education Office.

Ms. Laura Kennedy, a candidate for the SM degree in Toxicology working with Prof. Steven R. Tannenbaum, was the recipient of a PEEER Martin Fellowship from the *Programs for Environmental Engineering Education and Research*, awarded by the PEEER Steering Committee.

PERSONNEL

Prof. Steven R. Tannenbaum has been appointed Director of the Division of Toxicology, effective September 1, 1996. He will replace Prof. Gerald N. Wogan, who will return to research.

Gerald N. Wogan

HARVARD-MIT DIVISION OF HEALTH SCIENCES AND TECHNOLOGY

The Harvard-MIT Division of Health Sciences and Technology (HST), established in 1970, is a collaborative program that facilitates and initiates educational and research opportunities that could not be exploited as effectively by either MIT or Harvard through independent efforts. The HST MD curriculum trains 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. In addition to administering faculty research, the HST Division facilitates and administers multidisciplinary research at the interface of technology and medicine.

Because of its interdisciplinary and inter-institutional nature, HST's administrative home at MIT is the Whitaker College of Health Sciences and Technology. The Division is headed by two Co-directors who report to J. David Litster, Professor of Physics, Vice President for Research, and Dean For Graduate Education, along with and S. James Adelstein, Professor of Medical Biophysics and Executive Dean for Academic Programs at Harvard Medical School (HMS). On 1 February 1996, Professor Martha Gray, Kieckhefer Associate Professor of Electrical Engineering and Computer Science, was appointed interim Co-Director to succeed Dr. Roger Mark, Grover Hermann Professor of Health Sciences and Technology, who stepped down as Co-Director after ten years of service. Dr. Michael Rosenblatt, Robert Ebert Professor of Molecular Medicine, is the Harvard Co-director, and Dr. Joseph Bonventre, Associate Professor of Medicine at HMS, serves as Associate Director of HST and Director of Student Affairs for HST-MD students.

HIGHLIGHTS OF THE YEAR

- The HST Division proudly celebrated its Silver Jubilee in December, 1995. Faculty, students, alumni/ae, sponsors, and friends gathered at the Museum of Science to hear remarks from Dr. Irving M. London, HST's architect and first Director. Other distinguished speakers on the two-day program were Paul Gray (Chairman of the Corporation), Joel Moses (Provost, MIT), S. James Adelstein (Executive Dean for Academic Programs, HMS), J. David Litster (Vice President for Research and Dean of the Graduate School), and Albert Carnesale (Provost, Harvard). A scientific session and poster session presented by HST alumni/ae and faculty was held at Harvard Medical School.
- The graduate program in Speech and Hearing Sciences, directed by Professor Nelson Y.S. Kiang, was reviewed by an external advisory committee and received high praise. The committee report described the program as "unique" and "innovative and without compare." The committee report went on to say that, "The combination of Harvard and MIT faculty, and the truly unique students that the program has already attracted, is unprecedented."
- The Clinical Investigator Training Program, headed by Drs. Robert Rubin and Alan Moses and sponsored by Pfizer Corporation was also reviewed and received similarly high praise. The Advisory Committee report stated that the program "is visionary in its approach to training clinical investigators" and "includes the highest quality physicians pursuing the discipline of clinical investigation in the United States."
- Pfizer Corporation announced that funding for the Clinical Investigator Training Program has been extended until the year 2005.
- The Center for Engineering in Medicine (CEM) at the Massachusetts General Hospital received a Whitaker Foundation Development Award. In partnership with HST and Harvard teaching hospitals, the CEM will provide a coherent structure to integrate engineering with life science and clinical activity. Martin L. Yarmush, the Helen Andrus Benedict Professor of HST and Surgery, is the Director of the Center.
- The Thomas D. Cabot Fund to train Cabot Research Scholars in the HST Division was established through the generosity of Thomas Cabot, a benefactor and advisor for HST.

HONORS AND AWARDS

David E. Housman, Ph.D., co-director of Molecular Biology and Genetics in Modern Medicine, has been appointed the Ciba-Geigy Professor of Biology and MIT. An enthusiastic and highly esteemed teacher, Professor Housman is credited with the discovery of the genes responsible for Huntington's disease and myotonic dystrophy as well as for the isolation of the Wilm's tumor gene. Carl Rosow, M.D., Ph.D., Associate Professor of Anesthesia at Harvard

Medical School, was chosen to receive the 1996 Irving M. London Teaching Award, recognizing the excellence of his teaching in Pharmacology. Laurence R. Young, Sc.D., Professor of Aeronautics and Astronautics at MIT and a member of the HST affiliated faculty, has been appointed the first Apollo Program Professor of Astronautics.

PROGRAM HIGHLIGHTS

- 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 ten individuals (including the directors).
- A total of 286 graduate students were registered in HST degree programs during the academic year. There were 186 MD candidates of whom 95 were simultaneously pursuing PhD degrees. HST doctoral programs registered 101 students: 72 in the Medical Engineering and Medical Physics (MEMP) track, 22 in the Speech and Hearing Sciences (SHS) track, and 7 in the Radiological Sciences Joint Program which is sponsored jointly by HST and the Nuclear Engineering Department.
- Admission to programs continues to be extremely competitive, with about 400 applicants for 40 MD slots, 175 applicants for 10 MEMP slots, and 30 applicants for 7 SHS slots.
- The MD degree was awarded by Harvard Medical School to 28 HST students this year, of whom nine received honors in a special field.
- Thirteen students received MEMP doctoral degrees from MIT.
- Two students received doctoral degrees from the Radiological Sciences Joint Program.
- Two students received a Master of Science degree in Health Sciences and Technology.

RESEARCH ACHIEVEMENTS

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; regulation of gene expression; gene therapy; virus replication and assembly; 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 '96 research volume is \$4.9M (including subcontracts). The research activities of the Clinical Research Center, organizationally part of HST, are reported separately.

BIOMEDICAL ENGINEERING

H. Frederick Bowman, Senior Academic Administrator in HST and Director of the MIT Hyperthermia Program, reported the development of a needle embedded with microchips that can measure a variety of parameters, including temperature and oxygen levels, using a single device. The needle is 30% smaller in diameter than current probes and can be used for characterizing both normal and tumor tissues.

BIOMEDICAL PHYSICS

Richard J. Cohen, Professor of Health Sciences and Technology, is studying the electrical and mechanical regulation and stability of the cardiovascular system. Dr. Cohen's laboratory has developed a noninvasive means of identifying individuals at risk for dying of sudden cardiac death. Sudden cardiac death in adults results from disturbances of electrical conduction processes in the heart and is the cause of 300,000 deaths per year in the United States alone. The technology developed in Dr. Cohen's laboratory has now been successfully commercialized for clinical use.

BIOMEDICAL PHYSICS

James Weaver, Senior Research Scientist, has discovered that “high voltage” (about 100 volt) pulses to human skin create new aqueous pathways that lead to large increases in molecular transport across the skin. This is interpreted

as “skin electroporation”, which is being investigated as a new approach to transdermal drug delivery and non-invasive sensing.

BIOTECHNOLOGY AND TISSUE ENGINEERING.

Lisa Freed, Research Scientist in HST, and Gordana Vunjak, Research Scientist at Whitaker College are studying in vitro tissue morphogenesis using isolated cells, three-dimensional polymer scaffolds and tissue culture bioreactors. Ongoing research involves cartilage and bone tissue engineering, physiological and pharmacological studies of contractile cardiac tissue constructs, and a long term microgravity bioreactor cultivation of cartilage constructs aboard the space station Mir. These studies have significance for designing tissue engineering bioreactors and the in vitro cultivation of functional tissue substitutes for clinical use.

CARDIOVASCULAR BIOLOGY AND PATHOPHYSIOLOGY

Accomplishments in the laboratory of Robert S. Lees, Professor of Health Sciences and Technology, included advances in both basic science and clinical research. A new, more powerful and accurate method was developed for non-invasive assessment of human arterial vasoreactivity in normal and diseased tissue. The work was part of the Ph.D. thesis research of a Medical Engineering-Medical Physics (MEMP) graduate student. In addition, a large angiographic arteriosclerosis regression trial was completed, part of which was the M.S. thesis of a MEMP student. An innovative device for treatment of refractory hypercholesterolemia, based on selective removal of low density lipoprotein, was undertaken in the laboratory and the data were critical in achieving FDA approval.

CYBERNETICS

Dr. Chi-Sang Poon, Principal Research Scientist, investigates cybernetics, which, according to the definition of Norbert Wiener, is the study of communication and control in both living and man-made systems using principles and techniques drawn from the mathematical, physical, and engineering sciences as well as molecular, cellular and systems biology in physiology and medicine. One of the major contributions in the last year has been the development of a highly efficient and sensitive computational technique for the detection of chaotic dynamics in experimental time series (Nature 381:215-217, 1996; patent pending). Based upon a mathematical theory originally formulated by Wiener, this technique is now being used as a data analysis tool by investigators in various areas of biomedicine as well as other research fields such as earth sciences and economics. In our lab, we have successfully applied this technique to the diagnosis of patients with congestive heart failure based upon heart rate time series derived from their electrocardiograms.

EXPERIMENTAL PHARMACOLOGY & THERAPEUTICS

Robert H. Rubin, M.D., Gordon & Marjorie Osborne Associate Professor, is involved with research primarily concerned with the development and application of quantitative imaging techniques to assess a patients physiology with the pharmacology of new drugs. In particular, his center has developed a technique for defining the distribution of CD4 lymphocytes noninvasively in individuals. The potential for this test is very great in defining therapy in AIDS patients and patients with immunologic disorders.

MEDICAL INSTRUMENTATION IN THE DEVELOPING WORLD

Dr. Stephen Burns has a long-term interest in the fate of medical instruments in the developing world. Specific issues include maintenance and repair and mechanisms for providing local technical expertise. In collaboration with the American Medical Resources Foundation, we have proposed a Center in the University of Hanoi to repair and up-grade medical instruments using modern computer technology. This involves understanding the instrumentation problem and replacing its original electronic control and display function with something ranging from a single-chip microcomputer to a locally procured personal computer. Mr. Neil Ghiso, HST-98, has upgraded a BEAR-3 respirator with a single-chip processor and traveled to Hanoi to design and initiate a study of current medical technology in Viet Nam. The respirator is an important technology, widely used, and dominated by air-handling hardware. The addition of a personal computer allows much more complex data-dependent control as well as providing quantitative measurement and data storage and retrieval; in summary--an upgraded instrument.

MICROBIOLOGY AND MOLECULAR GENETICS

Lee Gehrke, Lawrence J. Henderson Associate Professor, is studying RNA-protein interactions in the context of virus replication and assembly. His laboratory identified a single amino acid that enables a viral coat protein to bind

RNA specifically. These findings have significance for understanding mechanisms of virus replication and particle assembly.

MOLECULAR BIOLOGY OF HEMOGLOBIN SYNTHESIS AND HUMAN GENE THERAPY

Irving M. London, Professor of Health Sciences and Technology and Professor of Biology, Emeritus, is studying the regulation of hemoglobin synthesis at both transcriptional and translational levels. His laboratory has discovered and characterized the main enhancer elements that control the transcription of the human β -globin. In collaboration with Dr. Philippe Leboulch of the Harvard Medical School faculty, he is also focusing on novel gene transfer strategies for the gene therapy of human diseases.

MRI IMAGING FOR ASSESSING CARTILAGE PHYSIOLOGY

Professor Martha Gray's research activities this year have centered on the use of magnetic resonance for measuring composition and functional integrity of cartilage. The fixed charged density of cartilage is one of the most important factors in reflecting the mechanical integrity of cartilage. Our NMR methods have exploited the fact that there is a quantitative relationship between the concentration of fixed charge and the concentration of ions in the tissue fluid. It is the concentration of these ions that we measure using MRI in order to infer functional integrity. With our new approach we have been able to identify focal lesions in intact joints and small explants of cartilage. The recent pilot studies suggests this method may be feasible clinically and in animal models. Thus, this approach has the potential to provide the unprecedented opportunity to nondestructively monitor disease progression and evaluate therapeutic efficacy.

REGULATION OF GENE EXPRESSION

Jane-Jane Chen, Principal Research Scientist, studies the regulation of hemoglobin synthesis by the heme-regulated eIF-2 alpha kinase (HRI) that is responsible for the translational regulation by heme of globin synthesis. Dr. Chen's group has demonstrated that expression of HRI is restricted to immature erythroid cells. They have also identified the N-terminal 103 amino acids of the HRI protein that are essential for heme-binding and heme regulation. These data have significance for further understanding of the role of HRI in the production of hemoglobin, a vital oxygen carrying protein.

VASCULAR BIOLOGY, TISSUE ENGINEERING

Elazer R. Edelman, Hermann von Helmholtz Associate Professor, is studying how the physical contiguity of cells and adjacent tissues contributes to autocrine and paracrine modes of growth control. In particular he has used elements of pharmacology, cell and molecular biology and biochemistry, high resolution microscopy and computer-based image analysis, finite element analysis, and tissue engineering to examine the communication between the endothelial and smooth muscle cells of the blood vessel wall. He and his students have demonstrated that disruption of the normal regulation these two cells impose on each other is the hallmark of accelerated proliferative vascular disease. These diseases now account for more morbidity and mortality than all other diseases combined.

PERSONNEL

Elazer Edelman, M.D., Ph.D. was appointed Associate Professor of Health Sciences and Technology at M.I.T. Dr. Edelman is an expert in the area of cardiovascular biology. Professor Nelson Kiang has announced plans to retire, and Professor Lou Braid, Henry Ellis Warren Professor of Electrical Engineering, has assumed the position of head for the Speech and Hearing Sciences Program.

FUTURE PLANS

The most pressing challenge for the Division is to identify and recruit a Co-Director to succeed Professor Mark.

Three main programmatic goals are envisioned for the upcoming year: imaging, graduate curriculum development, and medical informatics. A task force, headed by Professor Eric Grimson (Electrical Engineering and Computer Science), co-headed by Professors Deborah Burstein (Harvard Medical School and Beth Israel Hospital) and Ron Kikinis (Harvard Medical School and Brigham and Women's Hospital) and involving representatives from MIT and Harvard is working to establish milestones to direct initiatives taken by HST in imaging over the next 1-5 years. Subject areas for these initiatives could range from student advising to establishing a research center. Efforts in the area of graduate curriculum will center on a need to enhance focused interdisciplinary training. Although graduate students are expected to bring together the faculty expertise needed to do their multidisciplinary research, the HST

Division has not aggressively organized faculty to teach graduate-level courses in these multidisciplinary areas. Promoting such courses has the dual benefit of providing role models for the students, and providing new insights and colleagues for faculty. Our goal is to initiate the development of one or two such courses in the coming year. Areas in which a need has been identified include: biomaterials, microscale engineering, sensory systems, biological thermodynamics, and imaging. Medical informatics is a discipline that reflects the explosion in computing power and in available information; it has evolved to satisfy the need for sophisticated and coherent approaches for addressing problems ranging from automated diagnosis to genotyping. For several years, HST has served as the academic home for a training grant in Medical Informatics. The goal for the coming year is to explore ways to leverage the current activities in medical informatics for the mutual benefit of the training grant participants and HST. Participating faculty from MIT and Harvard Medical School include Dr. Robert Greenes (Harvard Medical School, and PI of the training grant) and Peter Szolovitz (Electrical Engineering and Computer Science).

Martha L. Gray

CLINICAL RESEARCH CENTER

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.

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 Dr. John Burke, Professor of Surgery at the Harvard Medical School, 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 Harvard-MIT Division of Health Sciences and Technology (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.

On June 1, 1995, the CRC submitted a competing grant application to the NIH for renewal of funding for the next project period beginning in December, 1996. The CRC received its best priority score ever and anticipates funding of up to four years at a total of eight million dollars.

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. During 1995 - 96 six post-doctoral fellows and four graduate students participated in research projects at the CRC. At the undergraduate level, 13 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 three research staff positions became available. Three women were hired, two minorities. Three Visiting Scientists were appointed, two women (one minority) and one male. The Center will continue its efforts to increase the pool of qualified minority applicants as positions become available.

Recently, Dr. Leticia Castillo, Visiting Scientist, was a recipient of a National Institutes of Health Research Supplement for Underrepresented Minorities award. This NIH program provides opportunities for minority scientists to gain further research experience and at the same time, allowing them to strengthen the pool of independent minority biomedical research investigators. Dr. Castillo is conducting studies on arginine metabolism.

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, Cecil H. Green Distinguished Professor and Program Director, MIT CRC) - studies on the effects of drugs, foods and hormones on brain composition and behavior; studies on melatonin and sleep, and 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 352 inpatient days and 2,680 outpatient visits.

CLINICAL INVESTIGATOR TRAINING PROGRAM

The Clinical Investigator Training Program (CITP), which is based in the GCRC, was recognized by the Faculty Council of the Harvard Medical School in the following fashion: all Fellows successfully completing the program will receive a Master of Medical Science in Clinical Investigation from Harvard -- recognition of their unique training and experience. In the coming year, the didactic material developed for the CITP will form the basis of an elective program for medical students and graduate students, as well as a training program for scholars in Latin America and Asia.

CENTER FOR EXPERIMENTAL PHARMACOLOGY AND THERAPEUTICS

This year the Center for Experimental Pharmacology and Therapeutics (CEPT) was established within HST under Professor Robert Rubin, and located within the CRC. Its mission is to facilitate application of MIT-generated quantitative science and technology to the study of human physiology and the discovery of treatments for disease. The focus of the CEPT is on pathophysiologically-oriented, patient-centered, quantitative, and measurement-based clinical research, as well as on the education of fellows and students in the performance of such research. Research programs relate to experimental therapies and to experimental measurement technologies. Both are viewed as probes for understanding normal physiology and for understanding and managing disease.

COMPUTER FACILITY

The computer facility is now independent of both the Vax and PDPN systems. It provides administrative report support and statistical assistance to all researchers. Design of the system fully integrates web services with the local database. Researchers continued to make use of the SAS statistical software available on the CRC computer system. They also began using the resources available on the Internet.

CORE LABORATORY/MASS SPECTROMETER FACILITY

The Core Laboratory (CL) specializes in assays that directly support the research efforts of CRC investigators. The most important and complex assays are undertaken by the Mass Spectrometer Facility (MSF), where stable isotope tracer analyses are performed. The MSF is a shared instrument facility that allows CRC investigators to conduct human metabolic studies using stable nuclide tracers. 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 has 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 continue to examine the role of dietary arginine as a precursor of signal transducer nitric oxide. The novel doubly labeled water ($^2\text{H}_2^{18}\text{O}$) method is being used to define the energy requirements for adolescent and elderly subjects, and the 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.

High performance liquid chromatography (HPLC) techniques are also utilized by the CL. A Beckman System Gold Amino Acid Analyzer HPLC provides resolution of up to 42 physiologic amino acids. Other HPLC assays include tests for choline, tryptophan, the catecholamines and cytidine.

RESEARCH HIGHLIGHTS

- Richard J. Cohen, M.D., Ph.D. and his associates demonstrated that analysis of beat-to-beat variability in hemodynamic signals provide a powerful, quantitative and noninvasive means of assessment of closed-loop hemodynamic regulation. They also demonstrated that system identification techniques can noninvasively quantify the baroreflex without the need to use pharmacologic agents.
- Suzanne Corkin, Ph.D., and her colleagues showed that three learning systems exist, i.e., a “memory” system for cognitive learning, which acquires knowledge, and whose neural substrate is limbic circuits; a “habit” system for noncognitive learning, which forms automatic connections between a stimulus and a response, and whose neural substrate is the striatum; and a “priming” system mediated cortically. Event-fact learning corresponds to what Graf and Schacter term “explicit” memory, whereas skill learning and priming are instances of what the term “implicit” memory. Corkin’s project tests predictions derived from Mishkin’s model (extended to accommodate priming) against memory dissociations found in human subjects who have lesions that disrupt the reciprocal connections between limbic structures and cortex (in global amnesia), between striatum and cortex (in PD and HD), or within cortex (in AD and focal cortical lesions), in terms of three domains of performance: event-fact learning, skill learning, and priming.
- William H. Dietz, M.D., Ph.D. and his co-workers demonstrated in a large cohort of non-obese pre-menarcheal girls, that components of energy expenditure include total daily energy expenditure, resting metabolic rate, the energy spent on non-basal energy expenditure, and VO_2 max did not differ in girls whose parents were overweight. Self reported vigorous physical activity appears a better predictor of HDL-cholesterol and LDL cholesterol levels. In addition, ongoing studies of the accuracy of dietary intake demonstrate that young girls report their food intake more accurately than adolescents. Finally, comparisons of bioelectrical impedance (BIA) measurements of body composition showed that BIA provided accurate measurements of fat free mass but measurements of body fat were no more accurate than triceps skinfold.
- Paul A. Spiers, Ph.D., and Gail S. Hochanadel, Ph.D., this year published their research that *Citicoline Improves Verbal Memory in Aging* in the May, 1996 issue of the Archives of Neurology. After careful statistical analysis with the help of CRC Biostatistician Ray Gleason, Spiers and Hochanadel identified a subgroup of normal elderly who were most helped by Citicoline and which other studies have suggested may be those individuals who are the most at risk for developing some form of dementing illness. They also presented this research at the annual scientific symposium of the Massachusetts Neuropsychological Society in June. Spiers and Hochanadel have been helping to interpret the data from a national, multi-center trial of Citicoline given to patients acutely after cerebrovascular accident. At the same time, they are recruiting subjects for their own CRC protocol on the effects of Citicoline on memory after ischemic stroke which seeks to give this drug to patients who are chronic and may have had their stroke as much as five years earlier. This project is ongoing.
- Judith J. Wurtman, Ph.D. and her colleagues showed that weight gain among normal weight women undergoing a three month smoking withdrawal program can be minimized by treatment with dexfenfluramine although withdrawal of the drug following a three month treatment regimen causes weight to be gained. Fluoxetine treatment minimized weight gain for the first month of treatment; subsequently, weight gain among the fluoxetine treated group was similar to placebo and continued after the end of drug treatment. They also demonstrated that patients with obsessive compulsive disorder describe patterns of snack intake that include daily consumption of carbohydrate-rich snacks and self-reports of eating such foods when distressed. When their snacking habits were compared with a control population of patients attending a dermatology clinic, the snacking habits of both males and females with OCD were significantly different from the control group and was not related to either gender or weight status.
- Richard J. Wurtman, M.D. and Dr. Irina Zhdanova demonstrated for the first time, that very low melatonin doses (0.1 or 0.3 mg), which raise daytime blood melatonin levels only to those which occur normally at night, make people sleepy and facilitate sleep initiation. The results obtained in 20 healthy people also suggest that the *normal* secretion of melatonin, each evening and night, is partly responsible for physiological sleep. In subsequent studies using low melatonin doses given later in the evening, using standard polysomnography,

demonstrated that low melatonin doses at *all* of the time points tested cause sleep onset without disturbing the normal sleep structure. They additionally showed that melatonin administration causes no differences in mood and performance of people tested on the morning after melatonin or placebo. These preliminary results suggest that induction of melatonin concentrations close to normal physiological levels does not negatively affect humans' performance and mood the morning following treatment.

- Vernon R. Young, Ph.D, D. Sc., received two awards during this fiscal year: October 1995, Bristol Myers-Squibb Mead Johnson Award for Distinguished Achievement in Nutrition Research and, in May 1996, Roger J. Williams Award in Preventative Medicine. Dr. Young and his colleagues earlier demonstrated that it is feasible to estimate whole body leucine balance using ¹³C-leucine as a tracer. Through continuous 24h intravenous 1-¹³C-leucine tracer studies they established the basis for a precise determination of daily leucine balance. This opened the way for a new approach for estimating the nutritional requirements for this amino acid in healthy subjects. Recent studies have been expanded to include other nutritionally essential amino acids, such as phenylalanine and lysine. These studies by Young and co-workers have received international acclaim and have resulted in a profound change in concepts regarding the quantitative significance of the dietary amino acid intake level on human well-being.

Richard J. Wurtman, M.D.

MIT/WHOI JOINT PROGRAM IN OCEANOGRAPHY

The Joint Program of the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology offers advanced 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.

HIGHLIGHTS OF THE YEAR

Effective July 1, 1995, Marcia McNutt, Earle A. Griswold Professor of Marine Geophysics in the Earth, Atmospheric and Planetary Sciences Department (EAPS), became the new MIT Director of the Joint Program, replacing Prof. Sallie W. Chisholm of the Civil and Environmental Engineering Department.

A passive link option was installed in two of the classrooms in Building 54 with the addition of secured cameras and microphones. This added configuration enables individuals to schedule meetings over the microwave link between MIT and WHOI on occasions where a cameraman is not needed.

There is now a Web page for the Joint Program. It can be found through the MIT Home Page or at <http://web.mit.edu/mit-who/wwww>.

The Joint Program graduated 24 students in 1995-96; of these, 16 received the doctorate, five received the master's degree, and three received the engineer's degree. The breakdown by discipline is as follows: Chemical Oceanography (two); Biological Oceanography (four); Marine Geology and Geophysics (two); Physical Oceanography (five); and Applied Ocean Science and Engineering (eleven).

Enrollment in the Joint Program has remained stable for the last two years at a level of 146 students. The projected enrollment estimate for September 1996 is 150 students, with 17 in Chemical Oceanography, 34 in Marine Geology and Geophysics, 33 in Biological Oceanography, 30 in Applied Ocean Science and Engineering, and 36 in Physical Oceanography.

FUTURE PLANS

As we look towards replacing the microwave link with a fully digitized system at some point in the future, we are continuing our consultations with specialists in the field of long-distance learning.

We anticipate that there will be an external review of the Joint Program in the fall of 1996, as a follow-up to the Internal Review which was conducted in 1994.

Ronni Schwartz

TECHNOLOGY LICENSING OFFICE

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 26 (11 licensing professionals and 14 administrative and support personnel) are responsible for identifying marketable technologies, managing the patenting and copyrighting of these technologies, finding licenses to develop the technologies and negotiating licenses.

A total of 81 License and Option agreements were signed in FY 1996, including 9 new startup companies. Five biomedical products received FDA approval.

Gross Income for the year was \$10.2 Million, which included no cash-in of equity. Of the gross, \$8.1 Million was in royalty income and \$1.2 in patent reimbursement income. \$1.2 Million was distributed to inventors, \$1.3 to departments, \$199K to Whitehead, and a net of \$1.35 Million 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 and the Association of Federal Technology Transfer Executives.

Lita Nelson

CENTER FOR MATERIALS SCIENCE AND ENGINEERING

In September of 1994, the Center for Materials Science and Engineering (CMSE) at MIT was awarded one of the first National Science Foundation Grants under the new Materials Research Science and Engineering Center (MRSEC) program. CMSE won the largest of the 11 grants creating new Centers at universities throughout the nation. We describe below the mission of CMSE and the methods used to reach its goals.

MIT has an extraordinarily strong and broad effort in materials science and engineering involving approximately 110 faculty members in 11 departments in the schools of science and engineering. There is great opportunity in this environment to solve problems that address the needs of society more effectively by encouraging collaboration. Thus, 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.

CMSE also provides seed and initiative funds. While preference is given to young faculty, CMSE uses seed 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. Seed funding provides CMSE with the flexibility necessary to initiate high-risk research. During the past year CMSE held its second open competition for seed grants. Eight seeds are now supported. In addition, 14 faculty are active in three initiatives, which are groups of faculty that may become new IRGs.

INTERDISCIPLINARY RESEARCH GROUPS MICROPHOTONIC 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 creation and control of electromagnetic radiation. These materials are 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 μm 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 μm , composed of a set of colinear air holes in Si. Similar structures in GaAs are being tested.

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).

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. This group has recently discovered a new way of making light-emitting polymer films and super-paramagnetic films that may be useful in security applications.

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).

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. The chief focus is the study of gels with random distributions of positive and negative charges. The gel work recently received the Discover Magazine Technology Award and the R&D Magazine R&D 100 Award.

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).

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. This group has recently demonstrated a correlation between the chemistry and electrical properties of interfaces in ZnO varistor material.

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 (MSE); and Dr. A. J. Garratt-Reed (CMSE).

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 La_2CuO_4 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- T_c 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. Using these crystals the group recently discovered the spatial ordering of oxygen used to dope La_2CuO_4 .

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

NEW INITIATIVES

MICROSTRUCTURE AND MECHANICAL PERFORMANCE OF POLYMERIC MATERIALS

The research focuses on identifying the mechanistic connections between structure, morphology, and macroscopic properties of polymers. The project aims at establishing the fundamental connections between polymer microstructure and mechanical performance, and the design of new forms of heterogeneous polymer systems.

Participating faculty and departmental affiliations: A. S. Argon, M. C. Boyce, and D. M. Parks (Mechanical Engineering); G. C. Rutledge and R. E. Cohen (Chemical Engineering).

MULTISCALE MATERIALS MODELING FROM THE ELECTRONIC STRUCTURE-ATOMISTIC LEVELS

This program seeks to couple current techniques in *ab-initio* electronic structure calculations with Monte-Carlo based simulations in order to relate quantitatively the microscopic information on local bonding and chemistry to the kinetics of defect mobility and microstructural evolution. First-principles quantum mechanical methods and atomistic and mesoscopic simulations will be applied to develop a quantitative description of dislocation nucleation and mobility on epitaxial semiconductor films in order to provide a sound modeling tool.

Participating faculty and research staff and departmental affiliations: T. A. Arias (Physics); Dr. V. Bulatov (Mechanical Engineering); and S. Yip (Nuclear Engineering).

ELECTRONIC TRANSPORT IN MESOSCOPIC SYSTEMS

This initiative exploits new capabilities for processing of mesoscopic systems, including self-assembled arrays of semiconductor quantum dots and the fabrication of mesoscopic structures in Ge/Si. The group will study electronic transport in these systems to better understand the fundamental physics. In addition, the effects of GHz to THz radiation on the conductance of mesoscopic structures will be studied with an eye to possible applications.

Participating faculty and departmental affiliations: R. Ashoori, M. A. Kastner, P. Lee, L. Levitov, X.-G. Wen (Physics); M. G. Bawendi (Chemistry); E. A. Fitzgerald (Materials Science and Engineering); and Q. Hu (Electrical Engineering and Computer Science).

SEED PROJECTS

AB INITIO STUDY OF THE PROPERTIES OF MATERIALS ON THE NANOSCALE

Progress has been made in developing new methods of calculating physical and chemical properties of materials from first principles. These are being applied to corrosion of Cr and dislocation motion in Si. T. A. Arias (Physics).

CONFIGURATIONAL BEHAVIOR OF CHARGED DEFECTS IN OXIDES

Calculations are underway to predict the structure and defect chemistry of grain boundaries in ZnO. Predictions of boundary structures and analysis of the thermodynamics of de-segregation of Bi from grain boundaries are being tested by members of IRG-IV. G. Ceder (Materials Science and Engineering).

INVESTIGATIONS OF SPIN DIFFUSION AND LOCAL ORDERING BY HIGH RESOLUTION NMR SCATTERING

Recently developed high resolution scattering techniques are used to characterize both the dynamics of spin diffusion and local ordering in condensed phases. It is planned to quantify both the short and long time behavior of spin diffusion in well characterized systems, and to apply these new methods to studies of structural and phase behavior in the presence of quenched disorder. D. G. Cory (Nuclear Engineering).

INVESTIGATION INTO NONWETTING PHASE ENTRAPMENT DURING IMMISCIBLE FLUID TRANSPORT IN POROUS MEDIA

Centrifugal techniques are used to determine the residual saturation of trapped non-wetting phase following a wetting displacement as a function of pore geometry. The data are used to construct phase diagrams. P. J. Culligan-Hensley (Civil and Environmental Engineering).

DESIGN AND SYNTHESIS OF THERMOPLASTIC ELASTOMERS WITH SIDE CHAIN LIQUID CRYSTALLINE SOFT SEGMENTS

Block copolymers with an amorphous block and a ferroelectric liquid crystalline block are being synthesized. Such materials may have useful electro-optical or mechano-optical properties. P. T. Hammond (Chemical Engineering).

POLYMER GEL ACTUATORS AND SENSORS

Phase transitions in gels discovered by Tanaka and studied intensively by IRG-III, may be useful as synthetic muscles, servomechanisms, and sensors. Gels containing ferrofluids are being synthesized that are sensitive to magnetic fields and gels that are sensitive to specific contaminants in water. S. B. Leeb (Electrical Engineering and Computer Science).

GELS FOR MOLECULAR RECOGNITION, ACCUMULATION, AND RELEASE

This project is working to establish and demonstrate the guiding principles for the design and synthesis of polymers capable of molecular recognition and enzymatic activity. The research will develop an understanding of the principles that govern the macroscopic phase behavior of gels in terms of molecule-mediated attraction between polymers. S. Masamune (Chemistry).

INTERFACIAL ROUGHNESS IN ORGANIC MULTILAYER FILMS

For thin film organic heterostructures, of the kind fabricated by IRG-II, layering, perfection and interfacial structure are important to device performance. X-ray and neutron reflectometry is used to characterize roughness as a function of the number of polymers layers. A. M. Mayes (Materials Science and Engineering).

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) brings 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 course entitled 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 11 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 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. During the past year, CMSE facilities have been utilized by 26 commercial organizations and 11 outside academic institutions. The current CMSE/IBM X-ray participating research team (PRT) at the National Synchrotron Light Source (NSLS) at Brookhaven, the CMSE/IBM/McGill PRT under construction 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 participate in 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

Two male members were added to the staff during the past year: Dr. Fang Cheng Chou, Research Associate, and Dr. David C. Bell, Postdoctoral Associate, who were both appointed in January, 1996. Departures from the Center's staff over the past year include research staff members Dr. Neil Rowlands, who resigned in March 1996, and René Holaday, who resigned in August, 1995.

Of the 13 students participating in the CMSE Undergraduate Research Opportunities Program, funded by the National Science Foundation as part of the MRSEC Program, eight were women and five were men. Again this summer, CMSE is collaborating with the MPC in sponsoring a joint ten-week summer internship program. Nine interns were selected from applications submitted by over 100 undergraduates from both MIT and other universities from around the country. Four of these scholars are women. The interns include Blake M. Ashby (Utah State University), Anna Domnich (Columbia University), Jay B. Ewing (Reed College), Thomas J. Fennimore (Swarthmore College), Mahesh K. Mahanthappa (University of Colorado), Andrea R. Palmisano (Tulane University), Rachel A. Soltis (Bryn Mawr), Joshua S. Weitz (Princeton University), and Melody T. Yung (MIT).

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 six students employed this year, one was a woman and three were African-American men. Peter Bennett, Jeol Holmes, Suzanne Nicol, Sleamms Petit-Maitre, Costas Pitsillides, and Andrew Williamson worked as co-op students in two of the Center's SEFs.

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 woman, Shani Colley, who formerly participated in the science and engineering day camp, worked for the entire school year.

The Center continued its science and engineering summer day camp for seventh- and eighth-grade students from a local public school who are members of underrepresented minority groups, including nine African-Americans and three Hispanic-Americans, of which four were male and eight were female. The students were supervised by volunteer faculty and staff, as well as four MIT students, including one African-American woman, and one Hispanic man. These students were Jaime Amaya, Sharonda Bridgeforth, Merideth Rising, and Peter Tsang.

We continued the CMSE graduate minority research assistant (RA) program to fill the need for support for minority students in their last two years of graduate study. During the 1995-96 academic year, the Center provided RA support to an African-American woman in the Department of Physics and an Hispanic male in the Department of Chemistry. In addition, seed funding was granted to one female faculty member working in the field of materials science and engineering who is a member of an under-represented minority group.

Marc A. Kastner

ENERGY LABORATORY

The Energy Laboratory and its associated Center for Energy and Environmental Policy Research (CEEPR) are multidisciplinary organizations bringing together sectors of the MIT community with research interests related to energy supply, conversion, policy, technology, and utilization and associated environmental, economic, geographical, and societal impacts. Our mission is to conduct research, educate students, and perform public service in support of economically sound, globally conscious, and environmentally responsible energy policies and technologies.

HIGHLIGHTS OF THE YEAR

In May, the activities of the Energy Laboratory were reviewed by our External Advisory Board which is composed of eighteen senior executives from the public and private sectors. The chairman, Joseph Moore (President of Bonner and Moore Associates), submitted a report to Dean David Litster on behalf of the thirteen members attending the review. The Board found that the Energy Laboratory and its MIT partners have *created a unique ability to address important research areas that reflect the confluence of technology, economics, politics, science, and social forces*. A number of constructive suggestions were offered to enhance the Energy Laboratory's ability to connect our faculty and their research interests to potential sponsors in industry and government.

HONORS AND AWARDS

Professor John Heywood was chosen this year as the winner of the US Department of Transportation (DOT) *National Award for Advancement of Motor Vehicle Research*. Professor Adel Sarofim received the US Department of Energy (DOE) *Homer H. Lowry Award*, which honors outstanding achievement in fossil energy research and development. Dr. Victor Wong and co-authors won a Society of Automotive Engineers (SAE) *Arch T. Colwell Merit Award* for a 1994 paper which was judged one of about the top ten papers of the several thousand published by the society each year. Professor Simone Hochgreb received the 1996 SAE *Ralph R. Teetor Award* for her contributions to teaching and research and participation in student extracurricular activities.

PROGRAM HIGHLIGHTS

- Fiscal 1996 research support was \$13.1 million (including \$4.2 million in subcontracts to other universities), up from \$8.5 million in Fiscal 1995 largely due to two new programs supported by DOE.
- We successfully completed the first full year of managing the Idaho National Engineering Laboratory University Research Consortium involving 47 university research projects including 17 new projects at MIT.
- We obtained seed funding from the Geothermal Division of the DOE to organize and fund initial research for the new National Advanced Drilling and Excavation Technologies (NADET) Institute and programs.
- We prepared for the *Third International Conference on Carbon Dioxide Removal* to be held at MIT in September 1996, which is being organized by a committee chaired by Howard Herzog.
- We completed integration of an interacting global climate systems model from separately developed sub-models (with the Center for Global Change Science).
- We established a major research effort on the US sulfur emissions trading program.

RESEARCH ACHIEVEMENTS

Many of the Laboratory's projects involve quantitative and cross-disciplinary study of complex energy and environmental systems. 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. Research in the automotive area is being extended to marine engines in a Department of Transportation Maritime Administration sponsored program to evaluate strategies for reducing particulate pollutants from diesel engines for marine vessels. [\$1.2 million support]

Energy Laboratory 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 Energy Laboratory is an active member of the *Program for Environmental Engineering Education and Research* (PEEER) under the leadership of Professor David Marks and has also worked over the years with the *Building Technology* program (led by Professor Leon Glicksman) in

research on energy efficient, “healthy” buildings. Professor Jefferson Tester is a member of the Provost’s *Council on the Environment*.

Professor Sarofim is leading an Environmental Protection Agency (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 Janos Beér, Heywood, Hochgreb, Jack Howard, Gregory McRae, Sarofim, and John Vander Sande. In addition to the research, the Center hosted a Summer Symposium entitled *Effective Technologies for Reducing Vehicle Emissions*, which was chaired by Professors Heywood and Robert Sawyer (Berkeley). [\$1.3 million support] 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. Professor Maria Flytzani-Stephanopoulos (Tufts) is the associate director coordinating the MIT research programs, which seek new methodologies for preventing pollutant formation and for reducing or eliminating industrial pollutant emissions. [\$570K support]

Professor Leon Glicksman continues an active research program on pressurized fluidized bed combustors with special emphasis on scaling laws for moving from model experiments to full size combustor designs. [\$275K]

Continuing our prior internationally visible work relating to technologies for carbon dioxide mitigation through capture and sequestration of fossil-fueled power plant emissions, we are conducting a study for the DOE to investigate the potential environmental impacts of ocean disposal of carbon dioxide. Howard Herzog of the Energy Laboratory and Dr. Eric Adams of the Parsons Laboratory are leading the team for this project. Mr. Herzog has also procured funding for and organized the *Third International Conference on Carbon Dioxide Removal*, to be held at MIT in September 1996 when it is the North American turn to be host. There are obvious synergies between mitigation technologies and the *Joint Program on the Science and Policy of Global Change* (described further under the CEEPR), which we hope to highlight in conjunction with this meeting. [\$250K support] Mr. Herzog, Professor Nazli Choucri, and Dr. Elisabeth Drake also completed studies relating to energy technology comparisons and the roles of energy technology choices under sustainability goals under the direction of the International Energy Agency with sponsorship from NEDO (Japan). Case studies were done for China and India, and technology and implementation agreement data bases were developed. [\$110K support]

Professor Kent Hansen and Dr. Malcolm Weiss are continuing research sponsored by the DOE related to management of nuclear waste from the DOE weapons program. Present work is related to the Hanford waste tank system. The waste stored in the tanks represents one of the most significant public risks in the entire weapons complex. Management of the operations of the system is very complex technically and administratively. The research focuses upon developing a system dynamics model of the waste tank management and operations to permit simulation of performance for a variety of policy options. Results will assist DOE in developing management strategies under a variety of possible future decision alternatives regarding regulations, finances, and technology developments. [\$255K support]

The Electric Utility Program (EUP), directed by Mr. Stephen Connors, is jointly sponsored by over twenty-five electric utility companies, equipment manufacturers, and fuel suppliers, and the DOE. EUP facilitates the development of collaboratively funded electric industry related research by bringing together MIT faculty and researchers with EUP members through an annual series of workshops and meetings. Topics discussed at these meetings over the past year have focused on issues relevant to the evolving competitive electric industry structure. Prominent among them were analytic techniques and technologies which allow the industry to get the most out of the existing infrastructure and presentation of management approaches to help industrial sponsors better utilize resources to compete in the future. Separate workshops focused on corporate planning and the management of technology techniques for utilities and enhanced utilization of power system operations and resources. The annual planning meeting, entitled *Strategic R&D for Innovation and Competition*, highlighted almost every department within the School of Engineering as it reviewed the advanced monitoring and control techniques for electricity generation, transmission and distribution, and management of customer loads, and discussed new technological opportunities under competition. [\$160K support]

The Analysis Group for Regional Electricity Alternatives (AGREA), also directed by Mr. Connors, continued its long-standing project sponsored by New England's electric utilities, analyzing cost-effective ways to meet environmental regulation, including the performance of cap and trade type systems for NO_x control, and the issues of resource diversity and electrotechnology performance under competition. In addition to its work with the New England utilities, AGREA worked with the Tennessee Valley Authority to communicate about its electric power options with its customers, and has been developing an enhanced application of its multi-attribute tradeoff analysis approach with ETH in Switzerland under the Alliance for Global Sustainability. [\$150K support]

The MIT Energy Laboratory organized and is managing the *University Research Consortium* (URC) for the Lockheed Martin Idaho Technologies Company, the management and operations contractor for the DOE's Idaho National Engineering Laboratory (INEL). The purpose of the URC is to help INEL in its reorientation to new goals set by DOE for its national laboratories. Those goals include developing new technologies useful in our competitive economy or in meeting national needs such as environmental management. Key MIT participants are Professors Tester and Mujid Kazimi as co-Principal Investigators for the URC, Drs. Drake and Weiss as co-Directors, and Professors Thomas Eagar, Michael Golay, and Kenneth Smith, as heads, respectively, of the three research areas of the program: engineering systems, nuclear technology, and environmental technology.

The URC Program consists of a portfolio of research projects funded by INEL and conducted at universities in the US. In order to help reorient the INEL and to ensure commercial relevance, each project is intended to have at least one active collaborator on the INEL staff and at least one active collaborator from the private sector; INEL collaboration has not been fully realized yet because of funding limitations. URC projects in the current portfolio are the outcome of a solicitation and review process that began in February 1995. In response to a published solicitation, MIT received 620 prospectuses (3-page informal proposals) from 80 universities in 41 states. Invitations to submit formal proposals were extended to 133 prospectus-writers. Of those proposals, 47 were awarded funds (including 17 at MIT) totaling \$7.63 million in fiscal 1996, distributed among 23 universities in 17 states. Funding decisions were made after peer review by Lockheed Martin Idaho management on recommendation of a committee consisting of representatives of MIT, INEL, and DOE. Most current projects will run for three years each. [\$8.7 million support, including \$4.2 million in subcontracts to other universities].

Several different programs are under way in the area of Advanced Energy and Manufacturing Technologies. A major collaborative program between MIT and the Idaho National Engineering Laboratory, with funding from DOE Basic Energy Sciences, seeks new engineering understanding to improve efficiency and materials conservation in energy-intensive processes. This program, with one project led by Professor David Parks and another collaborative project involving Professors Eagar, David Hardt, and Jeffrey Lang, is directed by Professor Hardt and managed by Dr. Drake. [\$530K support]

The Energy Laboratory is in the fourth 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, funded a research project completed this year on oil and gas reserve valuation (Professor Morris Adelman). A current project addressing the development of R&D planning methods, considering energy, environmental, and economic benefits of alternatives related to processing and use of advanced materials, is led by Professor Joel Clark; Dr. Marija Ilic, looking towards needs of a restructured electric transmission and distribution system, is leading a third project focusing on effective energy management under competition with real-time controls, accounting, and supporting systems. She is collaborating with Dr. Richard Tabors in another project looking at modeling, control systems, and dynamic pricing for a distributed utility in an imperfect market. Another major project, directed by Professors Marks, Fred Moavenzadeh, and John Sterman 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. Dr. Ellerman is conducting another project studying the price and productivity change in the US coal industry. [\$540K support]

Professors Yet-Ming Chiang and Jackie Ying are the co-investigators for *A Research Needs Assessment for Future Use of Nanofabricated Materials in Energy Applications*, a project supported by the DOE Office of Energy Research. Groups of experts discussed potential applications of nanoscale technologies to catalysis; separations

processes; photovoltaics and photochemistry; batteries, fuel cells, and sensors; structural ceramics, coatings, and hard materials; and to other promising energy applications. A final report on this work has recently been published. [\$90K support]

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 (ARO). Goals are to develop new understanding of important chemical and physical processes for successfully applying this technology, e.g., how rapidly and completely wastes can be destroyed, how fouling of vessel surfaces by solids can be minimized, how solid byproducts can be separated, and how corrosion of processing construction materials can be controlled. A major objective is to use this understanding 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 David Cory, Peter Griffith, Jonathan Harris, Howard, Ronald Latanision, and Kenneth Smith, Dr. William Peters, and Mr. Herzog. Other work supported by Sandia (Livermore) focuses on kinetic studies pertinent to destruction of wastes of interest to DOD. Still other studies address use of supercritical fluids for improved synthesis of organic chemicals, e.g., replacements for environmentally hazardous solvents and/or improved synthetic pathways (Professors Tester and Rick Danheiser). [\$780K support]

THE CENTER FOR ENERGY AND ENVIRONMENTAL POLICY RESEARCH AND THE JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

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 and the associated Joint Program receive financial support from 24 corporate sponsors, four agencies of the US government, and the Norwegian government.

For the past three years, CEEPR's principal research focus has been the *Joint Program on the Science and Policy of Global Change*, jointly sponsored with MIT's Center for Global Change Science, and with the collaboration of the Woods Hole Marine Biology Laboratory. This program, led by Professors Henry Jacoby and Ronald Prinn, draws on MIT's traditional strengths in science and economics to conduct interdisciplinary work to support global climate policy. A significant milestone was achieved in the past year: fully interacting runs of the heretofore separate components of the Integrated Global Systems Model. The component submodels address: 1. anthropogenic emissions and policy assessment, 2. atmospheric chemistry, 3. natural sources and sinks of greenhouse gas emissions, and 4. terrestrial ecosystems.

This past year was the first of a two-year evaluation of compliance with the acid rain provisions of the Clean Air Act Amendments of 1990 by CEEPR. These provisions are remarkable for use of fully tradable sulfur emission permits instead of command and control regulation. Initial results from this innovative method of achieving compliance with environmental objectives are very encouraging. The first year of the project has been devoted to obtaining the data on 1995, the first year of compliance, and performing preliminary analyses on different aspects of the allowance trading market. [\$290K support]

PERSONNEL

Professor Jefferson Tester, is the Director of the Energy Laboratory, supported by Associate Directors Dr. Elisabeth Drake and Dr. William Peters. John F. O'Brien, Jr. is the new Administrative Officer, replacing 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 Fiscal '96 involved about 50 undergraduates and 130 graduate students, along with about 58 associated faculty members from twelve Academic Departments representing all five of MIT's Schools.

With a fairly small, low-turnover 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 is female.

FUTURE PLANS

Under the leadership of the Program in Environmental Engineering Education and Research, the *Alliance for Global Sustainability* is a major new collaboration between MIT, Eidgenössische Technische Hochschule (ETH - Switzerland), and the University of Tokyo. As part of the *Alliance*, several Energy Laboratory researchers are developing collaborative proposals among the universities. Dr. Drake is participating in an overall “framing” project; Professor Heywood is involved in a collaboration on sustainable transport and economic development; several faculty are formulating a program on developing planning models for cleaner technologies and processes; Dr. Ilic and others are looking at interconnected electric power systems in the 21st century, building analysis tools and multicriteria optimization models; Mr. Connors and others are studying decision-making processes in the electricity sector under sustainability constraints; and Mr. Herzog is leading a project on CO₂ mitigation strategies.

The Energy Laboratory is coordinating a national program aimed at developing new technologies for rapid drilling, tunneling, and cavity creation in rock formations. Under the leadership of Professor Carl Peterson, a National Advanced Drilling and Excavation Technologies Institute has been established at MIT with initial funding from the DOE. The role of the NADET Institute is to facilitate research, development, demonstration, and commercialization of advanced technologies for industries that depend critically on drilling and excavation operations and for the manufacturers that supply those industries. With substantial and continuing guidance from participating industries, the Institute will plan, monitor, and coordinate programs ranging from basic research to commercial demonstration of advanced systems. NADET Institute activities during the first year of operations have included: holding a series of introductory and information gathering workshops with the involved industries, establishing contacts throughout the relevant industry, government, and academic communities, and initiating approximately \$1 million of support in a variety of advanced drilling technology research programs.

We continue to work for expanded governmental and private sector support for research, development, and demonstration projects on hot dry rock geothermal and hydrothermal energy resources. A sizable MIT-led program to analyze several years of data from the DOE Fenton Hill Hot Dry Rock Field Station has been proposed (Professor Tester and Mr. Herzog).

Mr. Herzog's continuing research on CO₂ mitigation and environmental effects of ocean disposal with Dr. Adams and others may be expanded if MITI (Japan) decides in late 1996 to make ocean disposal of CO₂ a national program. Based on our prior work which has been funded by groups in Japan and elsewhere, MIT has been approached about participation in an international research program associated with the potential national ocean disposal program in Japan. If this materializes, it will also help leverage further research support from the DOE.

New collaborations with the MIT Earth Resources Laboratory are being pursued. Dr. Roger Turpening and Professor Nafi Toksoz are developing initiatives to apply seismographic diagnostics to study hazardous nuclear wastes stored in tanks like those at the DOE Hanford site. Professor Dale Morgan is investigating opportunities for United Nations supported MIT collaboration with researchers in several Caribbean nations to explore and advance the use of geothermal energy in that region.

New initiatives have been proposed to NSF and DOE to apply optical diagnostics to waste destruction and chemical synthesis processing in supercritical fluids (Professors Jeffrey Steinfeld, Tester, Danheiser, and Dr. Peters). DOE support is also being sought for applying nuclear magnetic resonance imaging to diagnosis of mixing, transport, and other physicochemical properties of supercritical water (Professors Kenneth Smith, Tester, and Corey). We also are in the early stages of planning an MIT-led international industrial consortium to sponsor enabling R&D for applying supercritical water and other supercritical fluids to waste destruction, chemical synthesis, and separations.

With the help of a significant grant from the National Science Foundation, the Joint Program has initiated a new research effort on the interaction of local and global pollution. This research is driven by the recognition that the local pollution will be acted upon much sooner than greenhouse gas emissions, and that local pollution is a significant contributor, positively and negatively, to global warming.

In the past year, CEEPR has created a unique mine level data base for coal mining that will provide the basis for continuing research over the next few years into the microeconomic bases of observed productivity change and related phenomenon of declining price and apparent chronic over-capacity.

Jefferson W. Tester

FRANCIS BITTER MAGNET LABORATORY

Over the past year, the Francis Bitter Magnet Laboratory (FBML) has made notable advances in several different areas of science and engineering involving high magnetic fields. The research program in Magnetic Resonance (primarily nuclear magnetic resonance (NMR), but also electron paramagnetic resonance (EPR)) has evolved to the largest effort at the FBML. The program continues to be funded primarily by the NIH and DOE, and involves ~20 NMR and EPR magnets and spectrometers which have been custom designed or acquired commercially. These include a wide bore 360 MHz, two wide bore 500 MHz, three 600 MHz, and two 750 MHz NMR systems. In addition, we have constructed and now operate the sole 140 GHz EPR spectrometer in North America, and have recently acquired a new widebore magnet with an expanded range sweep coil for this system. The general purpose high field Bitter and Hybrid magnets capable of providing fields up to 35 T remain at the FBML, and a grant application is pending with the NSF to purchase a new power supply and resume operation of those magnets. If that grant is approved then the Laboratory will again be able to provide high magnetic fields as a tool in areas of condensed matter physics including quantum effects in interacting electron systems, superconductivity, atomic and molecular systems, and in magnet technology.

RESEARCH HIGHLIGHTS

During the past year we published the initial low resolution structure of a peptide derived from b-amyloid, the protein thought to cause Alzheimer's disease. Several important advances have been made in dipolar recoupling in magic angle spinning (MAS) spectra, so that it is possible to perform spectral assignments and measure internuclear distances in solid biological materials in a general manner. Multiple quantum NMR techniques for observing high resolution spectra of quadrupolar nuclei have been demonstrated. The importance of these experiments is that in principle they enable observation of high resolution isotropic spectra of ~70% of the periodic table which has $I \geq 3/2$. These experiments will function optimally at high magnetic fields. We have developed new techniques for decoupling solids which yield increases in resolution of ~5-10 depending on the samples. Despite several intense research in this and in other laboratories, this is the first significant improvement in decoupling since the introduction of high resolution solid state NMR ~25 years ago. In addition, we have developed an approach to dynamically polarize protein solutions resulting in enhancements in signal strengths by factors of up to 185. The approach utilizes the gyrotron oscillator developed in collaboration with the MIT Plasma Fusion Center and DNP/NMR spectrometer we have assembled. It appears to be generally applicable.

High frequency 140 GHz EPR has also proven to be a valuable tool in the investigation of inhibition of protein free radicals. We have concentrated on two inhibitors of ribonucleotide reductase and demonstrated that an azide inhibitor results in the formation of a Cys-N Σ radical and a difluoromethylene inhibitor yields an allyl radical.

High field solution NMR experiments were employed to determine the structure of the complex between peptides from the HIV Rev protein and the Rev-Responsive Element (RRE) RNA. The primary tool in this work was multidimensional heteronuclear NMR. This structure provided insight into the manner of RNA-protein recognition, which is an important problem in structural biology, as well as information which could prove helpful for design of novel therapeutic strategies for HIV.

NMR microscopy research was focused on the application of radiofrequency field gradients to improve the efficiency of solution NMR experiments, which in turn will improve the efficiency of studies of the structure and dynamics of large molecules. Recently the area of radiation damping and how to avoid it have been addressed and mechanisms discovered whereby damping can be initiated by a noise source and quenched by introduction of an effective field which couples the transverse and longitudinal components of magnetization.

The condensed matter physics effort at the FBML is focused on spin-dependent tunneling between magnetic films of CrO₂. The films have potential applications in the digital electronics industry, automobiles and medical diagnostics. In addition, the Stark-Faraday effect in GaAs-AlGaAs structures at 0.8 μ m has been observed. The effect has possible optoelectronic device applications.

FACILITIES

The Magnet Technology group completed the winding of the major part of the 45T hybrid magnet to be installed at the National High Magnetic Field Laboratory in Tallahassee. In addition, the past year has seen the acquisition of five new magnets for the magnetic resonance research effort. These include a 104 mm, 500 MHz magnet for solid state spectroscopy, a 52 mm, 600 MHz magnet and spectrometer for microscopy and a similar system for solution NMR, and a 62 mm, 750 MHz magnet for solution and solid state experiments. Finally, we have acquired a 125 mm 5T magnet with a sweep coil for extended high field EPR experiments.

EDUCATION AND PERSONNEL

The Laboratory contributes to undergraduate education by participation in the Undergraduate Research Opportunities Program (UROP) a program that encourages and supports research-based intellectual collaborations of MIT undergraduates with Institute faculty and research staff. In addition the laboratory has 35 full time graduate and 10 postdoctoral students who are performing research.

FUTURE PLANS

Plans are continuing 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 senior faculty members in the area of functional MRI, and the FBML Director is working closely with HST faculty toward the recruitment of renowned individuals in this field.

A comprehensive proposal submitted in 1995 awaits action by the NSF. If the proposal is funded the Operations group previously employed at the Laboratory would be rehired along with several new hires. The motor-generators would be replaced by a thyristor power supply and new magnets would be built to reach 40 T.

A proposal to the NIH for the development of very high field, wide bore NMR magnets also awaits a decision. If funded, the Technology Group would pursue the program for three years.

Robert G. Griffin
John E.C. Williams

HAYSTACK OBSERVATORY

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 11 educational and research institutions in the northeast (Boston University, Brandeis University, Dartmouth College, Harvard University, Harvard-Smithsonian Center for Astrophysics, MIT, State University of New York at Stony Brook, Tufts University, University of Massachusetts, University of New Hampshire, and Yale University.) The Observatory receives financial support primarily from 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 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; and 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. The radar is operated in conjunction with an optical observatory to measure airglow emission and determine upper atmospheric winds.

Highlights of the radio astronomy program using the 37m-diameter radio telescope in the past year include the detailed observations of the speed of gravitational infall in dense molecular clouds which is fundamental to the star formation process. Due to the high spectral and angular resolution of the upgraded Haystack radio telescope at millimeter wavelengths, observations of the spectral shape of tracer molecules such as C_3H_2 and H_2CO and CS have allowed Dr. Philip Myers and colleagues at the Harvard-Smithsonian Center for Astrophysics to determine the infall rates in different core types such as embedded clusters, isolated protostars and starless cores. MIT Professor Jacqueline Hewitt and nine graduate and undergraduate students utilized the telescope to search for radio emission at 35 GHz from gamma-ray bursts in order to clarify their emission mechanisms, improve their position determination, and measure their distance. The search was conducted over a two week period without detection of new radio sources at the 1-sigma emission limit of 0.5 Jy. This search is expected to be continued when MIT's High Energy Transients Experiment (HETE) satellite is launched. HETE is expected to provide improved positional accuracies of the gamma-ray bursts which will facilitate the radio observations at Haystack.

During the past observing season, a total of 38 observing projects were conducted at Haystack by members of the astronomical community, including 12 graduate students. A majority of the observing projects were carried out in the 85–115 GHz frequency range which takes advantage of the newly-upgraded telescope, and were conducted successfully using the recently installed digital servo control system and a renovated console that allows future connection to the Internet for remote control of the telescope. Our plans are to continue the automation of the radio telescope for remote operation, and to encourage its utilization by undergraduates for research. Through radio astronomical observations with the Haystack telescope and a smaller 3m-telescope that can be constructed and installed at small colleges, we believe that we can contribute to our national goal to strengthen the linkage between undergraduate education and research.

During the past year, we have completed conceptual studies for the installation of a new surface on the Haystack antenna that will enhance the aperture efficiency of the radio telescope at frequencies of 100–150 GHz. The surface will consist of lightweight panels that are aligned using actuators, and a laser measurement system that determines the distortions from a parabolic surface. Efficiencies of 45% are expected from the new antenna, roughly 3 times better than can be achieved at present, and telescope operations will be possible under all thermal conditions. Applications in radio astronomy and planetary radar research will benefit from such a capability at Haystack. These studies have been conducted in collaboration with Lincoln Laboratory which is pursuing radar projects at 35 and 95 GHz using the improved antenna surface.

In VLBI applied to astronomical observations at 3mm-wavelength, the Coordinated Millimeter-VLBI Array (CMVA) which has been organized under MIT Haystack's leadership has begun successful formal operations. Ten radio telescopes, globally distributed in the US, Europe, and South America, have participated in 12 experiments during the past year, which have yielded images of quasars with a resolution of 50 μ arcsec. A survey of sources available for such imaging has been completed, and observations of the center of our galaxy have been made. Haystack has been responsible for the coordination and planning of the observations at the various telescopes, technical improvements at the participating telescopes, processing of observations on the Mark IIIA correlator at the Observatory, development of post-processing software, and scientific analysis of some of the observations.

Work has continued during the past year on VLBI technological developments, both in high data rate recording and in high speed data processing. Thin-film recording head-arrays are being developed by Seagate Tape Technology Division for application to VLBI and the interface electronics design has been initiated at Haystack. These head-arrays will enable magnetic tape recording at rates in excess of 2 Gb/s and high data storage capacity (1 TB) at a much reduced cost compared to the present ferrite headstacks. In data processing, the VLSI chip designed specially for the advanced VLBI correlator, the Mark IV system, has been successfully produced in large quantities, and the correlator boards that utilize these chips have been fully tested and are in the production phase. Several correlators will utilize this design for national and international programs. This includes the NASA/GSFC geodesy program, the US Naval Observatory time services program in Washington, DC, the Smithsonian Institution Submillimeter-Array project, the Joint Institute for VLBI in Europe for astronomical data processing, the Netherlands Westerbork array, and the Institute of Applied Geodesy for data processing at the Max Planck Institute in Bonn, Germany.

Our VLBI research program has resulted in a spin-off that is beneficial to the nation, namely a system that can provide the accurate location of a cellular phone issuing a 911 emergency call. Under the sponsorship of the Associated Group, Inc., a system based on precise range determination using the time delay of signals received at various cellular sites has been designed and tested in the city of Philadelphia and elsewhere. The most challenging aspect of this application has been the accounting for multipath effects in order to realize location accuracies in the 200m range. At present, production systems are in development by industry for implementation, while Haystack engineers are examining the application of such a location system to digital cellular phones.

In our atmospheric science research program at Millstone Hill, the prime emphasis has continued on the specification of the coupling of the Earth's upper atmosphere with the lower atmosphere through tidal wave propagation from the stratosphere and mesosphere. Measurements of tidal wave parameters in experiments involving as many as 15 radars distributed globally have been conducted to characterize these oscillations and to calibrate general circulation models. The Observatory's atmospheric sciences group has continued to lead studies of the effects of geomagnetic storms on the earth's ionosphere, with particular emphasis on "space weather" phenomena caused by coronal mass ejections on the sun that propagate in the solar wind and perturb the earth's upper atmosphere. These effects result in communication problems, satellite orbital changes, and ground induced currents, and the prediction of these effects is the subject of a newly-formed National Space Weather Program.

In our optical aeronomy program, the effort has been concentrated on observing winds from nighttime airglow spectra measured using Fabry-Perot Interferometry at the oxygen and hydroxyl lines in the 85–100 km altitude region, and at the oxygen line above 250 km at night and in the daytime. Most recently, a 24 watt Nd-Yag laser has been installed at the Lincoln Laboratory Firepond 1.2m telescope to observe Rayleigh scatter from the mesosphere and stratosphere, in collaboration with Clemson University. The objective is to measure density and temperature at 30–100 km altitude, in order to characterize the inversion layers that are seen in the mesosphere and investigate their relationship to tidal wave variability observed with the Millstone Hill radar at higher altitudes.

Finally, our graduate and undergraduate educational programs have continued successfully during the past year. In addition to students using the Haystack instrumentation for observing projects, an undergraduate summer internship program involving 13 students has been conducted this year. The students are provided with research experiences and mentored by our staff. In addition, our Young Scholars program aimed at pre-college outreach involves 56 students and four science teachers from the local area in a three-week summer program. This will be followed by individual student projects and special mentorship by our staff during the academic year.

Joseph E. Salah

NUCLEAR REACTOR LABORATORY

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 cancer therapy, nuclear engineering, computer control of reactors, training in reactor operations, dose reduction and materials performance in power reactors, and radio-chemistry and trace analysis applied to the health effects from energy use, nutrition, earth and planetary sciences, archeology, environmental studies, and nuclear medicine. Plans are in progress for an upgrade of MITR to 10 MW. Engineering studies have indicated that the current core design will allow doubling of the reactor's power with relatively minor changes to the heat removal systems. The license extension to 1999 will provide ample time to finalize plans for an upgrade and submission of a relicensing document.

Especially noteworthy developments were the successful initiation of a multiple specimen, actively loaded in-core test for stress corrosion cracking studies of cold-worked stainless steels for BWR application and the continued program in joint research with New England Deaconess Hospital on the treatment of cancer utilizing the boron neutron capture method. The clinical trials of boron neutron capture therapy were continued successfully with no observed toxicity and with clear indications of tumor regression in several cases.

NEUTRON BEAM TUBE RESEARCH

The prompt gamma neutron activation analysis facility was used both for research and in support of the neutron capture therapy clinical trials. A new initiative in neutron beam tube research has been initiated and, as a first step, neutron reflectometry will be developed by a faculty team headed by Professor X.-L. Zhou in Nuclear Engineering.

ENVIRONMENTAL RESEARCH AND RADIOCHEMISTRY

Professor Frederick A. Frey, Department of Earth, Atmospheric, and Planetary Sciences, and Dr. Pillalamarri Ila operate a Neutron Activation Analysis Facility dedicated to determining the abundance of trace elements in natural materials. During the past year their research has focused on lavas erupted during the 115 Million year history of the Kerguelen Mantle plume which has been a major control in forming the oceanic crust of the eastern Indian Ocean. Many of the studied lavas are submarine and they have been recovered by the Ocean Drilling Program. A major drilling program on the Kerguelen Plateau is anticipated in 1998.

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 following: Brandies University, California Institute of Technology. Commercial organizations that utilized the NAA expertise of NRL during the past year were Physical Sciences Inc., Andover, Massachusetts; the Empire State Electric Energy Research Corporation (ESEERCO), New York; the Electric Power Research Institute (EPRI), Palo Alto, California; CARNOT, Tustin, California; Florida Power and Light, Florida, RTP Environmental Assoc., Inc., Westbury, New York.

Within MIT, research support has been provided to several departments. This research support includes: identification of possible inorganic catalyst contamination for Cogeneration Project, analysis of ultrahigh molecular weight polyethylene for Professor E. W. Merrill (Department of Chemical Engineering) to search for elements that may cause broad signal in electron spin resonance experiments; doing sediment analysis for Dr. Richard Lanza (Department of Nuclear Engineering); 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 fish tissue 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 is completed.

The study of the fate of mercury in the environment (ESEERCO, \$600,000/three years) is completed.

Major collaborative effort to provide basic scientific information that will serve air quality management in the eastern United States is continued. Three Ph.D.'s and one Master Thesis were completed.

Course, 22.78 Nuclear Techniques in Environmental Analysis, was offered by Dr. I. Olmez. There are currently two Ph.D. candidates (Nuclear Engineering Department and Chemical Engineering) and a master student from Center for Environmental Health Sciences 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

Clinical trials of boron neutron capture therapy for cancer were successfully continued up to the second dose level of 1250 RBE-cGy. No adverse reactions have been observed on the subjects. However, two out of three of the lowest dose irradiations of deep seated melanoma have resulted in significant tumor regression. All approvals for initiation of Phase One studies of brain cancer were obtained and these irradiations will start shortly.

A new high intensity and low background epithermal neutron beam has been designed for the MITR-II. The design is based on using spent fuel from the MITR-II in a fission converter concept. This beam would be able to irradiate patients in several minutes and would be suited for advanced clinical trials and routine therapy involving treatment of many patients per day.

BNCT research at the MIT Research Reactor, is under the direction of Professor Otto K. Harling and is carried out in collaboration with medical staff at the New England Deaconess 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. Research topics and support for Health Physics Students were provided by NRL projects especially the BNCT and Dose Reduction Projects of Professor Otto K. Harling.

DOSE REDUCTION AND COOLANT CHEMISTRY STUDIES FOR NUCLEAR POWER REACTORS

Evaluation of the basic mechanisms of zinc injection effects on PWR corrosion continued with funding from the French Center of Energy Atomique.

IRRADIATION-ASSISTED STRESS CORROSION CRACKING (IASCC)

A multiple specimen, constant load test facility was constructed and put into operation. This facility loads ten specimens in an autoclave at BWR conditions. Five specimens are in-core and five are immediately above core. Testing of the remaining specimen can continue after specimen breakage. A program of testing using this facility to study the problem of BWR core shroud cracking is in progress with funding from the Tokyo Electric Power Company and EPRI. This work is under the direction of Dr. Gordon E. Kohse and involves Professor Ronald G. Ballinger and Professor Otto K. Harling as well as several graduate research students.

SENSOR PROJECT

Instrumental crack growth specimen irradiated last year have been removed from the reactor core tank and are being prepared for shipment to the GE Vallecitos Nuclear Center for post-irradiation evaluation.

MITR RELICENSING AND REDESIGN

With funding from MIT, efforts to examine options for upgrading the MITR have continued. A senior Nuclear Engineering professor, several research staff, and several graduate students were involved in this effort during the last year. An increase in power to 10 MW from the current 5 MW appears feasible with relatively minor changes to the current heat removal systems. Studies on the thermal-hydraulic behavior of such an upgraded reactor were recently completed. These established a method for generating the appropriate safety limits. This work is directed by Dr. John A. Bernard, Director Reactor Operations at NRL.

A new nuclear safety system, capable of 10 MW operation, has been purchased and is being installed.

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. David Slaughter of the University of Utah using track etching techniques to determine the uptake pattern of heavy metals by human as well as the environment; 4) evaluation of copper and gold for arthritis treatments by Dr. Alan B. Packard of Children's Hospital; and 5) study of neutronic behavior of acrylic rods doped with boron and lithium for use in neutron monitoring devices by Dr. John Doyle of Harvard University.

In a number of other areas reactor irradiations and services were also performed for research groups outside MIT. Most of these represent continuations of previous research: 1) Dr. Alan P. Fleer of Woods Hole Oceanographic Institute used irradiation to determine natural actinides and plutonium in marine sediments; 2) Dr. Robert Kaiser of Entropic Systems, Inc., is studying the irradiation of fluorinated oils, (3) Mr. Leonard Cirignano of Radiation Monitoring Devices, Inc., is investigating the effects of irradiation on liquid crystals; 4) Mr. David Paquette of the SAIC is investigating calibration of ultra-sensitive neutron monitoring devices by thermal neutron fission of uranium foils; 5) Dr. Gerjian P. Van Bakel of Northwestern University is studying neutron damage of Ni-Al alloys; 6) Dr. Fitzgerald of the University of Connecticut at Storrs evaluated air samples for mercury; and 7) Dr. Xiao-Lun Wu of University of Pittsburgh used fresh D₂O to perform small-angle scattering experiment. The D₂O was provided by the NRL and the experiment was performed at NIST. 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 not-for-profit institutions (including teaching hospitals and middle and high schools). Under this program 500 students and 64 faculty and staff from over 35 other educational institutions benefited from visits to and use of the MITR during the past year.

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 United States; 2) irradiation of air particulate samples for NAA by Professor Gerald Koeler of the University of Michigan; 3) gamma irradiation of plant seeds for several area high school students participating in science fair projects; 4) measurements of boron concentration and work on high resolution track etch autoradiography for Professor Robert Zamenhof of New England Deaconess Hospital; 5) participation in several special high school student projects; 6) neutron activation analysis of subsurface water supplies by Professor Jack Beal at Fairfield University; and 7) neutron activation analysis of ice core samples by Professor Chester C. Langway, Jr., of the State University of New York at Buffalo.

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, 6 students, 3 visits.

MAJOR REACTOR SERVICES

A major project to neutron transmutation dope semiconductor grade silicon single crystals continued for a successful third year. Approximately 12 metric tons of Si crystals were accurately irradiated in shielded, automated irradiation facilities at the MITR-II. This project is under the technical direction of Professor Otto K. Harling.

AFFIRMATIVE ACTION

The NRL supports the affirmative action goals of the Massachusetts Institute of Technology. Of a staff of 35 there are currently four 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. Three women are currently in training to become licensed reactor operators.

MIT RESEARCH REACTOR

The MIT Reactor completed its 38th year of operation, its 22nd since the 1974-75 shutdown for upgrading and overhaul. The reactor originally operated on a Monday through Friday schedule. However, for the past several years the reactor has often 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 108 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 370,722 megawatt-hours at June 30, 1996. The MITR-I generated 250,445 MW in the sixteen 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. A modified version of the irradiation assisted stress corrosion cracking facility is installed and operating for long-term in-core irradiation. The number of specimen irradiations was 695. There were 16 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 1027 people toured the MIT Research Reactor during 1995.

Otto K. Harling

OPERATIONS RESEARCH CENTER

The Operations Research Center (ORC), established in 1953 as a first-of-a-kind interdepartmental graduate degree program, completed its 43rd year of operation in 1995-96. The Center administers its own graduate programs and a varied research program of methodological and applied projects. This report summarizes the Center's 1995-96 activities and briefly reviews its educational, research and outreach programs.

FACULTY, STUDENTS, STAFF

Thomas L. Magnanti, George Eastman Professor of Management Science, continued as Codirector of the Center. Robert M. Freund, Professor of Operations Research at the Sloan School of Management, served as Acting Codirector of the Center.

This year the ORC had 32 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, Nuclear Engineering, and Urban Studies and Planning.

The Operations Research Center offers two interdepartmental graduate degree programs, a Ph.D and a master's degree. During 1995-96, these programs enrolled 47 students — 33 Ph.D candidates and 14 SM candidates. The Center conferred 11 master's degrees and 10 Ph.D's. Several other Ph.D theses were in the final stages of completion in the summer of 1996.

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 among application and methodological domains.

This past year, as part of MIT's new master's degree program in Systems Design and Management, ORC faculty offered two of MIT's first distance learning courses (in Engineering Risk Benefit Analysis and in Systems Optimization), taught to company employees at eight sites. The faculty taught these courses interactively using compressed video technology.

By design this year, the Center admitted fewer students since the Center's faculty collectively felt that the student population had grown too large in comparison to current funding capabilities and space commitments.

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 linear, nonlinear, and combinatorial optimization, solution methods for integer programming, interior point methods for linear and nonlinear programming; cluster analysis; parallel and distributed computation and algorithms; network flow algorithms; network design; probabilistic combinatorial optimization; deterministic and stochastic facility location; queueing theory, including queueing networks; risk analysis, stochastic processes; classical and Bayesian statistics; and decision analysis and statistical decision theory.

ORC faculty are also currently contributing to application domains as wide ranging as manufacturing, communications, transportation, public services, logistics, marketing, financial services, health care, and nuclear engineering. Current projects are addressing such topics as air traffic control, epidemiology, AIDS testing; life-cycle modeling of municipal solid waste, criminal justice, safety and risk analysis in air transportation, telecommunication network design, supply chain management, production scheduling, and transportation logistics.

Several organizations sponsored research projects at the ORC during 1995-96, 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; MCI; MITRE Corporation; Office of Naval Research; 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.

The Center maintains a reading room with a small library and as well as a contemporary computational environment of workstations and micro computers.

The Center's graduate students are diverse: they represent over 26 countries and, in keeping with the Center's tradition of seeking and attracting outstanding women, the number of female students has consistently averaged about 25%. The Center's primary support staff — one administrative assistant and one administrative officer — are both women, one is 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.

The ORC faculty offered one professional course during the 1995 summer session: "Airport Systems: Strategic Planning and Detailed Design."

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: J. Pang (John Hopkins); M. Cohen (Wharton School); J. Bartholdi, III (Georgia Inst. of Tech); P. Jackson (Cornell); E. Kaplan (Yale); W. Jordan (General Motors); M. Daskin (Northwestern); S. Meyn (U. of Il); M. Fisher (Wharton School); B. Schmeiser (Purdue); D. Kirschner (Texas A&M); M. Harrison (Stanford); R. Garfinkel (U. of CT); J. Renegar (Cornell), P. Diaconis (Harvard); W. Cunningham (U. of Waterloo).

The Center also offered a program of activities during the January independent activities period, including a series of presentations on the practice of operations research and management science presented by S. Raghavan (U.S. West), Christopher Athaide (JP Morgan), and Rina Schneur (PTCG).

PROFESSIONAL ACTIVITIES

The ORC-affiliated faculty and students continue to assume positions of leadership and receive many awards within the Operations Research and Management Science Community. Professor Dimitris Bertsimas received the 1996 INFORMS Erlang Award for the outstanding probabilist under the age of 35. This is only the second time the Erlang Prize has been awarded, and the previous winner was Professor Lawrence Wein, also one of the Center's affiliated-faculty members. Professor Bertsimas and Michel Goemans were awarded the SIAM Activity Group on Optimization Prize, awarded to the author(s) of the most outstanding paper on a topic in optimization, published in a peer-reviewed journal in the calendar years 1992-1995. Thomas Magnanti received an honorary doctorate degree from Linköping University. Two ORC students (Georgia Mourtzinou and Chung-Piaw Teo) were among the five finalists in the INFORMS Nicholson student paper competition and an ORC graduate, S. Raghavan, received the INFORMS Dantzig Award for best doctoral dissertation in the practice of operations research within the last three years.

Robert M. Freund
Thomas L. Magnanti

PLASMA FUSION CENTER

The primary objective of the Plasma Fusion Center (PFC) 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 of the activities at the PFC has been to develop a scientific and engineering base for the development of fusion power. Nevertheless, nonfusion applications involving plasmas at the PFC 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 is recognized as the leading university laboratory in developing the scientific and engineering aspects of magnetic confinement fusion and related plasma science and technology. 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 compact high magnetic field, diverted plasmas), (b) the basic physics of energetic plasmas (plasma theory, theoretical support of ITER and IGNITOR, new confinement concepts, nonneutral plasmas, coherent EM wave generation, development of high-temperature plasma diagnostics, basic laboratory and ionospheric plasma physics experiments, and novel diagnostic of inertial fusion experiments), (c) a broad program of fusion technology and engineering development that addresses problems in several areas (e.g., magnetic systems, superconducting materials, fusion environmental and safety studies, advanced millimeter-wave sources, system studies of fusion reactors, including operational and technological requirements), and (d) a significant activity of environmental waste treatment using plasmas.

Approximately 30 percent of the Center's activities are associated with the Alcator C-Mod tokamak experiment, 40 percent with the research and development on superconducting magnet system components for future fusion devices (including substantial industrial subcontracts), and the remaining 30 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 Sciences. There are approximately 250 personnel associated with PFC research activities. These include: 18 faculty and senior academic staff, 49 graduate students and 15 undergraduate students, with participating faculty and students from Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Physics; 77 research scientists and engineers and 31 visiting scientists; 34 technical support personnel; and 26 administrative and support staff.

This was a turbulent year. As a result of major DOE-OFE budget cuts (33%) by Congress, the total funding of the Plasma Fusion Center decreased by about 25% and total staff and number of students were reduced from 305 to 250. These cuts threatened to terminate the Center's high-field tokamak, Alcator C-Mod. However, the project was ultimately saved and continued operation at a reduced budget (approximately a 38% reduction from the year before). A 15% reduction in staffing was necessary, but no graduate students or RAs were terminated. Because of prior year investments, the experiment operated with great success. Another project that did not fair well was our collaboration on the Tokamak Physics Experiment (TPX), to be built at Princeton. This project was terminated by Congress in 1995. Nearly all the termination costs were covered by DOE-OFES.

The 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 gyro-frequency. In the magnetics area, the PFC leads the US ITER-Home Team effort in an extensive, internationally coordinated program of superconducting magnet development leading to construction of magnets on a scale and at a performance level well beyond that of present-day experience. The funding of the magnet program remained strong in FY'96. Noteworthy in FY'96 was the startup of the Pulsed Test-Facility (or PTF), a \$2M superconducting magnet test facility built in the Nabisco Laboratory. In the area of millimeter wave RF source development, the gyrotron program was in danger of termination, but ultimately the MIT research activity was saved. The Varian/CPI (California) development program was cut significantly and may be terminated next year. MIT is acting as the DOE-OFES oversight monitor for this activity.

In the area of plasma treatment of contaminated soil and waste, the PFC has enjoyed considerable media success. There were numerous television broadcasts and newspaper articles on our results, including the visit of Jack Williams of WBZ (Channel 4) TV. We were pleased to learn that Drs. Daniel Cohn and Paul Woskov won another R&D 100 award for their invention of a microwave plasma emissions monitoring system.

Our theory program enjoyed considerable scientific success and a modest increase in funding was obtained this year. The basic experimental plasma physics program lost OFES funding, but it was countered with new funding from the

inertial fusion research activity through collaboration with Lawrence Livermore National Laboratory (LLNL) and the University of Rochester Institute of Laser Energetics (ILE).

ALCATOR DIVISION

The Alcator Division, led by Prof. Ian Hutchinson, carries out experimental research on Alcator C-Mod, a compact, high-performance, high magnetic field divertor tokamak devoted to investigating the physics of high temperature magnetically confined fusion grade plasmas. The total staff of the Alcator Project is about 95, including 16 full-time research physicists, 2 faculty members and 20 graduate students. In the past year a sustained campaign of experimentation was conducted during November 95 through March 96, during which a variety of important results were obtained, especially in the areas of divertor physics, radiofrequency heating, confinement, and disruption studies. The capabilities of the tokamak were further enhanced and its operating space was broadened. Details are outlined in the succeeding sections. These results were accomplished despite a significant funding reduction in FY'96 from \$16.2 M to \$10 M, which necessitated significant staff reductions, as well as reduced operations relative to the prior year.

Alcator C-Mod is now established as one of the three major U.S. tokamak facilities, along with DIII-D at General Atomics, San Diego, and TFTR at Princeton. It is also recognized as one of the five key divertor tokamaks in the world. Alcator C-Mod is the only diverted high-field compact experiment in operation, and therefore it plays a unique role in providing critical tests of confinement scaling and theory at high power density. Alcator C-Mod is thus extremely favorably placed to contribute vital information to fusion science research, and to do so in a highly cost effective way because of its compact approach. Because of its high power density, C-Mod will contribute uniquely to ways of achieving ignition at low cost, and of exploring advanced tokamak physics regimes. Its vertical plate divertor geometry has been adopted as the reference design for ITER, and its shape is essentially the same as that envisioned for ITER. It also is presently unique in having high-Z metallic plasma facing components. Such components are planned for ITER.

The unique capabilities of Alcator C-Mod were recognized by the Fusion Energy Sciences Advisory Committee (FESAC) in its report on *Restructuring the U.S. Fusion Program*, which recommended increased support to bring the C-MOD facility closer to "full, maximally productive utilization." According to this report, the program should maintain "Continued full utilization of DIII-D and C-Mod at least through 2001, including some upgrades, as user facilities to pursue the rich science to be gained." Although the level of support expected for C-MOD in the next funding cycle falls somewhat short of that consistent with the FESAC recommendation (the present Presidential funding projection is \$13.5 M at MIT), we are proceeding, to the extent possible, to exploit the scientific promise of this unique facility mostly through collaborations with the University of Texas (an additional \$1.1 M) and the Princeton Plasma Physics Laboratory (an additional \$0.6M). In essence, we are moving toward becoming a national resource for fusion science research.

OPERATIONS AND ENGINEERING SECTION

The operations and engineering section, led by Dr. James Irby, is comprised of more than 50 engineers, supervisors, and technicians. This group is responsible for operation and maintenance of the tokamak facility and also for most facility upgrades. We continue to make changes to the machine and power systems required to achieve higher plasma performance. During the last year, a boronization system was implemented which greatly improved the stored energy and impurity levels in our discharges. After an extensive modeling effort, changes were made to the outer divertor so that plasma currents of up to 1.5 MA at toroidal fields of 8 Tesla can be obtained during the next run campaign. We are now in the process of installing a prototype divertor cryopump that will provide better plasma density control. New tunable radio-frequency sources (40-80 MHz) are being brought on line to increase the versatility of our RF heating capability power levels. Depending on available funding, in FY'97 a diagnostic neutral beam will be installed to provide a new means of measuring, among other things, ion temperature, density fluctuations, and plasma current profiles.

Our alternator has undergone a complete inspection during the last year. This system provides approximately 250 MW of pulsed power to the magnets during a plasma discharge. Very detailed ultrasonic measurements of the flywheel, rotor, and bearings were made. In addition, high voltage tests of the windings were done to assure safe operation at 13.8 kV. The alternator is now back in operation and is being brought back up to full speed.

RF HEATING AND ADVANCED TOKAMAK SECTION

This section, led by Prof. Miklos Porkolab and Dr. Yuichi Takase, implements and analyzes plasma heating using radio frequency (RF) power, including investigation of advanced tokamak physics (ATP) scenarios.

Operational improvements implemented during the past year have increased the reliability of high power operation (up to 3.5 MW into the plasma) of the 4.0 MW (source power) 80 MHz RF heating system, which is essential for carrying out various elements of the Alcator C-Mod experimental program. Reliable coupling of RF power into a variety of plasmas including pellet injection, was achieved. High power heating of H-mode ("high-confinement") plasmas in the H minority regime (5.3T) produced impressive plasma parameters, approaching the MHD stability limit. Heating efficiency in low single-pass absorption schemes, including the ^3He minority heating scheme at 8T, was improved substantially by controlling the high-Z impurity influx using boronization of the first wall. Off-axis electron heating by ion Bernstein waves produced by mode conversion was demonstrated in D- ^3He plasmas at 8T. This mode of operation will provide the current profile control capability necessary for future advanced tokamak experiments. Particularly impressive advanced tokamak scenarios with high confinement and high beta have been predicted by numerical modeling. In collaboration with the Princeton Plasma Physics Laboratory, current drive studies are scheduled to start in 1997-98 using the new 40 MHz power (currently being installed).

PLASMA SECTION

The Plasma Section, led by Dr. Stephen Wolfe, is involved in advancing the understanding of the tokamak configuration in the areas of transport (coordinated by Dr. Martin Greenwald) and MHD physics (Dr. Robert Granetz), as well as for developing and implementing optimized control procedures for tokamak operation.

Improved H-mode confinement results were obtained after implementation of boronization for effective wall-conditioning, which reduced the level of core radiation during high-power ICRF heating. H-factors (the ratio of the energy confinement time relative to standard L-mode scaling) above two were obtained over a wide range of plasma parameters. This result is particularly significant because extrapolations from larger experiments had predicted much smaller H-mode confinement enhancements on C-Mod.

Experiments on the threshold conditions for the L-H transition have continued, leading to the observation that the threshold corresponds to a necessary condition on the magnitude of the edge electron temperature. For typical C-Mod conditions, with $B \approx 5$ Tesla, the transition occurs when the temperature at the 95% flux surface exceeds 150eV, and a reverse transition back to the L-mode happens when the temperature again falls below this value. Further experiments are planned to determine the underlying physics of H-Mode transition.

Analysis of the MHD stability properties of the high performance H-mode discharges indicates that the edge pressure gradients increase to approximately the so-called ideal "ballooning limit." The total "normalized" pressure reaches $b_N \approx 1.5$, about a factor of two below the expected b (b is the ratio of plasma pressure to magnetic field pressure, $b_N = b/(I/aB)$ where I is the plasma current, a is the minor radius, and B is the toroidal magnetic field) limit with optimized profile shape, but in the range where pressure-driven MHD modes may appear.

Studies of disruptions have continued, with special attention to halo currents, which flow partly in the plasma and partly through the conducting vessel. The ratio of halo current to plasma current has been shown to be proportional to $1/q$ (with $q = (B_T/B_P)(a/R)$, the "safety" factor). Toroidal asymmetries and rotation of the halo currents have been measured, and a correlation between halo currents and the occurrence of integral values of an effective rotational transform, including the current path through the wall, has been observed. Mitigation of disruption effects has been demonstrated using "killer pellets", or silver-doped plastic pellets which can dissipate most of the plasma kinetic and magnetic energy in a millisecond by means of radiation.

EXPERIMENTS SECTION

The experiments section, headed by Dr. Earl Marmor, is responsible for edge/divertor physics studies under the leadership of Dr. Bruce Lipschultz, and for the development of new plasma diagnostics. In the last 12 months, excellent progress has been made, both in terms of experimental capabilities and in divertor physics research. The achievement of high-power RF-heated H-mode plasmas with good energy confinement (reduced transport) has greatly expanded the operational space for edge studies. This type of operation has led to narrower profiles of parallel heat flow in the edge plasma with accompanying parallel heat flows which are reactor-like (500 MW/m^2 , higher than achieved elsewhere). The research has concentrated on reducing power flow to the divertor plates through volumetric loss processes (radiation and charge-exchange by gas puffing), while maintaining good core confinement and plasma purity. These experiments have been very successful, with reductions of the power flow to the material surfaces by about a factor of 10 as the plasma is "detached" from the divertor plates.

The study of edge characteristics has also included a thorough investigation of the transport of the majority species (deuterium) in the edge. The results of this study shows that the edge perpendicular thermal diffusivity increases

with increasing distance from the core plasma, and that the diffusivity drops by an order of magnitude when central plasma confinement increases after transition into H-Mode.

Experiments have also been performed to study impurity transport utilizing puffing of trace gases at different points around the plasma edge. These experiments have shown that for recycling gases, the impurity source location affects the probability of its penetration into the core plasma (as opposed to convecting into the divertor). These techniques have also been used to determine that impurities penetrate into the core plasma more easily after the plasma detaches from the divertor plates.

PHYSICS RESEARCH DIVISION

Headed by Prof. Miklos Porkolab, this Division seeks to develop a theoretical and experimental understanding of plasma physics and fusion science. Experimental work is carried out on smaller devices with more modest plasma parameters, or focuses on developing novel diagnostics for exploring new physics in large scale fusion devices. This Division is also a base for developing new confinement concepts, including "Proof of Principle" experiments, exploring inertial fusion energy, space plasma physics, and new physics applications of plasmas. In the past year the funding of this Division has remained relatively steady.

FUSION THEORY AND COMPUTATIONS

DIVERTOR AND EDGE PLASMA PHYSICS THEORY

The MIT Divertor Task Force (Dr. Dieter Sigmar and coworkers) through its leadership of the national tokamak plasma edge physics and divertor initiative, has focused on analytic and numerical edge plasma physics investigations. Observations from the Alcator C-Mod tokamak and other devices are used to develop an improved understanding of basic plasma physics phenomena. The goal of this effort is to find ways to divert the severe heat flux from the first wall while maintaining good plasma purity in present day experimental fusion devices, and ultimately in ITER. This group has developed the only neutral-plasma fluid code capable of modeling current tokamaks and fusion reactor relevant high density divertor regimes. During the past year, the code has successfully modeled the C-Mod experiment and highlights the crucial role of charged particle recombination in dense plasmas. In addition, a fully kinetic edge plasma code has been developed which is used to interpret more accurately probe measurements in present day experiments.

For most operating regimes of interest there is a wide variation in the neutral particle mean free path length. Current approaches using either Monte Carlo or Navier-Stokes numerical techniques cannot yet deliver an entirely satisfactory description of neutral transport in the entire edge plasma domain. Recently, the MIT edge physics group has assumed leadership in a national effort to build a plasma-neutral hybrid code that will allow all regimes of neutral collisionality (arbitrary mean free path) to be modeled. When finished, these new codes, as well as existing ones, will be employed to develop scaling laws capable of predicting fusion reactor performance based on present experimental results.

PLASMA RF THEORY GROUP

The RF Plasma Theory Group under the direction of Prof. Abraham Bers and Dr. Abhay K. Ram has been extending its studies on the mode conversion of fast Alfvén waves to ion-Bernstein waves to include the effect of poloidal mode numbers and of magnetic shear. These studies show that, in addition to the ion-ion hybrid resonance, there exists another resonance where the fast Alfvén wave loses some of its power. Detailed analytical and numerical analysis is ongoing to quantify the effect of this resonance on the mode conversion process. The same group has also continued its studies on the propagation and damping of ion-Bernstein waves in tokamaks. It has been found that the ion-Bernstein waves can be used to drive currents in plasmas provided that the magnitude of the parallel (to the magnetic field) wave numbers at mode conversion are below a critical value. This critical value has been determined numerically. Finally, the group has been investigating a mode conversion scenario for electron cyclotron heating and current drive in spherical tokamaks. Here the extraordinary mode of the electron cyclotron wave can couple to the electron-Bernstein wave at the upper-hybrid resonance. The previous expertise on mode conversion analysis is being extended to this high frequency regime.

HIGH ENERGY PLASMA THEORY GROUP

The research program of the Physics of High Energy Plasmas (PHEP), under the leadership of Prof. Bruno Coppi, is concerned with the theoretical study of magnetically confined plasmas in regimes of relevance to present day advanced experiments, as well as the proposal and planning of new experiments directed towards the study of fusion burning plasmas. The recent redirection of the U.S. fusion program toward developing the basic science of fusion plasmas, as well as innovative concepts, brings the activities of this group (PHEP) directly into line with the mainstream goals of the new national program.

The PHEP group has been the first to undertake the proposal and the study of magnetically confined ignition experiments, taking a leading role in the development of both their physics and engineering. The Ignitor experiment was the first proposed (originally in 1975) ignition experiment in the world. It has become increasingly clear that the most suitable and cost effective type of experiment to pursue the goal of ignition is the line of machines that operate at high magnetic field, employing cryogenic normal conducting magnets, which this group has pioneered, such as the Alcator series of experiments at MIT, the FT machines at Frascati, Italy, and the ignition experiment "Ignitor" in Italy.

This group has also maintained a pioneering role in developing the theory of high temperature plasmas. Of note are the region of second stability for finite pressure plasmas, the principle of profile consistency of the electron temperature, the degradation of energy confinement by ion temperature gradient driven modes, the isotopic effect on the confinement time, the existence of impurity-driven modes localized at the plasma edge, the stabilization of sawteeth by energetic particles, and the time dependent path to ignition in magnetically confined plasmas.

The ideas concerning transport processes in high temperature plasmas and the fact that it can be nonlocal in nature, as indicated for example by the principle of profile (temperature) consistency, have been confirmed by different experiments around the world. These concepts now form the basis of several widely adopted approaches to the theory of plasma transport. Many of the ideas that the PHEP group has proposed in the 1970's, including the toroidal ion temperature gradient driven (or ITG) modes, have been incorporated recently in sophisticated codes that have been used successfully to interpret present experiments.

ADVANCED TOKAMAK PHYSICS AND MHD STABILITY THEORY

In this effort, under the leadership of Drs. Paul Bonoli, Jay Kesner, Jesus Ramos, and Profs. Jeffrey Freidberg and Miklos Porkolab, a state of the art simulation code has been developed to compute self-consistent MHD equilibria in the presence of non-inductively driven currents. Such studies are of great importance to the C-Mod program since they offer a means to improve tokamak performance, ultimately leading to a more attractive steady state tokamak reactor. This code has been coupled to an MHD stability code at Princeton in collaboration with Dr. C. Kessel. This combined model has been used to demonstrate the feasibility of achieving MHD stable operating modes in Alcator C-Mod near the beta limit. These so-called advanced tokamak operating modes are characterized by relatively high fractions of non-inductive bootstrap current (approximately 75%) and non-monotonic ("reversed shear") profiles of the safety factor. Such profiles are believed to improve tokamak stability and particle and energy confinement. The current profile control required to maintain these equilibria may be achieved through a combination of on-axis fast wave current drive and off-axis lower hybrid current drive. A reverse shear mode of operation at high bootstrap current fraction and moderate plasma current for the ITER device was also developed. Again the necessary current profile control is accomplished through a combination of off axis lower hybrid current drive and on-axis fast wave drive (or neutral beam injection).

Some of these codes were also used to analyze ICRF heating experiments in Alcator C-Mod in which off-axis electron heating via mode converted ion Bernstein waves (IBW) have been observed. Detailed comparisons have been made between the model predictions for RF electron power dissipation and the RF power densities inferred experimentally via RF power modulation technique. The implications of the off-axis electron heating for current drive via the mode converted IBW were also examined. Preliminary estimates indicate that significant RF current (up to 200 kA) can be generated in Alcator C-Mod, thus providing another means to achieve current profile control and advanced tokamak operation.

Tokamaks operating in a mode in which the current is mostly sustained by bootstrap current tend to naturally form reversed shear profiles. For a fixed heating profile the improved core confinement will cause the pressure profile to peak, which effects the equilibrium through the bootstrap current term. It has been shown that steady state equilibria do not, in general, exist for tokamaks with a high bootstrap current fraction and enhanced confinement in the reversed shear region, unless the following conditions are satisfied: (1) an additional stabilizing mechanism is utilized (for example flow shear) to create a region of reduced transport which can exceed the size of the region of reversed shear and, (2) the bootstrap fraction is reduced and non-inductive current drive is utilized to maintain a reversed shear current profile of substantial size.

PLASMA THEORY APPLIED TO SUPERCONDUCTORS

Professor Jeffrey Freidberg and Dr. Ali Shajii have explored the possibility of applying plasma theory techniques to a class of fluid flow problems in superconducting technology. As a result of these studies, the following discoveries were made: (a) A new class of low Mach number discontinuous fluid flows was developed. The flows are similar to "standard" contact discontinuities except that they are strongly modified by the presence of a metallic wall. The wall

not only introduces new velocity jumps into the flow, but produces a thermal drag that can stabilize the flow against Rayleigh-Taylor instabilities which always destroy the structure of the "standard" contact discontinuity. This phenomena is important in understanding the propagation of a quench in large, superconducting, fusion magnets. (b) A new theoretical model describing low Mach number compressible flow was developed. Such flows occur in long superconducting cables used for fusion magnets. A surprising result is that when sufficient external heat is supplied to the fluid, the flow direction actual reverses against the direction of the pumping pressure. This phenomena has been observed experimentally and cannot occur in an incompressible fluid. (c) A theoretical explanation of the phenomenon, "thermal hydraulic quenchback," was developed.

PLASMA PHYSICS EXPERIMENTS

PHASE CONTRAST IMAGING ON DIII-D

The PFC has collaborated for the past several years with General Atomics, in San Diego, California, on turbulence studies in the DIII-D tokamak. Mr. Stefano Coda, a graduate student in the Physics Department under the direction of Professor Porkolab, carried out his Ph.D. thesis research on location at General Atomics. The project consisted of the development and operation of a novel diagnostic apparatus, a CO₂-laser phase-contrast imaging (PCI) system, which provides detailed measurements of the density fluctuations at the tokamak edge with excellent sensitivity and fine spatial and temporal resolution. The chief motivation for this undertaking has been the need for a more accurate characterization of the turbulence spectrum in the edge region, especially in the long (several-cm) wavelength range which is believed to have a strong influence on energy transport. A similar PCI system is now being developed at the PFC and will be installed on the Alcator C-Mod tokamak, where it will be employed both to investigate turbulence and to carry out a novel study of externally launched radio-frequency waves in the plasma.

Thorough studies of the properties of edge turbulence in various heating and confinement regimes have been carried out in the course of this project. In the past year, particular attention was devoted to the fine-scale correlation characteristics of the fluctuations, especially to the rapid change in the correlation length that accompanies the transition from the low (L) to the high (H) confinement mode. The reduced correlation length was shown to be correlated with the reduction in transport, resulting in improved confinement. In addition, the leading theory of the H-mode, which relates the modification in the turbulence spectrum to an increased shear in the plasma rotation velocity, has been confirmed quantitatively for the first time. The novel observation of the existence of radially propagating spectra has also been found to be in agreement with recent analytical and numerical work on the global structure of a class of plasma instabilities (ITG modes) that are considered to be a dominant component of transport-enhancing turbulence.

The PCI system has also been successfully employed to investigate the nature of semi-periodic edge instabilities known as ELMs (edge localized modes). These modes, if properly controlled, will be essential to the operation of a future reactor, as they serve the dual purpose of ejecting deleterious impurities from the plasma and of regulating the plasma energy content in a stable steady state. In spite of their importance, the experimental and theoretical understanding of ELMs is still in its infancy. We have been able to shed new light on these phenomena by characterizing their spectral content and temporal evolution, and by determining systematic differences between some of the known subclasses of ELMs.

INERTIAL FUSION DIAGNOSTIC DEVELOPMENT

This program, under the leadership of Dr. Richard Petrasso, is the key element of our participation in inertial fusion energy (IFE) research. The National Ignition Facility (NIF), currently under design, would be the center of inertial fusion research in the U.S. in the next several decades. With colleagues at the Lawrence Livermore National Laboratory and at the University of Rochester, our group at the PFC has written an article on the "Science On The NIF," a document which explores the unique opportunities for the exploration of new science on NIF. For example, in the NIF experiments, we expect to achieve densities and temperatures of 1000g/cm³ and 100,000,000^o K. At these conditions we can, for the first time, study fusion energy reactions under conditions similar to that found in the center of stars. Equally important and interesting, the pressures we will achieve are some 1,000 billion atmospheres. To put this in some perspective, the pressure at ocean bottom is about 1000 atmospheres; at earth's center, a few million; and at the center of the sun, 100 billion atmospheres.

A second major project has focused on the development of novel diagnostics for the NIF. Because of the extraordinary densities, current diagnostics will be ineffective. We recently submitted to Physical Review Letters a scientific paper which proposes the utilization of energetic 31 MeV protons, generated within the NIF capsule, to diagnose both the implosion symmetry and core capsule conditions.

A third major effort involves the building of novel charged-particle spectrometers for both the NOVA and OMEGA laser fusion facilities at Lawrence Livermore and the University of Rochester, respectively. These spectrometers exploit the properties of CCDs to measure very accurately the energy of protons, deuterons, and tritons that are emitted during the implosion process. From the flux and energy of these charged particles, important physics information can be gleaned about the dynamics of the implosion process. This will be the first time such spectrometers have been fielded on inertial fusion experiments. This proposal is based on the favorable experimental results we obtained in our laboratory at MIT during the past year (see last year's President's Report).

IONOSPHERIC PLASMA RESEARCH

The PFC Ionospheric Plasma Research Group (Prof. Min-Chang Lee, Visiting Professor and students) has been conducting experiments on RF (radio-frequency) wave excitation and interaction with magnetized plasmas on the Versatile Toroidal Facility (VTF). They have successfully reproduced the intriguing spectra of radio wave-induced Langmuir waves observed at Arecibo, Puerto Rico. The results of VTF experiments support a theory developed by Prof. Min-Chang Lee and coworkers that the frequency-downshifted (cascading) spectrum of Langmuir waves is produced by the parametric decay instability (PDI), while the frequency-upshifted spectrum results from the nonlinear interactions of PDI-excited Langmuir waves with pre-existing lower hybrid waves. In collaboration with the Air Force Phillips Laboratory, Arecibo Observatory/Cornell University and Stanford Research Institute (SRI), the PFC's Arecibo experiments using the NSF's newly upgraded radar and HF heater have been scheduled in September, 1996 and January, 1997. These experiments are aimed at investigating ionospheric plasma turbulence and its effects on radio communications and space weather. A Ph.D. student, Dan Moriarty, recently completed his Ph.D. dissertation entitled *Laboratory Studies of Ionospheric Plasma Processes with the Versatile Toroidal Facility (VTF)*. Following Dan Moriarty's work, several graduate students and UROP students will continue the research on laboratory simulation of RF suppression or enhancement of ionospheric plasma turbulence.

NEW INITIATIVES

PLASMA CONFINEMENT IN COMET-SHAPED TOKAMAKS AND IN A LEVITATED DIPOLE

Dr. Jay Kesner and Prof. Miklos Porkolab have submitted a proposal to DOE to test a new tokamak confinement approach: a cross-section shaping that features an oblate plasma with negative triangularity which leads to a comet shaped cross-section. It has been suggested [R. Miller, M.S. Chu, R. Dominguez, T. Ohkawa, Comments Plasma Phys. Controlled Fusion, 12, 125 (1989)] that this shaping would reduce or reverse the curvature driven precessional drift of ions and electrons and is therefore expected to improve confinement with respect to these modes. This proposal was favorably reviewed but due to lack of funds was not funded. Our group will continue to study theoretically the feasibility of a COMET shaped tokamak as a means to improve tokamak confinement.

It was suggested in 1987 by Hasegawa [Comm. Pl. Phys. & Cont. Fus, 1, (1987) 147.] that a levitated dipole might provide a considerably simpler confinement scheme for fusing plasmas. Dipole confinement is observed in nature (in the earth's and the jovian magnetospheres) and in fact this suggestion was based on an increasing understanding of magnetospheric confinement. Satellite measurements have shown that in magnetospheric plasmas the ratio of plasma pressure to magnetic field pressure (or beta) can exceed unity and the plasma appears to be relatively quiescent. Ultimately, the levitated dipole configuration would most likely be utilized at high betas for advanced fuels (D-D or D-³He). Conceptually, a dipole offers several potential improvements vis-a-vis a tokamak as a fusion reactor. It is inherently steady state and free of disruptions. Since the plasma is located outside of the coil the flux can be greatly expanded so as to reduce the divertor heat load. Current drive is not required as there are no non-inductive currents flowing. There are no particle drifts off from the flux surfaces and there are theoretical reasons to believe that confinement may be good, possibly close to irreducible minimum value (termed "classical"). This may be the "ultimate" alternate confinement concept. Potential problems include shielding of the floating superconducting ring from plasma and heat bombardment.

In the laboratory, the dipole confinement concept may be realized by levitating a superconducting coil in a large vacuum chamber, and forming a plasma in the magnetic configuration by RF (microwave) heating. Dr. Jay Kesner in collaboration with Columbia University scientists (Prof. Michael Maul) is exploring such a concept. A proposal may be prepared and submitted this fall to DOE-OFES, for building such a facility in the Nabisco Laboratory. Such a project may carry an annual budget of \$2 M, equally shared between MIT and Columbia University. This project will be oriented towards basic plasma physics and it is expected to include strong student involvement.

SMALL TOKAMAK AS SOURCE OF RADIATION FOR X-RAY LITHOGRAPHY AND MICROSCOPY

In the past year (July 1995 - June 1996) the Princeton - MIT team (Profs. Suckewer, Porkolab and coworkers) has performed several experiments on the Versator II Tokamak. The main goal of the experiments was to measure (a) the radiation near 13 nm and (b) the total radiation versus the injected gases like Ar, Kr and Se, as well as versus the

influx of C from the graphite rod introduced to a plasma. Initial measurements using a time integrated bolometer indicated, as expected, an increase of the emitted radiation with increasing density of low- and high-Z atoms in the hydrogen plasma. However, a deduction of quantitative values was difficult to make, owing to decreasing of the plasma duration time with increasing density of the highly radiating ions.

In order to perform more precise measurements, highly sensitive bolometers were introduced, which provided information about the time evolution of emitted radiation. Measurements of total radiation and radiation in a quite narrow spectral band (~1 nm) in the vicinity of 13 nm were performed using a multilayer mirror with maximum reflectivity at 13 nm and a A 1-filter for a cut-off flux of visible and VUV radiation to a detector. The plasma was viewed at a different height from the midplane. The radiation profile and its time evolution were in quite good agreement with the expectation, however the absolute value of radiation intensity at 13 nm was too high in comparison with the intensity of the total radiation. We suspect that some of the VUV radiation was not sufficiently absorbed by the A 1-filter. Therefore we have designed two new composed filters, which will be installed in the front of the multilayer mirror and the bolometer in a new series of experiments, the results of which will be a part of the proposal for design and construction of a small tokamak as a new source of radiation.

PLASMA TECHNOLOGY AND SYSTEMS DIVISION

This Division is headed by Dr. Daniel Cohn with Associate Division Head Dr. Paul Woskov. The main activity of this Division is to develop new plasma technologies which provides major improvements over existing technology. Particular emphasis is given to the development of new environmental technology.

RESEARCH HIGHLIGHTS

Capability for sensitive real-time monitoring of plutonium in an air stream was demonstrated using a microwave plasma spectrometer system. Laboratory tests were conducted at the Battelle Pacific Northwest National Laboratory at the Department of Energy (DOE) Hanford site. This capability is important for the DOE objectives of using thermal technologies to meet environmental remediation goals with acceptable environmental impact.

A plasmatron device for conversion of hydrocarbon fuels into hydrogen-rich gas was constructed, and initial tests were made at the PFC. The initial tests have shown that both methane and gasoline can be converted into hydrogen in compact devices without soot production.

The calibration and range of application of the microwave plasma air stream metals emission monitoring system have been significantly improved. The monitoring system is being prepared for use on an engineering-scale furnace which will be operated in a radioactive environment at Battelle Pacific Northwest National Laboratory. This furnace and the related monitoring technology is regarded as one of the leading efforts in the DOE program to treat mixed (radioactive and chemical) waste.

An evaluation of practical commercial application of the electron-beam generated cold plasma technology developed at the Plasma Fusion Center was prepared for the Department of Energy.

In the area of fusion plasma diagnostic development, alpha particle gyrotron scattering diagnostic measurements were carried out in the TFTR tokamak at the Princeton Plasma Physics Laboratory. The interpretation of these low-power experiments were hindered by non-thermal lower-hybrid wave emission. This experiment will be continued at high scattering power, using a gyrotron source at the Joint European Tokamak (JET). Personnel have already been transferred to Europe to prepare these experiments.

FUTURE PLANS

Future plans include participation in plasma vitrification tests at the Battelle Pacific Northwest National Laboratory facility which will use radioactive material. The Plasma Fusion Center will also implement the microwave plasma metals emission monitoring system and a millimeter wave pyrometer system for temperature measurements at the Battelle Pacific Northwest National Laboratory Facility.

At the PFC, new environmental diagnostics will be developed including a refractory material deterioration monitoring system. Meanwhile, more detailed experimental and theoretical studies will be made of plasma manufacturing of hydrogen.

HONORS AND AWARDS

An R&D 100 Award for the microwave plasma metals emission monitoring system was received in September 1995 at an Award Ceremony in Chicago. Paul P. Woskov and Daniel R. Cohn from the Plasma Fusion Center attended, along with collaborators Jeffrey E. Surma of Battelle Pacific Northwest National Laboratory and Charles H. Titus of

T & R Associates. This is the second consecutive year that the Plasma Technology and Systems Division has won and R&D 100 Award.

The microwave plasma metals emission monitoring system was also a finalist in the *Discover Magazine* Innovation Award competition. Paul P. Woskov, representing the Plasma Fusion Center group, attended the Award Ceremony in Orlando, Florida. Paul was one of seven finalists in the environmental area out of a starting field of about 500.

Three plasma-based environmental technologies developed at the Fusion Center were identified by Energy Secretary Hazel O'Leary as outstanding fusion spin-off applications at a Fusion Forum luncheon on Capitol Hill in May 1996.

TECHNOLOGY AND ENGINEERING DIVISION

The Technology and Engineering Division is headed by Drs. Joseph Minervini and Bruce Montgomery, 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. Funding for this Division remained relatively steady this year.

This year most of the Division's work continued to focus on magnetics R&D for the Department of Energy, Office of Fusion Energy Sciences supported next step tokamak project, the International Thermonuclear Experimental Reactor (ITER). Work on the U.S. Tokamak Physics Experiment (TPX) continued through September 30, 1995 at which point the project was canceled by the U.S. Congress. Some project termination costs (\$400k) allowed completion of reporting and documentation activities through December 1995, and paid for the severance pay of most of the engineers associated with TPX.

In-house research for ITER concentrates on superconductor development, subscale testing, and magnet design and analysis. Significant results have been obtained in understanding the stability limitations of fast ramping the superconducting coils, and an understanding of current distribution and crossover from strand to strand within a conductor is beginning. A new area of developing fiber optic instrumentation for superconducting coil diagnostics has continued with the highly successful tests of fiber optic sensors located in a subscale magnet coil and tested at the SULTAN facility at EPFL-CRPP in Switzerland. The test, called QUELL (quench in long lengths) was part of the ITER program, and all ITER parties contributed sensors. The MIT fiber optic sensors were the most successful and performed better than the conventional sensors also tested. The Pulse Test Facility (PTF), a new moderate-sized, test facility has been completed in the Nabisco Laboratories at a cost of \$2M, and will start testing large size superconductors and joints for ITER.

Prof. Ron Ballinger's Materials Science and Technology Group continues a new ITER task for detailed mechanical characterization of the superalloy Incoloy 908 which was initially developed in his laboratory for superconducting magnet applications. Results to date have removed many of the concerns of our ITER allies regarding the use of this material in the conduits for the ITER cable-in-conduit conductor.

Extensive collaboration with U.S. industries continued under the ITER program for fabrication of the U.S. contribution to the model coil program, including sub-contracts with Lockheed Martin, INCO Alloys International, Teledyne Wah Chang, and Intermagnetics General Corp., among others. As a cost-saving measure, a site has been leased in Hingham, MA where PFC engineers and technicians will perform a significant part of the coil fabrication, with the balance being subcontracted to several industries.

NEW INITIATIVES

Recent congressional actions on the fusion energy budget for next fiscal year indicate that a second reduction is likely. Although, at this time, the main ITER program funding appears secure, the Technology and Engineering Division has begun actively seeking new programs outside the Department of Energy supported fusion program. New initiatives have resulted in funding through INEL for a large scale, electromagnetic seismic simulator platform, and from the U.S. Navy for design and analysis of conductor types for a Superconducting Magnetic Energy Storage magnet system. The Basic Energy Sciences Department of South Korea has expressed interest in MIT, assisting them in the development of a new superconducting tokamak called StarX. Funding for this program will come through Princeton Plasma Physics Laboratory and a small contract (\$40 K) this year. Significantly greater funding may be available next year. This work takes place in conjunction with the Department of Energy under a recently signed U.S. - Korea bilateral research agreement. As StarX will be similar to TPX in scope and design, this is a good match to our relevant experience from the TPX and ITER programs. The Division also has active proposals in several other areas of magnet technology which are likely to result in near level personnel support into the next fiscal year.

In a new collaborative research project with Applied Science and Technology (ASTEX) of Woburn, MA, (Dr. Jay Kesner and Professor Kevin Wenzel at the PFC, and Larry Bourget and Xing Chen at ASTEX) graduate research assistant Khash Shadman is studying high-density plasma vapor deposition of metal oxide materials and metals. The goal of the metal oxide deposition is to develop and understand novel methods for fabricating high-temperature superconducting materials. The films will be deposited at laboratory facilities at ASTEX, and their electrical properties will be determined at the PFC.

WAVES AND BEAMS DIVISION

The Waves and Beams Division, headed by Dr. Richard Temkin, conducts research on novel sources of electromagnetic radiation and on the generation and acceleration of particle beams. This effort has experienced substantial budget cuts by OFES, mostly through a cut of the funding of the CPI/Varian effort (a subcontract through PFC, including monitoring responsibility). The MIT research effort was saved, including the salaries of the research staff.

GYROTRON RESEARCH

The gyrotron is a novel source of microwave, millimeter wave and submillimeter wave radiation. It uses a helical electron beam in a high magnetic field to generate radiation by stimulated emission at the electron cyclotron frequency. Gyrotrons are under development for electron cyclotron heating (ECH) of present day and future plasmas as well as 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 Dr. Kenneth Kreischer.

Research has concentrated on investigating the physics issues which affect the 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. We have completed the first phase of a program of research to demonstrate a high power, high frequency gyrotron suitable for application to the International Thermonuclear Experimental Reactor (ITER). A prototype experiment at MIT has been built and has met its first milestone: demonstration of a 1 MW power level gyrotron at a frequency of 170 GHz with an efficiency of over 35%. This was the first successful demonstration of a prototype 1 MW, 170 GHz gyrotron by any of the four parties in the ITER program. This work was carried out in collaboration with Communication and Power Industries Inc. (CPI, formerly a part of Varian), General Atomics, Univ. Wisconsin, Univ. Maryland and Lawrence Livermore National Lab. The MIT gyrotron group has the lead role in this effort. In the next phase of this work, we intend to demonstrate power output in a Gaussian free space mode. We also plan to study a depressed collector which can increase the gyrotron efficiency to over 70%.

A program of research is also underway to demonstrate a coaxial cavity gyrotron. This experiment is at 140 GHz in collaboration with Dr. Michael Read of Physical Sciences, Inc. of Alexandria, Virginia. The coaxial cavity gyrotron may be capable of higher power than conventional cavity gyrotrons, up to 3 MW. In 1995-6, this experiment was successfully operated at power levels of up to 1 MW. The power was limited by the focusing of the electron beam. Improvements to the gyrotron electron gun are planned to improve the focusing.

HIGH GRADIENT ACCELERATOR RESEARCH

The High Gradient Accelerator Group 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 17 GHz klystron power source will drive the electron gun. This electron beam can be directly applied to microwave generation experiments or it can be used as an injector into a 17 GHz, high gradient accelerator. This research supports the program to build new electron accelerators which can reach the TeV range of energies.

The RF gun experiment has been operated with a microsecond pulse length klystron source at power levels of 5 to 10 MW at 17.145 GHz. The power coupled into the electron gun was monitored using the forward and reflected microwave power. A stored field equivalent to an on-axis accelerating gradient as high as 150 MeV/m was obtained, a record high value. Work is also progressing on generating the required laser pulse for the photocathode. Laser operation has been significantly improved in the last year making the picosecond laser system reasonably reliable and useful. The laser 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.

Research is continuing on a high power, 17 GHz klystron in collaboration with Haimson Research Corp. of Palo Alto, CA. The klystron electron gun and the klystron cavities were built by Haimson Research. The klystron has previously demonstrated power levels of up to 26 MW in 1 μ s pulsed operation using a 560 kV, 95 A beam. These are record power levels for a relativistic klystron operating at such a high frequency in pulse lengths in the μ s range.

An efficiency as high as 51% was achieved. Work is continuing on optimizing the klystron performance and applying it to high gradient acceleration experiments. The klystron has been recently rebuilt by Haimson Research to eliminate parasitic microwave emission. Testing of the rebuilt source is now underway.

INTENSE BEAM THEORETICAL RESEARCH

This effort lead by Dr. Chiping Chen, has contributed very significantly to our understanding of coherent radiation generation and particle acceleration. Topics covered include coherent radiation sources (CARM, FEL, gyrotron, relativistic klystron, relativistic TWT), intense beam transport and beam halo formation, 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.

A new research program has been initiated by Dr. Chiping Chen on the topic of theoretical and computational investigation of periodically focused intense charged particle beams. This research will support the U. S. program to construct advanced accelerators for such applications as nuclear waste treatment, heavy ion fusion and free electron lasers. Research will explore self-field-induced nonlinear resonant and chaotic phenomena in intense charged particle beams.

EDUCATIONAL OUTREACH PROGRAMS

The Plasma Fusion Center has established an educational outreach program primarily focused on heightening the interest of K-12 students in scientific and technical subjects. The Mr. Magnet Program, headed by Technical Supervisor Paul Thomas, has been particularly successful. Mr. Magnet, with the help of a graduate student, brings a traveling demonstration on magnetism into local elementary schools, inspiring and exciting students with the chance to take part in hands-on experiments with magnets. He stresses that science is a valid pursuit for boys and girls. Over the past year he has worked with over 15,000 students. The PFC also seeks to educate students and the general public by conducting general tours of experiments being done here. Special "Outreach Days" are held twice a year, encouraging high school and middle school students from around Massachusetts to visit the PFC for a day of hands-on demonstrations and tours.

Given the success of "Mr. Magnet," we are exploring ways to raise additional funding for Mr. Paul Thomas. Until now he has been funded by Dr. Cohn's Division. Beginning this fall, we will fund him from other Divisions up to 25% of his time. However, given that he is booked up to 50% of his time with school visits, we need to find other sources of support (from schools, local industry, and possibly DOE), or his activities will have to be reduced from 50% to 25% of his time.

The PFC has also been involved in the Contemporary Physics Education Project (CPEP), a collaborative effort of fusion facilities around the U.S. The goal of this group is to create a fusion-oriented curriculum, along with supporting hands-on experiments and graphics, for use in high schools around the country. Mr. Paul Rivenberg has worked on the "Chart Committee" of this project, which has created a wall chart that will aid in the understanding of fusion.

FUSION FORUM DAYS IN CONGRESS

The Fusion Forum, held each year on Capitol Hill, is a community-wide effort to show Congress the goals of the national fusion program and its gains over the past year. Fusion fundamentals are also outlined to educate new Congressmen and staff members. In May 1996 Miklos Porkolab, Bruce Montgomery, Dan Cohn, Albe Dawson and Paul Rivenberg, together with Tobin Smith of the MIT Washington office participated in the Forum. An exhibit was brought to Washington to show 1) our K-12 educational outreach programs, 2) Alcator C-Mod and ITER magnetics accomplishments and 3) the PFC's plasma-science-based spin-off technologies, including hazardous waste remediation, microchip manufacture, and cutting tool plasma-spray coatings to increase surface hardness and tool life up to 100-fold at a very small cost increase. Videotapes, showing plasmas in the C-Mod vacuum chamber and internet control of the Alcator C-Mod tokamak, received considerable attention. The PFC also contributed to a special exhibit on the topic of superconductivity.

APPOINTMENTS AND PROMOTIONS

During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas:

Appointments include: Jennifer Crockett (Consortium of Financing Higher Education) appointed Assistant Fiscal Officer in the Fiscal Office.

Internal promotions in the Plasma Fusion Center during the past year include: Joanna Iwanow, promoted to Assistant Fiscal Office in the Fiscal Office; Sangkwon Jeong, promoted to Research Engineer-Experimental in the Fusion Technology and Engineering Division; Stephen Kochan, promoted to First Wall Engineer in the Alcator Division; Sergeui Kracheninnikov, promoted to Research Scientist-Theoretical, in the Physics Research Division; Joseph Minervini, promoted to Division Head in the Fusion Technology and Engineering Division; and Christopher Reddy, promoted to Magnet Cooling and Structural Engineer, in the Alcator Division.

The Plasma Fusion Center has also hosted 68 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: Phillip Borchard, M.S., Mechanical Engineering; Darren Garnier, Ph.D., Physics; James Gilmore, Ph.D. Nuclear Engineering; Ruxandra Golinescu, Ph.D., Nuclear Engineering; David Jablonski, Ph.D., Nuclear Engineering; Boris Lekakh, Ph.D., Nuclear Engineering; Hunwook Lim, Ph.D., Mechanical Engineering; Daniel Moriarty, Ph.D., Nuclear Engineering; Suzanne Murphy, M.S., Electrical Engineering and Computer Science; David Nelson, M.S., Mechanical Engineering; Artur Niemczewski, Ph.D., Nuclear Engineering; Todd Rider, Ph.D., Electrical Engineering and Computer Science; Ying Wang, Ph.D., Physics; and Mamoon Yunus, M.S., Mechanical Engineering. We take this opportunity to wish these graduates success in their future professional endeavors.

Miklos Porkolab

RESEARCH LABORATORY OF ELECTRONICS

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 1995 are briefly mentioned. The interested reader can obtain further information from RLE Progress Report No. 138, which describes research activities during calendar year 1995.

ELECTRONICS AND OPTICS MATERIALS AND FABRICATION

Professor Jesús del Alamo has been studying pseudomorphic high-electron mobility transistors. Special attention is paid to the electrostatic interaction of the device's source with its gate, which degrades the device's gate-to-drain breakdown voltage. These studies have led to new insight into the design and characterization of these devices, which permit high-voltage operation. Professor Clifton Fonstad has developed a unique process to fabricate complex monolithic optoelectronic integrated circuits. These circuits combine integrated light-emitting diodes and photodetectors with high-performance VLSI-density gallium arsenide electronic circuitry available from commercial sources. This new technology is being applied to components in fiber communications systems and infrared focal plane arrays, and raises the possibility of a portable digital ophthalmoscope.

QUANTUM-EFFECT DEVICES

Professor Marc Kastner continues to focus his research on the production of single-electron transistors that can operate at liquid nitrogen (or higher) temperatures using silicon. Operation of these transistors has already been achieved at temperatures of up to 20 K using conventional lithography. Considerably higher temperatures are expected with fine-line lithography and improved device design. Professor Patrick Lee has studied the behavior of two quantum dots connected in series. Additional charge to this structure can reside in either one of the two dots, resulting in a rich, resonant structure. He has found that transmission of current through the double quantum dots displays peaks as a function of gate voltage, and that the height of these peaks depends on temperature in a power law manner. A new x-ray mask alignment system called interferometric broadband imaging has been developed by Professor Henry Smith. Using this technique, mean misalignments as small as one-tenth of a nanometer can be reliably detected. He has also developed new techniques for spatial phase-locked electron-beam lithography on a global fiducial grid. This will enable commercial ULSI technology to move into the sub-100-nanometer domain, which will be needed in the 21st century.

OPTICS AND DEVICES

Professor James Fujimoto has developed new technology for *in vitro* optical imaging of human tissue. A new, high-resolution fast acquisition imaging instrument has been developed, which will be important for a variety of medical fields such as cardiology, urology, and gastroenterology. In these fields, the visualization of microscopic tissue morphology plays a role in the diagnosis and intervention of disease. Professor Hermann Haus has made substantial improvements to fiber-ring lasers that operate at the 1.54 micron wavelength. Having previously shown that the timing jitter can be attributed fully to fundamental quantum noise, he has demonstrated the lowest amplitude noise

and timing jitter ever observed in a mode-locked laser. Professor Qing Hu has built a micromachined millimeter-wave superconducting receiver and an uncooled bolometric detector. Both achieved performance that was comparable to the best sensors by using conventional waveguide technology. Professor Erich Ippen has developed a high-power femtosecond fiber laser that is attracting interest for applications in communication systems and in scientific instrumentation. It has already been patented and licensed for commercial use. He has also developed a new method to study ultrafast dynamics in semiconductor laser diodes, in addition to demonstrating all-optical wavelength shifting of picosecond pulse signals in semiconductor quantum well waveguides. This will be important for wavelength division multiplexed networks.

SURFACES AND INTERFACES

Professor Robert Birgeneau has been using x-ray diffraction techniques to study silicon surfaces miscut from the (111) orientation, up to 8 degrees towards the (112) orientation. This has revealed dynamical changes in the surface morphology that are reversible, and which can be controlled by the direction of current flow through the crystal. The ability to manipulate the morphology of silicon surfaces on a mesoscopic scale is directly relevant to silicon device fabrication.

CIRCUITS AND SYSTEMS

Professor Anantha Chandrakasan has demonstrated that embedding power supply control circuits into variable-load digital signal processing computation systems can significantly reduce energy consumption. The supply voltage and clock frequency are lowered during reduced computational workload periods. This can reduce power by more than a factor of five in some applications, when contrasted with conventional fixed-voltage systems. In addition, signal statistics can be exploited in order to further reduce power consumption in a variety of digital filter structures. A new low-bandwidth protocol for battery-operated multimedia terminals in a network environment has optimized the partitioning of computation between high-power remote servers and low-power portable systems. Professor Srinivas Devadas has provided several compiler optimizations that improve the quality and performance of embedded control software in mixed hardware-software systems. These results are helpful in exploring the architectural design space of digital signal processing systems. Professor John Wyatt, working with Dr. Joseph Rizzo of the Massachusetts Eye & Ear Infirmary and Harvard Medical School, has been working on the development of a microelectronic retinal implant device to restore useful vision to patients blinded by diseases of the outer retina (specifically, retinitis pigmentosa and macular degeneration). They have completed a large biocompatibility study in which five materials were placed in a rabbit's eye for one year, while the health of the retina and the eye was monitored. No damage to the eye was found from using these materials. In addition, a major *in vitro* study of the response of rabbit retinal ganglion cells to minute electrical stimulation was completed. This study will be essential to further development of the prosthetic device.

LANGUAGE, SPEECH, AND HEARING

SPEECH COMMUNICATION

Dr. Joseph Perkell has consolidated evidence from several projects that support a new theoretical overview of speech production. In this view, phonemic information is transmitted by the actions of neuromuscular synergisms, which are organized to achieve articulatory and acoustic goals. Acoustic goals are achieved through the use of an internal model of the relations between the articulatory commands and sound output. Auditory feedback is used to acquire and maintain the model, and to enable situation-dependent adjustments in several parameters that influence clarity and intelligibility. Dr. Stefanie Shattuck-Hufnagel has shown that intonational phrase structure influences the placement of pitch accents on different syllables within a word. She has demonstrated that word-initial vowels are more likely to be produced with glottalization (a rapid decrease of fundamental frequency) when they occur at the onset of a new intonational phrase or at a pitch accent. These results have been facilitated by the use of a large new prosodically labeled speech database. Professor Kenneth Stevens has studied the variability in speech sounds and words, depending on the speaker and on the context in which the sound or word is produced. Through an acoustic analysis of vowels, the range of characteristics that occur in the pattern of vocal-fold vibration among male and female speakers has revealed different attributes. This is important for the improved synthesis of female voices by computers.

SENSORY COMMUNICATION

Mr. Nathaniel Durlach has been studying human perception and sensory motor performance in the context of human-machine interfaces for teleoperators and virtual environments. Multimodal interactions have been character-

ized and modeled, and a theory of adaptation to altered perceptual cues associated with the use of such interfaces has been completed. Dr. Kenneth Salisbury, in collaboration with Dr. Mandayam Srinivasan, has developed new touch perception algorithms that enable robots to deduce contact conditions from simple force-sensing fingertips. Work continues on a new force-controllable multifinger hand and on planning algorithms that enable the hand to continuously reorient objects held in its fingertips. Dr. David Zeltzer has developed a new prototype virtual environment system for training the officer of the deck on a submarine. In this way, naval officers can learn this difficult task in a virtual environment, without the need to involve actual submarines in difficult docking situations.

AUDITORY PHYSIOLOGY

Dr. Donald Eddington and Mr. Joseph Tierney have developed a new sound processing system for use with cochlear implants. Qualitative assessment of this new system has been positive, and subjects have reported that the range of sounds (in loudness and pitch) is much greater with the new processor, and that their ability to understand speech is significantly improved. Professor Dennis Freeman has developed a computer microvision system that can measure nanometer motions of micrometer-sized targets. This system combines stroboscopic illumination with video microscopy in order to acquire sequences of stop-action images. Motions are determined directly from the video images using algorithms originally conceived for robot vision. This approach has been extended to the design and fabrication of microelectromechanical systems, which now allows frequency response in three dimensions to be accurately characterized.

FOCUS AREAS

ATOMIC, MOLECULAR, AND OPTICAL PHYSICS

Professor Wolfgang Ketterle has demonstrated the production of a Bose-Einstein condensate. He has shown that if sodium atoms are cooled below a critical temperature, they behave as a coherent matter wave. Work continues on splitting a condensate into two coherent halves that can then be made to interfere within the range of the de Broglie wavelength. This work will demonstrate the feasibility of an atom laser that could be used as a source of coherent matter waves. These atom sources are likely to replace conventional atomic beams in demanding applications such as atom interferometry, precision measurements, future atomic clocks, matter-wave microscopy, and the creation of microscopic structures by direct-write lithography. Professor Daniel Kleppner has developed a new form of spectroscopy to investigate the connections between quantum and classical mechanics, including the problem of quantum chaos. Professor David Pritchard has demonstrated that his new separated-beam atom interferometer is approximately as sensitive to rotations as commercially available laser gyroscopes. This work is promising for compact and ultraprecise gyroscopes.

PLASMA PHYSICS

Professor Abraham Bers has been studying the interaction of ionospheric ions with electrostatic waves in the upper auroral atmosphere. This study is being conducted in order to understand rocket observations which show thermal ionospheric oxygen and hydrogen ions are accelerated to gravitational escape energies by intense lower hybrid waves. These waves were found to be spatially localized to narrow regions that are perpendicular to the geomagnetic field. Professor Bruno Coppi has developed several techniques to study the physics of high-temperature plasmas. These include the degradation of energy confinement by ion temperature gradient-driven modes, the isotropic effect on plasma confinement time, the existence of impurity-driven modes that are localized at the plasma edge, and the time-dependent path to ignition in magnetically confined plasmas.

RADIO ASTRONOMY

Professor Jacqueline Hewitt is carrying out time-delay measurements in gravitational lens systems, thereby providing a measurement of linear distance in a high redshift system. This provides cosmographic information that constrains the values of the Hubble constant, the deceleration parameter, and the cosmological constant--all of which are parameters of the standard cosmological model. Dr. Philip Rosenkranz has studied techniques for the interpretation of measured, or simulated, microwave radiometer data in order to infer parameters describing the state of the atmosphere. These results indicate soundings comparable in accuracy and superior in timeliness to low or earth-orbit microwave instruments can be obtained.

DIGITAL SIGNAL PROCESSING

Professor Gregory Wornell has developed new multiscale models for fractal point processes. These are applied to the problems of modeling and managing data traffic in packet-switch communication networks. He has also intro-

duced new methods to efficiently exploit transmit diversity through large antenna arrays and wireless communication systems, such as cellular, personal communication, and broadcasting systems.

ADVANCED TELEVISION AND SIGNAL PROCESSING

Professor Jae Lim and his group have contributed to the design of the Grand Alliance's digital high-definition television system. This system has been judged to meet or exceed all test requirements, and is expected to serve as the basis for the United States' high-definition television standard for terrestrial broadcasting. Professor William Schreiber has completed the development of a new advanced television system for terrestrial broadcasting. The most important performance factors of the system are the efficient use of over-the-air spectrum, support for less expensive receivers for less demanding applications, and the existence of a practical transition scenario from the current terrestrial broadcast system. In addition, this system has been shown to operate successfully in the presence of strong analog channel impairments.

ELECTROMAGNETICS

Professor Jin Au Kong has developed new techniques for the interpretation of remote sensing data, has modeled microstrip integrated circuits, and has developed new precision navigation instrument landing systems.

OPTICAL COMMUNICATIONS

Professor Jeffrey Shapiro has completed the study of the role of local oscillator optimization in quadrature noise squeezing. These techniques have been used in conjunction with his earlier research on Raman noise in fiber four-wave mixing in order to predict a new Raman squeezing regime. Dr. Ngai Chuen Wong has fabricated periodically poled lithium niobate as a versatile nonlinear optical material that can be phase-matched over a broad wavelength range. This will be applicable to widely tunable sources in nonlinear optics as well as optical amplifiers and frequency shifters in optical communication.

ELECTRONICS FOR BIOLOGICAL ANALYSIS

Dr. Mark Hollis is developing a new technology for DNA sequence determination that offers the potential for much lower cost and higher throughput than conventional techniques based on gel electrophoresis. His approach exploits the natural base-pairing property of DNA by attaching short, single-stranded DNA fragments (probes) of known sequences to specific sites on a microelectronic chip. Single-stranded DNA fragments (targets) of unknown sequence are then washed across the chip. The target DNA binds or hybridizes strongly to probes that contain the Watson-Crick complement, and much less strongly to other probes. Specialized circuitry on the chip detects and reports the sites that contain hybridized DNA, thus enabling the base sequence of the target DNA to be derived by using a novel algorithm.

INDIVIDUAL RESEARCH

Professor Donald Troxel is developing tools and infrastructure to enable virtual and physical prototyping of advanced microsystems. For example, a remote microscope was developed that allows users to operate and view an actual microscope located at a distant microfabrication facility. In this way, semiconductor processing facilities can be shared by many users in a cost-effective way.

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 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, fifteen searches were conducted, resulting in the hiring of three females and one African American male.

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. 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 in addition to its research mandate.

In FY 1996 the National Office of Sea Grant awarded MIT \$2.53 million. MIT, industry partners, the Commonwealth, the Massachusetts Water Resources Authority (MWRA) and other federal and non-federal agencies provided more than \$2.7 million. In all, these funds provided partial support for 22 faculty members, nine post-doctoral fellows and 40 students from the departments of Chemical, Civil and Environmental, Ocean, and Mechanical Engineering and Earth, Atmospheric and Planetary Sciences and Sloan School of Management (as well as partial support for faculty and students at UMASS/Amherst, UMASS/Boston, UMASS/Lowell, Brandeis University, Boston College, Boston University, Harvard University, Northeastern University, Massachusetts Maritime Academy, Woods Hole Oceanographic Institution (WHOI), University of Washington and University of California).

A substantial portion of the \$2.7 million is represented by the first year portion of a five year \$11.6 million award from the Office of Naval Research (ONR). This award is intended to further the development of the Autonomous Oceanographic Sampling Network (AOSN) and will involve our Autonomous Underwater Vehicles Laboratory in collaboration with WHOI, the University of Washington and the University of California at San Diego (Scripps Institute of Oceanography).

RESEARCH

Research at MIT Sea Grant is guided by the unique intellectual resources of colleges and universities in the Commonwealth and by the needs of the marine community. Our research is divided into two categories. The first area is our core research program, which reflects the ongoing MIT Sea Grant management process and the guidance provided by our two advisory bodies: the State Advisory Council and the Faculty Committee. Within the core research area, we have two major theme areas, with quite specific concentrations: *Marine Biotechnology* and *Coastal Management and Utilization*. The second research category is our focused research, intended to address major regional and/or national issues or needs. Projects under focused research are also called *Marine Center* projects. In addition, *Automation in the Manufacture of Marine Systems*, now supported entirely from sources outside Sea Grant, continues to be one of Sea Grant's strongest activities. We continue to build upon advances made in these areas.

Sea Grant's research objective in *Marine Biotechnology* is the advancement of technology that can contribute to better use of the biological resources of ocean and coastal ecosystems. Recent and ongoing research has included studies of the development of novel delivery systems for the vaccination of farmed fish (Professor Robert Langer and Dr. Yonathan Zohar, Visiting Scientist, MIT Department of Chemical Engineering), the relationship between vanadium and tunichrome in sea squirts (Professor William E. Robinson, University of Massachusetts), design of instrumentation for automated detection of plankton (Professor Sallie W. Chisholm, MIT Department of Civil and Environmental Engineering), and improvements in processing underutilized fish (Professor Herbert Hultin, University of Massachusetts). Professor Ralph Mitchell, Harvard University, continues to study zebra mussels, an invading species threatening inland water supplies and ecosystems.

Interdisciplinary Sea Grant investigations of *Coastal Management and Utilization* seek to advance the science and engineering needed to more effectively utilize our coastal and ocean resources. Projects included studies aimed at discussing the effects of seawalls on coastal sediment transport (Professor Ole S. Madsen, MIT Department of Civil and Environmental Engineering), and understanding biological and chemical transformations of mercury in sea water (Visiting Professor Francois M.M. Morel, MIT Department of Civil and Environmental Engineering), and rapid maneuvering of autonomous underwater vehicles through vorticity control (Professor Michael S. Triantafyllou, MIT Department of Ocean Engineering). Another major project in this area, *Membrane Inlet Mass Spectrometry: A Universal Chemical Sensor for in situ and*

Autonomous Underwater Vehicle Applications, focuses on the development of a versatile chemical sensor that can operate aboard a small AUV (Professor Harold F. Hemond, MIT Department of Civil and Environmental Engineering). Research also includes the application of vibration theory to suppress vibration and drag in cables and tethers (Professor J. Kim Vandiver, MIT Department of Ocean Engineering).

Work on underwater systems is carried out under *Coastal Management and Utilization*. Unique in its status as a research laboratory within a Sea Grant program, the MIT Sea Grant Autonomous Underwater Vehicles (AUV) Laboratory is the center of much of MIT Sea Grant's AUV research and development. Its projects are aimed at making autonomous underwater systems useful tools for coastal and open ocean research and/or engineering programs. Investigations focus on intelligent control, navigation and application of autonomous vehicles to specific scientific missions. Major events for the AUV Laboratory this past year included studies of benthic habitats on Stellwagen Bank using recorded camera video. Work completed at the beginning of this year over the Juan de Fuca Ridge established records for survey mission time (3.5 hours) and depth (1,400 meters). Recent field trials in Buzzards Bay concentrated on establishing the performance of three different docking mechanisms, which allow an AUV to automatically dock at a fixed mooring platform. Professor Henrik Schmidt, MIT Department of Ocean Engineering, oversees this research area as associate director for research, and Principal Research Engineer James G. Bellingham directs the AUV Lab with support from Research Engineers, Thomas R. Consi, John J. Leonard and James W. Bales. Research on biomimicry investigates the olfactory behavior of lobsters. This work is done by Consi in collaboration with Professor Jelle Atema of Boston University. The AUV Laboratory also investigates the scientific and manufacturing aspects of underwater optical communication between multiple vehicles - this work is directed by Bales. The laboratory supported six postdoctoral fellows and seven graduate students.

Focused research typically establishes a six-year set of interrelated projects initially funded exclusively by MIT Sea Grant. Projects must line up substantial co-funding from outside sources in years two through six. This past year began with three projects still active. One of these, *Coastal Water Quality*, formed in 1989 and overseen by Dr. E. Eric Adams, MIT Department of Civil and Environmental Engineering, has since completed its final year. This project has been sponsored by MIT, MIT Sea Grant, the Massachusetts Water Resources Authority, National Science Foundation (NSF) and the U.S. Environmental Protection Agency. The other two projects concerned the development and application of Autonomous Underwater Vehicles (AUVs) and are both overseen by Professor Schmidt and Dr. Bellingham. *AUV: Basic Technologies* is now in its final year. *AUV: Scientific and Industrial Applications* will complete its six year research program next year. These last two Marine Centers have been sponsored by MIT (Vice President for Research, the Ocean Engineering Department and the Bantrell Fellowship), MIT Sea Grant, Charles Stark Draper Laboratories, ONR, NSF, the French Institute for Research and Sea Exploration, and the Department of the Navy. Additional funding sources for support of the AUV Marine Centers and/or the AUV Laboratory include Florida Atlantic University, NASA, National Undersea Research Program, RD Instruments, Lockheed Martin, and the Henry L and Grace Doherty Professorship.

In our solicitation of new research proposals last year, we opened the competition up for additional focused research that would lead to new Marine Centers. A proposal submitted by a team led by Dr. Adams as Principal Investigator, *Behavior of Capped Sediments*, was successful in the peer review process and has been included in our current Omnibus Proposal to the National Office of Sea Grant and approved.

EDUCATION

Sea Grant is committed to providing learning opportunities for 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.

Sea Grant UROP directly provided \$25,000. Support from other departments (primarily Ocean Engineering) raised the total funding to \$65,000, which includes \$35,000 from NSF. Twenty-five UROPs were supported this year. Undergraduates from nine MIT departments were represented, including a student from the University of Oklahoma, sponsored by MIT's minority-outreach.

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. The 1996 award was given to Electrical Engineering and Computer Science student Jamie Cho for his work involving underwater chemical sensing and chemically-mediated guidance of an autonomous vehicle.

MIT Sea Grant's eighth John A. Knauss Sea Grant Policy Fellow is Samantha Woods, who this past year completed the Masters of Science degree program at UMASS/Boston, with a major in Environmental Science/Marine Ecology. Woods is currently working for NOAA/National Marine Fisheries Service in the Office of Research and Environmental Information.

We were successful this past year in submitting a proposal for the Sea Grant Industrial Fellows Program, *Operational Optimization of an Ocean-Based Aquaculture Facility*. Neil Best, a candidate for the Master of Engineering in Marine Environmental Systems here at MIT, will be the Ocean Spar Technologies/Sea Grant Industrial Fellow for this program. Sea Grant's legislation explicitly provides funds for technology transfer as an integral part of its program. Additionally, technology-transfer projects are designed to bring user needs to the attention of MIT Sea Grant researchers. Thus, technology exchange may better describe our efforts.

TECHNOLOGY TRANSFER

The MIT Sea Grant Marine Industry Collegium promotes the active transfer of marine research and technology through the sponsorship of workshops, the 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 other campus organizations in sponsoring symposia and workshops. Of particular note is the involvement of the Industrial Liaison Program (ILP) membership in Collegium activities. ILP members are invited and have been enthusiastic participants in these events.

During the past year, under the direction of Richard Morris, the Collegium has concentrated on developing a stronger focus on areas of increasing interest. A series of meetings over the past twelve months involving participants with a broad set of interests in aquaculture resulted in an important conference this past spring. This conference, *A Seminar for the Financial Community: Understanding Aquaculture Locally and Globally*, recognized the need to begin an educational process for the financial community here in the Northeast. In so doing, it serves as a preliminary step in a series of Collegium events with a more structured business orientation. Participation was very high and subsequent discussions indicate the value of this conference format.

Extensive effort has gone into the Collegium events planned for the coming year. In September, an international conference on welding technology will serve to honor Professor Koichi Masubuchi, who will retire after a long and distinguished career in the Ocean Engineering Department at MIT. Plans to hold a symposium on electronic integrated navigation systems and technology revealed the need to involve the relevant government agencies in a more broadly focused set of issues. This symposium will be held later this year. Plans have also been developed for a conference on marine sensors and for continuing the series on AUV development and applications.

MIT Sea Grant's engineering focus in marine fisheries continues with the Center for Fisheries Engineering Research (CFER). This project was initiated in 1982 and today continues to have a national impact by applying analysis and model-testing techniques to the hardware-related problems associated with marine living resource utilization. The project has assisted industry in the development of resource-sparing and selective trawl nets. Current work by CFER director Cliff Goudey includes the development and demonstration of gear and techniques to reduce the mortalities of marine mammals in the Atlantic tuna fisheries. In addition, he has initiated a project with Saltonstall-Kennedy funds to develop trawl nets with less wasteful by-catch and reduced bottom impact.

MIT Sea Grant's involvement in marine aquaculture is focusing on two important areas: the development of hardware for offshore fish farming and land-based recirculating operations. Sea Grant enhancement funds (\$80k) were secured to establish a National Engineering Test Center for Offshore Mariculture. With industry collaboration the engineering techniques used in fishing gear are being applied to the sustainable production of seafood in the U.S. Exclusive Economic Zone (EEZ). This funding has also provided for the first aquaculture site in the EEZ, currently located south of Martha's Vineyard, for the growing of sea scallops. We have also established the first, prototypical aquaculture site in Boston Harbor, at the Charlestown Navy Yard. This facility will be used for research and public education on the culture of finfish in an urban environment.

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 continued to track the social impact of new fisheries regulations and has planned focus groups for Gloucester and New

Bedford to assess their effects. Christine James, under the direction of Hall-Arber, has been effective in linking with state agencies and sportsmen's clubs to educate them on zebra mussels. She also developed a summer camp program to introduce youngsters to hands-on science through zebra mussel and other exotic species-watch activities. Hall-Arber is President-elect of the American Fisheries Society's Subcommittee on Socio-economics and a member of the Atlantic States Marine Fisheries Commission's Committee on Economics and Social Sciences. In addition to these posts, Hall Arber serves on the advisory board of the Massachusetts Coastal Zone Management Program, is a member of the New England Marine Advisory Council, and is president of the Women's Fisheries Network. Public education efforts continue through exhibits, participation in conferences and festivals and articles in *Commercial Fisheries News*.

The Sea Grant Communications/Information Service produces outreach materials for a wide variety of consumers. In 1995-1996 the Communications/Information Service published 23 technical reports and brochures. *The Quarterly Report* newsletter (circulation 2,000) is scheduled to be replaced with a joint publication in collaboration with WHOI Sea Grant.

Communications continues to write the *Nor'easter* magazine (circ. 12,000), along with other Sea Grant programs in the Northeast region. Working with the press and the MIT News Office resulted in stories in *TechTalk*, the MIT Research Digest, the Boston Herald, *Fish Farming News*, *USA Today*, and other news media, as well as national and international trade journals. Staff members were involved in several innovative outreach projects: assisting in the establishment of a small aquaculture facility at Re-Vision House, a group home for pregnant and parenting teens; organizing and sponsoring a Charles River Clean-up day, which is slated to become a regular event; teaching make-your-own-home-page WebShops to marine education, business and service professionals, locally and nationally; and producing an educational *Live from Haro Strait* Web site aimed at K-12, which is tracking the MIT Sea Grant AUV Lab's field experiment off the coast of Vancouver.

A new addition to MIT Sea Grant, the Center for Coastal Resources, brings science and technology research to state and federal agencies' staff, local government officials and other entities. The Center helps improve decision making in management of coastal resources and strengthens policy development. Manager Judy Pederson's efforts during the past year included the first two workshops in a three-workshop sequence focused on sources of pollutants, modeling, and problems related to meeting water quality criteria in coastal and estuarine water. In October a workshop entitled *Measuring Mystic River Water Quality*, involved field work in which various commercial techniques were employed to acquire appropriate data. This was followed in January with a workshop, *Use of Models for Environmental Assessment*, to describe the transport, fate and effects of a pollutant (in this case nitrogen) in coastal ecosystems.

These courses featured researchers from MIT, the Woods Hole Oceanographic Institution, the University of Massachusetts and other academic institutions, attracting scientists, students and those involved in managing coastal resources from all New England states. Other activities include sponsoring or co-sponsoring workshops where Sea Grant -funded researchers and others presented findings regarding introduced species, factors in groundfisheries decline, and the impacts of contaminants on marine organisms.

During the past year, the New England Science Center was funded to develop an electronic atlas using an accessible Geographic Information System and data from Boston Harbor for use by teachers in grades 5-12. A 6-week training program introduced teachers to the World Wide Web, provided hands-on opportunities for them to become familiar with the information and encouraged them to identify ways to use the materials in their science curricula.

PROGRAM MANAGEMENT

The program director is Chryssostomos Chryssostomidis, professor in the Department of Ocean Engineering. Associate directors for research are Professor Henrik Schmidt and Dr. E. Eric Adams. Richard Morris, who had been Manager, Industry and Federal Relations, was promoted to Executive Officer.

MIT Sea Grant administers the Doherty Professorship, endowed by the Henry L. and Grace Doherty Foundation. In 1996, Paul E. Laibinis, assistant professor of chemical engineering, was awarded the two-year chair for his proposal to study the preparation of organic barrier films that will impede metal corrosion in aqueous and saline environments. Heidi Nepf, assistant professor of Civil and Environmental Engineering, holds the chair for a second year. Professor Chryssostomidis continues to serve as the Henry L. and Grace Doherty Professor of Ocean Science and Engineering.

Chryssostomos Chryssostomidis

TECHNOLOGY AND DEVELOPMENT PROGRAM

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 socio-economic and technological problems.

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

The past year saw the continuation of the multi-year collaborative program established with the Government of Mendoza to provide research, education, and administrative assistance to the newly created Fundación Centro de Innovación Tecnológica (CIT) Mendoza.

Work on the three joint projects (Regional Planning for Intermodal Transportation in Mendoza; Internationalization and Competitiveness: the Case of the Mendoza Region of Argentina; and Multi-Attribute Evaluation of Water and Energy Resources in Mendoza) continued. Mini projects include: Information Technology, Remediation of Organic Contaminants Using In-Situ Air Sparging; and Fiber Reinforced Metal Matrix and Ceramic Matrix Composites.

On June 20, 1996 Dr. Paul E. Gray signed two separate collaborative program agreements between TDP and the Foundation for Research, Education, and Enterprise (FREE). The first was for \$6 million to support a Collaborative Program of Science and Technology between MIT and the National Science Technology and Development Agency of Thailand and the second was for \$2,250,000.00 to support a Collaborative Program of Science and Technology between MIT and the King Mongkut Institute of Technology, Thonburi.

CURRENT EDUCATION INITIATIVES

The TDP-sponsored Middle East Program at MIT completed its tenth year. 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; and it examines the processes of socio-economic change, technological development, political change, institutional development, capital flows, and business and investment patterns in the region. Two interdepartmental courses are offered by the program: Politics, Growth, and Development in the Middle East; Technology, Business and Public Policy in the Middle East. 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.

Fred Moavenzadeh

LIBRARIES

Academic year 1995-1996 marked the beginning of a new era in the MIT Libraries. In January 1996, Ann J. Wolpert assumed the position of Director of Libraries, bringing closure to the long and distinguished career of Jay K. Lucker.

As befits a transition year, this annual report reflects the strengths of the Libraries' past while pointing to directions for their future. If there is a common theme across all aspects of this year's report, it is the expectation for strategic renewal within the MIT Libraries. Excellence in library and information service has always required diligent attention and periodic renewal. Today's volatile environment, more than ever, demands the Libraries' continued focus on service to its core communities and on the strategic importance of information for education and research.

The Libraries successes and challenges rest firmly in the context of MIT's outstanding academic and research requirements. The Libraries must, therefore, always strive to be relevant to the world-class programs and activities of MIT. The Libraries have an equal obligation to seek the highest quality in its staff, resources, and services, and to represent MIT with distinction in its dealings with alumni and the external community.

In keeping with this mandate, the new Director's early months were dedicated to discovering the research, educational, and administrative requirements for Libraries services within MIT. At the same time, the Libraries' operations and plans were reviewed to gain detailed insights into the system's capabilities and issues. A few initiatives were suspended, the vast majority were advanced. The Music Library undertook dramatic renovations, a cooperative agreement was signed with Harvard's Graduate School of Design Library, additional databases were acquired, numerous service innovations were initiated, a modest development program was launched, training needs for professional staff were identified, and the Libraries' presence on the World Wide Web was expanded.

This year's annual report reflects the tensions inherent in a rapidly evolving planning environment. A number of factors currently influence the mission of premier academic research libraries, and the MIT Libraries are no exception.

- The costs of operating in a digital environment are, thus far, supplemental rather than displacing. New ways of publishing and delivering information are capital intensive, sustain additional annual recurring costs, and involve significant levels of support in many areas of the Libraries. These additional costs will continue to be incurred until electronic publishing stabilizes and the constituencies serviced by the MIT Libraries can readily accommodate electronic alternatives.
- The rate of inflation in scientific and technical publishing, both print and electronic, continues to outpace inflation by a significant margin. Exchange rates add to this financial burden.
- The growth in volume and complexity of both traditional and nontraditional publishing continues to accelerate. Selection of and access to appropriate materials, in multiple formats, in support of education and research at MIT, is a significant and growing challenge.
- The need for appropriate and functional space evolves, but continues.

And, unique to MIT, the Institute's sophisticated but heterogeneous network and desktop environment present special challenges to the ubiquitous delivery of contemporary library services.

The MIT Libraries have notable strengths to carry into the next century. Foremost among these strengths are the excellence of the staff, a strong commitment to service, innovation in process design, and the quality of the resources. As the Libraries move toward the 21st century, traditional assumptions will continue to be challenged. First, the definition of library excellence will change as the Libraries meet new and emerging needs within MIT. Second, the Libraries utilization of technology and space will evolve to accommodate new ways of scholarly communication, student learning and MIT research. Third, Libraries' staff capabilities and expertise will continue to develop to deliver quality service in a changing MIT environment.

Under the exceptionally able leadership of the Associate Directors, despite the transitional nature of this academic year, the Libraries have advanced many of the strategic objectives articulated for the year. The individual reports which follow illustrate the Libraries' considerable accomplishments during academic year 1995-1996.

The Libraries annual report also reflects the staff's ingenuity and professionalism in addressing these challenges. The activities highlighted below reflect innovation and initiative - in the design of fundamental processes, in the creation of new services, in the Libraries' use of technology. In the pursuit of these goals, the Libraries are appreciative of support received from many other quarters within MIT - most notably Information Systems, Resource Development, individual Deans and faculty members, the Associate Provost for the Arts, the Faculty Committee on the Library System, and the Office of the Provost. The reports that follow would not have been possible without the assistance of these and other exceptional individuals at MIT.

ADMINISTRATION

The major accomplishments for Administrative Services were in the areas of re-engineering and Geac Advance implementation. Both areas hold the prospect of future advantage to the work of Administrative Services.

Re-engineering continued to touch on many of the Libraries' administrative functions including new procedures for hiring temporary help, team-based building custodial services, and new mail handling procedures. The new SAP financial system has held considerable interest for the Libraries, in that many of the modules under development will impact directly on library operations. Modules for purchasing, accounts payable, and accounts receivable have obvious application in the Libraries. Administrative Services is pleased to be a test site for the Purchasing Department's Electronic Catalog system for obtaining office supplies.

The other major accomplishment for Administrative Services this year was the successful implementation of the Geac Advance acquisitions module. The work of the department is reflected in both the design of the module by Geac and in the implementation of the module within the Libraries. The Geac Advance acquisitions module provides the Libraries with a level of fund accounting, invoice processing control, and financial reporting not previously available.

Administrative Services has also coped admirably with Institute administrative mandates, such as the new parking fee and the new MIT identification card; MIT Libraries mandates, such as creation of a Web-based staff locator; and the impact of the early retirement incentive program on long-standing relationships across the Institute.

Ann J. Wolpert

COLLECTION SERVICES

This year staff involved in all areas of collection development and collection management faced daunting workloads and extraordinary change, and yet - by "working harder, faster, smarter" - realized significant success.

BUILDING AND SHAPING OUR COLLECTIONS

Guided by the Preservation and Collections Librarian and the Collections Managers, the subject specialists continued to build and shape the Libraries' collections. Two significant projects consumed their attention. In addition, an expanding focus on the selection of electronic information resources continues to be a challenge for all.

Serials Review

The Libraries' materials budget continues to be inadequate to sustain our collections at a rate equal to the growth in the scholarly literature and the increases in prices. For the fourth time in the last decade, the subject specialists carried out a review to select serial titles for cancellation in order to contain costs. They gathered data related to use, citation history, price increases, and availability at other libraries or from commercial suppliers. They used this data to compile lists of potential cancellations for review by faculty departments, and, after considering the responses, made final decisions. Based on this work, the Libraries will cancel approximately nine percent of its subscriptions in order to bring expenditures back into line with the budget for another few years.

Approval Plan

The second project, while also very time-consuming, was a more positive activity. It was directed at speeding the receipt of new books and simultaneously freeing some staff time for more attention to the acquisition of electronic products. This was accomplished through the selection and implementation of an approval plan for book acquisitions -- a sort of outsourcing of the selection process. A subject profile was prepared with a vendor, who now supplies books which match the profile (without requiring a prior purchase order process by the Libraries). Incoming books are reviewed before they are added to the collections, and titles which are inappropriate can be returned to the vendor. However, the vast majority are suitable and are added to the MIT Libraries' collections shortly after they are published.

Selecting and Acquiring Electronic Resources

Subject specialists are selecting electronic resources as additions to the Libraries' array of information offerings at an expanding rate. The selection decisions for these materials are far more complex than those for print materials. In addition to considering the subject focus and the quality, authority, and uniqueness of the information, the selector needs to answer questions such as these: Which form of delivery is best for the Libraries' and the Institute's circumstances? Are the search and navigation tools adequate? Are the license conditions satisfactory to the Libraries' purposes and the fair use rights of the Libraries' customers? Is the price negotiable? What local support will be needed? Every product brings new questions and decisions.

A clearly emerging new trend this year was the trend toward consortia negotiation for electronic products. The Boston Library Consortium charged an Electronic Resources Working Group to consider networked resources for shared access by its member institutions. Products under review are *Chemical Abstracts*, *BIOSIS*, and three citation databases from ISI. Two Libraries' committees, CMG (Collection Management Group) and NUT (Network User-Interface Team), began discussions with Harvard University Libraries related to a joint project to tape-load *Environmental Periodicals Bibliography*. Finally, the Libraries learned of and joined with a group of Northeast research libraries which are organizing themselves into a consortium for the purpose of negotiating joint access to electronic resources. By the end of the year, access to the electronic versions of all of Academic Press journals was being negotiated for the group by Yale University Libraries. While all of these projects are still in the formative stages, together they give a clear indication of the growing importance of consortia agreements in the environment of electronic distribution of information.

Gift of Rare Architectural Treatises

On the other end of the spectrum, an important addition to the print collections this year was a gift to the Rotch Library consisting of rare architectural treatises from the library of William W. Cordingley. The gift includes early and original works which will be of immeasurable value to students in history, theory, and criticism courses of the Department of Architecture.

ACQUIRING AND PROVIDING ACCESS TO THE COLLECTIONS

Geac Advance Implementation

The implementation of Geac Advance, coupled with co-development efforts for an intended Geac client-server product, was the consuming activity for our acquisitions and cataloging staff this year.

The summer months were a period of intense analysis and training as staff learned the intricacies of the new system and made the myriad decisions necessary to begin using it. The Head of Serials Copy Cataloging and Records Maintenance carried out a special assignment to coordinate library-wide training in the use of the new system. The new training room in the basement of Building 14 greatly facilitated this effort.

The Geac GLIS system was turned off at the end of the 1994-95 fiscal year, but we were unable to bring up the new Geac Advance system until August 24. Due to our decision to continue using OCLC for our cataloging work, we were able to continue cataloging during this period, although the record loads were postponed until just before the August 24 implementation. In a significant shift, the record loads and bibliographic table maintenance became the responsibility of staff in Bibliographic Access Services (BAS) and Serials and Acquisitions Services (SAS) instead of the Systems Office staff.

The summer downtime was much more problematic for acquisitions than it was for cataloging, resulting in backlogs of orders, claims, unpaid invoices, unreceived books, and unresolved problems that took many subsequent months to work through. For serials acquisitions, the challenge was even more daunting, as the Libraries were moving to automated processing for the first time, and all of the manual check-in records had to be input. In a year of many significant accomplishments, the intensive effort to achieve this goal stands out. Collaboration of staff from Serials Acquisitions, Serials Cataloging, Bibliographic Access Services, and divisional and branch libraries, resulted in the creation of orders, "copysets", holdings statements, and serial item linking for 8,000 serial titles over a period of only five months. Even one of our vendors commented on this as an amazing achievement!

Co-Development of a Client-Server System

In addition to the staff's efforts to implement Geac Advance, many of them were also involved in teams working on co-development of the Geac client-server systems. This work ranged from responding to documentation or beta products in the areas of cataloging and authorities, to a more active collaboration with Geac staff on the design of an acquisitions client. Due to contractual issues with Geac, these efforts ceased in the spring months. While there was a mixed reaction of disappointment and relief, the staff's initial involvement in the process was valuable in stimulating analysis and articulation of basic functional requirements that will prove useful in future systems evaluation.

CARING FOR AND STORING THE LIBRARIES' COLLECTIONS

Preservation Activities

Preservation services continued at levels typical of recent years. Special attention continued to be given to the Rotch Limited Access Collection, including a summer cleaning project, purchase of Clarkson Book supports to protect rare volumes, and a special project to clean and display materials from the Cordingley gift.

Storage Program

Approximately 20,000 volumes were moved from MIT Libraries to the Retrospective Collection (RSC) housed in N57, and, in turn, a transfer of Archives theses and circulating volumes from RSC were moved to the Harvard Depository (HD). With the completion of the transfer of theses to HD, we are faced with much more difficult processes in the future to continue to make room in RSC for materials which need to be moved from our various libraries. The selection process for materials to be moved to HD will be difficult because we will need to move items with greater potential for user recall. In addition, this will require significantly greater staff effort to change bibliographic records and barcode materials. A planning effort for this new phase of our storage program was initiated early in the summer.

CONTINUED PRODUCTIVITY AND NEW WAYS OF WORKING

Productivity Achievements

Considering the intense effort required to migrate to a new system and work on the development of a future system, it is a great credit to the staff that productivity in cataloging and acquisitions remained at normal levels.

Achievements in serials cataloging were particularly noteworthy in that they included the highest CONSER contributions since the Libraries joined the program in 1988, and the reduction of materials in the pre-cat collections to the lowest in "recorded history". In addition, all Collections Services departments continued work on our long-term goal of expanding the coverage of the Libraries' collections in the on-line catalog, including: significant progress on cataloging Rotch art pamphlets; completion of retrospective conversion of records for all MIT theses from 1940 to date; continued retrospective conversion and reclassification (from DDC to LC) of materials in the areas of history, mathematics, and biography; and planning for and initiation of summer projects to convert records for sound recordings and unclassified serials.

Creative Use of Technology

Innovative applications of OCLC's Passport for Windows software have provided efficiencies in several areas of processing. A BAS staff member programmed function keys to automate procedures for inputting mandatory local system information into the OCLC records and for examining OCLC records to determine the potential for "fastcat" processing. The latter has enabled BAS to adjust its workflow so that approximately thirty percent of incoming receipts can be separated from more complex materials and processed immediately. An SAS staff member used OCLC Passport for Windows software to create macros to streamline the monograph receiving process as well as the summer serials retrospective conversion project.

Great progress was made this year in the use of the Internet for making Collections Services information available to staff throughout the Libraries. A Collection Services Web Team was created in the fall and worked throughout the year to create Collections Services Web pages to assist staff in their work. The most notable resources now on our Web pages include the following: a book search form for the use of local units, the Acme Bindery list of "out-of-house" titles, a Collection Services decisions archive, and an inventory of journal issues available in Gifts. In addition, the pre-existing serials commitments list, government documents databases, and Cataloging Oasis of external and internal policy and procedures information were incorporated. The Web has thus become a major working resource for staff within Collection Services and throughout the Libraries, and the team members have acquired and shared important new skills.

Flexible Utilization of Staff Resources

Several situations required and benefitted from the flexible use of staff across department and unit lines. These examples illustrate a significant transition in the way we work. As already indicated, there were contributions from staff from both BAS and Serials Cataloging in the process to convert serial records to the automated system. In addition, a BAS staff member who had formerly worked in serials acquisitions was called upon to help resolve serials invoicing issues which resulted from the need to convert records. Without her expertise, it would have been very difficult to complete this essential work before the end of the fiscal year. Two other BAS staff members were trained in receiving and invoice approval and assisted with the backlog of monograph receipts once Geac Advance was operational. The newly acquired skills will be utilized on a more long-term basis. As a result of MIT's early retirement program, the staff in monograph acquisitions has been reduced. In order to provide sufficient coverage, one of these BAS staff members will continue to supplement the staff in receipts processing, and a staff member from the Documents Section will be a back-up for the ordering process.

In another instance, we were also able to capitalize on skills acquired during a temporary assignment. In February, the responsibilities of the previous half-time Gifts Librarian were permanently assigned to a staff member who had filled in as Gifts Librarian during a vacancy a few years ago. The position resulting from this merger of responsibilities, Assistant Librarian for Monograph Acquisitions and Gifts, brings together related activities and provides a new stability for the gifts operation. It should also be noted that until February the Gifts position was filled on a temporary basis by the Head of the Retrospective Collection (RSC).

Collection Services is realizing significant benefits from a need to utilize more staff outside of their usual departmental or unit assignments to solve ad hoc problems: broadening the staff skill base and "whole process knowledge", and enabling more flexible use of staff in new job design.

SUMMARY

A major serials review, initiation of an approval plan, and implementation of Geac Advance were dominant activities this year. Significant new trends were the expanded consortia efforts to acquire electronic resources, a shift toward more difficult storage decisions, creative advances in the use of technology, and increased flexibility in the use of staff resources.

In Collection Services, this has been a year of incredible challenge and note-worthy accomplishment, summed up best in the words of the Head of the Serials Acquisitions section: "In a very unusual year, many people made unusual efforts. We are thankful for all of them."

Carol J. Fleishauer

PUBLIC SERVICES

EDUCATIONAL INITIATIVES

Innovative ways of working with faculty to impart to students a set of skills which will make them self sufficient in retrieving information here at MIT and in their future educational, research, and private lives has been a priority for many years. This year saw an extraordinary number of new and creative approaches come to fruition. A sampling:

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- 2.73, Design Projects, Department of Mechanical Engineering. Eight librarians worked with faculty and teaching assistants in planning a curriculum which involved information gathering and analysis skills. One librarian was assigned to each course section, working as a member of the student/faculty team. The culmination of the course was the final student design demonstration. A website was also created to enhance the instructional program. It included course lecture notes, guides to appropriate library resources, pointers to other sites of interest, announcements, an interactive reference facility, and inspirational quotations.

This class was also an opportunity for the Institute Archives to experiment in the documentation of classroom activity. Recognizing the importance of the educational process in the classroom, and the difficulty in documenting that process, the Archives staff developed a documentation strategy for this course. Records assembled include faculty notes and overhead transparencies, librarian and archivist notebooks, e-mail correspondence among faculty and students, the class website, videotapes of classroom sessions, etc.

- 10.491, Integrated Chemical Engineering, Department of Chemical Engineering. Two librarians worked with the faculty member to design a course of instruction which incorporated computer literature searching and document retrieval for a final presentation on waste treatment for a proposed hospital at Hanscom Field. In this case, the faculty member recognized from his own research experience the importance of information handling to problem solving.
- 16.621, Experimental Projects and Writing Practicum, Department of Aeronautics and Astronautics. Three librarians created a suite of classroom presentations and in-library demonstrations of electronic resources to support both the classroom curriculum and the Institute's writing competency requirement.
- 4.621, Orientalism and Representation, Department of Architecture. Two librarians worked with faculty to develop teaching materials involving caricatures of Muslims in publications of the Western world. These materials later served as the basis of an exhibition and guest lecture funded by MIT's Committee on Race Relations.
- 4.602, Modern Art and Mass Culture, Department of Architecture. A librarian and a faculty member teamed to develop a website, 'Manet: Study Images and Related Works,' a process which resulted in a redesign of the course.
- 4.106, 4.123, 4.143, 4.155, Architectural Design, Department of Architecture. A librarian conducted library research sessions which reached, for the first time, all educational components of the graduate design programs.
- 9.00, Introduction to Psychology, Department of Brain and Cognitive Sciences. An existing website was refined to supplement 18 instructional activities by Libraries' staff. This course and the "Library Liaison" concept developed over the past several years, has served as a model for other faculty/librarian collaborations.
- 15.837, Special Seminar in Marketing, Sloan School. Three librarians, representing multiple disciplines, taught market research skills in this seminar on MIT technologies having new venture potential.
- 15.615, The Manager's Legal Function, Sloan School. A librarian worked with a faculty member to teach and explore the Libraries' legal resources.
- 15.346, Doctoral Seminar in Behavioral and Policy Sciences, Sloan School. Two librarians, a faculty member, and seven graduate students explored information sources in organizational behavior.
- 21M500, Senior Seminar in Music, Music and Theater Arts. A librarian and a faculty member collaborated to provide analytic and research skills in music and library resources for eight undergraduates.
- SP452, The Politics of the Feminist Movement, Special Programs. This course, which considers a variety of feminist and activist perspectives on contemporary women's lives, was enriched by the participation of a librarian who helped students navigate the world of information, both print and electronic.

In each case, one or more librarians worked with a faculty member to integrate information retrieval skills into the classroom instruction. Frequently the conversations between librarian and faculty influenced the design of the

course, making it a true collaboration. In all cases, faculty gained a new appreciation for the expertise of their librarians and the librarians felt enthused about their participation in the educational process.

INDEPENDENT ACTIVITIES PERIOD

Just as the faculty has been using IAP in recent years to supplement the curriculum with credit courses, the Libraries staff has had great success in focussed instructional activities. This past January saw more than a dozen well-attended activities. Examples:

"GeoRef: Down to Earth." Hands-on instruction in the use of the GeoRef CD-Rom product which indexes the literature of the geosciences.

"Introduction to FirstSearch." Another hands-on activity to teach students and researchers how to access 20 databases from their desktop.

"Blast Your Way Through the Aerospace Literature." An in-depth session with the Aerospace Database on CD-Rom.

"Everything You Wanted to Know About Patents." The ins and outs of the patent process at MIT, taught by a patent attorney, a staff member of MIT's Technology Licensing Office, and two librarians.

"Introduction to the World Wide Web." Two librarians teamed to do an overview of the WWW with a focus on library resources.

"Pointers for Post Docs." Segmenting the market of library users, this seminar focussed on online searching options, finding journal literature, current awareness products, and access to other libraries in the Boston area.

"Introduction to Online Searching for Chemists." A full day devoted to learning the basic command language of STN in the Registry and Chemical Abstracts files: the basic online databases for chemists.

"Searching MEDLINE for Biology and Neurosciences." Another market segment targeted for special attention in a hands-on session.

"How to Do Your Bibliography Electronically." Two librarians presented the strengths and weaknesses of various bibliographic software packages to compile and manipulate citations.

"Electronic Access to High Technology." Two subject specialists teamed to offer a combination of lecture, demonstration, and hands-on instruction on electronic databases covering the high tech field, from both a technical and business perspective.

As the Institute confronts the issues surrounding the use of Independent Activities Period, the Libraries will continue to mirror the emerging patterns of offerings. Recent experience has demonstrated that it is an ideal time to capture the attention of the students in targeted activities that enhance their core information literacy competencies.

SERVICE INNOVATIONS

The creativity and energy of the staff was demonstrated in a series of new service initiatives.

- **Electronic Records.** The Institute Archivist, together with an Information Systems colleague, has undertaken a campaign to educate senior officers, staff, and faculty about the long-term problems of preserving and managing electronic records. Opportunities were sought and collaborations initiated to address these issues; particularly the development of policies that are needed to support the creation, preservation, and appropriate management of the Institute's electronic records.
- **Interlibrary Services.** Innovations in workflow and procedures enabled the staff to absorb a 13% increase in business; the fifth straight year of such increases. Incorporation of a web-based form, adjusted workflows, use of the

Boston Library Consortium's new Courier Dispatch Service, and redesign of student work have enabled the absorption of the continuing increase in volume.

- Team-based approaches to work were initiated in the Rotch Library circulation department and the Document Services search and retrieval unit, and revitalized in the Dewey and Humanities Libraries processing unit. In all cases, staff received training and support for this new way of organizing work. As the Institute's Re-engineering Initiative introduces the team concept in various arenas, the Libraries has begun to test the waters.
- Document Services instituted a number of changes in business practices to better meet user needs; e.g., initiation of rush service, workflow redesign in search and retrieval functions, adoption of DHL WorldMail as the standard method of international shipment, and full implementation of the department's customer database/ order-entry system.
- In engineering and the sciences, an existing librarian position was redesigned to focus on developing programs to promote core information competencies. Recognizing the importance of user education, this librarian plans and implements innovative instructional programs, works with faculty to identify ways of integrating instruction into the curriculum, and coordinates the user education work of a dozen engineering and science librarians.
- Rotch Visual Collections created several innovative websites. "Exploring Image Collections on the Internet" provides an overview of resources for images, including image types, issues, and subjects. "Visual Communications in Building Technology," funded by the Robert B. Newman Fund, is a case study educational tool featuring documentation on the construction of Sixty State Street, including 300 digital images. "Aga Khan Collections of Islamic Architecture" presents an overview of textual and visual collections at MIT, with 175 images.
- The new Chemistry Librarian created a chemistry and chemical engineering faculty research profile database, as a way of getting to know the faculty and their interests, in order to better meet and anticipate their information needs.
- Experiments with current awareness and document delivery services were launched in the Engineering and Science Libraries, as a way of providing desktop access to fulltext information and compensating for canceled serial subscriptions.

FAN MAIL

A sampling of feedback from library users:

"I can't tell you how grateful I am to have this service and how much easier it makes dissertation research."

"You provide an extremely valuable service."

"This...affords me the opportunity to express my appreciation to you...and your student staff for the consistent, efficient, conscientious, professional, and friendly service that you provide to graduate students in our department."

"The students were very appreciative...and I send our collective thanks to you and those who helped them. By the way, the presentations...were much improved over a similar assignment that we had in the beginning of the semester... So hats off, you certainly had an impact!"

"I appreciate your thoughtfulness."

"I am deeply grateful for your prompt and full reply to my recent inquiry..."

You uncovered precisely the information I was seeking. Virtually every page you sent was helpful..."

SYSTEMS AND PLANNING

Geac Advance

The Libraries successfully migrated from the Geac 8000 legacy system to the Geac Advance system, as a planned step in the movement toward a client-server library automation product. The migration of bibliographic,

acquisitions, and circulation databases was accomplished during the summer of 1995 through the work of teams consisting of library staff with expertise in each database, Systems Office staff, and vendor assistance. By the beginning of the fall semester, library patrons were using the new Advance online public access catalog; reserve materials were being processed, and items circulated, with the Advance software; and the acquisitions module was being used to order materials.

For the first time in the history of the MIT Libraries, serials are now managed in an automated environment. The design of the Advance serials system has made implementation a complex and frustrating endeavor. The goal of providing end users with timely and accurate information about our serials was difficult to achieve but has been accomplished thanks to the hard work and perseverance of the implementation team.

Fall and winter were periods of intense testing and learning as the staff attempted to get the maximum functionality from this new online system. The need to balance the modification of existing processes and procedures to accommodate the new system, with special programming to achieve desired functionality, drove the strategy.

The migration to Advance also marked the migration of machine maintenance from the Libraries to I/S. The new SparcStation server, upon which Advance runs, is maintained under contract by I/S and is physically located in I/S space. This shift signals a new way of doing business for both organizations.

Co-Development

In a parallel process, during Advance implementation, a co-development initiative was in progress to develop, with Geac, a client-server based library automation product. The terms of our contract with Geac afforded us the opportunity to work with a commercial vendor in developing the next generation of library automation and, at the same time, put the MIT Libraries in the forefront of library technology. Co-development teams of Libraries' and Geac staff were launched in the following areas: online public access catalog, cataloging, circulation, reserves, acquisitions and serials control, archives and records management, visual images, and security. The agreed upon co-development process involved stages of requirements analysis where the staff spelled out the task to be accomplished; functional analysis which resulted in a draft of specifications by the vendor; design where a prototype was developed for staff review and testing, and implementation where a mature product was ready for MIT and for the marketplace.

The schedule was ambitious. A promised completion date of Summer 1996 for all modules became increasingly unrealistic and the quality of the co-development relationship deteriorated during the Spring. The vendor's revised completion date of 1998 was unacceptable to MIT and the co-development project was terminated. The termination of the project was both a disappointment and a relief. The staff is certainly disappointed that the effort expended on co-development did not result in a "product." At the same time, it was clear by the ever extended deadlines that the project had stalled. The decision to focus on the Advance installation while monitoring the emerging client-server industry has been accepted by both the Libraries and I/S collaborators on this project.

Other Technology Developments

- WebZ interface was used to provide public access to the Burndy Library catalog.
- Implemented WebZ World Wide Web-Z39.50 gateway to enhance access to OCLC's WorldCat.
- Began introduction of Windows'95 using centralized support NT server model.
- Upgraded all machines to 16MB RAM.
- Collaborated with Institute Archives to provide web access to Faculty Minutes.
- Implemented web forms for Interlibrary Borrowing and RSC activities.

David S. Ferriero

LINCOLN LABORATORY

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, the Defense Advanced Research Projects Agency (DARPA), and the Ballistic Missile Defense Office (BMDO) supplied approximately 81% of the Laboratory's budgetary support. The Federal Aviation Administration (FAA) provided most of the non-DoD support. Lincoln Laboratory is permitted to carry out precompetitive research with industry under approved Cooperative Research and Development Agreements. For the federal fiscal year 1995, Lincoln Laboratory received \$337 million, supporting the efforts of 1082 professional technical staff, of whom 770 are principal members. (The Laboratory is now reporting total professional staff for consistency with DoD reporting requirements.)

ADMINISTRATION

The following administrative changes occurred at the Laboratory Steering Committee level during the year: Dr. Herbert Kottler became Assistant Director, Dr. Antonio F. Pensa became Head of the Aerospace Division, Mr. William M. Brown Jr. became Associate Head of the Aerospace Division, Mr. Raymond R. LaFrey became Associate Head of the Surveillance and Control Division, Dr. Jonathan F. Schonfeld became Assistant Head of the Surveillance and Control Division, Dr. Richard W. Ralston became Associate Head of the Solid State Division, and Mr. Frank D. Schimmoller became Associate Head of the Administration Division.

PROGRAM HIGHLIGHTS

Activity at the Laboratory focuses on surveillance, identification, and communications technology development for the DoD, and on air traffic control technology for the FAA. Technical work areas 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

FOLIAGE-PENETRATION SYNTHETIC APERTURE RADAR TECHNOLOGY

Lincoln Laboratory continues to support DARPA and the U.S. Air Force Wright Laboratory in their efforts to develop a Foliage-Penetration (FOPEN) Synthetic Aperture Radar (SAR) system for the detection of stationary ground targets that are obscured by foliage. In September 1995, an experiment was conducted by Lincoln Laboratory that utilized the Naval Air Warfare Center/Environmental Research Institute of Michigan P-3-aircraft-mounted ultrawideband SAR to collect polarimetric UHF SAR imagery. This experiment was the culmination of a series of FOPEN experiments performed in 1995 that collected over 2,500 square kilometers of clutter including target data. Lincoln Laboratory has found encouraging results from applying change detection algorithms to the FOPEN target-detection problem.

SYNTHETIC APERTURE RADAR IMAGE EXPLOITATION

A program to develop and demonstrate an image exploitation ground station for present and future airborne SAR systems was initiated at Lincoln Laboratory in late 1994. The goal is to develop a semiautomatic system, requiring only a few operators to process and interpret very large quantities of SAR imagery. The task is to detect and recognize stationary ground vehicles with high confidence. Preliminary real-time automatic detection experiments were carried out in New Mexico in May 1995 as part of the U.S. Government Roving Sands/Goldpan exercises. Currently, a large-scale processing system has been constructed and is now being tested. It will be ready for deployment to Edwards AFB in late fall of 1996 to participate in tests at the National Training Center.

NEW LANDSAT SENSOR DESIGN AND FLIGHT PROGRAM

Lincoln Laboratory is responsible for the design, development, and demonstration of the Advanced Land Imager (ALI) that will be launched on the National Aeronautics and Space Administration's (NASA) Earth Orbiter-1 mission in December 1998. ALI is a land imaging instrument that will demonstrate advanced technology that will meet NASA's Mission to Planet Earth science needs in the 21st century. The new technologies dramatically reduce the size, weight, and power of ALI versus the LANDSAT-7 Enhanced Thematic Mapper. The ALI multispectral and hyperspectral images will be compared with 100 to 200 images from LANDSAT-7 to validate the new technologies.

ENVIRONMENTAL MONITORING

Lincoln Laboratory is collaborating with the MIT Civil and Environmental Engineering Department in an effort in remote monitoring of in-situ contamination using optical spectroscopy. This work uses miniature, fiber-coupled UV lasers to excite fluorescence in organic pollutants such as benzene, toluene, and xylene. The ultimate objective of the research is to develop a multiprobe system for long-term monitoring of contaminants in soils and ground water. This past year, laboratory measurements in soil samples were made with a prototype sensor.

DETECTION OF MAN-MADE ORBITAL DEBRIS

The Haystack Long Range Imaging Radar (LRIR) has collected data on man-made orbital debris for more than 4 years. Recently, the Haystack Auxiliary (HAX) radar has joined this effort to increase the data collection capability. The data thus far collected represent the largest data base available to help researchers characterize the space debris environment. The LRIR and HAX radars operate in a "stare" mode pointing at a fixed point in space. They detect debris objects passing through the beam and record data for later analysis. Debris size, altitude, and orbital inclination have been determined. A new "stare and chase" mode will allow acquisition and tracking of debris objects to characterize their orbits.

MISSILE DEFENSE

THEATER HIGH-ALTITUDE AREA DEFENSE PROGRAM

The Theater High-Altitude Area Defense (THAAD) system is currently in development to provide large-area defense against theater ballistic missiles. This past year, Lincoln Laboratory supported several key elements of this development for the THAAD radar, which is the surveillance and fire control sensor for the system and which came on line early in the year. Laboratory support included testing and analysis of the THAAD radar baseline discrimination architecture, characterization of the radar performance, and analysis of the radar performance during THAAD flight tests at White Sands Missile Range for government evaluators.

LEXINGTON DISCRIMINATION SYSTEM

Development of the Lexington Discrimination System (LDS) has continued in an effort to incorporate a broader set of missile defense critical functions. The LDS is the key facility for assessing the performance of algorithms to be used in the various elements of missile defense. With its extensive field measurement data base it provides the ballistic missile defense community with the highest-fidelity phenomenology inputs available to exercise the key algorithms.

THEATER MISSILE DEFENSE TESTING AT KWAJALEIN MISSILE RANGE

The Kwajalein Missile Range (KMR), for which Lincoln Laboratory serves as Scientific Director, is preparing to support testing of theater missile defense (TMD) components and several other test programs aimed at acquiring data to support advanced development of such components. The Laboratory is aiding in preparations for these tests with test-planning activities and a program of improvements and modifications to various optical and radar sensors. Two new telescopes designed to collect metric and signature data in the mid-wave infrared (MWIR) band have been built, and one will be installed at KMR for use on Theater Missile Defense Critical Measurements Program missions. These systems, in conjunction with bandwidth and pulse repetition frequency upgrades at the Millimeter Wave radar, are expected to provide the extremely accurate miss-distance/impact-point measurements needed by the TMD community during planned intercept tests. A major addition to KMR's capability to support TMD testing is the recently completed KMR Mobile Range Safety System, which will be used to support the launch of target vehicles from Wake or other Micronesian sites. Lincoln Laboratory participated in the system design and provided computers, telemetry and command destruct antennas, and the stabilization system sensors for this shipboard system.

COBRA GEMINI RADAR

Lincoln Laboratory is developing the prototype COBRA GEMINI radar system, which will be used to acquire data in rest-of-world (ROW) ballistic missile launches. Since the end of the Cold War and dissolution of the Soviet Union, the missile data collection effort has been focused on ROW countries rather than on Soviet systems. A key and consistent recommendation of studies addressing ROW missile data collection has been to develop a number of low-cost, air and ground transportable, mechanical scanning dish radars. The COBRA GEMINI system will be dual frequency and have a high-resolution, wideband imaging capability. The design and development information from

this operational prototype radar will be transferred to industry for use in their manufacture of at least two additional radar systems.

THEATER MISSILE DEFENSE CRITICAL MEASUREMENTS PROGRAM

The Theater Missile Defense (TMD) Critical Measurements Program (TCMP) provides IR and radar measurements to address critical issues for TMD elements through a sequence of flight tests executed at KMR. The objective of the current flight test campaign (TCMP-2) is twofold: first, to collect sensor data (IR and radar) to support resolution of TMD element critical issues and, second, to provide measurements to characterize and mitigate plausible countermeasures. TCMP-2 consists of three medium-range theater ballistic missile flights from Wake Island to Kwajalein Atoll, one scheduled for July 1996 and two for March 1997. Lincoln Laboratory is supporting TCMP-2 in four task areas during the current fiscal year: (1) mission planning and integration, (2) payload development, (3) fly-away IR sensor development, and (4) data analysis. The planning for the next campaign (TCMP-3) has begun. There will be two medium-range theater ballistic missile flights scheduled for FY98 and two longer range flights for FY99.

NATIONAL MISSILE DEFENSE GROUND-BASED RADAR PROGRAM

The Ground-Based Radar (GBR) is being developed as a surveillance and fire control sensor for the National Missile Defense (NMD) system, which is currently in its design phase. A prototype GBR is to be built and tested at KMR. This past year, Lincoln Laboratory supported several key elements of this development. GBR NMD discrimination architectures were developed and tested to check the performance of the baseline algorithms that will be used during the upcoming prototype demonstrations in FY98. Additional research was conducted on the more sophisticated algorithms and architectures that will be required to meet future requirements for NMD.

NAVY THEATER BALLISTIC MISSILE DEFENSE TECHNOLOGY PROGRAM

Over the past several years, Lincoln Laboratory and the Advanced Electronic Guidance and Instrumentation System (AEGIS) PMS-400 office have been supporting the development of the Navy Area (or lower tier) Theater Ballistic Missile Defense (TBMD) System. Much of the early work covered an analysis of the AEGIS Weapon System performance in autonomous and cued search modes. The studies quantified the cueing accuracies of systems such as the Defense Support Program satellites, netted AN/SPY-1 and Patriot radars, and airborne Infra-Red Space Telescope/Laser Detection and Ranging sensors. The AN/SPY-1 firm-track ranges and SM-2/BLK-IVA flyout capability were then related to potential defended footprints against a wide class of TBMs.

More recent work has covered a TBM debris environment characterization based on the measurement data base. Data from Lincoln Laboratory supported sensors such as the Kwajalein radars, Cobra Judy, and the Airborne Surveillance Testbed were used to quantify the radar and IR characteristics of TBM debris. The results of the analysis have been used to define system requirements for Lockheed-Martin, Raytheon, and Hughes. Following the debris characterization the Laboratory worked to develop the discrimination algorithms and timelines for the Area TBMD System. The discrimination approach is based on radar cross section scintillation and atmospheric drag measurements and has been tested using data from the TBM debris data base. The results show that the Area TBMD System has a significant discrimination capability against incidental debris and some countermeasures.

This year the Laboratory has begun systems analysis work for the Navy Theater-Wide (or upper tier) TBMD and Anti-Air Warfare Programs. This work has included an assessment of potential radar and IR discrimination metrics in the exoatmosphere. Other work has covered an analysis of new sensors and techniques for area defense against low-altitude cruise missiles. The results have been used to plan an acquisition strategy for developing new Navy surveillance and fire control systems.

AIR DEFENSE TECHNOLOGY MOUNTAINTOP PROGRAM

In 1994 the ARPA Mountaintop Program moved the Radar Surveillance Technology Experimental Radar (RSTER) to the Pacific Missile Range Facility's (PMRF) Makaha Ridge Site on the island of Kauai in order to continue the development of techniques and technology related to Space Time Adaptive Processing. The phenomenology measurements program at Makaha Ridge has concentrated on collecting and analyzing data related to bistatic scattering, low-flyer detection, noncooperative target recognition, and sea clutter. Technology development efforts

have included testing several antennas which can be used in a phased-array system capable of placing adaptive nulls in the direction of active and passive sources of interference.

The Navy Mountaintop Program moved the RSTER system to the Kokee site on Kauai, where it functioned as the surveillance sensor in the Cruise Missile Defense Advanced Concept Technology Demonstration Phase I. RSTER acted in concert with the Cooperative Engagement Capability system to hand over target detections to an MK-74 fire control radar. Throughout the series of live fire tests, involving SM-2 missiles launched from AEGIS cruisers, the Mountaintop sensors successfully provided accurate directing information to the AEGIS cruisers, resulting in over-the-horizon intercepts of BQM-74 target drones that had been launched from Barking Sands at PMRF. Following the series of demonstrations, RSTER was moved back to Makaha Ridge where the ARPA Mountaintop Program is continuing.

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 (ASTB) is an instrumentation platform developed by Lincoln Laboratory to investigate these challenges and identify appropriate seeker architectures and signal processing algorithms for dealing with them.

The ASTB is based in a Gulfstream II aircraft which provides high-fidelity reference instrumentation sensors that are used in parallel with special purpose wing pod payloads carrying production seekers or sensors under test. The IR instrumentation provides high-resolution imagery of target and background environments.

COMPUTER-BASED RECOGNITION TECHNOLOGY ADVANCED DISTRIBUTED SIMULATION

Under the Advanced Distributed Simulation Program, funded principally by DARPA and the Defense Modeling and Simulation Office, Lincoln Laboratory developed software implementing an initial prototype of a common run-time infrastructure (RTI) for linking together a broad variety of DoD models and simulations. This reusable RTI software is a critical element of the DoD High-Level Architecture for Modeling and Simulation, which is currently being evaluated for adoption as a DoD standard. The Laboratory completed a feasibility assessment and developed a straw man architecture for linking virtual simulations with instrumented combat vehicles in unprepared locations. Such instant ranges can be used for rehearsing planned operations and evaluating alternative courses of action, using the same command, control, communication, computing, and intelligence (C4I) equipment that would be used in actual combat.

SPEAKER AND LANGUAGE IDENTIFICATION

With the explosion in global speech communication, the identification of the language of a speaker and the verification of his or her identity are important factors contributing to reliable information interchange. Over the past several years, Lincoln Laboratory and a number of other key research laboratories in the U.S. and Europe have been developing automatic algorithms for both language identification and speaker verification. During the first half of 1996, tests were conducted under the supervision of the National Institute of Standards and Technology, which compared both speaker and language identification systems of all the participating laboratories on a battery of test measures using standardized evaluation data. The Lincoln Laboratory systems outperformed all the others in both the speaker and language identification evaluations.

AUTOMATED ENGLISH/KOREAN TRANSLATION FOR ENHANCED COALITION C4I

Lincoln Laboratory has developed a prototype system for automated two-way English/Korean text and speech translation of military messages, and has demonstrated this system successfully aboard the USS Coronado, command ship of the Third Fleet, in conjunction with the June 1996 Rim of the Pacific Coalition exercises. The system builds directly upon advances over the past decade at the MIT Laboratory for Computer Science in natural language understanding and generation, and extends this technology to a new language (Korean), a new application (translation), and a new domain (military messages). Natural language understanding is used to transform the input message into a military interlingua, referred to as a Common Coalition Language; this approach facilitates extensions to other languages. The system is implemented as a translator's aid, running on either a workstation or a Pentium laptop, and is configured for robust operation, so that when the understanding system encounters new sentences which it cannot fully translate, a backup to a phrase-by-phrase or word-for-word translation is invoked.

Currently, the system achieves fully correct sentence translation on 85% of the training/development sentences and on 65% of new sentences in a 2000-word vocabulary Naval Operations Report domain.

MULTI-RATE SECURE VOICE CONFERENCING DEMONSTRATION

In collaboration with the Air Force Rome Laboratory, Lincoln Laboratory has developed a secure voice conferencing system that allows for a natural speaker interrupt capability in contrast to speaker selection techniques used in previous narrowband conferencing systems. A prototype system, including a compact vocoder built by Motorola on subcontract, which integrated the Lincoln multi-rate Sinusoidal Transform Coder algorithm with Motorola's Secure Telephone Unit (STU-III), was demonstrated in September 1995 as part of the Joint Warrior Interoperability Demonstration. During the two-week demonstration, over 1000 persons, including high-level government communications officials, had the opportunity to hear and use the equipment from sites at Hanscom AFB, Massachusetts; Camp Pendleton, California; Ft. Gordon, Georgia; and aboard a KC01 Airborne Command Post aircraft.

SOLID STATE COLOR NIGHT VISION TECHNOLOGY

Lincoln Laboratory is developing advanced night vision technology that has diverse military and civilian applications. The technology will provide a useful night vision capability at lower light levels than are now possible with image intensifier technology, will function under a wider range of ambient light and scene variability conditions, and will enhance the overall utility of night vision devices by the addition of a pseudo-color capability derived from the fusion of visible and thermal IR images. Highly sensitive charge-coupled device (CCD) imagers have been developed at Lincoln Laboratory to image in the visible through the near-infrared spectrum under starlight or darker conditions at video rates. Dual-band imagers are being developed using these low-light CCD imagers and thermal IR imagers (both cryogenic forward-looking IRs and uncooled thermal imagers). The dual-band imagery is processed, using neural models of biological color vision, to create a fused color rendition of the scene in real time.

MACHINE INTELLIGENCE FOR DEFENSIVE INFORMATION WARFARE

Research and development are under way at Lincoln Laboratory on techniques, mechanisms, and tools for detecting computer network intrusion attempts and computer misuse. A user-configurable filter architecture is being pursued, which monitors interfaces between a local area network and the Internet or other outside entities, and supports automated recognition of command/response sequences characteristic of exploitation of specific network security vulnerabilities. The system goals are to achieve low miss and false-alarm probabilities for catalogs of known security vulnerabilities, and for newly discovered intrusion indicators adaptively targeted through the programmability feature as they are discovered by network security operators in the field.

COMMUNICATIONS AND NETWORKING

ARCHITECTURE FOR GLOBAL DEFENSE NETWORK AND TACTICAL THEATER COMMUNICATIONS

The most likely foreign military crises for the United States in the near future will be regional (likely Third World) conflicts that threaten our interests overseas. Since these conflicts can occur anywhere geographically, there is the need for a global defense communications network that can provide instant connectivity to surveillance/reconnaissance assets, rapid deployment forces, and other military assets in a newly formed theater of operation as well as CONUS. This information infrastructure should have global reach and will comprise an interconnection of multiple, sometimes very disparate, communications systems or networks, some of which will be new and some will include heritage systems in existence or planned for deployment in the near future. These systems include (1) satellite communications systems for the relay and downlinking of very high data rate sensor data; (2) military and commercial satcom systems for voice, video, and data communications (such as Milstar, the Defense Satellite Communication System, the Global Broadcast System, the Tracking and Data Relay Satellite System, and the International Maritime Satellite); (3) mobile satcom terminals for aircraft, ground forces, and ships; (4) communications relay nodes on board unmanned air vehicles (UAVs) and other airborne platforms; and (5) a global reach ground network infrastructure that includes military and commercial networks.

ALL-OPTICAL FIBER NETWORKS

In 1993 a DARPA-sponsored consortium made up of AT&T Bell Laboratories, Digital Equipment Corporation, and MIT was formed to develop architectures and technologies to exploit the unique properties of fiber optics for

advanced broadband networking. Two promising technologies are being investigated for utilizing the large bandwidth of a fiber: wavelength-division multiplexing (WDM) and time-division multiplexing, the latter utilizing soliton pulses. Both approaches have merit and each will likely find applications in future civilian and DoD networking environments.

The Wideband All-Optical Networks WDM effort consists of developing architectures, technology components, and a test bed for the realization of scalable, high-speed (user data rates from 10 Mbps to 10 Gbps), high-capacity (~Tbps) transparent optical WDM networks. The architecture addresses all-optical transport over wide, metropolitan and local areas utilizing wavelength partitioning, wavelength routing, and active multiwavelength cross-connect switches to achieve a network that is scalable in the number of users, data rates, and geographic span. The network supports three optical services which can be point-to-multipoint, or multipoint-to-multipoint simplex or duplex connections. A 20-channel local and metropolitan area WDM test bed has been developed and deployed in the Boston metropolitan area based on these architectural principles using advanced components. Multiple rate and format connectors over a variety of optical services and over 130 Gbps of capacity through a metropolitan area hub have been demonstrated. A full all-optical network (AON) control and management system has also been developed and implemented.

In March 1996 the Advanced Technology Demonstration Network (ATDNet) was initiated to integrate AON technology into Washington, D.C. ATDNet is a DoD-sponsored networking initiative with six principal network nodes: the National Security Agency, Naval Research Laboratory, Defense Information Systems Agency, Defense Intelligence Agency, NASA, and DARPA. The interoperation of ATDNet with an advanced technology test bed will provide an early indication of the efficacy of AONs in a realistic DoD setting. Quantitative information concerning the utility and performance transparency and the major increase in capacity of the WDM network can be obtained. Field evaluation of the two networking technologies will provide important qualitative and quantitative results for guiding future architecture, technology, application development, and procurement decisions.

SATELLITE COMMUNICATIONS

The Satellite Communications Technology Program is responsive to evolving satellite communications service trends and challenges, including the need to lower costs (via smaller, lighter-weight implementations) and the performance-related goals of increased capacities (especially to small, mobile terminals), interoperable networking (where satellite communications extend national/international information networks to remote areas and/or mobile users), and robustness against co-user as well as intentional interference. Many of the concepts and technologies that are being developed are also applicable to augmentation of tactical communications via UAVs and to the emerging commercial wireless and mobile satcom services. One of the key accomplishments during this year has been the development of an architecture for efficient data services via satellites. Key elements are an on-board packet-switching processor and a satellite-compatible link layer protocol that can accommodate all of the standard data transfer techniques (e.g., asynchronous transfer mode, transmission control protocol/Internet protocol, and file transfer protocol).

ADVANCED DISTRIBUTED SIMULATION

Under the Advanced Distributed Simulation Program—funded by DARPA, the Defense Modeling and Simulation Office, and the Simulation, Training, and Instrumentation Command—the Laboratory developed a set of network communication control algorithms that achieved a tenfold reduction in total backbone traffic for ARPA's Synthetic Theater of War Exercises, conducted in September 1994. The lessons learned from this highly successful effort are being incorporated in the development of the "Next Generation" Distributed Interactive Simulation architecture for the DoD. Also, the feasibility of linking virtual simulations with instrumented combat vehicles to create a range environment that can be quickly established at an unprepared location was studied. Such an "instant range" could be used to great advantage in rehearsing planned operations and evaluating alternative courses of action, using the same command, control, communication, and intelligence equipment that will be used in actual combat. Key instrumentation, data link transmission, and distributed network issues have been identified.

AIR TRAFFIC CONTROL TERMINAL AUTOMATION

By developing planning aids for the air traffic controllers responsible for landing aircraft, Lincoln Laboratory is helping the FAA to enhance air safety, reduce controller workload, and increase airport capacity. The Center/Terminal

Automation System (CTAS) helps coordinate activities between arrival controllers located at en route centers and final approach controllers located at airport radar control facilities.

In January 1996, a Lincoln Laboratory CTAS field prototype became operational linking the new Denver Airport with the Denver En route Center in Longmont, Colorado. In addition to providing a well-structured and fully tested and documented software system, Lincoln Laboratory developed a complete suite of interfaces to existing FAA equipment to extract the necessary surveillance, flight plan, and weather data and to enable the automation software to access existing radar display terminals. Lincoln Laboratory also designed and built a comprehensive test environment for the automation logic. This realistic test equipment allowed FAA controllers to evaluate the automation logic under simulated operational conditions and supported rigorous operational testing.

The system at Denver has been enthusiastically received by controllers because it provides them greater awareness of traffic flows, giving them advance warnings of situations that may cause problems and allowing them to develop more efficient traffic management plans to reduce delays and increase safety.

DATA LINK SYSTEMS

The Mode S radar beacon system was developed, prototyped, and tested at Lincoln Laboratory for the FAA and is now being deployed at 144 sites nationwide. Mode S has an integral air-ground digital data link, and Lincoln Laboratory has developed data link applications for use by air transport and general aviation aircraft. The Traffic Information Service provides pilots with the location of nearby aircraft by uplinking surveillance information gathered by the Mode S radar. The Text Weather Service and Graphical Weather Service provide pilots with weather text and graphics uplinked via Mode S from ground-based weather sources, including weather radars. These data link applications have been implemented in an operational Mode S radar at Dulles International Airport for a field evaluation in preparation for a national implementation. General aviation groups such as the Aircraft Owners and Pilots Association have equipped their aircraft with data link avionics built by industry in collaboration with Lincoln Laboratory and are participating in a 1-year field evaluation. Several airlines are participating in a demonstration of text data link products derived from the Terminal Doppler Weather Radar and transmitted on the airlines' own VHF data link, the Aircraft Communication Addressing and Reporting System.

GLOBAL POSITIONING SYSTEM BASED AIRCRAFT SURVEILLANCE

A new Laboratory-developed technology for surveillance of airborne and surface aircraft is the broadcast of Global Positioning System (GPS) determined position, and other key flight data, via the Mode S data link to all listeners. This technique, termed GPS-Squitter, was first demonstrated for surface surveillance at Logan Airport in Boston in February 1994. A successful evaluation was then conducted for air surveillance in December 1994 in the Gulf of Mexico for helicopters servicing oil platforms. In 1996, GPS-Squitter was demonstrated for the air-to-air Cockpit Display of Traffic Information. It has been adopted for use by the Traffic Alert and Collision Avoidance System now carried by all airliners in U.S. airspace. GPS-Squitter is expected to become the accepted technology for improved cooperative surveillance in U.S. airspace.

SURVEILLANCE RADAR IMPROVEMENTS

The last FAA airport surveillance radar, ASR-9, uses computer processing technology dating to the early 1980s. Its obsolete hardware and software limitations prohibit the installation of needed improvements and upgrades. In 1993, Lincoln Laboratory initiated a program to design and program a single plug-in card (the ASR-9 Processor Augmentation Card, or 9-PAC) to replace the radar's data processor. This card offers ten times the processing power and improved software maintainability and upgradability. In addition, the new 9-PAC data processing algorithms improve aircraft tracking over roads and through heavy radar clutter and reject false beacon targets. The software automatically adapts its processing parameters to the radar environment, eliminating the need for intensive manual site adaptation procedures. Following intensive FAA testing in 1995, prototype 9-PAC boards are now operating in commissioned FAA air traffic control radars located at airports in Los Angeles, Dallas-Fort Worth, Oakland, and Honolulu.

AVIATION WEATHER DETECTION AND PREDICTION

A continuing 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. The system provides wind shear information automatically to air traffic controllers, pilots, and air traffic control automation systems. Lincoln Laboratory is

supporting the refinement of the wind shear detection and storm motion algorithms utilized in the Laboratory-designed Terminal Doppler Weather Radar 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 to be equipped with a Weather Systems Processor, providing similar wind shear warning and storm motion capability at the nation's medium-density airports.

A Laboratory-developed Integrated Terminal Weather System (ITWS) is under test to determine its ability to delineate hazardous airspace conditions and to provide short-term forecasts of significance to aviation. The Laboratory is developing the ITWS algorithms that will utilize data from FAA and National Weather Service systems such as terminal sensors, lightning mappers, and numerical forecast models. The Laboratory is continuing to operate ITWS test beds in Memphis, Orlando, and Dallas-Fort Worth to increase the ITWS data base and test enhanced products as they become available. An additional experimental site in San Francisco supports the development of ceiling and visibility products.

ELECTRONIC DEVICES

MID-INFRARED SEMICONDUCTOR LASERS

Lincoln Laboratory has been developing high-performance semiconductor lasers emitting in the mid-infrared spectrum between 2 and 5 μm . Such lasers are potentially important for detecting trace gas concentrations (as low as 1 part per billion) and for IR countermeasures to protect aircraft against heat-seeking missiles. The lasers are fabricated from heterostructures and quantum wells containing antimony-based III-V compounds grown by molecular beam epitaxy on either GaSb or InAs substrates. Lincoln Laboratory was the first to demonstrate high-power diode lasers emitting approximately 1 W at 2 μm in continuous-wave (cw) operation at room temperature. (Previously, the maximum cw power had been approximately 1 mW.) At longer wavelengths reduced operating temperatures are required because of Auger recombination, a parasitic loss mechanism. At 3.5 μm , quantum-well diode lasers have operated cw up to -98°C , with cw power of 430 mW at -193°C (liquid nitrogen temperature). At 4 μm , double-heterostructure lasers, pumped optically using 0.94- μm high-power diode lasers as pump sources, have operated with a peak power of 2.7 W and average power of 350 mW at -193°C . Work is continuing in an attempt to increase the operating temperature by optimizing the laser structures and epitaxial growth conditions. In parallel with the laser development, compact prototype subsystems have been built for field demonstrations.

0.2- μm SILICON-ON-INSULATOR CMOS LOW-POWER HIGH-SPEED DEVICES

Significant milestones have been reached in the Laboratory's 193 nm lithography program. In a major effort to refine and commercialize the 193-nm technology pioneered at Lincoln Laboratory, the U.S. semiconductor industry has adopted the goal of using 193 nm for volume production of 0.18- μm feature-size integrated circuits in the 2001 time frame. The Laboratory's unique large-field 193-nm lithography tool, capable of patterning features below 0.2 μm , was used for all 11 masking levels in a low-power, high-performance, silicon-on-insulator CMOS process. First-pass success was achieved on both test devices and simple circuits, with 0.2- μm -gate-length inverter delays of 29 ps at 3 V and 57 ps at 1 V. The latter represents a ten times reduction in power consumption and a simultaneous two times improvement in speed when compared with conventional 0.5- μm technology.

W. E. Morrow, Jr.

SCHOOL OF ARCHITECTURE AND PLANNING

During the 1995-96 academic year, the School of Architecture and Planning continued to build and renew its faculty, to improve its core facilities, to develop new computer and digital telecommunication capabilities, and to sponsor new ventures in research and teaching.

FACULTY

Faculty development and renewal remains a top priority. During 1995-96 there were important faculty appointments in all units of the school.

In the Department of Architecture Ann Pendleton-Jullian and Sibel Bozdogan were promoted to Associate Professor and Leslie Norford was granted tenure. Dennis Adams, previously a visiting artist, and Mark Jarzombek, a Visiting Associate Professor in the History of Architecture, were both appointed Associate Professor with tenure. A leader in advanced studies in design theory, George Stiny joined the faculty this year. Art historian Michael Leja, an Eldredge Prize winner for his recent book, *Reframing Abstract Expressionism*, has also joined the faculty this year.

In Media Arts and Sciences Assistant Professor Aaron Bobick has been named the LG Career Development Professor of Media Arts and Sciences. Neil Gershenfeld, Kenneth B. Haase, Jr., and Mitchell Resnick have been promoted to the rank of Associate Professor of Media Arts and Sciences. Associate Professor Resnick has also been named the Fukutake Career Development Professor of Research in Education. Hiroshi Ishii, whose primary research interest is the creation and development of collaborative workspaces that merge video and graphics technologies, joined the faculty as an Associate Professor of Media Arts & Sciences. Professors Marvin Minsky and Seymour Papert retired during this academic year, however, both continue a half-time affiliation with the Media Lab and its academic programs.

The Department of Urban Studies and Planning lost three faculty to retirement this year. Professors Ralph Gakenheimer, and Gary Marx as well as Adjunct Professor and Director of the Community Fellows Program Melvin King have all retired. Omar Razzaz, Assistant Professor of Urban Planning, and James Morrison, half-time lecturer in writing and argumentation, have joined the department this year. Professor Lawrence Susskind was appointed Ford Professor of Urban and Environmental Planning.

SPACE

The renovations of departmental headquarters for both Architecture and Urban Studies and Planning on the third floor of Building 7 were completed as well as the installation of a piece by the American artist Frank Stella, the generous gift of Elliot Wolk.

During the spring semester of 1996 the major renovation of School space in the main complex continued. The most recent phase of the renovation, on the 4th floor around the Building 7 dome and in Building 3, has brought on-line four additional electronic design studios, a model shop, and a cafe area. A key new facility will be completed during this stage of renovation: a visualization theater. This state-of-the-art facility will be equipped with high-end computer video projection and videoconferencing capability, allowing remote experts to participate in studio reviews. The total renovation has proceeded in stages over the last three years. One of the goals of the renovation is to create spaces that are flexible and can respond to changes in teaching methodologies of the future.

EDUCATIONAL INITIATIVES

Curricula throughout the School continue to evolve vigorously in response to emerging conditions and opportunities.

In the Department of Architecture the first students who entered under the new curriculum will graduate with a Master of Architecture degree during the fall term of 1996. The curriculum for this program continues to be fine tuned with the addition of a subject in professional practice to be offered in parallel with the thesis. Ties with several major architects have been established to further the goal of having upper level studios taught by internationally recognized architect/teachers.

The use of external reviewers on Architectural Design Thesis is now being utilized as an effort to improve the process and product of theses.

Though it offers no undergraduate degree, Media Arts and Sciences offered nine undergraduate subjects this year and provided an extraordinary number of openings (242) in the Undergraduate Research Opportunities Program. Three faculty and Media Lab staff also participated in undergraduate education by conducting freshman advising seminars or serving as freshmen advisors.

The Department of Urban Studies and Planning offered six Freshman Advising Seminars and are reorganizing their undergraduate courses to offer six to eight magnet courses each semester. The Special Program for Urban and Regional Studies hosted 16 Fellows from around the world while the Community Fellows Program brought 12 mid-career community activists to MIT to build their skills to enable them to develop youth-oriented programs for their disadvantaged communities. The department also offered a twelve-week faculty colloquium, funded by a grant from the Kellogg Foundation, which explored topics related to Advanced Information Technology, Low-Income Communities and the City. Papers and dialogs generated by the colloquium series are being combined into a book.

The Aga Khan Program for Islamic Architecture hosted two visiting scholars. Khalil Pirani, who is funded by the American Institute of Architects for his research in Mosque architecture in North America, and Shakeel Hossain, who is working on the Ta'zia project. Shakeel Hossain is also a 1988 DIS alumnus.

To reflect changes in the real estate industry the Center for Real Estate has revised two core courses. They have expanded Managing the Real Estate Company by including segments on negotiation and team building. They have also replaced Construction Technology and the Building Construction Process with Building Technology in Real Estate Decision Making which focuses on evaluating existing structures and building systems rather than new construction.

Five scholars from the People's Republic of China participated in a week-long workshop, directed by Professor Wheaton, to carry out a comparative study of real estate market information systems in Beijing, Shanghai and the United States. The center also hosted a day-long focus group on changing practices and emerging challenges in the property management industry attended by 290 senior executives from firms that provide or consume management services in commercial office buildings.

Steve Benton has been appointed as Director of the Center for Advanced Visual Studies. This department is once again offering the degree Master of Science in Visual Studies. It is offered jointly with the Visual Arts Program as part of the graduate program in Public Art. To re-establish itself as a leader in the field of critical art and design the center has changed its emphasis and has begun to redesign its programs, including educational and research methods programs, accordingly.

OUTREACH AND AWARDS

The academic year was marked by a series of outstanding public events. Some showcased innovative work from within the School; others offered us the chance to learn from leading international figures in design and social issues.

The tenth day of the tenth month of 1995 saw the remarkable 10/10 events marking a decade of intense intellectual activity at the Media Laboratory. The day-long symposium and open house provided a vibrant window onto the present and future of digital media and celebrated one of the great success stories in the Institute's recent history.

Over the course of the academic year, we had the fortune to hear directly from some of the world's leading designers and artists on the process and meaning of their work. In the Department of Architecture, Visiting Professor William Bruder, one of the most creative younger designers in America, delivered the Arthur Schein Memorial Lecture, while Japan's Fumihiko Maki, one of the most respected of those who have made Japanese architecture internationally influential, delivered the Pietro Belluschi Memorial Lecture. In an informal public discussion coinciding with the opening of the Wolk Gallery, Frank Stella offered insights into the genesis of his own recent work.

The John Howard Memorial Lecture was sponsored by The Department of Urban Studies and Planning. The event included a retrospective of Professor Howard's career in the department and featured a keynote address by Mitch Kapor, the founder of Lotus Development.

Two international conferences and a roundtable discussion were sponsored by the Aga Khan Program this year. In the fall AKPIA sponsored the roundtable discussion, "From Classic to Arab Cities: Urbanism in the Levant During the Medieval Period," and co-sponsored "Expressions of Identity: Mosques in North America." In the spring they sponsored the conference "Rethinking the XIXth Century Town: the Morphogenesis of the Urban Fabric."

The Ralph Adams Cram Award for outstanding interdisciplinary work at the Master's level was presented to June Lisa Burke, 1995 graduate of the Center for Real Estate. The Lawrence B. Anderson Award, which is made every two years to an alumnus of the School for a proposal to research and document a significant aspect of the build environment went to Erik Gunnar Haugsnes, who received his B.S.A.D. from the Department of Architecture in 1983, for a proposal to study the architecture and urbanism of the Tibetan Diaspora that has taken place during the last thirty years.

SUMMARY

This was a year of great progress. It ended on a high note with preparations to move the majority of the Department of Architecture's activities back from Building N51-52 to new studio and office space at the central 77 Massachusetts Avenue location, and to reunite Architecture, DUSP, Library, and Administrative functions.

William J. Mitchell

DEPARTMENT OF ARCHITECTURE

1995-96 was a contributive year in the rebuilding of the department and its several programs(both in the events of the year and in planning for the future. Notable accomplishments and problems will be reviewed here according to the organization of our department in four discipline groups, and subsequently under headings for the other major issues.

ARCHITECTURAL DESIGN

Architectural Design is the core group of the department, having primary responsibility for the professional Master of Architecture degree program as well as both undergraduate and graduate studies in architecture.

MASTER OF ARCHITECTURE DEGREE

The first students who entered under our new curriculum will graduate in the fall term of 1996. We continue to fine tune this curriculum. The fundamental course in drawing introduced last year was extremely successful in itself and in its contribution to the conviction with which students engage their primary studio work. The culminating, integrative subject in building technology was taught for the first time and with excellent results. Plans were laid for an innovative subject in professional practice which is the last new element of the curriculum and will be offered in parallel with the thesis during the fall term.

Architectural Design Studios

Recent improvements in the level of development, completion, and presentation in architectural design were maintained. Our goal of having more upper level studios taught by internationally recognized teachers was furthered in plans that will now begin to appear. Michael McKinnell, a local architect of international stature and noted as an exceptional teacher, joins us as an Adjunct Professor teaching one studio each year. We have established ties with several major architects who will offer visiting studios on a periodic basis: these include Dimitris Antonakakis of Athens, Charles Correa of Bombay, and Ada Karmi-Melamede of Tel Aviv. Fumihiko Maki of Tokyo may make briefer appearances.

Architectural Design Theses

Recent efforts at improvement in both the process and product of theses were revealed in an exceptional group of MArch theses that permitted excellent criticism, and even celebration, for the first time by a group of noted external reviewers.

Design Inquiry/Design and Computation

All students have taken the fundamental subject in solid modeling. More advanced subjects in computer visualization are offered by Professors Julie Dorsey and Takehiko Nagakura as well as Research Scientist Kent Larson. The use of the computer for technical analysis of models is increasingly common, largely through the Building Technology faculty. The integration of computation in studio work is most evident in special studios taught by Professor Andrew Scott and Dean William Mitchell, but increasingly appears in other studios largely through the initiative of students.

George Stiny joined the faculty as a leader in advanced studies in the rationalization of design. Professor William Porter led the Design Inquiry section which incorporates not only a range of computationally-based research (representation, visualization of light and acoustic phenomena, etc.) but also innovative studies in programming, the changing workplace, and so on. Andrew Scott continued with the staged integration of issues of sustainability and architecture; he has organized an international conference for next academic year.

MASTER OF SCIENCE IN ARCHITECTURE STUDIES DEGREE

This two-year post-professional degree continues to perform well as one of the nation's few serious advanced masters programs. The number, diversity and strength of theses in the Design Inquiry area improved markedly. Applications (and acceptances) for next year were strong in all the divisions -- notably increased in History, Theory and Criticism.

BUILDING TECHNOLOGY

Searches for two faculty members in areas of Building Technology that most strongly interact with architectural studios (a weakness in recent years) resulted in one appointment (Chris Luebke from the University of Oregon) and another that may mature soon. Other recently appointed faculty enjoyed remarkable success. Both Julie Dorsey and Yan Chen won multi-year NSF grants as well as other significant funded research. A new indoor air research facility for Professor Chen is nearing completion in Building N51. Professor Leon Glicksman brings the Architecture Department into the Alliance for Global Sustainability. (Andrew Scott of the design faculty also has support from AGS.)

HISTORY, THEORY AND CRITICISM

The rebuilding of this section is moving faster than anticipated. Though we had to rely significantly on visitors this year, both performance and esprit were high. The pool of applicants was large and very good; we enlisted all of our top choices. With the fall term, our two new mid-career appointees -- the art historian Michael Leja and the architectural historian Mark Jarzombek -- will be in place. Both are noted for their research, distinguished teaching, and collegiality. Leja's recent book, *Reframing Abstract Expressionism*, won the Eldredge Prize of the Smithsonian Institution.

VISUAL ARTS

To the recently consolidated appointment of Krzysztof Wodiczko, we added the appointment of another world-recognized artist, Dennis Adams. Both these artists are also remarkably theoretically aware and articulate -- exceptional people for an academic environment. It is now vital to provide them with the resources that will lead them to work through MIT, rather than away from it.

STUDENT AID

We are grateful for considerable student aid assistance from the Provost's office in the last two years, making us more competitive with other schools than two years ago. Nevertheless, competition is still severe and the needs of our students, who are in fields with long degree programs and low professional salaries, are profound.

SPACE RENOVATION/DEPARTMENT CONSOLIDATION

Renovation of the remaining available studio space in buildings 3 and 7 should be completed for the fall term. With this we will be able to unify almost all of our studio teaching in the Main complex, and thus bring the majority of our teaching programs into proximity with one another and with Rotch Library and the department administration.

AGA KHAN PROGRAM FOR ISLAMIC ARCHITECTURE

We have never had such an excellent and ambitious AKPIA faculty as now: Attilio Petruccioli and Nasser Rabbat supplemented by Sibel Bozdogan. Their teaching is excellent and Petruccioli conducts international symposia every term.

PROGRAM ENROLLMENTS AND STUDENT AWARDS

A total of 69 undergraduates and 171 graduate students (including 95 MArch, 42 SMArchS/SM without specification, 8 SMBT, 3 SMVisS, 23 PhD resident and 15 PhD non-resident, and 2 non-degree special students) were counted in Course IV this year.

Student Awards designated by the Department or Institute: The William Everett Chamberlain Prize for graduating BSADs for achievement in design (Kara Bartelt). The Sydney B. Karofsky '37 Prize for the outstanding Master of Architecture student with one further year of study (Frederick Gutierrez). The Francis Ward Chandler Prize for achievement in architectural design (Carlos Ridruejo). The Alpha Rho Chi Medal for leadership, service for the school and department, and promise of real professional merit (Richard Stump). The AIA Certificate of Merit for second-ranked master of architecture student (Winston Lim). The AIA Medal for the top-ranked master of architecture student (Robert Benson). The SMArchS Prize (Michael Fox, Rupinder Singh, Joseph Raia). The Imre Halasz Thesis Award (Carlos Ridruejo). The AIA Foundation Scholarship nominees (Melanie Coe, Scott Tulay). The Caminos Memorial Fund Award for students concerned with third world and first world issues (Owiso Makuku). Tucker-Voss Award nominees for students showing particular promise in building construction (Henry Harvey). The Kristen Ellen Finnegan Memorial Award in History, Theory, and Criticism of Architecture (Annie Pedret, Sarah

Whiting). Faculty Design Award (Nina Bischofberger, Soyoung Kang, Tinchuck Agnes Ng). Schlossman Research Fellow (Osama Tolba). Ann Macy Beha Travel Award (Frank Hekel, William Lackey, Sandra Ventura). Louis C. Rosenberg Travel Award (Christine McGrath, William Scholtens). Robert Newman Student Fund Award (for acoustics) (Deirdre Terzian). Phi Beta Kappa (Matthew Gorbet).

External Awards: Citation of Merit, Carter Manny Award (Francesca Rogier). Mary Davis Fellowship, National Gallery of Art, Center for Advanced Study in the Visual Arts (Edward Eigen). Historians of Islamic Art Fellow (Shirine Hamadeh). Institute of Turkish Studies Grant (Shirine Hamadeh). Aga Khan Travel Award (Shirine Hamadeh). Kress Travel Fellowship (Brian McLaren). Short Term Opportunity Grant for German and European Studies, Modern Culture and The Ethnic Artifact Conference (Brian McLaren). Kress Foundation Dissertation Fellowship in Art History (Francesca Rogier). Chester Dale Fellowship, National Gallery of Art, Center for Advanced Study in Visual Arts (Samuel Isenstadt). Kress Fellowship (Rejean Legault). Doctoral Fellowship, Social Sciences and Humanities Research Council of Canada (Annie Pedret). American Association of University Women International Fellowship (Shirine Hamadeh).

HIGHLIGHTS OF THE PAST YEAR

FACULTY

Ann Pendleton-Jullian and Sibel Bozdogan were promoted to Associate Professor effective 1 July 1996. Leslie Norford was granted tenure effective 1 July 1996.

Visiting faculty included Dimitris Antonakakis, William Bruder and Donlyn Lyndon, T. Kelly Wilson, and Bill Hubbard who each taught one semester of design studio; Paul Donnelly who taught in the building technology group; and James Ackerman who taught in the History, Theory, and Criticism section. Dennis Adams returned as Visiting Artist in the spring; his appointment as Associate Professor of Visual Arts with tenure was approved and becomes effective July 1, 1996. Mark Jarzombek was Visiting Associate Professor in the History of Architecture; his appointment as Associate Professor with tenure also was approved and becomes effective July 1, 1996.

Leon Groisser, Professor of Structures, Ákos Moravánszky, Visiting Associate Professor in History, Theory, and Criticism, and Leonard Morse-Fortier, Assistant Professor of Building Technology, completed the last year of their appointments.

The Building Technology section was involved in two searches, resulting in the appointment of Chris Luebke as Assistant Professor beginning next January and in the identification of a strong candidate for the second position which is still in the negotiation stage. The Architectural Design search identified a candidate as well, although the academic approval process is not yet complete.

DEPARTMENT ACTIVITIES

Students extended their learning as well as their abilities to contribute solutions to design opportunities through workshops in India, Northern Pakistan, and Spain. An urban design studio was conducted partially in Taiwan and another in Bukhara, Uzbekistan. A preliminary studio experience in Peru led to further interaction with two Peruvian instructors participating in the studio upon the students' return. A drawing course traveled to Rome in June. A design workshop is acting as consultants with the public school system in Washington, D.C. As the department has accumulated experience in such international and real-world efforts, the results have been increasingly beneficial to both the students and their hosts.

The Architecture Lecture Series brought Dimitris Fatouros, John Habraken, Michael Leja, and Peter Testa in the fall. William Bruder gave the tenth Arthur Schein Memorial Lecture and Fumihiko Maki gave the third Pietro Belluschi Lecture. The Architecture/Machine Debates, organized by Julian Beinart, focussed panel discussions with MIT faculty and distinguished visitors, and invited audience participation, on four questions: What Could Architecture Be? Urbanism: Does Distance Matter? How Will Architects Practice? How Will We Learn with Machines? In the spring, speakers included Kurt Forster, Santiago Calatrava, Donlyn Lyndon, Renée Kemp-Rotan, and James Ackerman.

The department publication, *Thresholds*, examined the nature of the design thesis. The weekly newsletter, *PIN UP*, continued to build a loyal readership and featured opinions and articles, reviews of lectures and exhibits, calendar

items, photos and drawings, and doses of humor to enliven its pages. In particular this year, the editors notably strengthened its role as a means of dialogue among faculty and students.

Aga Khan Professor Attilio Petruccioli organized two two-day conferences with international participation, funded by The Aga Khan Program for Islamic Architecture at Harvard and MIT, and concerned with: "Expressions of Identity: The architecture of Islamic centers in North America" and "Rethinking the XIXth Century Town."

Faculty members continue to be well represented in the respected journals of their fields with articles reflecting their interests in research, theory and practice. Faculty members receiving awards include Andrew Scott (with Takehiko Nagakura and Dean William Mitchell)(1996 American Institute of Architects Education Honors Award); Paul Donnelly and Andrew Scott (Building Integrated Photovoltaics Competition, First Prize); John Habraken (BKVB Award, The Netherlands); Michael Leja (Eldredge Award, Smithsonian Institution); Stanford Anderson (American Institute of Architects 1995 International Book Award). The MIT Museum hosted an exhibition of work by Jan Wampler; the new Wolk Gallery hosted an exhibition of work by Professor Emeritus Eduardo Catalano.

I would assess the past year as marked by steady progress on most fronts, especially in the quality of MArch theses and of faculty appointments in this and recent years.

Stanford Anderson

PROGRAM IN MEDIA ARTS AND SCIENCES

Graduate studies in Media Arts and Sciences continues to flourish, with over one hundred students engaged in research within the Media Laboratory. Added to this population are another hundred-plus undergraduates per term as active UROPers - the largest population of any unit at MIT. This strong commitment to provide a creative environment for both undergraduate as well as graduate students is one of the reasons the Media Laboratory and its academic programs remain highly visible within the institute, despite our small faculty. Our subject offerings also serve to open doors to engaging experiences within the Media Laboratory, beginning with Professors Negroponte and Hawley's *Introduction to Media Arts and Sciences* attended by over one hundred students. This introduction is then followed by a set of "hands-on" subjects: *Tools for Thought* (Professors Resnick, Cassell and Brand), *Story: Representation and Process* (Professors Davenport and Haase) and *Intentionality* (Professors Pentland and Richards) as well as a host of other subjects that cover more advanced topics that aim to bring ongoing research into the classroom. The culmination and highlight this year of two of these advanced offerings will be Professor Tod Machover's *Brain Opera*, which premieres at the Lincoln Center in July. Currently our faculty are exploring other ways to further enrich the undergraduate experience.

EDUCATION

One hundred and eighty-nine applications for our graduate program were received this year, from which 27 were selected for admission (including 6 women), 19 for the Master's program, and 8 for the Doctoral program. Our graduate student population this year consisted of 94 students (19 women, 2 underrepresented minorities, and 24 foreign students), of whom 49 were in the Master's program and 45 in the Doctoral program. Thirty-five advanced degrees were awarded during the year (32 S.M. and 3 Ph.D.). Twenty-two graduate subjects were offered by the Program.

This year we offered nine undergraduate subjects. The number of active UROP students in the Media Laboratory was 242. Of these students, many pursue their undergraduate thesis research under our faculty's supervision. Three of the MAS faculty and Media Lab staff conducted freshman advising seminars or served as freshman advisors.

FACULTY AND STAFF

Assistant Professor Aaron Bobick has been named the LG Career Development Professor of Media Arts and Sciences. Professor Bobick's research spans human and machine vision, integration of perceptual information, and symbolic understanding of visual situations, and he has pioneered the field of dynamic scene annotation.

Assistant Professor Neil Gershenfeld was promoted to Associate Professor of Media Arts and Sciences effective July 1996. Professor Gershenfeld's overarching intellectual theme is the relationship between physics and information. He has contributed in the field of complex systems, specifically the non-linear analysis of time series events.

Assistant Professor Kenneth B. Haase, Jr. was promoted to Associate Professor of Media Arts and Sciences effective July 1996. Professor Haase is noted for his work on using analogy to index, retrieve and organize very large scale databases of information.

Assistant Professor Mitchel Resnick was promoted to Associate Professor of Media Arts and Sciences effective July 1996. He has also been named the Fukutake Career Development Professor of Research in Education. Professor Resnick's research explores how new technology tools and media support new ways of thinking and learning. His group is creating new computational tools that help people (particularly children) develop new ways of thinking about systems-oriented phenomena (such as self-organization and emergence).

Dr. Hiroshi Ishii joined the Media Arts and Sciences faculty as an Associate Professor of Media Arts & Sciences and is currently supported by Interval Research Corporation. He received his PhD from Hokkaido University (Japan) in 1992, and came to MIT from Nippon Telegraph and Telephone Corporation (Japan) where he was a Senior Research Engineer. His main research interest is the creation and development of collaborative workspaces that merge the video and graphics technologies.

Dr. John Maeda will join our faculty as an Assistant Professor of Computation Design effective July 1996. Dr. Maeda received his PhD from Tsukuba University Institute of Art and Design in 1996 and has already achieved international recognition for his design work.

Dr. Joseph Jacobson has also been appointed as an Assistant Professor effective July 1996. Dr. Jacobson received his PhD from MIT in 1992. For three of the past four years he has been a postdoctoral fellow at Stanford University, and over the past year he has been an Instructor in the Media Arts and Sciences Program. His research interest is in "electronic paper".

We are pleased that both Professor Marvin Minsky and Professor Seymour Papert will continue at half-time affiliation with the Media Laboratory and its academic programs.

HONORS AND AWARDS FOR FACULTY AND STUDENTS

Professor Stephen Benton, E. Rudge and Nancy Allen Professor of Media Arts and Sciences, received a Vinci of Excellence award in the 1995 Science for Art Competition sponsor by LVMH Moët Hennessy and Louis Vuitton, Inc. Professor Benton was cited for his contributions to holography as an imaging medium, especially for inventing the silver "rainbow" or "Benton" white-light hologram, for developing methods for creating computer-generated holograms, and for inventing, with the Spatial Imaging group, the world's first interactive holographic video system.

Adjunct Professor Danny Hillis has been named the first Disney Fellow of the Walt Disney Corporation.

Honorary Doctorates were awarded to Professor Nicholas Negroponte from Ball State University and Professor Marvin Minsky from Connecticut College, Center for Arts & Technology. Professor Minsky was also awarded the Joseph A. Priestley Award from Dickinson College, Carlisle Pennsylvania.

Other Newsworthy Events

Constructionism in Practice: Designing, Thinking and Learning in a Digital World edited by Mitchel Resnick with Yasmin Kafai (Lawrence Erlbaum Associates Publishers, 1996). This book further develops the intellectual underpinnings of constructionist theory - a theory for learning and a strategy for education.

Perception as Bayesian Inference by D. Knill and W. Richards (Cambridge University Press, 1996).

Jerome B. Wiesner: A Random Walk through the 20th Century, directed by Glorianna Davenport and Cheryl Morse. This is the first hybrid CD-Rom/WWW site for 10/10 and also appears as a stand alone WWW Java Site with video.

Whitman Richards

DEPARTMENT OF URBAN STUDIES AND PLANNING

Although the field of urban and regional planning has changed significantly over the last seventy-five years, at its core it still draws inspiration from a normative vision of the "good society." In the Department of Urban Studies and Planning, this vision is nurtured by a commitment to a distinct notion of social progress which frames the teaching and research of the faculty and the mindset of the graduates.

The key elements of our commitment to this social progress involve:

- A belief in the abilities of cities and regions to steadily improve the quality of life of their citizens.
- An emphasis on democratic decision-making. This involves the responsibility of individuals, governments, and corporations, but also acknowledges the necessity of government leadership in ensuring greater social and economic equality.
- A positive approach to technological innovation as a major force of social change.
- A deep trust that the built environment can meet the needs of diverse populations and serve as a source of meaning in their daily lives.

This notion of social progress guides not only the scholarly deliberations on industrialized countries, but also provides a shared moral sensibility for the study of industrializing countries whose destinies are believed to be interlinked in a world deeply connected by the flow of capital, goods and services, population and ideas.

This moral vision is translated into professional education in a distinctly unique way. There is strong emphasis on theorizing from practice. This theorizing draws on different institutional actors and institutional settings, and involves the study of programs delivered by the public, private, and non-profit sectors at various levels--local, regional and global. And, learning from these programs is aided by analytical techniques strongly influenced by continuous innovation in information technology.

And finally, learning from these efforts is aided by analytical techniques strongly influenced by continuous innovation in information technology. Collectively, this philosophy facilitates a learning environment which nurtures the normative vision of social progress unique to the department and informs the type of courses we offer and the research we conduct.

DEPARTMENT EARNS GLOWING REVIEWS

The department received high marks from both our Visiting Committee's fall review and a national accreditation visit in the spring. Both committees reconfirmed the 1991 accreditation report conclusion that, "The Department of Urban Studies and Planning at MIT is clearly one of the premier planning programs in the world." The 1996 accreditation committee found that our program had improved even more since the earlier visit, particularly in the areas of hiring women faculty, connections to professional practice, and faculty books and other publications. Our student services were declared the envy of other planning schools.

RESEARCH AND TEACHING ON URBAN PLANNING

The intellectual life of the department is organized around five program groups, which reflect five major areas of current planning practice. Regular seminar series sponsored by each of the groups bring faculty, students and outside scholars and practitioners together to debate cutting edge topics. In addition, each group engages faculty and students in scholarship and fieldwork. Some highlights of the past year include:

Faculty and students of the Design and Development group completed a plan for metropolitan Bangkok, and a group of students traveled to India over Independent Activities Period (IAP) to study low-income housing with the Aga Khan Foundation. The group also awarded its first Urban Design Certificates to four graduating Master's students.

The Environmental Policy group continues to expand its work on environmental management and environmental dispute resolution worldwide. EPG faculty were involved in efforts to guide privatization of water management facilities in newly independent states and Latin America, adoption of environmental impact assessment procedures

in African, Asia, and Latin America, and reform of the global environmental treaty-making apparatus of the United Nations.

In addition to its continued emphasis on housing and community development, the Housing, Community and Economic Development group, with the generous support of Mr. Daniel Rose, launched the Daniel Rose/HCED Weekly Luncheon Series to bring in outstanding speakers in the area of employment and training.

Faculty from the International Development and Regional Planning group initiated its third project in Brazil. Six Ph.D. and three Master's students were trained to carry out field work this summer evaluating the efficacy of decentralized government programs in the state of Maranhao.

The Planning Support Systems group continued its work on understanding spatial structure and facilitating participation in planning the future of urban areas through the development and use of spatial analysis tools, multimedia software, and appropriate spatial data infrastructure. Project sponsors include the National Science Foundation, the U.S. Department of Transportation, the National Association of Regional Councils, the Federal Geographic Data Committee, the National Capital Planning Commission, plus several MIT sources and local planning agencies.

GRADUATE DEGREE PROGRAM ACTIVITIES

The faculty deliberated a number of issues at its meetings and fall retreat, including: the cost of education for Master's in City Planning (MCP) students, faculty responsibility, fund raising, and the future of the Community Fellows program (see below).

This year, the size of our entering Master's class increased by 18%. Out of a total of 187 graduate students, 51% were women, 10% were students of color and 45% were international students. The department granted 66 MCP, 2 S.M and 11 Ph.D. degrees.

At the annual Commencement Breakfast, a number of students were presented with awards. Diana Markel received the American Institute of Certified Planners Outstanding Student Award. Daniel Serda won the Flora Crockett Stephenson writing prize. Andrew Crabtree was awarded the sixth annual Wallace, Floyd Award for Urban Design. New awards given this year included the Departmental Service award which went to Aleem Walji. Scott Schiamberg won the award for Outstanding Contribution to the Intellectual Life of the Department; Honorable Mentions went to Clare Epstein and Elizabeth Schave for organizing a lecture series.

A number of Institute-wide awards went to our students as well. Janet Martinez won the Ida M. Green Fellowship, and Carroll Wilson Awards went to Amanda Bickel and Judith Morrison. Sumila Gulyani won the Hugh Hampton Young Memorial Fellowship and John Matthew Carpenter received the first Kristin E. Finnegan Prize. Scott Schiamberg won the Council for the Arts, Dean's Gallery Award for his wheatfield exhibit in Lobby 7. Ph.D. students Rosemary Sandford and Anuradha Joshi received Center for International Studies International Energy and Environmental Policy Research Grants, and Mona Mourshed won the Siegal Prize.

Other award recipients were: Clare Epstein, who won an Eisenhower Fellowship and Catherine Preston, a finalist for the Presidential Management Internship Program. Ph.D. student Adil Najam received the Association for Research on Non-profit Organizations Emerging Scholar Award, as well as the Kann Rasmussen Initiative in Environmental Leadership Fellowship, a Predissertation Fellowship of the Academic Council of the United Nations System, and was appointed a J.D. Rockefeller, 3rd Fellow at the Program on Non-Profit Organizations.

First-year doctoral student Ayo Okada's research paper "What Explains Infant Mortality Reduction in Pre-war and Wartime Japan: Economic Growth, Female Education, or Political Commitment?" was awarded second prize in the International Cooperation Scholarship Award competition, sponsored by the Association for Promotion of International Cooperation and Nippon Keizai Shinbun (Japan Economic Newspaper). Lynn Pikhholz won the Edward McClure Award for Best Paper from the Association of Collegiate Schools of Planning. Elizabeth Stock's Master's thesis, "The Problems Facing Labor-based Road Programs and What to do About Them: Evidence from Ghana," was published by the World Bank. She also received the Center for Science, Technology and Society Best Thesis Award and a prestigious White House Fellowship.

ALUMNI/AE INITIATIVES

Under the leadership of Adjunct Professor Paul Levy (SB, MCP '74), we had unprecedented participation by alumni/ae in departmental activities and fundraising. More alumni/ae pledged more money during the fall telethon than ever before. Panels of alumni/ae gave career advice to students. Alumni/ae attending the national American Planning Association conference gathered to discuss the future of the department and the profession. Our new alumni/ae journal, DUSP@MIT.now, keeps alumni/ae and the department in touch with each other. Alumni/ae were also active beyond the Department. Joan Martin Roth (Ph.D. '81) and Elizabeth Seifel (MCP '79) received the Harold E. Lobdell '17 Distinguished Service Award for alumni/ae activities.

The sixth annual Professional Development Institute (PDI), held during IAP, offered professionals and MIT students alike the opportunity to take short courses to sharpen professional skills like public speaking or learn about the latest cutting edge planning issues like technology and economic development. Participation this year increased more than 20%; four courses were offered for credit.

UNDERGRADUATE PROGRAM ACTIVITIES

While the main focus of the department is on its graduate programs, the department responded to the call by the President by offering six Freshman Advising Seminars. Instead of emphasizing majors, we are reorganizing our undergraduate courses to offer six to eight magnet courses each semester.

The Teacher Training and Education Program saw an increase in its enrollment to 32 students.

Senior Anthony Ives made news when he organized twenty-five of his fellow students to spend their Spring Break in Washington, D.C. teaching inner-city students through the Teach for America Program. Ives and classmate Dhaya Lakshminarayanan also won the William L. Stewart, Jr. Award.

FACULTY ACHIEVEMENTS

The department welcomed two new faculty members this year. Omar Razzaz, a Jordanian-American, joined the faculty as an Assistant Professor of Urban Planning. James Morrison is a half-time lecturer in writing and argumentation. Professor Lawrence Susskind was appointed Ford Professor of Urban and Environmental Planning. Professor Judith Tandler won the Irwin Sizer Award for the Most Significant Improvement in MIT Education, not only for the high quality of her classes but for integration of fieldwork into her teaching.

Four faculty retired at the end of this academic year: Professor Ralph Gakenheimer in the area of transportation and infrastructure in developing countries; Gary Hack in urban design; Gary Marx in urban sociology; and Adjunct Professor and Director of the Community Fellows Program, Melvin King, a specialist in urban issues and youth development. Searches for replacements for Professors Gakenheimer, Hack and King will take place next year.

SPECIAL EVENTS AND PROGRAMS

A twelve-week faculty colloquium, funded by a grant from the Kellogg Foundation, explored topics related to Advanced Information Technology, Low-Income Communities and the City. A book is in progress which will include papers commissioned and dialogs generated by the colloquium. A graduate level course was taught simultaneously and a web site generated additional interaction.

The Institute-wide State of the Union Lecture Series focused on the forces that shape our society and our cities and featured such distinguished speakers as Nicholas Lemann, National Correspondent for the "Atlantic Monthly" and author of *The Promised Land*; Tom Edsall, Senior Political Reporter from the Washington Post and co-author of *Chain Reaction*; Robert Hartman of the Congressional Budget Office; Lawrence Bobo, Professor of Sociology, UCLA; and, Nathan Glazer, Professor Emeritus of Education, Harvard University.

A Planners' Forum Speakers Series, co-sponsored by the department and the Massachusetts chapter of the American Planning Association, drew large crowds of alumni/ae and other professionals to hear Linda M. Harr of the Boston Redevelopment Authority/Economic Development Industrial Corporation speak about "The New Boston Master Plan: Linking Districts and Enhancing the Public Realm." While a last-minute scheduling conflict prevented Trudy

Coxe, Secretary of the State Executive Office of Environmental Affairs from speaking, her deputy delivered her remarks on "Streamlining Environmental Regulations: Ensuring Quality, Efficiency, and Public Participation." In the spring, author James Howard Kunstler sparked lively debate with his talk: "Can America Survive Suburbia?"

Our non-degree programs also completed successful years. The Special Program for Urban and Regional Studies (SPURS) hosted 16 Fellows from around the world, including participation for the first time by one Fellow from Uzbekistan. This year's participants included thirteen men and three women. Fellows worked on projects ranging from urban transportation and quality management in Manila to nuclear power and energy problems in Chernobyl. Fellows were funded by the Muskie Fellowship Program, Institute of International Education, Council for International Exchange of Scholars, Inter-American Foundation and governments of their home countries.

The domestic counterpart, the Community Fellows Program, brought 12 mid-career community activists from communities of color in the US to build skills to develop youth-oriented programs for their home communities. Fellows were supported by the Ford and Kellogg foundations and their projects ranged from using the Internet to link all grassroots neighborhood-based organizations focusing on African-American youth in the US to developing pathways to careers for youth in the health care field. Fellows participated in a new course, "Advanced Technology and Low-Income Cities" as the program develops a new focus on this theme. Nearly three hundred people turned out over a weekend in May for a retirement symposium honoring Director Melvin King.

FUNDRAISING

Visiting Committee Chair Charles H. Spaulding recently announced that he will fund a Career Development Professorship in the department. With his assistance, we are also seeking additional funds from private donors. Faculty raised over \$1.5 million in grants and contracts for the following research projects: Professor Bernard Frieden, \$682,000 for a three-year project funded by the US Department of Commerce for "Reuse of Military Bases"; Professor Karen Polenske, \$170,000 from the Joyce Foundation for "Industrial Restructuring Infrastructure in the Midwest"; Professor Jeanne Bamberger, \$357,000 for a three-year project sponsored by the National Science Foundation for "Collaboration for Excellence in Science"; Christie Baxter, \$220,000 from the Ford Foundation for "Program-Related Investment"; Joseph Ferreira, Jr., \$38,800 from the US Department of the Interior for "NSDI Implementation" (development and testing of client/server strategies for browsing geospatial data repositories); Michael Shiffer, \$50,000 from the National Association of Regional Councils for "Computer-Aided Technologies and Tools."

Bish Sanyal

AGA KHAN PROGRAM FOR ISLAMIC ARCHITECTURE

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 and outreach activities. The central office, located at MIT, serves as a liaison for activities at both universities; coordinates joint, program-wide activities; and maintains an exchange of fiscal and substantive information between the program and the donor.

During the 1995-96 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, which was published through the fall of 95.

Lecture series at MIT were organized by Aga Khan Professor Attilio Petruccioli, and included talks by Ludovico Micara, School of Architecture, Pescara, Italy; former AKPIA student Scott Redford, Georgetown University; Hugh Kennedy, University of St. Andrews, Scotland; Indian designer Rajeev Sethi; Alessandro Giannini, School of Architecture, Genoa; and Maurizio Tosi, University of Bologna. Lectures were also given by AKP Visiting Scholar Shakeel Hossain, former Visiting Scholar Amir Pasic, and others, including a public recital of modern Arabic poetry and traditional songs from Iraq. In October, the AKPIA presented an exhibition, "Samarkand and Bukhara in Central Asia: Preservation and Development," which included drawings and surveys by students in the MIT Department of Architecture.

Two international conferences and a roundtable discussion were organized by Aga Khan Professor Attilio Petruccioli. The fall saw the roundtable discussion, "From Classic to Arab Cities: Urbanism in the Levant During the Medieval Period," which brought together architectural historians, archaeologists, architects, and urban planners to discuss this process. They included Irene Bierman, UCLA; Renata Holod, UPenn; Thomas Leisten, Princeton; Scott Redford, Georgetown; and MIT Professors Stanford Anderson, Nassar Rabbat and Aga Khan Professor Attilio Petruccioli. Two International Conferences were sponsored by the Aga Khan Program in this past academic year. The first was a symposium co-sponsored by the AKPIA, "Expressions of Identity: Mosques in North America," organized by MIT Department of Architecture's Visiting Associate Professor and former Aga Khan Program Visiting Scholar Hasan-Uddin Khan, which presented six case studies of representative examples of community mosques in North America. The participants included professors Jerrilyn Dodds, NYU; Renata Holod, UPenn; Syed Gulzar Haider, Carleton University; Akel Kahera and Latif Abdul Malik, Princeton; Aga Khan Professor Attilio Petruccioli; Sibel Bozdogan and Nassar Rabbat, MIT; architects Mokhless Al-Hariri; Michael Keselica; Javed Sultan; Richard Shepard; Anwar Hossain; Ilhan Zeybekoglu; and Javid Malek, and Aga Khan Program Librarian Omar Khalidi, and Aga Khan Visiting Scholar Khalil Pirani, and Hasan-Uddin Khan. In the spring, the Aga Khan Program presented a conference titled, "Rethinking the XIXth Century Town: the Morphogenesis of the Urban Fabric," which drew participants from around the world. Papers were presented by Jeremy Whitehand and Karl Kropf, the University of Birmingham, UK; Hidenobu Jinnai, Hosei University, Japan; Pierre Pinon, Ecole d'Architecture Paris-La Defense; Jean Castex, Ecole d'Architecture de Versailles; Guiseppe Strappa, University of Bari, Italy; Sylvain Malfroy, Ecole Polytechnique Federale de Lausanne; Anne Vernez-Moudon, University of Washington, Seattle; Erick Valle, University of Miami; Michael Conzen, University of Chicago; Brenda Scheer, University of Miami, Cincinnati; and Julian Beinart, Stanford Anderson, Roy Strickland, Aga Khan Professor Attilio Petruccioli, and John Habraken of MIT.

FACULTY AND STAFF

The AKPIA Committee, charged with policy decisions, included Stanford Anderson, head, Department of Architecture, MIT (chair); 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; Gulru Necipoglu, Aga Khan Professor, Harvard; Attilio Petruccioli, Aga Khan Professor and AKPIA acting director, MIT; William L. Porter, Leventhal Professor of Architecture and Planning, MIT; Nassar Rabbat, Aga Khan Development Professor, History Theory and Criticism Program in the Department of Architecture, MIT; Andras Riedlmayer, Aga Khan Program Bibliographer, Harvard; Merrill Smith, Associate Rotch

Librarian, MIT; Irene Winter, chair, Department of Fine Arts, Harvard; and Christoph Wolff, dean, Graduate School of Arts and Sciences, Harvard.

In November, Dina Freedman joined the Program as a part-time senior secretary. In January, Renee Caso, AKPIA administrator, left to join the staff at the Department of Architecture Headquarters at MIT. Attilio Petruccioli remained as Aga Khan Professor and acting director of the Program. Robert Marlatt, part-time senior office assistant, and Dina Freedman remained to assist the acting director with Program administration and professorial support.

In June, as part of a design studio for the upcoming fall semester, Professor Petruccioli traveled with a group of graduate students to Essaouira, Morocco and Como, Italy to study urban situations in historic contexts.

ACADEMIC PROGRAMS AT MIT

In 1995-96, four 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. Tuition and living expenses for the SMArchS students at MIT were funded in whole or in part by AKPIA current funds. Three of these AKP students graduated in May: Can Bilsel, Aparna Datey, and Joseph Raia.

Student reflection and debate focused on both practical and theoretical issues concerning the architecture characteristics 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.

In the fall semester, students participated in a level III architectural design studio led by Professor Petruccioli which examined establishing a dialog between the old and new in Bukhara and Kuwait City, and reacting logically to the messages of history. Professor Petruccioli also taught a design workshop, "The Architecture of the Territory and Forms of the Landscape," which emphasized the understanding that the landscape is not an empty space to be filled with emerging "monuments," but a continuous structure with complex formal relationships and hierarchical elements. In the spring Professor Petruccioli offered a workshop, taught along with Professor Renata Holod at UPenn, "From Region to Neighborhood: Reading the Islamic City," which was a multidisciplinary approach to the study of the urban fabric.

Of the six AKPIA doctoral students in the HTC program, Maha Yahya, Panayiota Pyla and Kishwar Rizvi were in residence in Cambridge; and Shrine Hamadeh returned to Cambridge and MIT after preparing dissertation research in Istanbul last year; Iffet Orbay was in Quebec writing her dissertation; and Richard Brotherton continued work on his dissertation while based in New York. Tuition and living expenses for the Cambridge residential doctoral students at MIT were funded in whole or part by the AKPIA endowed scholarship fund.

Assistant Professor in the History of Islamic Architecture Nassar Rabbat offered "Religious Architecture and Islamic Cultures," and "Orientalism and Representation," taught with Assistant Professor Sibel Bozdogan. E.J.Brill, in Leiden, Netherlands, published Professor Rabbat's book, "The Citadel of Cairo: A New Interpretation of Royal Mamluk Architecture" in the fall of 1995.

VISITING SCHOLARS

During 1995-96, the AKPIA hosted two visiting scholars. Khalil Pirani's research on Mosque architecture in North America was funded by the American Institute of Architects. Shakeel Hossain, a 1988 DIS alumnus, continued his work on his Ta'zia project; he traveled to India and organized an exhibition presented at the Triennale in Milan, which will also be on exhibition at the MIT Museum in the fall of 1996.

LIBRARY RESOURCES AND PUBLICATIONS

Specialized acquisitions and services at the Rotch Architecture Library continued to be provided through endowed funds. Ahmed Annabal continued as the AKPIA archivist at the Rotch Visual Collections (RVC). The AKPIA's videodisc system, Images of Islamic Architecture, continued to be a valuable resource to students, faculty and staff. The Rotch Visual Collection has created a worldwide Web site that includes a link to textual and visual resources on

Islamic architecture at MIT, including a “World-Wide Tour Of Islamic Monuments” featuring images from the Aga Khan Visual Archives. Omar Khalidi, reference librarian for the AKPIA at the Rotch Library, continues to assist students and faculty with the AKPIA book collection.

Attilio Petruccioli

CENTER FOR REAL ESTATE

The Center for Real Estate (MIT/CRE) was founded in 1984. The mission of the center is to improve the quality of the built environment through education and research and by facilitating communication among members of the real estate industry worldwide. To this end, it 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 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 first issue of its new, newsletter-format Research Report containing abstracts and articles about faculty and student research. The Research Report which is edited by center Director William C. Wheaton, Professor in the Departments of Economics and Urban Studies and Planning, is scheduled to be published twice a year alternately with the center's newsletter, and mailed to alumni, supporting members, and more than 10,000 real estate professionals worldwide.

EDUCATION

Twenty-two members of the eleventh class of MIT/CRE graduates received their SM degrees in Real Estate Development in September, 1995. Eight more students received degrees in February or June 1996. The 36 members of the incoming Class of 1997, which includes four joint degree candidates, were selected from a strong applicant pool in March. The new class of four women and 32 men includes eight international students and 11 students who already hold advanced degrees in other disciplines.

The center revised two core courses to reflect changes in the real estate industry. Course 15.941 Managing the Real Estate Company taught by Gloria Schuck, Lecturer in the Department of Urban Studies and Planning, was expanded by the addition of segments on negotiation and team building, taught by Sandra Lambert, who is also a Lecturer in the Department of Urban Studies and Planning. A new course, 4.453, Building Technology in Real Estate Decision Making, taught by Leonard J. Morse-Fortier, Assistant Professor in the Department of Architecture, is the successor to 1.413 Construction Technology and the Building Construction Process. It focuses on evaluating existing structures and building systems rather than new construction.

Lisa Burke, a 1995 graduate of the MSRED program was awarded the Ralph Adams Cram Award by the School of Architecture for her thesis on mixed-use development. The thesis draws on several disciplines to provide new insight into the interactions between financing and design in large urban projects. William D. Browning, MSRED 1990, currently Director of Green Development Services at the Rocky Mountain Institute, was also honored. The center presented him with the Charles H. Spaulding award for outstanding professional achievement.

RESEARCH

Sandra Lambert published a substantial report covering phase two of the "CRE 2000" project on the management of corporate real estate. CRE 2000 is sponsored by the Industrial Development Research Council and Foundation. The report's co-authors Jean Poteete and Alison Waltch are graduates of the MSRED program. The research is going forward with phase three studying how corporations and the service providers they engage are managing real estate globally.

Five scholars from the People's Republic of China visited the center in November to participate in a week-long workshop with an MIT research team of graduate students directed by Professor Wheaton. They are carrying out a comparative study of real estate market information systems in Beijing, Shanghai and the United States.

The center hosted a day-long focus group on changing practices and emerging challenges in the property management industry in November. Taking part were 20 senior executives from firms that provide or consume management services in commercial office buildings. A report on the session by Lecturer Lambert and Marc Louargand, specialist in asset management and former Lecturer in the Department of Urban Studies and Planning, is available from the center as a working paper.

The center published six working papers this year in addition to the one mentioned above. Two papers were authored by Assistant Professor Timothy J. Riddiough and concerned risks associated with securitized commercial real estate debt, and a review of the impacts of regulatory taking risk on land development. Professor Wheaton co-authored two studies of the cyclic behavior of real estate markets--the London commercial office market, and the US market for hotel space. He also modeled the effects of population density on land use in congested cities, and discussed the implications of the increasing use of communications technology for the real estate industry.

PROFESSIONAL EDUCATION

The center's professional education program included the 1996 Summer Institute of the Pension Real Estate Association (PREA) and the center's own professional development courses. The PREA Institute is a tightly focused professional education program which this year hosted 52 pension fund real estate investors and asset managers. Professors Wheaton and Riddiough were joined by three outside practitioners for a two-and-a-half-day program on real estate cycles.

The eleventh summer of professional development courses brought almost 400 attendees to campus in June and July of 1995, a thirty percent increase over the previous summer. A new advanced finance course on risk management presented by Assistant Professor Riddiough proved very popular, as did the other two finance courses which were filled to capacity. The increased demand for professional education in real estate finance held steady in 1996 as well. By the end of June, July finance courses were almost fully booked, as was a new course in due diligence focusing on building systems.

MEMBERSHIP

Income from membership held steady as the center closed the year with 87 supporting members (including 22 offshore members), a net loss of two over the previous year. With leadership from Blake Eagle, Chairman of the center, and Associate Director Patricia Brady, the center added ten new member firms in 1996. In addition to annual fees, many members supported the center in non-financial ways by providing case study sites, lecturing in classes and in the Lunchbox Lecture series and supporting student thesis work.

The center hosted two members' meetings. The November meeting on changing US demographics featured Professor of Management and Economics, Lester C. Thurow discussing potential impacts of the global redistribution of purchasing power. Frank Levy, Professor of Urban Economics in the Department of Urban Studies and Planning, described changes in US income distribution. Other speakers discussed various aspects of the changing population profile and their impacts on real estate. The November meeting introduced a one-day workshop format focusing on entertainment and recreation. Members heard presentations on a variety of types of entertainment and then broke into discussion groups to evaluate potential real estate opportunities. Among the speakers was MSRED alumnus Liam Thornton, '90 Senior Development Manager for Walt Disney Imagineering. Former center Director, Lawrence S. Bacow, Professor of Law and Environmental Policy in the Department of Urban Studies and Planning and Chair of the Faculty, closed the day with a passionate speech to the members on "The Future of the Research University, Why Should We Care?"

ADMINISTRATION

The leadership of the center remained consistent throughout the year and is expected to continue through the coming year.

William C. Wheaton

MEDIA LABORATORY

In many ways, the 1995-96 academic year was a significant one for the Media Laboratory. On October 10, some 1,300 Media Laboratory sponsors, staff, and friends from around the world came to Cambridge to join in 10/10, the Laboratory's tenth birthday celebration. As part of the event, we hosted a day-long symposium and open house, where Media Laboratory researchers presented glimpses of what might be coming down the digital pike in the near future: a new generation of electronic books; autonomous agents to handle mundane daily tasks; perceptive environments; and a world of intelligent, everyday objects.

10/10 highlights included A Day in the Life of Cyberspace, the first global portrait of life in the digital age--where the Laboratory asked millions of people worldwide to share "Guinness bits" of their lives on line; and the inauguration of the Laboratory's newest consortium, Things That Think (TTT). TTT will work closely with sponsor companies, which range from clothing manufacturers, to telecommunications companies, to theme park developers, to create more capable and less obtrusive devices, embedded in the environment and linked to robust, distributed networks. We envision a day when you will wake up in the morning and have your shoes retrieve the day's personalized news from your carpet, for delivery to your eyeglasses--while your coffee maker anticipates your need for a second cup of fresh coffee.

This past year also brought a significant increase in Laboratory sponsors. Its total annual dollar volume (research funds, academic, and equipment gifts) reached \$24 million in Fiscal Year 1996 (up from less than \$1 million during the Laboratory's first year of operation in 1985). Some 89 percent of this research support now comes from close to 130 sponsors worldwide, an increase of approximately 40 percent over last year.

RESEARCH ACHIEVEMENTS

A sampling of 1995-96 Media Laboratory research accomplishments include:

- Advances in electronic paper, which may one day result in the world's first single-volume library. Electronic paper involves the development of electronic "ink" made of tiny particles that are black on one side and white on the other, and "flip" depending on the electronic charge underneath them.
- PLUM, a news augmentation system that "personalizes" news stories. By providing annotations that place world events in a more familiar, local context, PLUM makes them more relevant and engaging to the reader.
- NetSound™, a new system built on the CSound software-synthesis language, that delivers higher quality sound quickly on the Internet. This software can deliver an entire Beethoven symphony in about 10 seconds, and render it in real time at CD quality.
- New intelligent agents that perform tasks ranging from buying or selling goods on the Internet, to continuously and unobtrusively searching your notes and electronic files for references to whatever you are currently reading or writing on your computer.
- Programs that can browse databases of hundreds of thousands of images and, based on user feedback, can select images according to perceptual models, using cues such as color, shape, and texture.
- New ways of making "bits" accessible through everyday physical surfaces, like walls or desktops.
- Development of a new generation of intelligent toys based on the Laboratory's Programmable Brick technology. Children can now build behaviors into toys.
- Full parallax holography, where you get the full effect of the hologram not only by looking side to side, but also by looking over and under the object.
- Intelligent scalability, which gives us new ways to display video equally well on a TV wristwatch, a 36" screen, or the side of a blimp.

-
- An interactive CD ROM (also accessible via the World Wide Web) entitled Jerome B. Wiesner 1915-1994: A Random Walk Through the Twentieth Century, which celebrates the life of Dr. Wiesner, former MIT president and co-founder of the Media Laboratory.

Much of the work of the Laboratory will be featured in the PBS television series "Scientific American Frontiers," whose premiere episode in the fall of 1996 will focus exclusively on the Media Laboratory.

SPONSORS

RESEARCH SPONSORS

The Laboratory's research volume continued to grow in Fiscal Year 1996, with \$10.3 million (89 percent) coming from corporate sponsors. Approximately \$1.3 million (11 percent) came from the U.S. federal government (Department of the Army, DOT, NEA, NSF, Office of Naval Research, and ORD). Geographically, the industrial component of Fiscal Year 1996 contract research sponsorship breaks down as follows: 65 percent the Americas; 20 percent Europe; and 15 percent Far East

DIRECTED SPONSORS

New directed research sponsors during Fiscal Year 1996 included:

ATR Media Integration & Communications Research Laboratories (Kyoto, Japan), which supported Professor Pentland's work on the ALIVE project;

AT&T Foundation, which provided a 1995 Special Purpose Grant in Science and Engineering to Professor Justine Cassell;

Cognex Corporation, which supported Professor Alex Pentland's work in perceptual computing;

U.S. Department of Transportation, which provided a grant to Ron MacNeil for "Innovative Railroad Information Displays for Dispatch and Train Engineer Functions;" and

National Endowment for the Arts, which provided a grant to Ron MacNeil for "Design Access: Civiscape."

CONSORTIA

In Fiscal Year 1995 the Media Laboratory initiated a new consortium: Things That Think (TTT).

Officially inaugurated at the Laboratory's tenth birthday celebration, TTT explores ways of moving computation beyond conventional sites, such as PCs or laptops, and adding intelligence to objects that are first and foremost something else. By sensing the movements or feelings of their owners or by learning their owners' habits, common devices such as toasters, doorknobs, or shoes will be able, in their own right and through communication with one another, to solve meaningful problems. By becoming truly responsive and unobtrusive, the information technology in the inanimate things around us will enhance the quality of daily living.

TTT brings together an unusual range of interdisciplinary talent and builds upon the close research partnership between the Laboratory and its sponsor community. TTT's principal investigators are: Neil Gershenfeld, Michael Hawley, and Tod Machover. Additional faculty members and researchers involved in the consortium include: Walter Bender, Richard Bolt, Justine Cassell, Hiroshi Ishii, Joseph Jacobson, Marvin Minsky, Seymour Papert, Joseph Paradiso, Alex Pentland, Rosalind Picard, and Mitchel Resnick.

As of June 30, 1996, the list of TTT sponsoring companies are:

American Greeting Corporation, AMP, Inc., Analog Devices, Inc., ASCII Corporation, AT&T Corp., Becton Dickinson and Company, Brother Industries, Ltd., Compaq Computer Corporation, Creative Technology, Ltd., Deutsche Telekom AG, EDS, Federal Express Corporation, FESTO, The Gillette Company, Inc. Hewlett-Packard Company, Interval Research

Corporation, The LEGO Group, Levi Strauss & Co., Lord Corporation, Microsoft Corporation, Motorola Inc., National Semiconductor Corporation, Neurotec International Corporation, NIKE, Inc., Nokia Corporation, Oki America, Inc., Olivetti, The Procter & Gamble Company, SEGA of America, Inc., Sensomatic Electronics Corp., Siemens AG, Steelcase Inc., Telia Research AB, 3Com Corporation, Volvo, Walt Disney Imagineering, WPP Group plc, and YAMAHA Corporation.

News in the Future

Grupo Estado (Sao Paulo, Brazil) and JC Penney Company (Plano, Texas) joined the Laboratory's News in the Future consortium in Fiscal Year 1996.

Television of Tomorrow

Riverland (Brussels, Belgium) joined the Laboratory's Television of Tomorrow consortium.

SPECIAL FUNDS AND EQUIPMENT GIFT SPONSORS

America Online, ATG, Berkeley Software Design, Inc., Digital Equipment Corporation, FORE Systems, Inc., GNN, Intel, NYNEX, Eastman Kodak, MegaDrive Systems, Prodigy, Quatum Corporation and Video On Line contributed to the development of "A Day in the Life of Cyberspace," as part of the 10/10 celebration.

AT&T continued to support the Laboratory through its Digital Media Research Fund. The following students were named AT&T Media Laboratory Fellows in the fall of 1995: Anthony Chavez, Daniel Gruhl, Richard Lachman, Lisa Stifelman, and Brygg Ullmer.

The following students were named Motorola Fellows for this fiscal year: Kevin Brooks, Roger Kermode, Alexandros Moukas, Rob Silvers, Joshua Smith, Flavia Sparacino, and Manish Tuteja.

Interval Research Corporation Fellows, named in the fall of 1995, were Karrie Karahlios, Teresa Marrin, Thomas Minka, Wendy Plesniak, Rob Poor, and Marina Umaschi.

Video On Line (VOL), a Gruppo Grauso company (Sardinia, Italy), made a grant to support five Media Laboratory Fellows: Amy Bruckman, Lenny Foner, Jennifer Glos, John Underkoffler, and Zhonghui Xu. In addition, VOL provided partial funding for Joseph Jacobson's research on electronic paper.

Equipment Gifts

Digital Equipment Corporation gave a \$1 million external research grant of general equipment, as well as \$300K in network/workstations in support of the 10/10 Web event.

Hewlett-Packard Company gave three recipient-enhanced grants for a total of \$575,000. An additional grant of test equipment, valued at \$36,700, supported the work of Professor Neil Gershenfeld.

Intel Corporation provided \$360,000 in workstations/servers in support of the 10/10 event.

Mitsubishi Electric gave projectors valued at \$88,000 in support of 10/10.

Steelcase donated furniture valued at \$30,000.

MEDIA TECHNOLOGY FUND SPONSORS

New Media Technology Fund sponsors during the year included: Citicorp/TTI, Scitex Corporation, Ltd., J. Sainsbury plc, Science Applications International Corporation (SAIC), and Southwestern Bell Technology Resources, Inc.

PERSONNEL

New Appointments

Glorianna Davenport, who has been associate professor of media arts and sciences since 1993, jointly with the Department of Architecture, was appointed principal research associate effective June 1, 1996. Ms. Davenport came to MIT as a technical assistant in the Department of Architecture's Film/Video group working with Professor Richard Leacock. She was promoted to lecturer in 1981, to assistant professor in 1988, and was appointed the first holder of the Asahi Broadcasting Corporation Career Development Professor of Media Technology in January 1990. Davenport will continue as director of the Laboratory's Interactive Cinema group.

Robert Bloomberg joined the staff as associate director of the Media Laboratory for administration and operations in January 1996. Bloomberg came to the Laboratory from MIT's central Purchasing Office, where he was assistant director for subcontracting. Previously, Bloomberg worked at McDonnell Douglas; Bolt, Beranek & Newman; and Hanscom Air Force Base.

Michail Bletsas joined the Laboratory as director of computer systems in January 1996. Bletsas came to the Laboratory from Aware, Inc., and is completing his PhD in computer engineering at Northeastern University. Mr. Bletsas replaces Gerald Hornik, who resigned his position as director of technical services and accepted the new position of manager of capital equipment and telecommunications in February 1996.

David Riquier joined the Communications and Sponsor Relations staff in September 1995 as the office's associate director. Previously, Riquier held a number of positions at Digital Equipment Corporation in marketing and communications.

Linda Lowe joined the Laboratory as project coordinator for the new Things That Think research consortium in August 1995. Ruth Rothstein joined the Laboratory as project coordinator for the TVOT research consortium. Dennis Irving joined the technical staff of the Laboratory in May 1996 as facilities coordinator.

The Laboratory appointed four new technical staff members during 1996: Marc Berjarano joined as network engineer in June; Jon Ferguson joined as systems programmer in February; Tomas Revesz joined as administrative computing specialist in April; and Eric Trimble accepted a temporary (one -year) systems programmer position in the Vision and Modeling section of the Laboratory in January.

New Visitors

Steven McGeady, vice president and general manager of Intel's Internet Technology Laboratory, was appointed visiting scientist for one year on May 1, 1996.

Carl Malamud, founder and president of the Internet Multicasting Service (IMS), was appointed visiting scientist to the Media Laboratory for two years beginning on June 1, 1996. At IMS he created the first radio program on the Internet and the Internet 1996 World Exposition.

Phillip Grey was appointed research affiliate to the Media Laboratory from British Telecom for the period from April 11 to July 10, 1996. Kenichi Mori was appointed research affiliate to the Media Laboratory from Toshiba Corporation of Japan on May 1, 1996. Richard Wurman was appointed visiting scientist for one year on July 1, 1995.

Promotions

Deborah Cohen was named associate director of the Media Laboratory for communications and sponsor relations on May 1, 1996. Cohen joined the Media Laboratory as director of communications and sponsor relations in November 1994.

Henry Holtzman was promoted to research scientist on May 1, 1996. Holtzman joined the Media Laboratory staff in 1985 as senior systems analyst, was accepted to the MS program in Media Arts and Sciences in 1989, and following completion of his degree in 1989, re-joined the Laboratory as a research specialist working with Andrew Lippman, associate director of the Laboratory, on the Movies of the Future research project.

Joseph Paradiso was promoted to technical director of the Things That Think research consortium in December 1995. Paradiso joined the Media Laboratory staff in 1994 as research scientist (physicist) to collaborate with Professors Neil Gershenfeld and Tod Machover on the development of new physical mechanisms for interface transduction.

Staff Members Join MAS Academic Program

Two members of the Laboratory's staff, Pascal Chesnais and John Watlington, resigned their positions as research specialists to become PhD candidates in the Program in Media Arts and Sciences.

Nicholas Negroponte

MEDIA LABORATORY SPONSORS

The following list indicates Media Laboratory sponsors (as of June 30, 1996) according to the categories of sponsorship defined in *Intellectual Property Rights of Media Laboratory Sponsors*:

RESEARCH CONTRACTS

Apple Computer
Bell Communications Research
BT
Central Intelligence Agency
Compaq Computer Corporation
Department of the Army
Department of Transportation
Hewlett-Packard
Honda R&D Company, Ltd.
International Business Machines
Korea Institute of Science and Technology (KIST)
LEGO Futura ApS
Microsoft Corporation
National Endowment for the Arts
National Science Foundation
NEC
NYNEX
Office of Naval Research
Oki Advanced Products Division
Samsung Electronics Co., Ltd.
Sun Microsystems
Texas Instruments, Inc.

RESEARCH CONSORTIA

News in the Future (NiF)
Aamulehti Group, Ltd.
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.
Grupo Clarín
Grupo Estado
Hearst Corporation
International Business Machines
JCPenney
Knight-Ridder, Inc.
Lotus Development Corporation
McCann-Erickson Worldwide
NY Times/Globe
Pulitzer Publishing Company
Televisa s.a. de c.v.
Thomson Newspapers Corporation
The Times Mirror Company
Tribune Company
Ziff-Davis Interactive

Singapore Digital Media Consortium (SDMC)

Aztech Systems Ltd.
iMedia (S) Pte. Ltd.
IPC Corporation Ltd.
Institute of Microelectronics (IME)
Institute of Systems Science (ISS)
Information Technology Institute (ITI)
National Computer Board (NCB)

Television of Tomorrow (TVOT)

Eastman Kodak
Hughes Aircraft
Intel
Nortel
Philips
Riverland
Sony
Televisa s.a. de c.v.
Toppan Printing Co., Ltd.
Viacom International

Things That Think (TTT)

American Greetings Corporation
AMP, Inc.
Analog Devices, Inc.
ASCII Corporation
AT&T Corp.
Becton Dickinson and Company
Brother Industries, Ltd.
Compaq Computer Corporation
Creative Technology, Ltd.
Deutsche Telekom AG
EDS
Federal Express Corporation
FESTO
The Gillette Company
Hewlett-Packard Company
Interval Research Corporation
The LEGO Group
Levi Strauss & Co.
Lord Corporation
Microsoft Corporation
Motorola Inc.
National Semiconductor Corporation
Neurotec International Corporation
NIKE, Inc.
Nokia Corporation
Oki America, Inc.
Olivetti
The Procter & Gamble Company
SEGA of America, Inc.
Sensormatic Electronics Corp.
Siemens AG
Steelcase Inc.
Telia Research AB

3Com Corporation
Volvo
Walt Disney Imagineering
WPP Group plc
YAMAHA Corporation

MAJOR EQUIPMENT GIFTS

AMP, Inc.
Bay Networks, Inc.
Digital Equipment Corporation
FORE Systems, Inc.
Hewlett-Packard
International Business Machines
Silicon Graphics
Sony Industrial Products
Sun Microsystems

MEDIA TECHNOLOGY GROUP

BT
Casio Computer Co., Ltd.
Citicorp/TTI
Hughes Electronics Corporation
Kodansha Ltd., Publishers
Nippon Columbia Co., Ltd.
Reuters
SAIC
Scitex Corporation, Ltd.
J. Sainsbury plc
Southwestern Bell Technology Resources Inc.
Tele Danmark A/S

SPECIAL FUNDS

AMP, Inc.
ATR Media Integration & Communications Research Laboratories
AT&T Corp.
Cognex Corporation
DDP Publishing, Inc.
Festo KG
Hewlett-Packard
Interlego A/S
Interval Research Corporation
Mitsubishi Electric
Motorola, Inc.
NEC
Toshiba
Video On Line
Brain Opera
NTT Data

ENDOWMENT AND NAMING GRANTS

Rudge and Nancy Allen
Asahi Broadcasting Corporation
AT&T Corp.
Armand and Celeste Bartos
Alex Dreyfoos, Jr

Fukutake Publishing
Gruppo Grauso
Interlego A/S
LG Electronics, Inc.
Misawa Homes
NEC
Schlumberger
Sony
Toshiba
Phillipe Villers
Muriel R. Cooper Memorial Professorship
Dohosha Publishing Co., Ltd.
Origin/Media Lab BV

CENTER FOR ADVANCED VISUAL STUDIES

The Center for Advanced Visual Studies continued its research and teaching under the direction of Krzysztof Wodiczko over the past year. The Center now has a web page at <http://web.mit.edu/mit-cavs/www/index.html>.

FACULTY

Krzysztof Wodiczko had retrospective exhibitions at DeAppel Center for Contemporary Art in Amsterdam and Galerie Lelong in New York, as well as an exhibit at Galerie Gabrielle Maubrie in Paris. He participated in the Next 5 Minutes Exhibition and Conference on Art, Politics and Independent Media in Rotterdam, and was the keynote speaker at the Veiled Histories Conference in San Francisco. He and Josh Smith completed media research and implemented his new *Porte-Parole*, an immigrant instrument, in France with support from the French Ministry of Culture. Reviews of Krzysztof Wodiczko's work appeared in *the New York Times*, *ArtForum*, *New York Magazine*, *Time Out*, *New Yorker*, *Flash Art* and *Art In America*. He gave lectures at Columbia University, Parsons School of Design, Ryerson Polytechnic and the University of Iowa.

Professor Wodiczko participated in the selection committee for graduate students in the program in Public Art and in the Search Committee for the Visual Arts Senior Faculty position, as well as in the Department Council and the MIT Advisory Council on Art, Science and Technology.

RESEARCH AND TEACHING

Design, Technology and Ethics, a studio seminar taught by Krzysztof Wodiczko, was developed to provide an intellectual and artistic/design laboratory for graduate and undergraduate students of the Department of Architecture, Research Assistants from the Media Lab, and students from the Harvard Graduate School of Design. The seminar focused on building cultural instruments that could address contemporary urban problems.

A Freshman Seminar, *Ethical Media Art*, offered in the Fall semester conducted with Warren Sack of the Media Lab, provided new students to MIT with an introduction to art and technology and the means to use technology to address current socio-cultural problems.

In collaboration with Josh Smith of the Media and Physics group of the Media Lab, extensive research was completed on a new project, interactive *Porte-Parole* and *Alien Staff*, the immigrant instruments. See <http://jrs.www.media.mit.edu/~jrs/krz/alien.html> on the web.

FELLOWS

Paul Earls has produced a laser work for the Kwang Ju Biennale in Kwang Ju, Korea, in conjunction with the Media Lab. He composed a piece of music for Otto Piene's sky events in Duesseldorf, Germany, at the Kunstmuseum im Ehrenhof. He also had a large installation at the Susquehanna Art Museum in Harrisburg, PA and did considerable preparations towards the upcoming ISQ-Portugal project for Expo '98. He received an award from ASCAP for his work as a composer. His composition, "And on the seventh day" was re-released on compact disc by BMG. His UROP student, Brian Chamberlain, completed an interactive audience-controlled installation.

Elizabeth Goldring continued her research on the *Visual Language for the Blind* project, with the assistance of UROP students and collaboration from the Visible Language Group at the Media Lab, mounting a web page that includes computer animation word-poems at <http://web.mit.edu/vlb/www/index.html>. In addition, she presented poetry readings at The Writer's Place and Poets At Large in Kansas City, MO, and presentations on *Creating a Visual Language for People who are Visually Challenged* at ISEA in Montreal and the College Art Association Conference in Boston.

During the year, CAVS Fellows conducted research in projects in art and technology at the Center for Advanced Visual Studies. Robert Dell exhibited his thermal sculptures and lectured on them at the Carpenter Center for the Arts at Harvard University. He conducted research towards a geothermal sculpture for Yellowstone National Park, using the thermal springs of the park. Susan Gamble installed a holographic piece, *The Form of the Visible*, at the Center for Advanced Visual Studies and also presented a paper, *Science: Not Just a Source of Imagery For Art/ An Artist's Experience in a Scientific Institution*, at the Royal Society, London, England. Piotr Kowalski, with the

collaboration of graduate students in the Department of Architecture, built a transatlantic communication installation, in which web sites at MIT and the Lyon Biennale were connected, offering video, written and speech communication between the two sites, including computer translations between French and English. A web site for the project is at <http://sap.mit.edu/projects/mit-lyon/project.html>.

Director Emeritus/Professor Emeritus Otto Piene held retrospective exhibitions in Boston, at the Suffolk University Gallery, in New York, at the American Academy of Arts and Letters where he received the Sculpture Prize, and at the Kunstmuseum Duesseldorf im Ehrenhof. The Duesseldorf exhibit included sky events and an extensive retrospective catalog. He also served as the Chairman of the MIT Advisory Council on Art, Science and Technology.

Initial work towards a CAVS presence at Expo '98 in Lisbon, Portugal is underway and includes coordinating an international art-science-technology collaboration.

Preparations were made to host Kyong Park, a current Rhodes Scholar, and the Emergency Broadcast Network to complete their research and digital presentation, *Nuclear Heritage Park*; as well as Shu Lea Chang and Muriel Waldvogel, an artist in residence at the AI Lab, as CAVS Fellows.

CAVS DIRECTIONS

Today, CAVS continues to support research projects integrating art, science and technology. The Center not only offers Fellows and students access to advanced technologies but also challenges them to a critical engagement with the intellectual and ethical questions posed by the social construction of these tools.

The Center for Advanced Visual Studies is once again offering a Master of Science in Visual Studies degree this time jointly with the Visual Arts Program as a part of the graduate program in Public Art. The CAVS branch of the program focusses on the relationship of art to science, technology and contemporary culture with an emphasis on a critical engagement with intellectual and ethical questions posed by the social construction of advanced technologies as media through work that will integrate art with science and technology.

Academic year 1995/6 was a year of active transition for the Center for Advanced Visual Studies. The Center has consolidated its new identity and is re-establishing itself as a potential leader in the field of critical art and design thanks to its new emphasis on integrating ethical, social and cultural study with the innovative experiment inspired by and challenging contemporary scientific and technological developments. In doing so, the Center for Advanced Visual Studies has begun to redesign its educational and research methods and programs. The last year was a process of establishing personal contacts and professional plans towards future educational or research collaborations with other Centers and Programs at MIT, specifically the Visual Arts Program, History, Theory and Criticism, Film and Media Studies Program, Media Lab, Artificial Intelligence Lab and the Department of Engineering. Similar steps were taken to establish professional relations towards future collaboration with contemporary art and design centers outside of MIT whose programs overlap with CAVS' intellectual and artistic agenda.

Krzysztof Wodiczko

SCHOOL OF ENGINEERING

The School of Engineering continues to be viewed as the premier institution of its type in the country. Built around traditional disciplinary curricula with a strong emphasis on engineering science, the School has excelled at the integration of research and education and, relative to our peers, at developing the interface between our research and educational programs and industry.

From this position of strength, the School of Engineering is in the midst of a transition that will give new emphasis to engineering practice and the broader context of engineering, as proposed in the School's Long-Range Plan. The timing for instituting change is opportune. The recently completed retirement program created over 35 vacancies in the School, roughly 10 percent of the faculty. Strategic redeployment of these faculty positions will be critical to moving the School in new directions. The School has entered into a strategic planning process for allocation of these positions; this process will be launched at an Engineering Council Retreat to be held in September 1996. The initial discussions will focus on resource allocation and on organization of the School for optimum development of programs in engineering systems and biomedical engineering.

Simultaneously with this planning, new undergraduate and graduate programs are emerging throughout the School, each with new emphasis on engineering practice and professional education. The new undergraduate Mechanical Engineering curriculum with their IAP subject, ME Tools (2.670) is a wonderful example of learning by design, as proposed by the effort in the ECSEL educational program. At the graduate level, professional educational programs developed solely by departments or as inter-school activities continue. The pilot-program of the System Design and Management (SDM) Program was run this year with 11 students. A full class of 30-40 students is expected in January 1997. Also, the Nuclear Engineering Department will launch its Masters of Engineering (M. Eng.) Program this fall. Master of Engineering Programs have already been established in three departments (Aeronautics and Astronautics, Civil and Environmental Engineering, and Ocean Engineering). Civil and Environmental Engineering expects over 30 students in fall 1996.

During the Academic Year 1996, the School of Engineering appointed 12 new faculty, all funded totally from Institute general and fund accounts. Even so, the fraction of faculty salaries funded on research contracts and grants continues to be a concern. After the retirement program is fully implemented, the average fraction of academic year salaries of the school funded by research will be considerably below 10 percent, but this burden will be unevenly distributed among departments and faculty.

The School is continuing to make efforts to interface both our research and educational programs better with needs of industry. We are working through individual meetings and focussed mini-conferences to establish dialog with industry sectors. Similar international interactions already have been successful. In 1996, a major new research and educational initiative has started with Thailand and will involve projects in four to five departments, as well as endowment support. Also, discussions with Malaysia are reaching a critical point where a proposal will be considered.

AWARDS

Bose Award for Excellence in Teaching was presented to Professor Alan V. Oppenheim of the Department of Electrical Engineering and Computer Science. This year a newly established Jr. Bose Award was presented to Assistant Professor Gregory W. Wornell of the Department of Electrical Engineering and Computer Science. The Bose Awards are funded with gifts from the Bose Foundation in recognition of outstanding contributions to undergraduate education.

Ruth and Joel Spira Awards for Teaching Excellence were presented this year to Professor Steven B. Leeb of the Department of Electrical Engineering and Computer Science, Professor Jung-Hoon Chun of the Department of Mechanical Engineering, and Professor Sidney Yip of the Department of Nuclear Engineering. 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 Mr. Mehul A. Shad, '96 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 winners from the School of Engineering: Timothy A. Chklovski, a sophomore in the Department of Electrical Engineering and Computer Science and Youssef M. Marzouk, a junior in the Department of Mechanical Engineering.

Reinhold Rudenberg Memorial Fund - This prize is awarded to students based on their senior theses in the area of energy conversion.

Three awards were made this year to Ryan J. Bryla, a student in the Energy Laboratory, for his thesis titled "The Use of Laser Induced Fluorescence for Measurement of Engine Oil Film Thickness," Tiffany K. Buffaloe, a student in the Laboratory for Electromagnetic and Electronic Systems, for her thesis titled "Fluorescent Lamp Optical Communication Scheme," and Peter W. Kassakian, a first year graduate student in Mechanical Engineering, for his thesis titled "Design and Testing of a Mechanical Arm for Use with Polymer Gel Muscles."

ENROLLMENT

	Undergraduate Enrollment				Graduate Enrollment		
	Oct. '95	Change '94-'95	%	%	Oct. '95	Change '94-'95	%
			Change '94-'95	Change '93-'94			Change '94-'95
Aero & Astro	95	-11	-10	-23	185	-13	-7
Chemical	324	9	2	4	225	-5	-2
CEE	114	-6	-5	-6	295	4	1
EECS	942	17	2	-5	805	-17	-2
Materials	116	-4		-6	176	2	1
Mechanical	415	-49	-10	1	417	12	3
Nuclear	18	-7	-28	-24	119	-8	-6
Ocean	12	1	9	-22	146	-16	-10
Totals	2036	-5	-2	-4	2368	-41	-2

AFFIRMATION ACTION

During the past year, faculty positions were offered to 31 individuals, including eight women and 2 African Americans, one of whom is a woman. One of the eight women has accepted the offer and joined the faculty last September. Two of the offers to women are still pending the candidate's decision. One of the two African Americans, Professor Wesley Harris, accepted. The other (the woman) declined.

The School is in its fifth year as a participant in the GE Fund's Faculty for the Future Program. The goal of the program is to increase the number of women and underrepresented minorities on engineering faculties throughout the United States. Grant funds are used to encourage women and minorities at each stage of the pipeline and provides support for undergraduate research, graduate fellowships, forgivable loans to Ph.D. candidates interested in teaching careers and start-up funds for Ph.D. recipients seeking faculty positions at MIT and elsewhere.

FACULTY SIZE AND FACULTY SALARY HARDENING

The special retirement incentive offered to MIT faculty and staff in 1995-96 resulted in 37 faculty retirements in the School of Engineering, at least five of whom will not be replaced thus reducing the School's authorized faculty headcount.

The School continues to make hardening faculty salaries a priority. The percentage of faculty salaries currently recovered from research stands at approximately 10%.

ENGINEERING COUNCIL

In January 1996 Professor Robert A. Brown formerly head of the Department of Chemical Engineering was named Dean of Engineering. Professor John VanderSande, who served as acting dean from June until mid-January when Professor Brown was named Dean, resumed his responsibilities as Associate Dean of Engineering. In June, Professor Robert C. Armstrong was named head of Chemical Engineering, succeeding Dean Brown in that post. Professor David Hardt, Acting co-director of the Leaders for Manufacturing Program was named co-director. Professor Rafael Reif, director of the Microsystems Technology Laboratory, was appointed to Engineering Council

ENGINEERING INTERNSHIP PROGRAM

In 1995-96, EIP placed thirty sophomores with member companies, up from 17 sophomores in 1995. The total number of interns placed were 54. One new company joined the EIP.

The Engineering Internship program is currently under review by both member companies and faculty to redefine its mission and goals. One goal will be to increase the number of students placed in internship assignments that meet both educational and corporate objectives. We will also examine options for a centralized internship program, and for an international internship program.

MINORITY INTRODUCTION TO ENGINEERING AND SCIENCE

During the summer of 1995, 49 high school juniors completed the 6 week residential program. Of the 49 students who attended MITES, 34 applied to MIT. Of the 29 admitted, we will enroll 18. That number represents 62% of the admitted students - which is the highest enrolling percentage since the same percent enrolled in 1986.

During the summer of 1996, 45 talented high school juniors will complete the 6 week residential program. MITES applications increased from 211 in 1995 to 586 in 1996, representing close to a three-fold increase. Five new corporate sponsors supported the MITES Program.

In February 1996 Hugh Robinson, '59, chairman of Tetra Group, hosted a reception at the Dallas African American Museum in honor of MIT's Minority Introduction to Engineering and Science Program. The event was attended by more than 40 MIT alumni and friends. Among the guests was Engineering Dean Robert Brown.

We will continue to develop plans for new initiatives, such as MITE²S (Minority Introduction to Engineering and Science) and mini-MITES (a local after-school outreach program).

Robert A. Brown

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

Academic Year 1996-1997 was one of considerable change for the Department of Aeronautics and Astronautics. On the educational side, we graduated the first students under our new SB program into a very strong job market. We also graduate our first student from the new Master of Engineering degree program after the pilot year of the offering. Our undergraduate and graduate programs were again rated by U.S. News and World Report as the top Aerospace Engineering offerings in the U.S.

The combination of Department demographics and MIT's Special Retirement Incentive Program for faculty and staff led to an unprecedented number of simultaneous retirements - 20% of the Course 16 faculty and two research staff members: Mr. Raymond Ausrotas, Prof. Eugene Covert, Prof. Shaoul Ezekiel, Prof. Walter Hollister, Prof. Jack Kerrebrock, Prof. James McCune, Prof. Thomas Sheridan, Prof. Robert Simpson, Mr. Albert Supple, Prof. Harold Wachman. Individually and collectively these colleagues represent an enormous level of accomplishment, experience, and wisdom. With their departure, Course 16 will undergo a major transition as new faculty and staff are hired in their stead. Three will continue teaching for varying periods, up to five years. Others will continue at MIT as Professors Emeritus. We will continue to enjoy their conversations and ideas.

Professors Earll Murman and Daniel Hastings stepped down as Department Head and Associate Department Head at the end of the academic year. Both will return to the active teaching and research faculty. Professors Edward Crawley and Edward Greitzer replace them.

UNDERGRADUATE PROGRAM

Undergraduate Enrollment over the Last Eleven Years

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
Soph.	106	120	96	103	75	76	61	33	36	36	30
Juniors	92	103	118	94	87	61	62	60	31	37	31
Seniors	106	98	105	130	104	104	73	66	66	38	37
Totals	304	321	319	327	266	241	196	159	133	111	98
% of women	18%	16%	19%	21%	25%	23%	27%	28%	32%	31%	29%
% of men	11%	10%	N/A	14%	18%	20%	14%	12%	23%	19%	16%

GRADUATE PROGRAM

A total of 256 applications were received for the Fall 1995 term. Out of this, 116 were admitted and 57 accepted the offer of admission. Enrollment for Fall 1995 included 107 S.M., 72 Ph.D., 1 EAA, 3 Meng degree candidates for a total of 183. Total minority students: 10 (4 Ph.D., 6 S.M.). Total women students: 24 (6 Ph.D., 18 S.M.). In the Spring 1996 term we received 28 applications. We admitted 9 and 5 enrolled. Four women applied, 1 was admitted, 1 enrolled. One minority application was received, zero enrolled. Enrollment for Spring 1996 included 104 S.M., 69 Ph.D., 2 Meng for a total of 175. Total women: 22 (5 Ph.D., 17 S.M.). Total minority: 10 (4 Ph.D., 6 S.M.).

Degrees Awarded	SM	EAA	Ph.D.	Meng	Total
Summer(Sept. 95)	18	0	1		19
Fall (Feb. 96)	10	1	5		16
Spring (June 95)	22	0	4	1	27
Total	50	1	10	1	62

FUNDING	Fall 1995	Spring 1996
MIT Fellows/Tuition Awards	8	6
Outside Fellowship	25	23
Staff Appointments (Afrapt, Draper Fellow, RA)	115	116
Teaching Assitants & Fellows	4	3
Engineering Internship Program	2	3
Other Types of Support (Employer, Foreign, Self)	29	24
Total	183	175

FACULTY NOTES

Professor Eugene Covert was awarded the Department Undergraduate Teaching Award.

Professor Edward Crawley was appointed Head of the Aeronautics and Astronautics Department.

Professor Edward Greitzer was appointed Associate Head of the Aeronautics and Astronautics Department.

Professor Nesbitt Hagood received the Young Investigators Award for 1996.

Professor Wesley Harris received the following honors; 1) Inducted into the National Academy of Engineering, 9/95, 2) Recipient, Doctor of Science, Honoris Causa, Old Dominion University, Norfolk, VA, 12/95. Received the following appointments; 1) Member, Federal Aviation Administration (FAA) Research, Engineering, and Development Advisory Committee, 1996-2000, 2) Member, American Helicopter Society (AHS) Board of Directors, 1996-1998.

Professor James Kuchar PhD thesis was selected for the RTCA Jackson Award.

Professor Paul Lagace was reelected president of ICCM (International Committee on Composite Materials).

Professor Earll M. Murman concluded a six year term as Head of the Department.

Professor Dava Newman's space flight experiment went up to the Russian Mir Space Station. The MIT experiment will assess astronaut-induced disturbances to the microgravity environment.

MASSACHUSETTS SPACE GRANT CONSORTIUM

The Massachusetts Space Grant Consortium now includes MIT (Lead), Tufts University, Wellesley College, Harvard University, Boston University, University of Massachusetts, Worcester Polytechnic Institute 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. Robert Seamans, Professor Emeritus, MIT, Department of Aeronautics & Astronautics.

Massachusetts Space Forum

The second meeting of the Massachusetts Space Forum was held in November 1995. The goal of the Massachusetts Space Forum is to favorably influence national planning and to stimulate regional cooperative activity in space education and business opportunities. Over 80 leaders from academia, industry and government attended the workshops and the luncheon presentation by NASA Administrator Daniel Goldin.

The next Space Forum is tentatively scheduled for early Fall 1996.

RESEARCH HIGHLIGHTS

ACTIVE MATERIALS & STRUCTURES LABORATORY

In its first year, the Active Materials and Structures Laboratory (AMSL) focused on the development of innovative technologies for active control of aerospace systems. Research has covered a broad range of disciplines including materials science, structural mechanics, structural dynamics, control, and solid state actuation systems. The laboratory has coordinated multidisciplinary research programs ranging from fundamental materials microstructure investigations to helicopter control systems feasibility studies. Major research thrusts were: development of new compositions and synthesis techniques for active materials suitable for control and sensing functions; development and characterization of active fiber composite material systems suitable for structural shape and vibration control; and the establishment of new control algorithms and microelectronics hardware for distributed control architectures. Fundamental research was motivated by a variety of ongoing applications programs. AMSL, a member of the Smart Structures Rotorcraft Consortium with Boeing, has continued to work on developing actively controlled helicopter rotor blades for vibration and noise reduction. In a cooperative program with the Jet Propulsion Laboratory, AMSL developed ultrasonic motors suitable for space robotics applications. The laboratory also continued to advance applications projects in the active control of structural acoustics: both far field radiated sound from panels as well as control of interior noise in aircraft. The laboratory facilities available were in active material and device characterization, static and dynamic structural testing, and real time control.

AERONAUTICAL SYSTEMS LABORATORY

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 as well as applied research on human performance in space.

The laboratory has developed rapid prototyping techniques which employ graphical workstation technology to evaluate advanced cockpit information systems. Recent or current activities include: development of general methods to set threshold criteria in alerting systems; evaluating traffic conflict detection systems for unstructured "free flight" ATC systems; understanding and mitigating errors in advanced Flight Management Systems; applications of GPS navigation systems to aircraft and portable computer systems; evaluating automatic systems for spacecraft; and increased airport capacity through close parallel approach systems as well as flight guidance methods to minimize community noise impact.

COMPUTATIONAL AEROSPACE SCIENCES LABORATORY

Research leading to the development of a "distributed flow simulation environment" has continued. This effort brings together various areas of expertise within the Laboratory such as Computational Fluid Dynamics, Visualization and Aerodynamics. The developed tools are being used for research, teaching and design. A new effort in the field of active flow control and aeroelasticity has also been initiated. Research continues in the areas of configuration design, aircraft wing optimization and plasma physics.

FLIGHT TRANSPORTATION LABORATORY

The focus for research in FTL is on automation of processes involved in air transportation - for airlines, for airport operators, and for the operators of a proposed "Global Automated Air Traffic Control" system. Research has also continued in the area of airline revenue management, with work supported by Continental Airlines, KLM and Swissair. In conjunction with the Ocean Engineering Department and the Center for Transportation Studies, FTL completed a Market Analysis study for FastShip Atlantic, a potential transportation system innovation that promises cargo delivery characteristics between existing air and ocean services. FTL is also completing a study for NASA on the economic feasibility of a very large all-cargo aircraft system.

FLUID DYNAMICS RESEARCH LABORATORY

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, including fluid mechanics of a micro-gas-turbine engine; 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

The "micro engines" (gas turbine engines of less than a centimeter in diameter) project has just ended its first year with a very successful program review. The research involves an integrated team of investigators in diverse disciplines (as well as different departments). The project, which is under the leadership of Professor Alan Epstein, brings together researchers in gas turbine fluid mechanics and structures, high speed bearing design, microfabrication of complex turbomachinery configurations, and microgenerators, with the goal of producing a working micro gas turbine engine.

The GTL has continued the strong collaboration with industry, as a source of problems which are not only technologically relevant, but have high intellectual challenge. There is also close collaboration with the government propulsion centers. In particular, as part of the multidisciplinary "smart engines" research, first-of-a-kind active aerodynamic stabilization (i.e., extension of the stable operating range) of a transonic axial compressor stage has been achieved, at a NASA Lewis Research Center test facility. The work was carried out by Harald Weigl, a student of Professor James Paduano, who designed and built (at MIT) a set of high bandwidth fluid injection devices for use at this facility, as well as by NASA engineers.

For the second year in a row, research at the laboratory received the American Society of Mechanical Engineers Gas Turbine Award for the outstanding gas turbine paper of the year (out of over 500). Both of these papers arose from the smart engines project; the awards are a measure of the high degree of recognition this work is receiving.

On 1 June, Professor Alan Epstein became the Director of the Laboratory.

LEAN AIRCRAFT INITIATIVE

In conjunction with the Center for Technology, Policy and Industrial Development and Sloan School faculty, and funded by the Air Force and 17 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. military aircraft industry. Results from over two years of research have paved the way for a number of implementation activities in industry and government, and paved the way for a second three-year phase of the project.

MAN VEHICLE LABORATORY

Results of flight experiments conducted on the Space Life Sciences 2 Spacelab mission were presented by the Man Vehicle Lab at scientific meetings in September, and five papers have been accepted for publication in the Journal of Applied Physiology and Experimental Brain Research. The Advanced Dynamic Load Sensors Experiment is being conducted on the Russian Space Station Mir this summer and fall. A experiment for the 1998 "Neurolab" mission is now starting the active development phase. Ground based research on human spatial orientation in real and virtual environments, tactile cueing systems continues, EVA biomechanics, and a new research initiative on artificial gravity physiology and human factors has begun. FAA sponsored flight simulator research on cockpit displays for GPS instrument approaches is underway, in collaboration with the DOT Volpe Center in Cambridge.

SPACE ENGINEERING RESEARCH CENTER

Active Acoustic Launch Load Alleviation

Launch loads are the prime driver for spacecraft structural design. Reduction of these loads allows the opportunity to use more off-the-shelf and lighter weight components in the spacecraft, thereby reducing costs. While payload isolation is a fairly well developed field, acoustic load alleviation has not received much attention. Several steps are required to alleviate acoustic launch loads: 1. Understand and develop models of the interaction of the payload, enclosed fairing, and enclosed and external acoustics. 2. Develop distributed actuators and sensors that allow modification of the enclosed acoustic field. 3. Formulate control laws which make use of the developed models,

sensors, and actuators to significantly reduce acoustic loads transmitted to the payload. The Active Acoustic Launch Load Alleviation team is pursuing each of these goals.

Middeck Active Control Experiment (MACE)

MACE was successfully completed on the STS-67 in March of 1995. Preparations for flight included finalizing the 0-g finite element model, designing on-orbit identification experiments, and design of pre-programmed controllers using the 0-g finite element model. These activities were carried out for 2 configurations of the MACE test article. The experiment collected invaluable data, three types of protocols were implemented during the flight, identification, control, and input shaping. Flight operations went much better than expected, with 14 days of on-orbit test time instead of 6. Post-flight analysis of the several gigabytes of sensor/actuator data, as well as the more than 50 hours of video, is currently taking place and will continue to occur for a long time to come.

MIT Program in Smart Composite Structures

A fundamental technology development program in smart structures is underway involving multidisciplinary collaboration between the departments of Materials Science and Engineering, Aeronautics and Astronautics (SERC), and Electrical Engineering and Computer Science. The program, funded by the Army Research Office, attempts to achieve the goals of high authority/ high strength actuation and highly distributed integrated processing within the constraints of manufacturability and strength. The program achieves this goal through the development of a smart composite system composed of 1) an actuation layer incorporating both passive structural fibers and active high strain electroceramic fibers embedded in a high dielectric epoxy matrix 2) etched inter laminar electrodes which create in-plane electric field without compromising structural integrity and act as a 3) flexible circuit board back plane for a distributed microelectronics control system. The program encompasses Materials Research, Mechanics Research, and Electronics and Controls Research.

System Integration-Evolution Testbed

SIET is a proposal to provide a systems focus for the development and integration of existing and new technology into a constellation of small identical satellites. This consists of a coherent series of ground hardware testbeds and concurrent space flights that provide clear milestones to access progress. The testbed will consist of one or more "satellites" that will allow the evaluation of various control methodologies, communications technologies, measurement systems, attitude and modeled propulsion systems. It will allow single satellite station keeping and attitude control as well as multi satellite array formation and steering. Currently Task A has been funded and begins July 1, 1995.

Active Wing

The MIT/NASA Langley Active Wing has as its main objective the demonstration of new actuation technology for the suppression of vibrations and stabilization of transport aircraft wings. This project applies these new actuation techniques with state-of-the-art control designs to improve the gust response of a wing for both load alleviation and ride comfort. Made of a graphite/epoxy composite laminate, it has piezoelectric actuation packages distributed on the spar from the root to roughly 60% of the spar length. This spar construction is covered with a segmented aerodynamic shell to provide more realistic aerodynamics. Further investigations into methods of improving the performance are being conducted currently.

SPACE POWER AND PROPULSION LABORATORY

The Space Power and Propulsion Laboratory (SPPL) has been absorbed by the newly formed Space Systems Laboratory (SSL). The Propulsion activity has continued to focus on various aspects of Electric Propulsion and space mission planning. A very small (50W) Hall thruster has been designed and built, and will shortly undergo preliminary tests. Theoretical work has continued on alkali-seeded hydrogen arcjets, which offers high efficiency potential at moderate specific impulses; both, 2-D numerical simulation, and ionization/electrothermal stability analysis are being pursued. Hall thruster PIC models have been extended and refined, and will soon be applied to guide design efforts at BUSEK, Inc. A program of experimental probing of internal plasma properties in Hall thrusters has been initiated in cooperation with NASA Lewis R.C. The Gamma Ray Burst mission being prepared in cooperation with the Center for Space Research has evolved to an all-chemical propulsion architecture, involving an Ariane 5 ASAP launch; this will yield lower mission costs than the earlier Electric Propulsion version, and was made possible through trajectory studies performed by one of SPPL's graduate students (Chris McLain). A proposal was prepared by a NASA-Industry-University team, including MIT's SPPL, to develop electrodynamic tethers for

the International Space Station; the tethers would provide either/or 5-10 kW of emergency-supplementary power, or use a similar amount of on-board power to provide of drag make-up thrust. MIT would be co-lead with the SAO in the definition phases of both, a 2-year demonstration flight phase, and a longer prototype and operational phases. Finally, a systems study is being completed of a future gaseous core nuclear rocket in which the strong vortex flow required for containment is provided by MHD forces using electricity generated on-board from the reactor's waste heat.

SPACE SYSTEMS LABORATORY

The Space Systems Laboratory (SSL), part of the Space Engineering Research Center (SERC) in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology, was founded in 1995. The SSL has the mission of developing the technology and systems analysis associated with small spacecraft, precision optical systems, and International Space Station technology research and development. The laboratory encompasses expertise in structural dynamics, control, thermal, space power, propulsion, MEMS, software development and systems. A major activity in this laboratory is the development of small spacecraft thruster systems as well as looking at issues associated with the distribution of function among satellites. In addition, technology is being developed for spaceflight validation in support of a new class of space-based telescope which exploits the physics of interferometry to achieve dramatic breakthroughs in angular resolution. The objective of the Laboratory is to explore innovative concepts for the integration of future space systems and to train a generation of researchers and engineers conversant in this field.

Space Flight Programs

The SSL has conducted an exciting series of Space Shuttle technology experiments starting with the flight of the Middeck 0-Gravity Dynamics Experiment (MODE) which flew on STS-48 in September, 1991 to investigate truss structure and fluid slosh dynamics in micro-gravity. The Middeck Active Control Experiment (MACE) flew on STS-67 in March of 1995 to explore advanced control concepts for attitude and instrument pointing control on future spacecraft. The Dynamic Load Sensor (DLS) experiment flew on STS-62 to acquire the most comprehensive database on the effect of crew push-off loads on the micro-gravity environment of ISS. Reflight of DLS will occur in 1996 when it will be made a permanent facility on the Russian Space Station MIR. The SSL was a co-Investigator on the Shuttle Wake Shield facility and on the SAMPIE experiment on STS-62 which studied high voltage solar cells. The SSL also has experience with free-flying experiments. The SSL was a co-Investigator on BMDO's AMASS program to demonstrate active solar panel damping. The SSL has also teamed with the M.I.T. Center for Space Research to study the ETA series of satellites for interferometric detection of gamma bursts.

Laboratory Facilities

Several world-class facilities comprise the SSL. The Middeck Active Control Experiment (MACE) facility provides students, staff and faculty with a state-of-the-art facility for the conduct of structural system identification and control experiments. The high bay, clean room environment accommodates a low frequency electric-pneumatic suspension system, signal processing data analyzers, and several realtime computers for LTI and adaptive control. The Interferometry facility consists of the testbeds and support equipment necessary for conducting nanometer and sub-arcsecond phasing and pointing control commensurate with the needs of space-based visible interferometry. Testbeds include a 3.5 meter tetrahedral truss structure and a pointing-phasing optics bench. Support equipment includes laser interferometers, delay lines, is a state-of-the-art computational facility for studies ranging from orbital mechanics to rarefied gas dynamics, siderostats, piezoelectric actuators, realtime computers, and miscellaneous optics. The ASTROVAC facility provides a 10⁻⁵ torr quality vacuum test chamber with a diameter of 12 feet and a height of 16 feet. Thermal, free-fall, clean room, and metrology capabilities are also provided. The CASL facility

Program Participations

The SSL is a member of NASA's Small Satellite Technology Initiative (SSTI), New Millennium Program, and International Space Station Technology Testbed Program. The Laboratory also has ties with the M.I.T. Lincoln Laboratory, NASA Langley, JPL and the Air Force Phillips Laboratory as well as the Departments of Electrical and Mechanical Engineering at M.I.T. and aerospace industries such as Draper, TRW, Lockheed-Martin, MDA and Hughes.

TECHNOLOGY LABORATORY FOR ADVANCED COMPOSITES

Over 30 students were involved with TELAC during AY 95-96 including 15 graduate students, 15 UROPers, and a number of students in 16.621/2 who performed their projects in TELAC. Two students finished their master's theses in the laboratory during this period. The laboratory issued a total of 14 reports during this period including a number accepted for publication in journals and proceedings. Laboratory personnel participated in conferences at the national and international level giving a total of 7 presentations. Included in these was a paper given by Mark Spearing at the biannual International Conference on Composite Materials held in Whistler, Canada in August where a new approach to the design of composite structures was introduced by the laboratory faculty. This philosophy had been developed by the laboratory faculty over the past several years and included discussions with government, industry and academic colleagues as well as the students at TELAC. Other major research accomplishments during the year include the development and verification of a universally-applicable nondimensional parameter to characterize the nonlinear response of pressurized cylinders at notches; achievement of an understanding of the bulging phenomenon in the damage arrest of metallic and composite pressurized cylinders (e.g. fuselages); continued extension of the understanding of impact behavior in composite structures, particularly in regard to shell configurations; development of an approach to consider probabilistic effects in the design of composite structures, particularly multifunctional ones; and development of an approach, using design diagrams, for the design of reliable layered materials. Through the generosity of the Instron Corporation, the Institute (through the Sloan fund), and NSF, the laboratory was able to make a major upgrade to its testing facilities. This includes retrofits of modern electronic controls on two existing large (100 kip) machines and the addition of two smaller machines (22 kip and 55 kip) along with associated equipment for high temperature testing. Refurbishment (software and hardware) of the current data acquisition and analysis equipment accompanied this effort.

WRIGHT BROTHERS WIND TUNNEL

The primary test activities fell into two classes. The first is the use of the wind tunnel for educational purposes. In the past year there were 16.621-16.622 projects:

- Effects of massive roughness on lift of a symmetric airfoil.
- Effects of winglets on flaps.
- Aerodynamic characteristics of an F-16A with "Pillow" tanks.
- Drag and side forces on a bicycle and rider with "Aerobars".
- Aerodynamic characteristics of a blended wing-body.

These tests used 31.75 wind on hours.

The second were commercial use of the wind tunnel to determine wind loads and pedestrian level winds for proposed construction in Boston.

- Pedestrian level wind for a hotel at World Trade Center.
- Pedestrian level wind for East Office Building at World Trade Center.
- Pedestrian level wind for proposed Colonnade Residence.
- Pedestrian level wind at north end of East Office Building at the World Trade Center.

The other use was for calibration of Second Wind Anemometer.

The commercial testing used 69.25 wind on hours.

DEPARTMENT AWARDS

UNDERGRADUATE

The James Means Memorial Award "for excellence in flight vehicle engineering" was given to Alex Y. Lee, a senior from Ontario, Canada; and to Sherwin S. Chen, a senior from Roslyn, N.Y.

The James Means Memorial Award "for excellence in space systems engineering" was given to Malinda K. Lutz, a senior from La Palma, CA; Robert L. Stephenson, Jr., a senior from Tellico Plains, TN; and Tresa V. Vidayathil, a senior from New City, N.Y.

The Henry Webb Salisbury Award "for achieving academic excellence in the Department of Aeronautics and Astronautics" was given to Dennis A. Burianek, a senior from Bremerton, WA; and Corinne R. Ilvedson, a senior from Auburn, WA.

The Admiral Luis De Florez Prize "for original thinking or ingenuity" was awarded to five students in the department. They are--Atif I. Chaudry, a senior from Greenwich, CT; Kerem Limon, a junior from Istanbul, Turkey; Peter S. Lively, a junior from Gaithersburg, MD; Jason Prest, a senior from Vero Beach, FL; and Craig A. Zimmerman, a senior from Big Lake, MN.

The Andrew G. Morsa Memorial Award was given to Jason C. Bunn, a senior from Manalapan, NJ; and Sherwin S. Chen, "for demonstrating ingenuity and initiative in the application of computers to the field of aeronautics and astronautics".

The Unified Engineering Award was given to Kei Y. Tang, a graduate student from Wilmette, IL, "for outstanding devotion to and leadership of the team of student assistance in Unified Engineering".

Takayuki Kohata (Taka) a sophomore from Yokohama-shi, Japan, is the recipient of the *Yngve K. Raustein Memorial Award*, "as the student in Unified Engineering who best exemplifies the spirit of the Norwegian Yngve Raustein, and for significant achievement in Unified Engineering."

The David J. Shapiro Memorial Award was given to Akwasi A. Apori, a sophomore from Houston, TX, for "foreign travel for the enhancement of scientific/technical studies by an undergraduate student in Aeronautics and Astronautics".

The Apollo Program Prize "for the best undergraduate research project on the subject of humans in space" was awarded to Patricia B. Schmidt, a senior from Biloxi, MS.

The General James H. Doolittle Scholarship was received by Christian L. Anderson, a junior from Cody, WY, for his "excellent academic record and breadth of interests."

The John F. McCarthy Jr. Scholarship was received by Dennis A. Burianek for his "superior scholarship achievement...".

The James E. Cunningham Scholarship was received by Corinne R. Ilvedson for her "superior scholarship achievement...".

The Boeing Company gave scholarships to Dennis A. Burianek, and to Tan T. Trinh, a senior from Lafayette, LA, for their "excellent work in the Summer 95 Internship Program."

GRADUATE

Three graduate students were selected as the Departmental Teaching Fellows.

Leonard Lublin	16.060	Charles Stark Draper Teaching Fellow
Kei Y. Tang	Unified	Raymond Bisplinghoff Teaching Fellow
Sanjay Vakil	16.83	Jerome C. Hunsaker Teaching Fellow

FUTURE PLANS

The Aero/Astro Department is faced with a unique opportunity: the ability to reinvent itself.

In the coming year the department will conduct a broad ranging and thorough strategic planning exercise to develop a new mission statement, make plans for initiatives in education, teaching and leadership. We intend to do this with a strong eye to the competitive positioning of our department - what will be our markets in the future? Who will be our competitors? What must we do to be number 1?

The process will identify the educational and research areas MIT should be in, and then work with other MIT organizations and departments to identify how to best organize to meet these needs.

From this plan will flow staffing, budget and resource development plans for the next five years.

Edward F. Crawley
Edward M. Greitzer

DEPARTMENT OF CHEMICAL ENGINEERING

1995-96 was an exciting and important year in the history of the Chemical Engineering Department. Professor Robert A. Brown, began his eighth year as Department Head and then in January, 1996 was named the new Dean of Engineering. Professor Charles L. Cooney, who replaced Professor Robert Armstrong as Department Executive Officer on July 1, 1995, became Acting Department Head while a search committee chaired by Professor William Deen prepared recommendations to the Dean. With the enthusiastic support of the Department, Dean Brown appointed Professor Robert C. Armstrong as the new Department Head beginning from June 1. Professor Cooney continues as the Executive Officer. During the year, Professors Edward Merrill and Adel Sarofim both announced their retirement effective September 30, 1996. Professor Sarofim will move to the University of Utah and Professor Merrill will remain active in the Department on a part time basis teaching and continuing his research.

On the administrative side of the Department, Robert Morrow our administrative officer retired effective in June and two long time support staff employees also retired during the year. Both Darlene Messmer-Slagle our personnel administrator and Michael Hegarty our financial officer have assumed expanded administrative responsibilities.

The Department continues to thrive with high undergraduate enrollments. For the 1995-96 academic year our undergraduate enrollment continues to exceed class sizes of 100 with 118 sophomores, 101 juniors and 103 seniors. Initiatives in undergraduate education include: two ECSEL sponsored programs to incorporate more design into undergraduate education, initiation of the minor program in biomedical engineering and the successful introduction of a new course in Molecular Aspects of Chemical Engineering. We also completed the construction of a new undergraduate Laboratory in Polymer Science in Building 31 that allows us to double the number of students taking this very popular course each term.

Our graduate program again received a high level of excellent applications. From 366 applications we offered admission to 64 students and 41 students accepted our offer, a yield of 64%. There were 33 students in the David H. Koch School of Chemical Engineering Practice; these students participated in projects at our sites at Dow Chemical and Merck stations. We also added a new site at Molten Metal Technology in Fall River, MA. We were again ranked number one in the country by the annual U.S. News & World Report survey. Support of graduate research in the Department continues at a high level with \$17M during the academic year; 50% comes from industry.

It was an especially exciting year for faculty chair appointments: Professor Robert C. Armstrong was named to the Chevron Chair in Chemical Engineering, Professor Jack B. Howard was named as the first Hoyt C. Hottel Professor of Chemical Engineering, Professor T. Alan Hatton became the first Ralph Landau Professor in Chemical Engineering Practice and Professor Robert E. Cohen was named to the new Raymond A. and Helen E. St. Laurent Professor of Chemical Engineering. There were two promotions effective July 1, 1996 with Professor Linda Griffith Cima and Jackie Y. Ying becoming Associate Professors. We have also hired a new assistant professor, Bernhardt Trout who will join us at the end of 1997 after completion of a postdoctoral position at the Max Plank Institute in Germany.

Several of our faculty received significant honors this year. Professor R. A. Brown received the Professional Progress Award of the American Institute of Chemical Engineers. Professor Paul Laibinis was selected as a Young Investigator of the Arnold and Mabel Beckman Foundation and named the Henry L. and Grace Doherty Assistant Professor of Ocean Utilization. Professor Robert Langer was selected as the recipient of both the William H. Walker award of the American Institute of Chemical Engineering and the prestigious Gairdner Foundation International Award. Professor Adel Sarofim received the Homer H. Lowry Award from the Department of Energy. Professor Jackie Ying received a David and Lucille Packard Fellowship and a Camille Dreyfus Teacher-Scholar Award.

UNDERGRADUATE EDUCATION

For the year 1991-92, sophomore enrollment was 96, juniors 72, seniors 58, total 226; 1992-93 sophomores 95, juniors 89, seniors 81, total 265; 1993-94 sophomores 115, juniors 90, seniors 84, total 289; 1994-95 sophomores 108, juniors 104, seniors 100, total 312; 1995-96 sophomores 118, juniors 101, seniors 103, total 322.

The trend in increasing enrollment since the 1987-88 academic year continued. The current projection for next year's sophomore class is about 100, indicating as expected that the class size is leveling off. Our classes continue to include about half women, with much interest in the areas of biochemical and biomedical applications of chemical engineering. Our teaching resources, both faculty and space, continue to be strained.

NEW POLYMER LABORATORY

The undergraduate polymer laboratory, initiated by Professor Robert E. Cohen in 1973 and further developed by Profs. Edward Merrill and Paula Hammond, has become an important component of our undergraduate program. With the growing undergraduate enrollment and the increasing importance of polymers in many products, the demand for the course far outgrew the capacity to teach it in building 66. With funding from the Dean's Office and Department we were able to relocate the laboratory to building 31 and double its capacity to 36 students in both the Fall and Spring terms. This elective laboratory meets an important need for undergraduates in satisfying their Department laboratory requirements, as well as introduce them to a central area of modern chemical engineering.

GRADUATE EDUCATION

In the 1990-91 year, Masters enrollment was 59, Doctoral enrollment was 164, total 223; 1991-92, Masters 37, Doctoral 164, total 201; 1992-93 Masters 51, Doctoral 159, total 210; 1993-94, Masters 62, Doctoral 147, total 209; 1994-95, Masters 64, Doctoral 166, total 230; 1995-96, Masters 56, Doctoral 169, total 225.

The total for 1995-96 includes 67 foreign students, 55 female students, and 14 minority students (not including Asian Americans). Graduate admissions data suggests that graduate enrollment will remain in the low 200s for the next several years.

DAVID H. KOCH SCHOOL OF CHEMICAL ENGINEERING PRACTICE

A total of 33 students participated in the Practice School Program during the 1995-96 academic year. The two permanent stations at Dow Chemical Company in Midland, MI, and the Merck Manufacturing Division in West Point, PA, and a third summer station at Molten Metal Technology in Fall River, MA, provided a wide variety of excellent projects and opportunities for the students. Some projects were also carried out at Dow Corning to supplement those offered by Dow Chemical. Dr. Janet Griffiths and Dr. Barry Johnston continued to serve as directors of the West Point and Midland Stations, respectively. The Fall River Station will be directed by Dr. Andrea O'Connor in June 1996 and Professor Arijit Bose, on sabbatical leave at MIT from the University of Rhode Island, for the remaining two 1996 summer months. Professor T. Alan Hatton continues to direct the Practice School from Cambridge. The stature of the Practice School was again elevated through the establishment of the Ralph Landau Professorship in Chemical Engineering Practice, which chair is to be held by the Director of the Practice School.

FACULTY NOTES

Professor Robert C. Armstrong completed a two year term as President of the Society of Rheology, one of the founding member societies of the American Institute of Physics. Professor Armstrong gave invited seminars at the California Institute of Technology, UCLA, and the University of Southern California. He also presented a keynote lecture at the Isaac Newton Institute at Cambridge University. This year he was named holder of the Chevron Chair in Chemical Engineering. Professor Armstrong serves on the National Awards Committee of the American Institute of Chemical Engineers.

Professor Paul I. Barton received an award from the Exxon Education Foundation. He gave invited lectures at the Chemical Process Control - V Conference, Purdue University and the University of Notre Dame.

Professor Howard Brenner, W.H. Dow Professor of Chemical Engineering, received the 1996 General Electric Gold Medal Senior Research Award of the American Society of Engineering Education. During the year, he was on sabbatical leave from MIT at several universities here and abroad, including an appointment as Lady Davis Professor at the Technion in Haifa, Israel. Invited lectures were presented to various universities in Israel, Mexico, Holland, Switzerland, France and Spain, as well as at various US universities.

Robert A. Brown, Warren K. Lewis Professor, served as Department Head until January when he became Dean of Engineering at MIT. He chaired the first "Frontiers of Engineering Conference" for the National Academy of

Engineering. The meeting was held in September of 1995 and brought together 100 leading young engineers from industry and academia to discuss research across all engineering disciplines. He was the Richard Wilhelm Lecturer at Princeton University in the fall. Professor Brown also began a three-year term as a Member-at-Large on the U.S. National Committee on Theoretical and Applied Mechanics of the National Research Council and also began service on the Materials Research Council of DARPA. Professor Brown won the Professional Progress Award of the AIChE in 1996, which will be given to him at the National Meeting in November.

Professor Linda Griffith Cima was promoted to Associate Professor. She gave a number of invited lectures, including the Gordon Conference on Biomaterials, two separate NIH-sponsored workshops on tissue engineering, the Keystone conference on Tissue Engineering, and at Georgia Tech and the University of Wisconsin. She will co-chair the Materials Research Society Spring 1997 meeting, and continues to serve as co-chair of the CBE biomedical engineering curriculum committee. She and her collaborators at Massachusetts General Hospital received international press attention when the BBC ran a documentary showing an experiment in which they demonstrated that cartilage in the shape of a human ear could be grown using a biodegradable polymer construct seeded with cells isolated from cartilage, and the "mouse with the ear" has now become a virtual symbol for tissue engineering.

Professor Robert E. Cohen was named the inaugural Raymond A. and Helen E. St. Laurent Professor of Chemical Engineering. The endowed chair was established with a gift from the late Helen St. Laurent who died in March of 1995. Her husband, Raymond St. Laurent was a member of the class of 1921. Professor Cohen was honored with the Shell Distinguished Lectureship in Materials Science and Engineering at Northwestern University. He also presented invited lectures at Johns Hopkins University and at Bayer Corporation in Leverkusen, Germany. As the Chemical Engineering Department's Graduate Officer, he chaired an Ad Hoc Committee to examine the structure of the Doctoral Program with a focus on reducing the residence time required to complete the doctoral degree in Chemical Engineering.

Professor Charles L. Cooney, was named as Executive Officer of the Department of Chemical Engineering effective July 1, 1995, and from January 15 through May 31, 1996 also served as Acting Department Head. Professor Cooney became co-director of a newly formed Consortium for Advanced Manufacturing in Pharmaceuticals, a joint MIT-Purdue University academic-industry consortium. He also was named chair of the Corporate Relations Committee and joined the newly formed Council on Industrial Relations.

Professor T. Alan Hatton was appointed the Ralph Landau Professor of Chemical Engineering Practice. He has been organizing an Engineering Foundation Conference on "Structured Fluids and Interfaces: Technical Applications and Opportunities for Organized Molecular Assemblies" (January 1997) and is serving on the organizing committee of the Engineering Foundation Conference on Separation Technology (October 1997). Professor Hatton was appointed a US Editor of the journal "Colloids and Surfaces". He presented invited seminars at the ETH, Zurich, Switzerland, Purdue University, and the University of Virginia.

Professor Jack B. Howard became the first Hoyt C. Hottel Professor of Chemical Engineering. The creation of the Hoyt C. Hottel Chair was announced at a departmental reception in honor of Professor Hottel and Professor Howard. Professor Howard also was elected to the Board of Directors of the Combustion Institute and was appointed to the National Aeronautics and Space Administration Committee on Microgravity Combustion Programs.

Professor Paul E. Laibinis was selected as a Young Investigator of the Arnold and Mabel Beckman Foundation and was named the Henry L. and Grace Doherty Assistant Professor of Ocean Utilization. Professor Laibinis was an invited lecturer at the 188th Meeting of the Electrochemical Society in Chicago, the 22nd Conference of the Federation of Analytical Chemistry and Spectroscopy Societies, the Gordon Research Conference on "Organic Thin Films", and the 7th Annual Symposium on Photoinduced Charge Transfer at the NSF Center at the University of Rochester. In 1995, he inaugurated a new applied chemistry course entitled "Molecular Aspects of Chemical Engineering" with Professor Hammond.

Professor Robert S. Langer was awarded the International Award, the highest award of the Society of Plastics Engineers, the Ebert Prize (American Pharmaceutical Association), the Gairdner Foundation International Award,

and the William H. Walker Award (American Institute of Chemical Engineers). One of his scientific papers was cited as one of the top ten medical advances of 1995 by the Harvard Health Letter. Professor Langer was selected as the Berkeley Lecturer (University of California at Berkeley), and the Avis Distinguished Visiting Professor (University of Tennessee). He also gave the Plenary Lecture at the 3rd Jerusalem Conference on Pharmaceutical Science and Clinical Pharmacology.

Professor Douglas Lauffenburger, also Director of the MIT Center for Biomedical Engineering, is serving as President-Elect of the Biomedical Engineering Society. In this past academic year he presented the Llewelyn-Thomas Distinguished Lectures in Bioengineering at the University of Toronto, as well as invited plenary lectures at the Gordon Conference on Biomaterials & Biocompatibility, the Keystone Symposium on Cell Migration in Development, Homeostasis & Pathology, the Johnson & Johnson Focused Giving Symposium, and the Whitaker Foundation Grantees' Conference.

Professor Gregory C. Rutledge took part in the organization and presentation of the Polymer Section of the Workshop on Molecular Modeling, co-sponsored by MIT, the Institute for Theoretical Physics, and UCSB, to bridge the gap between academic and industrial applications of modeling. He was an invited speaker at the 17th AFOSR Asilomar Conference on Polymeric Materials, at ANTEC'96 (meeting of the Society of Plastics Engineers), and at a symposium commemorating the 35th anniversary of the journal Polymer, of which he is an Editorial Advisory Board member.

Professor Adel Sarofim received the Annual Award for Innovation in Coal in September, 1995 given by the University of Pittsburgh to honor an individual who has made a recent and significant contribution to new technologies, new procedures or new policies toward coal utilization. The citation read "A strong and recurring characteristic of Professor Sarofim's coal conversion research is clarification of fundamental mechanisms underlying coal behavior in practical processes". In March, 1996 he received the Homer H. Lowry Award of the Department of Energy for outstanding research accomplishments in the field of fossil energy. It was stated that "Adel Sarofim is a compassionate human being who inspires students and colleagues, and who contributes significantly across the full spectrum from fundamental science through real-world design concepts".

Professor George Stephanopoulos was elected as the Vice-Chairman of the "Computing and Systems Technology" Division of the American Institute of Chemical Engineers. He will take over the chairmanship in 1997. Professor Stephanopoulos was the International Programming Committee chairman for two major international conferences; (I) ISPE-95, "Intelligent Systems in Process Engineering" (Snowmass, Colorado, July 1995), (II) ESCAPE-6, "European Symposium of Computer-Aided Process Engineering" (Rhodes, Greece, May 1996). He was invited by the chemical engineering students to present the Centennial Lecture of their student chapter at the Technical University of Delft, The Netherlands (October 1995). He also presented invited lectures at Princeton University, McMaster University, Carnegie-Mellon University, Case Western Reserve University, Wayne State University, Kyoto University, Imperial College, and University of Connecticut. In January 1996 he presented a series of lectures at the Technical Centers of Mitsubishi Chemical Corporation, Japan Energy Corporation, Bayer AG, and Shell Oil Corp. Academic Press, in its Advances in Chemical Engineering Series (Volumes 21 and 22), published the two-volume work on "Intelligent Systems in Process Engineering: Part I- Paradigms from Product and Process Design, Part II- Paradigms from Process Operations and Control" that Professor Stephanopoulos co-authored with his present and past Ph.D. students.

Professor Daniel I.C. Wang delivered a keynote lecture at the North-South American Conference on Biotechnology in November, 1995 in Cuernavaca, Mexico on "The Future Needs in Bioprocess Engineering Research". Professor Wang also delivered a keynote lecture at the International Chemical Congress of Pacific Basin Societies in December, 1995 in Honolulu, Hawaii on "Education and Research in Biochemical Engineering". He was invited to deliver keynote lecture at Cell Culture Engineering V Conference in San Diego, CA in February, 1996 on the "Past Developments and Future Challenges in Animal Cell Culture". In May, 1996, Professor Wang was invited to the Chemical Engineering Department, Zhejiang University, Hangzhou, People's Republic of China where he delivered a number of lectures on Biochemical Engineering and was given an honorary title of Advisory Professor of Zhejiang University.

Professor Jackie Y. Ying was recognized by several organizations this past year for her research in nanocrystalline materials and mesoporous structures. She received a David & Lucille Packard Fellowship for Science and Engineering, a Camille Dreyfus Teacher-Scholar Award, and the Royal Academy of Engineering ICI Fellowship for Young Academic Chemical Engineer. Professor Ying was an invited speaker at the 1st Annual National Academy of Engineering Frontiers of Engineering Symposium, TMS 1995 Materials Week, Engineering Foundation Conference on Interfacial Materials, 1996 World Car Conference, TMS International Symposium on Nanocrystalline Materials, and MRS Spring Symposium on Porous Materials. This summer she will be giving invited talks at the Office of Naval Research 50th Anniversary Symposium, the Gordon Research Conference on Solid State Chemistry, and the ACS Symposium on Macromaterials. Professor Ying's research is interdisciplinary in nature, with a theme in synthesis of advanced inorganic materials for catalytic, membrane and ceramic applications via structural tailoring on the nanometer scale. She currently holds the first Raymond A. and Helen E. St. Laurent Career Development Chair. She serves on the Editorial Board for the Journal of Porous Materials and Journal of Electroceramics, and is a Guest Editor for Nanostructured Materials and the AIChE Journal. She is on the Board of Directors of Alexander von Humboldt Association of America, and is the Ceramics Area Vice-Chair for the American Institute of Chemical Engineers.

RESEARCH HIGHLIGHTS

CENTER FOR BIOMEDICAL ENGINEERING

The mission of the Center for Biomedical Engineering (CBE) is to bring engineering into intimate contact with molecular and cell biology, for the purpose of developing innovative approaches to biomedical technology. It brings together efforts of more than 20 investigators at MIT, Harvard Medical School, and BU Medical School, in three major thrust areas: Molecular Engineering, Cell & Tissue Engineering, and Physiological Systems Engineering. The first thrust area primarily deals with characterization of physical and chemical properties of individual biomolecules, mainly proteins and DNA, via high throughput assays. The second aims at creating methodologies for delivering biotechnology-based molecular-, cell-, and tissue-based therapies. The third emphasizes minimally-invasive techniques for quantitative assessment of how these biotechnology-based interventions affect physiological function. CBE supports Core Facilities in Biomolecular Interactions & Cellular Responses, Histology & Immunochemistry, and Quantitative Microscopy & Image Analysis at the present time. It also administers the undergraduate Minor degree program in Biomedical Engineering. In May 1996 it offered, in conjunction with ILP, a Workshop on MIT/Industry Interactions in Biomedical Engineering. In June 1996 it organized and sponsored, along with the School of Engineering and the Departments of Chemical Engineering and Biology and the Whitehead Institute, a Summer Course in Molecular & Cell Biology for Engineering Faculty.

CENTER ON AIRBORN ORGANICS

The Center on Airborne Organics was established at the California Institute of Technology (Caltech), Massachusetts Institute of Technology (MIT), and New Jersey Institute of Technology (NJIT) to conduct research needed to provide the scientific tools for more rational decision making on issues related to the impact of airborne organics on tropospheric ozone, visibility, fine particles, and air toxics; more specifically, to develop improved methodologies and predictive and interpretive models to reliably connect the identities and concentrations of airborne organic compounds with major anthropogenic pollutant emission sources. A key feature of the Center's research program is the development of a mechanistic understanding of the factors that govern the detailed chemical compositions of the effluents from mobile and stationary combustion systems, and how these compositions are influenced by atmospheric transformation, for purposes of both developing better understanding of the use of signatures for source attribution purposes and guiding the development of risk-reducing strategies.

The Center was funded in June, 1992 with Professor Adel Sarofim as Director and Professor John Seinfeld of Caltech and Professor Dick Magee of NJIT as Associate Directors. Professor Jack Howard will take over as Center Director when Professor Sarofim takes early retirement on October 1, 1996. During its first four years of operation, the Center has developed new models for the formation of fine particles from organics both in the atmosphere and in flames, identified which of the sources of organics in ambient air are potential mutagens, and developed analytical techniques for characterizing the organics and relating soot to its sources. The soot prints which are potential signatures for the sources of the elemental carbon in airborne organics have received wide coverage in the media. Center projects funded at MIT include the efforts of Professors Heywood and Hochgreb of the Sloan Automotive Laboratory on the effects of engine deposits on hydrocarbon emissions, the research by Professor Jack Howard on developing comprehensive models of soot formation in flames, the development by Professor Greg McRae of tools

for allowing efficiently for the effect of uncertainties in input parameters on the predictions of complex models of atmospheric transformation, and the work on high resolution electron microscopy leading to the soot prints by Professors Sarofim and John Vander Sande of the Materials Science Department.

One of the highlights of the Center's activities have been the summer symposia held annually at Endicott House on the impact of the science being carried out in the Center on some of the more contentious issues in the air pollution field, including the issues of regulating ozone in the Northeast, the implementation of the air toxics provisions of the Clean Air Act Amendments, and effective technologies for low emission vehicles. The organization of these summer symposia has been greatly assisted by the Science Advisory Committee of the Center, of which a graduate of the Department, Dr. Bob Slott of Shell, has played a key role.

PROCESS AND SURFACE CHEMISTRY OF NANOSTRUCTURED MATERIALS

Materials engineering is entering an exciting era with new opportunities to tailor properties via nanostructure processing. Professor Jackie Ying's group is developing two broad classes of materials with designed nanometer-scale structural manipulation. The first is referred to as a nanocrystalline material, which is an ensemble of 1-10 nm-sized crystallites. The nanocrystallites possess unique hybrid properties characteristic of neither the molecular nor the bulk solid state limits. Nanocrystalline processing offers a practical way of retaining the results of property manipulation on the atomic or molecular level. Nanostructured catalysts have been developed with unique quantum confinement effects, ultrahigh surface area, and intimate surface interaction between components. These novel materials exhibit remarkable activities for environmental catalysis, eliminating effectively such pollutants as CO, SO₂, NO_x, and chlorinated organic compounds. With greater microstructural uniformity, advanced ceramics have also been achieved with superb strength and ductility by the nanocomposite approach for high temperature structural and biomaterial implant applications.

Professor Ying's laboratory is also investigating another class of nanostructured system characterized by the molecular assembly of structures consisting of nanometer-sized cavities or pores. Conventional porous structures with long-range crystalline order are typically limited to aluminosilicates (e.g. zeolites) and phosphates with pore openings of <15Å. The inflexibility in the composition and pore size of such materials does not address the needs of the variety of catalytic reaction and gas adsorption applications that exists in chemical industries. Ability to process nanoporous materials with greater control in compositional and pore structure variation will open up tremendous opportunities in advancing catalysis and separations technologies. Professor Ying's group has developed two approaches for synthesizing nanoporous materials, one involving ligated liquid crystal templating micellar structures, the second employing pillaring agents or molecular props between layered structures. The former led to the achievement of the first family of transition metal oxide molecular sieves, and the latter generated a new class of crystalline layered transition metal molybdates. The new porous structures offer exciting potential for a wide range of catalytic applications, including photocatalysis, stereospecific polymerization, solid acid catalysis, epoxidation and oxidative dehydrogenation.

DEPARTMENTAL AWARDS

The Chemical Engineering Department's annual Awards Ceremony provided an opportunity to acknowledge the achievements of our students, faculty and staff during the past academic year. In conjunction with the Student Financial Aid Office, Amoco Foundation Undergraduate Scholarships were acknowledged for recipients Brian J. Banaszak, a junior from New Carlisle, OH, Robert J. Meagher, a junior from Sterling Heights, MI, and Brian J. McDonald, a junior from Fort Myers, FL. Also acknowledged were NSF Scholars Gerardo Corona, a junior from Summit, IL, Shelly-Ann N. Davidson, a junior from North Miami Beach, FL, and Kimberly L. Miller, a junior from Guaynabo, PR. The Dow Chemical Company Outstanding Junior Award recipient was Ritesh A. Shah, a junior from Burr Ridge, IL, for his balanced record of achievement in academics and campus professional and social organizations, as well as work experience. The American Institute of Chemists Foundation honored Jessica R. Oleson, a senior from Auburn, MA, for her potential advancement in the chemical professions, based on her demonstrated record of leadership ability, character, and scholastic achievement. The Robert T. Haslam Cup was awarded to Katherine M. Notter, a senior from Wenatchee, WA, 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 Ashish R. Patel, a senior from Burlington, MA, in recognition of outstanding scholarship and research.

The Edward W. Merrill Outstanding Teaching Assistant Award was presented to Radha Nayak, a graduate student from Bangalore, India, for excellence in teaching in an undergraduate subject. A second place award went to Patrick M. Piccione, a graduate student from Sweden. Chemical Engineering Department Special Service Awards were given to Rajesh Venkataramani, a graduate student from Upper St. Clair, PA, Chase E. Orsello, a graduate student from North Saint Paul, MN, and Bryan J. Sanderson, a senior from Charlton, NY, for their unselfish contributions to the success of departmental activities.

The Outstanding Employee Award was presented to Maria Nargi, a Senior Office Assistant in the Chemical Engineering Administration 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. Individual Accomplishment Citations were presented to Chemical Engineering Facilities Manager Stephen K. Wetzel, and graduate student Lloyd P.M. Johnston, for their outstanding contributions to departmental life. Wetzel and Johnston were the first-ever recipients of this special award, and each received a personalized citation signed by the Department Head.

Robert C. Armstrong

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

The new Masters of Engineering Program (M.Eng.) and a revision of the Department's Strategic Plan dominated our activities last year. The former will be discussed under the Graduate Education section of this report.

After successfully completing most of the Action Items of the 1993 Strategic Plan, the Department felt compelled to revisit our long term agenda and define new initiatives for the next three years. For the first time a departmental theme was adopted: Sustainability of Large Integrated Systems. Large integrated systems are "open"; understanding their interactions with the social, political, and economic areas is critical to designing and optimizing them, and is central to developing viable policies for fostering long-term economic development, consistent with environmental concerns.

Given our theme, our foci are:

- Developing the engineering and scientific basis to guide economic growth in balance with the necessary environmental protection.
- Participating, as modern engineers and scientists, directly in the policy development process.

The Department's Strategic Plan is still founded on the three pillars on which we are built: infrastructure, environment, and information/logistics/management systems.

The revised Strategic Plan has several long term Goals; they are supported by short term Action Items. For the next few years the Action Items are: (1) carry out a full revision of the undergraduate curriculum; (2) further develop the M.Eng. program; (3) develop a strategy to increase fellowship support for graduate students; (4) study the feasibility and embark, if possible, on creating a series of textbooks using the latest in multimedia and information technology; (5) continue aggressive efforts to attract outstanding minority and women faculty hires to build on our past successes; (6) develop mechanisms which will permanently finance continuing improvements in computer facilities, technical support and laboratories; (7) develop a feasibility study for a new environmentally friendly and unified building for CEE; (8) complete our faculty salary hardening initiative; (9) review our organization seeking further reduction in bureaucracy and improvements in communications and cooperation; (10) develop a plan for international initiatives in education and research; (11) create mechanisms to develop a closer relationship to industry.

The year opened with successful and productive reviews by our Visiting Committee and by ABET throughout the year. The National Research Council ranked our doctoral programs first in quality of faculty and effectiveness in educating students nationwide.

Improvement of our physical environment continues. Major projects completed this year are the new M.Eng. dedicated classroom and computer facility and new concrete and non destructive evaluation laboratories. We are in the midst of constructing a new, fully equipped, Design Studio for graduate and undergraduate teaching.

The year ended with six of our colleagues taking advantage of the early retirement program, two staff members and four faculty members. Although some will keep up their involvement with the Department, this represents a significant loss of experience and know-how. They will be missed. On the other hand we continue to aggressively hire. We now have 13 outstanding, untenured, faculty members and were able to hire another individual to start July 1, 1997. We will continue to hire the new generation of leaders who will take this Department into the new century.

UNDERGRADUATE EDUCATION

Both undergraduate programs, Civil Engineering and Environmental Engineering Science, are ranked in the top five by *U.S. News and World Report*. Both programs are ABET accredited and were again reviewed last September.

The Environmental Engineering Science program has been slightly adjusted to serve as a pre-med option for MIT students. The impact of these changes are already evident in the incoming class.

As expected, our undergraduates are increasingly attracted to the new M.Eng. program, with the latter serving the role of a fifth year of specialization and professional education.

We are concerned about the apparent stagnation of enrollments, particularly in the Civil Engineering option (see Table). To address the issue we are embarking on a review of curricula and in developing processes to influence applicants to MIT, the admission process, and the freshmen selection of majors.

We continue to serve the Institute's undergraduate population with our Introduction to Computers and Engineering Problem Solving, by our participation in teaching the Institute's biology requirement and by leadership in environmental literacy courses throughout the Institute. We are pursuing other possible service roles that would be compatible with our educational objectives.

GRADUATE EDUCATION

Our first class of 21 M.Eng. students successfully completed the program and graduated in June. Exit interviews and questionnaires confirmed the overall satisfaction with the program. All students felt that their newly acquired degrees made them far more marketable, in better paying and more interesting jobs. They also made suggestions for improvements many of which will be implemented.

Next year we have an entering class of 30, five above our target for the year. Of these, 11 are our own undergraduates, a positive move in effectively making this degree a *de facto* first professional degree and a seamless addition to traditional MIT undergraduate education.

By all measures the M.Eng. program has been very successful. We have started the development of a new track in the area of high performance structures.

All our graduate programs are healthy. The attached figures show the history of enrollments and degrees awarded. Our applicant pool continues to grow and the quality of students is still excellent. We received over 2,414 inquiries and 428 applications.

Department of Civil and Environmental Engineering Enrollment 1990-1996				
Year	Faculty	Undergraduate Students	Graduate Students	Yearly Total
1995-96	39	114	290	404
1994-95	35	120	285	405
1993-94	37	134	301	435
1992-93	37	119	280	399
1991-92	36	113	304	417
1990-91	35	123	272	395

Department of Civil and Environmental Engineering Graduate Degrees 1990-1996					
Year	M.Eng.	Master of Science	Civil Engineer	Ph.D./Sc.D.	Yearly Total
1995-96	21	98	1	22	142
1994-95		93	1	33	127
1993-94		101	1	21	123
1992-93		83	3	23	109
1991-92		80	3	29	112
1990-91		80	3	20	103

FACULTY NOTES

Professors Yossi Sheffi, Moshe Ben-Akiva, Frank Perkins and Herbert Einstein enjoyed sabbatical leaves this year.

Professors Frank Perkins, Robert Logcher, Charles Ladd and Lynn Gelhar have taken advantage of the early retirement plan. Profs. Gelhar and Ladd will nevertheless maintain their research and educational activities.

Senior Administrative Officer Trond Kaalstad has also taken the retirement opportunity. So did Senior Machinist Arthur Rudolph.

Dr. Eric E. Adams served on an advisory committee to the New England Board of Higher Education exploring ways to improve undergraduate environmental education.

Professor Cynthia Barnhart was appointed Associate Editor of *Operations Research* for the practice section. She also co-edited two special issues of *Transportation Science*. Prof. Barnhart was also elected president of INFORM's (professional society) Forum on Women in Operations Research and Management Science.

Professor Moshe Ben-Akiva and his research team, The Intelligent Transportation Systems (ITS) Program, won two major research projects: Development of a Deployable Real-Time Dynamic Traffic Assignment System, sponsored by Oak Ridge National Laboratory, and Traffic Surveillance and Detection Technology Development, sponsored by the Jet Propulsion Laboratory. Prof. Ben-Akiva was elected to a second three-year term as a member of the WCTR Society steering committee and chair of its scientific committee. He won the Effective Teaching Award for the Department.

The first Bacardi and Stockholm Water Foundations Professor is Professor Rafael L. Bras. He has been appointed to the Board of the Stockholm Water Foundation (USA). Professor Bras opened the First International Meeting on Water Problems in Valencia in November 1995. Together with Prof. Daniele Veneziano and others he also began a new collaboration with the Italian National Research Council. He chairs an international panel overseeing the preparation of the Environmental Impact Assessment of the of the flood protection efforts in Venice, Italy.

Professor Oral Buyukozturk delivered the main lecture, "Simulation of Microwave Propagation in Concrete" in the International Symposium on Nondestructive Testing in Civil Engineering held in Berlin, Germany, September 1995.

Professor Ismail Chabini joined the faculty. He won the best thesis award of the Association des Transports et des Routes, Quebec, Canada. During the spring term he developed a subject on Computer Algorithms and Transportation.

Professor Sallie W. Chisholm was elected an AGU Fellow. The award recognizes scientists who have attained acknowledged eminence in a branch of geophysics.

Professor Jerome Connor published a new book, *Introduction to Motion Based Design*, co-authored with Dr. Boutros S.A. Klink ('95).

Professor Culligan-Hensley's developed a new graduate course in geo-environmental engineering entitled Waste Containment and Site Remediation Technology. She was awarded the 1996 Mosey Visiting Fellowship from the University of Western Australia, Perth, Australia.

Professor Richard de Neufville continues as chairman of the Technology Planning and Policy Program and was heavily involved in launching the new interdepartmental doctoral program in Technology Management and Policy.

The 1995 Hunter Rouse ('29 and '32) Hydraulic Engineering Lecture of the ASCE was delivered by Professor Emeritus Peter Eagleson.

Professor Herbert H. Einstein was elected First Vice President at the Eighth International Society for Rock Mechanics, as well as vice president for North America.

Professor Elfatih A.B. Eltahir was awarded the Gilbert Winslow Career Development Chair. He organized a special session in the AGU Fall meeting on land surface processes and climate.

Professor Dara Entekhabi received the American Geophysical Union's Macelwane Award in recognition of significant contributions to the geophysical sciences by a young scientist of outstanding ability.

Professor Lynn W. Gelhar was appointed the William E. Leonhard Professor.

Professor Lorna Gibson is about to publish a second edition of her book *Cellular Solids* with Mike Ashby of Cambridge.

Professor Phillip Gschwend successfully offered a new summer course on Assessing Organic Pollutants in the Environment.

Professor Harry Hemond chaired the Gordon Conference on Hydrology and Geochemistry of Forested Catchments in New London, New Hampshire. He gave the inaugural lecture for the Bacardi and Stockholm Water Foundation Chair.

Professor Eduardo Kausel was Konrad Zuse Guest Professor at the University of Hamburg.

Professor Charles C. Ladd will receive the 1996 Thomas A. Middlebrooks Award from the American Society of Civil Engineers for his co-authored paper, "Reliability Applied to Slope Stability Analysis".

Professor Steven Lerman was appointed to the National Research Council Committee on Information Technology.

Professor Christopher Leung co-chaired a symposium on Smart Structures in the 11th ASCE Engineering Mechanics Conference held in Fort Lauderdale from May 19-22, 1996.

Professor Ole S. Madsen assumed the Chair of the Department's Undergraduate Committee.

Professor David H. Marks is the Coordinator for the MIT/ETH/UT Alliance for Global Sustainability. He leads the MIT multi-disciplinary study "Management of the Future Uses of Chlorine" which had a major workshop in June 1996. He has led the CEE M.Eng. Program this year. He received an Outstanding Service Award from the Department. Professor Marks also co-chairs MIT's Council for the Environment.

Professor Dennis M. McLaughlin began a new collaborative study with ETH to develop sustainable water resources in arid regions. Professor McLaughlin and Professor Steven Lerman are jointly supervising an effort to distribute innovative software for training environmental remediation professionals. He has been promoted to full professor.

Professor Chiang C. Mei was appointed editor of a new book series on *Environmental Fluid Mechanics* and also helped Kluwer Publishers to form an International Editorial Board. He was appointed by the Italian Ministry of Environment to a five member Review Board for the Venice Lagoon Project.

Professor John Miller developed a new course to the construction management curriculum, 1.441 - Public Infrastructure Development Systems.

Professor Fred Moavenzadeh co-chairs MIT's new Council for International Relations. He is pursuing interests in Brazil and Thailand.

Professor Heidi Nepf, together with Professors Hemond and Thilly, explored an opportunity in distance learning aimed at high school students. They developed instructional material, including a case study, used as preparation for the interactive television program "Mutation Causes Disease". Professor Nepf won the CEE Effective Teaching Award.

The American Society of Civil Engineers' Technical Council on Computer Practices 1995 Best Journal Paper Award went to Professors Feniosky Pena-Mora and Robert Logcher, and Dr. Duvvuru Sriram for their paper, "Design Rationale for Computer-Supported Conflict Mitigation", published in 1995 *Journal of Computing in Civil Engineering*.

Professor Daniel Roos co-chairs MIT's new Council on Industrial Relationships.

Professor Sarah Slaughter joined the faculty this year. She received an NSF Careers Grant for her work in Computer-based Simulation of Construction Related Activities.

Professor Joseph Sussman received an Outstanding Service Award from the Department earlier this year, and also received a special certificate from ITS-Massachusetts for his pioneering role in the ITS area and his leadership in founding ITS-Massachusetts.

Professor Andrew Whittle developed new design curricula for undergraduate and graduate geotechnical subjects.

Professor John Williams has been one of the leaders of MIT's Design Studio of the Future that most recently received an award for the most significant application of Teleconferencing Programming and/or Distance Learning from the International Teleconferencing Association.

Professor Nigel Wilson is principal investigator of the collaborative research and education program between MIT and the University of Puerto Rico in support of the Tren Urbano project in San Juan.

Professor Shi-Chang Wooh started a new collaboration with the Korea Highway Corporation.

RESEARCH HIGHLIGHTS

Guided by our Strategic Plan the Department has weathered a difficult year with a small increase in sponsored research activity by faculty and staff. This group is presently responsible for over 12 million dollars of sponsored research.

Our strategy calls for internationalization of our efforts and for the development of larger umbrella projects. We presently have major new efforts in Argentina, Italy and Puerto Rico and hope to soon be involved in Thailand. These involve bilateral or multiparty collaborations and they involve both research and education.

The Intelligent Transportation Systems effort lead by Professor Ben-Akiva is a successful umbrella activity of large magnitude and involving several sponsors. It joins the Aberjona Project that for over five years has involved many faculty and students in logistically studying the natural and manmade environment of an urban watershed.

New opportunities are also opening up for many in CEE under the Alliance for Global Sustainability headed by Professor David H. Marks.

The twist that our new theme will create future opportunities and serve as a unifying research agenda for most of Civil and Environmental Engineering.

DEPARTMENTAL AWARDS AND OTHER SPECIAL RECOGNITION

Jeffrey Chapman '96 received an undergraduate scholarship by the New England Roundtable of the Council of Logistics Management. He also won the 1996 Chi Epsilon scholarship for the New England District.

Daniel Roth '94 (MS, transportation) received the Charley Wootan Award from the Council of University Transportation for his thesis, "Incremental High-Speed Rail in the US: Economic and Institutional Issues". He currently works at Price Waterhouse.

Robert Armstrong, graduate student in the Master of Science in Transportation program, has been awarded a \$2000 scholarship from the George Krambles Transit Scholarship Fund for work related to public transportation.

The Leo '24 and Mary Grossman Award for an outstanding undergraduate in transportation went to Diana M. Dorinson '96.

Winners of the Richard Lee Russel Award for outstanding seniors entering graduate studies in civil and environmental engineering were Eugene Y. Chuang '96, Jane Metzinger '96, Gabriel J. Riopel '96, and Enrique R. Vivoni '96.

Gabriel J. Riopel '96 (1C) received the Steinberg Prize, given to an undergraduate with an excellent academic record and an interest in construction management. He also was selected as the recipient of the Arthur S. Tuttle Memorial National Scholarship Fund.

Xu Jun Eberlein was awarded the second place in the Transportation Science doctoral dissertation prize for her dissertation entitled "Real-Time Control Strategies in Transit Operations: Models and Analysis" which she completed in May 1995. She was a graduate student in DCEE completing her Doctorate in Transportation.

Michael Kashambuzi '97 (1-C) won the \$3,360 General Electric Foundation Grant for a summer UROP.

Edmond Toy ('95, M.S.) won a best thesis award from TPP entitled "Screening for Estrogen-mimicking Chemicals: An Assessment of the E-screen and Its Implications".

The Tucker-Voss Award in Building Construction and Engineering was awarded to James F. Kennedy (G).

Rafael L. Bras

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

The department is almost done phasing in its Master of Engineering (M.Eng.) curriculum. This is a five-year program, leading to the simultaneous awarding of master's and bachelor's degrees. The Master of Engineering degree is being pursued by a majority of the department's undergraduate students. The five-year curriculum is structured, is seamless across the traditional boundary between undergraduate and graduate study, and is seamless between the traditional disciplines of electrical engineering and computer science. This year for the second time the department's Great Educator Award Program was used by Master of Engineering students to support their fifth year of study.

Undergraduate enrollment in the department continues to be large. Enrollment in computer-science subjects continues to rise. Undergraduates perceive exciting career opportunities in the various fields represented by the department.

It is with deep sorrow that we report that after waging a courageous battle against cancer, our Administrative Officer, Richard J. Caloggero, passed away on September 13, 1995. Dick served the Institute as well as the department with extraordinary loyalty, dedication and effectiveness. In his name, his friends at MIT have established a new award to honor department staff who have demonstrated Dick's special characteristics. The first Richard J. Caloggero Memorial Award was presented to Marilyn A. Pierce in May.

The department is pleased to welcome warmly our new Administrative Officer, Susan Gurlanick. Susan comes to us from the Energy Laboratory, where she served as Administrative Officer.

UNDERGRADUATE PROGRAM

Enrollment of undergraduates averaged 900 in 1995-1996 with about 30 percent in the Electrical Engineering program., 40 percent in the Computer Science program, and 30 percent in the Electrical Engineering and Computer Science program. From the Class of 1998, 330 students were enrolled in Course VI, about the same as the preceding year. About 330 students from the Class of 1999 have so far selected Course VI, with only 20 percent choosing 6-1, 45 percent 6-2, and 35 percent 6-3.

The new Master of Engineering (M.Eng.) program entered its third year with 220 students. We expect to have around 250 students in the graduate phase of the program next year, the fourth year of the program.

The following prizes and awards were won by our students:

The Ernst A. Guillemin Thesis Competition for outstanding performance on a Master of Engineering thesis in Electrical Engineering was won by Steve J. Steiner of Cambridge, MA, Jayson D. Strayer of St. Petersburg, FL, and Anant Sahai of Thousand Oaks, CA.

The David Adler Memorial Thesis Prize of outstanding performance on an Undergraduate Thesis in Electrical Engineering was presented to Naimish S. Patel of North Andover, MA.

The Charles and Jennifer Johnson Thesis Prize for outstanding performance on Master of Engineering thesis in computer science were awarded to Daniel K. Hartman of Fond du Lac, WI, and Matthew N. Condell of Argyle, NY.

The Morris Joseph Levin Award for Best MasterWorks Oral Theses Presentations were awarded to Raymond C. Chan of Cambridge, MA, James T. Kao of Playa del Rey, CA, Mohammad J. Khan of Carmel, IN, Edward C.F. Lovelace of Somerville, MA, Thomas E. Murphy of Falls Church, VA, and Su W. Teoh of El Toro, CA.

The William A. Martin Memorial Thesis Prize for outstanding performance on a Master of Engineering thesis in computer science was presented to Russell S. Schwartz of Old Greenwich, CT.

The George C. Newton Prize for the best undergraduate laboratory project as awarded jointly to Amit G. Bagchi of Potomac, MD, Christopher A. Fuchs of Fairfield, NJ and Tan T. Trinh of Lafayette, LA.

The Robert A. Fano UROP Award was given to Daniel L. Rosenband of Cambridge, MA.

The Northern Telecom/BNR Project Awards were made to Steven E. Czerwinski of New Lenox, IL, Stephen J. Schlueter of Olympia, WA, Hsiang C. Chuu of Bayville, NY, Charles J. Cavazos of El Paso, TX, Susan M. Dacy of Hudson, FL and Alice Wang of Melville, NY.

The David A. Chanen Writing Award was given to Debajit Ghosh of Exton, PA.

GRADUATE PROGRAM

In September, 1995 there were 800 graduate students enrolled in the department. About 20 percent of the total were foreign nationals. The department supported 380 Research Assistants and 100 Teaching Assistants. In addition, there were 177 fellowships including 55 National Science Foundation Fellows, 5 Hertz Fellows and 16 Office of Naval Research Fellows. The remaining students had industrial or foreign support or were using their own funds.

During 1995, the department awarded 171 Master of Science degrees, 14 Electrical Engineer degrees and 74 Doctoral degrees.

The department received 1782 applications for the 1995-96 year, a slight decrease from 1994. The applications continue to be generally excellent and 255 were admitted for 1995 (February, June and September), of whom 133 registered in September.

A number of awards were made to graduate students for excellence in teaching. Matthew J. Secor of Cambridge, MA, received the Carlton E. Tucker Award and Cynara C. Wu of Cambridge, MA, received the Harold L. Hazen Award. The Frederick C. Hennie III Awards for excellence in teaching were presented to Brian M. Perreault of Cambridge, MA, Patrick J. LoPresti of Watertown, MA, and Holly A. Yanco of Somerville, MA. Babak Ayazifar of Cambridge, MA, was promoted to Instructor-G in recognition of his demonstrated teaching ability and service to the department.

VI-A INTERNSHIP PROGRAM

In its 79th year, the department's VI-A Internship Program continued its popularity and excellent performance. This year 161 students applied during the annual orientation and selection process and 80 of the applicants were selected as members of the incoming VI-A class. These numbers were comparable to 1994 in which 150 students applied and 84 were selected. Because opportunities within the M.Eng. program are often as attractive as those for completing the VI-A Program with thesis research at the company, about 15 seniors have left the VI-A Program. However, with about 54 VI-A M.Eng. students graduating in June, 1996, the VI-A Program continues to provide an excellent educational program for those who complete it. In addition, about 106 VI-A seniors received their Bachelor's degrees.

A VI-A Fellowship Program initiated by Prof. Markus Zahn in 1995, which offers support for the term away to the VI-A graduate student on work assignment, is working out very well with all new companies and many of the existing ones participating. The Fellowship pays one term MIT tuition, a monthly stipend that is comparable to those available to on-campus assistantship and fellowship recipients, and medical insurance. Of the approximately 24 current VI-A companies, 8 offer their own VI-A graduate students support, 13 have joined the VI-A Fellowship Program, and 3 companies do not offer any VI-A graduate student support.

American International Group in New York, NY and SQA, Inc., in Burlington, MA, are two new companies which joined the VI-A Program in time for the 1996 orientation and selection process. Delco Electronics, Hewlett-Packard Labs., Intel Corp., Schlumberger, and Tektronix did not participate this year. In spite of this factor, many new companies have indicated an interest to participate, so we hope to keep the program size constant.

At the annual Department Awards Reception held in the West Wing of the Museum of Science in Boston, the following VI-A students were honored. Steven E. Szerwinski, Susan M. Dacy, and Alice Wang received the

Northern Telecom/BNR Project Award; Amit G. Bagchi and Christopher A. Fuchs received the George C. Newton Undergraduate Laboratory Prize; Debajit Ghosh received the David A. Chanen Writing Award; Naimish S. Patel received the David Adler Memorial Thesis Prize, and Steven J. Steiner was one of the recipients of the Ernst A. Guillemin Thesis Award.

At the 1996 Awards Convocation N. Katherine Merrilees was the recipient of the Betsy Schumacker Award and John L. Wallberg received the Howard W. Johnson Award.

Two VI-A students were recognized for their writing accomplishments. Lawrence K. Chang was awarded First Place in the drama category of the Boit Manuscript and Debajit Ghosh was awarded First Place for his Phase II paper entitled, "IHTFP: An Improved Hypertext Filing Proxy."

There were two VI-A students amongst the 31 sophomores and juniors selected as Burchard Scholars in the School of Humanities and Social Science in 1996. The awards are given to students who demonstrate unusual abilities and academic excellence in the areas embraced by the Institute. Our students so duly honored were Lawrence K. Chang and Grant Y. Smith.

Michelle Y. Eng received a Women in Science and Engineering Scholarship from Intel Corporation.

Mehul A. Shah was the recipient of the Henry Ford II Scholar Award in recognition of his academic record and potential for leadership in the engineering profession and in society.

Ben Y. Reis was one of the winners of a Marshall Scholarship which covers all expenses for two years of study and can be extended for a third year. He plans to pursue studies in computer science, cognitive science, and music at Cambridge, England.

Excellence in scholarship continues amongst the students in the program. Of the 100 students from the School of Engineering elected to Tau Beta Pi, the National Engineering Honorary, 22 were VI-As and Eta Kappa Nu, the Course VI Honorary, elected 64 members of whom 27 were VI-As. From 46 seniors and 4 juniors elected to MIT's XI Chapter of Phi Beta Kappa, 3 were VI-A students: Marlon E.D.R. Abayan, Mehul A. Shah, and Mario A.M. Yearwood.

FACULTY

Three new members of the faculty joined the department this year:

Dennis M. Freeman, Assistant Professor of Electrical Engineering, was a Research Scientist in the Research Laboratory of Electronics.

Amos Lapidoth, Assistant Professor of Electrical Engineering, received his Ph.D. at Stanford University.

Paul A. Viola, Assistant Professor of Computer Science and Engineering, received his Ph.D. at MIT and came to the department following a research position at the Salk Institute for Biological Research.

Associate Professor William J. Dally was promoted to Professor. Assistant Professors M. Frans Kaashoek (who was also named Jamieson Career Development Associate Professor) and Gregory W. Wornell were promoted to Associate Professor.

Honors and awards received by our faculty this year include:

Professor Harold Abelson received the IEEE Taylor L. Booth Education Award, in recognition of his contributions to the teaching of introductory computer science.

Associate Professor James E. Chung received the Institute's Frank E. Perkins Award, which honors excellence as an advisor and mentor to graduate students.

Institute Professor Mildred S. Dresselhaus was elected President of the American Association for the Advancement of Science.

Professor James G. Fujimoto received an IEEE Fellow Award for pioneering contributions to ultrafast optics and to optical coherence tomography.

Professor Shafrira Goldwasser was named a Phi Beta Kappa Visiting Scholar.

Institute Professor Hermann A. Haus received the National Medal of Science, awarded by President Clinton in a White House ceremony.

Professor Richard C. Larson was named Director of the Center for Advanced Educational Services, formerly the Center for Advanced Engineering Study.

Professor Hae-Seung Lee received an IEEE Fellow Award for contributions to CMOS high accuracy data converters.

Professor Barbara H. Liskov was elected a Fellow of the ACM.

Professor Alan V. Oppenheim received the Institute's Bose Award for Excellence in Teaching.

Professor Gerald J. Sussman was elected a Fellow of the American Academy of Arts and Sciences.

Several members of the faculty were away for all or part of the year:

Professor Harold Abelson spent time researching the role of the network in education.

Associate Professor Anant Agarwal helped to provide a smooth transfer of his company to a new CEO. Professor Michael Athans completed the manuscript for his textbook on multivariable control systems.

Professor William J. Dally spent time doing research and teaching at the University of North Carolina.

Associate Professor Jesus A. del Alamo worked on writing a textbook on integrated microelectronic devices.

Professor James G. Fujimoto worked on new research opportunities related to pulse generation in solid state lasers.

Professor David K. Gifford worked at Open Market, Inc., a company he founded to produce software solutions for Internet based electronic commerce.

Professor Charles E. Leiserson worked on new research in computer languages and began work on a new book.

Professor Jae Lim participated in the Grand Alliance activities and the FCC HDTV standardization process, and also updated his book.

Professor Roger G. Mark pursued new research in bioengineering.

Professor Sanjoy K. Mitter pursued research on learning, adaptation and architectures that support adaptive behavior.

Associate Professor Martin A. Schmidt spent time learning more about the medical and biological applications of microfabricated structures and the modeling tools being developed for such devices.

Associate Professor William E. Weihl worked on research at Digital Equipment Corp. in Palo Alto, CA.

Professor Alan S. Willsky pursued research in remote sensing and computer vision, and also worked on a new textbook.

Professor John L. Wyatt, Jr. finished a textbook and pursued research on thermal noise models for nonlinear elements and on neural network problems.

The department hosted five visiting faculty:

Associate Professor Meir Feder, from Tel Aviv University, worked with Professor Robert G. Gallager and also taught 6.341 Discrete-Time Signal Processing.

Professor James Modestino, from Rensselaer Polytechnic Institute, taught sections of 6.003 and worked on research with Professor Robert G. Gallager.

Assistant Professor Ronitt Rubinfeld, from Cornell University, taught a special graduate subject, Randomness and Computation, and worked on research with Professor Shafira Goldwasser.

Assistant Professor Nir Shavit, from Tel Aviv University, taught a special graduate subject, Multiprocessor Synchronization, and worked on research with Professor Nancy A. Lynch.

Professors Jerome H. Saltzer and William M. Siebert retired from the faculty this year.

Paul Penfield, Jr.

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

This past year has been an excellent one for the Department of Materials Science and Engineering. We were pleased to once again be ranked first in both undergraduate education and graduate education among the Departments of Materials Science and Engineering by *U.S. News and World Report*. In addition, the National Research Council issued its first ranking in more than a decade of the top graduate programs in the United States. We were ranked first in both quality of faculty and in effectiveness in educating graduate students. DMSE was the only department at MIT to receive first place ranking in each of these four polls. However, our challenge is to continue to improve and to become even stronger in the future.

In spite of the more difficult research funding climate, the research volume of the department has grown over 10% during the past year, and the number of graduate students has increased to 182. The undergraduate student population remains nearly constant at 121. In June we awarded 35 bachelors degrees, 20 masters and 14 doctorates. Our program of offering fellowships to a large percentage of domestic applicants continues to provide us with an outstanding graduate student body; 69% of our entering graduate student class in September 1995 were domestic.

The Graduate Program has evolved to a single General Examination for the department, rather than the six degree program examinations that we had previously. In addition, the faculty voted to increase the number of core graduate subjects from two to four. These will include subjects on "Materials at Equilibrium," "Kinetics," "Mechanics," and "Electrical, Optical and Magnetic Properties of Materials." Some of these new and revised subjects will be offered for the first time during the 1996-1997 academic year.

During the past year the department has assumed responsibility for the Archaeological Science Program at MIT. This program, which is home to two faculty, Professors Heather Lechtman and Dorothy Hosler, builds on the strong materials emphasis that was brought by Professor Cyril Stanley Smith '26 ML. This program has begun to flourish in the department with well over 100 students taking subjects in archaeology. We believe that this interface between archaeology and materials science is one of the strongest such programs in the world, and we hope that it will grow and prosper in its new home.

We are pleased that Professor Lorna Gibson of the Department of Civil and Environmental Engineering has elected to join our faculty ranks during the coming year.

It is with regret that I note that Professor Julian Szekely passed away in December of 1995 after an extended illness. Julian was responsible for bringing the concepts of heat and fluid flow to a central focus in the field of materials engineering. His leadership, enthusiasm and insights will be missed greatly.

Under the Institute's retirement incentive program a number of individuals have chosen to retire at the end of this academic year. Professor Robert W. Balluffi '47 ML, and Professor Keith H. Johnson have retired, but Bob will continue to maintain an office in the department and interact with many of us. In addition to the loss of these faculty, Joseph M. Dhosi '59 ML, our most capable and valued Senior Administrative Officer for the past twenty years; Patricia Gavagan, who has staffed the Undergraduate and Graduate Offices for more than thirty years; Guenter Arndt, who has been a Technical Staff Member for more than forty years; and Jean DiMauro, who has been on the Support Staff for more than forty years, have each elected to retire.

In the fall of 1995 we were pleased to host the Johns Hopkins University Center for Talented Youth Program for a Materials Science and Engineering Day. Over 250 eighth- and ninth-grade students and their parents visited MIT and attended presentations by faculty members where they were introduced to the science and technology of modern materials. In the spring of 1995 the department hosted the fourth Harry C. Gatos Distinguished Lecture which was delivered by Dr. Craig R. Barrett of Intel Corporation. His presentation was titled, "Technology Futures for the IC Industry."

Our faculty members continue to occupy a number of important leadership positions at MIT. Professor Vander Sande is Associate Dean of Engineering, and between the period June, 1995 and January, 1996 was Acting Dean of Engineering. Professor Kimerling serves as Director of the Materials Processing Center, Professor Thomas serves as Associate Department Head, Professor Rose continues as Director of the Concourse Program, Professor Rubner serves as Director of PPST (Program in Polymer Science and Technology), Professor Allen serves as Secretary of the MIT Faculty, Professor Latanision continues as Chairman of the MIT Council on Primary and Secondary Education, and Professor Lechtman is Director of the Center for Materials Research in Archaeology and Ethnology.

UNDERGRADUATE EDUCATION

Our undergraduate enrollment remains at historically high levels. Essential to maintaining our undergraduate body are extensive recruiting efforts including a three day Open House, our annual John Wulff Lecture, direct mailings to the freshman class, Freshman Advisor Seminars, and IAP Activities. Our III-B Internship Program continues to attract the majority of the undergraduate students in our department. Through this program we have strengthened our interactions with 35 companies and government laboratories while providing summer experiences for our undergraduates which are relevant to their educational development. Placement of students during the summer of 1996 was difficult, but nearly all eventually found suitable positions. Our undergraduate body currently comprises 51% women, 12% underrepresented minorities, and 3% foreign students.

Professor David C. Dunand has been instrumental in organizing the Materials Undergraduate Study Exchange Program (MUSE), and in signing agreements to establish the undergraduate exchange program with KTH Stockholm, ETH Zurich and the Ecole Nationale Supérieure des Mines de Paris. We hope to send the first students abroad under this program during the coming year.

Our undergraduate textbook initiative continues to progress after the publication of the first two volumes of *Thermodynamics* by David V. Ragone last year. A third text, *Physical Ceramics*, by Professor Yet-Ming Chiang with co-authors Professors Dunbar P. Birnie III and W. David Kingery of the University of Arizona was published in the spring of 1996. A fourth text has been sent for review.

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, assisted in the organization of the UROP Open House, sponsored seminars by departmental faculty members, planned socials, and assisted in tutoring of fellow students. Officers of the society during the fall semester were: Benjamin Hellweg (President), David L. Ngau (Vice President), William P. Chernicoff (Secretary), and Nancy K. Enright (Treasurer). New officers elected in spring 1996 are: William P. Chernicoff (President), Mary E. Hamilton (Vice President), Kim Marie Levis (Treasurer), and Neil T. Jenkins (Secretary).

GRADUATE EDUCATION

Approximately 22% of our graduate students are women and 2.5% are underrepresented minorities. The distribution of students among our six graduate degree programs and their affiliates is little changed from last year. As of February 1996 it was:

Degree Program	Percent of Total Graduate Students
Ceramics	14%
Electronic Materials	24%
Materials Engineering	25%
Materials Science	9%
Metallurgy	11%
Polymers	17%

Three of our students in Materials Engineering were enrolled in the Technology and Policy Program, and two were enrolled in the Leaders for Manufacturing Program. Sixteen of our Polymer students were enrolled in the Program for Polymer Science and Technology. We anticipate for the fall 1996 a total graduate class of about 180. The program we adopted five 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 46 for the coming fall, over 68% percent 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. Chin 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 Julian Szekely Fellowship, and the Department Endowed Fellowship).

Our endowed fellowships now provide sufficient annual income for one-term fellowships for approximately 9 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 up to four fellowships each year for a three year period, as well as a fellowship from the Lord Foundation of Massachusetts. These have been instrumental in assisting us to maintain the size and quality of our incoming

domestic student class. 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. Most recently we have received a fellowship from George N. Butzow, '51 GE, the founder of MTS Corporation. Of the 27 domestic students expected to enter in the fall of 1996, 13 will be entering on fellowships from the department and from a variety of sources including; NSF, DOE, DOD, LFM, NASA, ONR, and the Air Force.

Officers of the Graduate Materials Society (GMC) during academic year 1995-1996 were: Jeffrey Nystrom (President), Shuba Balasubramanian (Vice President), Valarie Benezra (Treasurer), Ben Tao (Secretary), Douglas Blom and Tracey Burr (DCGS Representatives), G. Kris Schwenke (GSC Representative), James Foresi (Social Chair), Kevin Eberman (Athletic Chair), and Harold Ackler and Tracey Burr (MESSEminars). GMC continued its seminars, monthly socials and end-of-the-year barbecue. The group continued to undertake the supervision of the arduous but important task of course evaluations. The GMC voted to revise its officer organization during academic year 1996-1997 by forming a Core Committee with Erika Abbas as Chair. GMC Core Committee members are: Vanessa Chan, T.A. Venkatesh and Phil Soo. Other newly elected officers are: Valarie Benezra (Treasurer), Srikanth Samavedam and T.A. Venkatesh (MESSEminar Co-Chairs), Nicole Lazo (DCGS Representative), Olivera Kesler (GSC Representative), Kevin Eberman (Social Chair), and Ram Ratnagiri (Athletic Chair).

Officers of the MIT Student Chapter of the Materials Research Society during the academic year 1995-1996 were: T.A. Venkatesh (Chair), and Valarie Benezra (Treasurer). Newly elected officers for academic year 1996-1997 are: T.A. Venkatesh (Chair), Valarie Benezra (Treasurer), and Kevin Chen, Christine Hau, and Michael Whitney (Special Projects Committee). The chapter has been working towards expanding its membership to include materials science students affiliated with other schools in the Greater Boston area, and has also undertaken a special project to check the feasibility, and subsequently initiate the formation of, a New England Chapter of MRS, to be based in Boston. The chapter arranged information sessions, seminars and special lectures dealing with issues of topical interest in materials science.

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 societies 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 1995-1996 were: Andrew Gouldstone and Lori Maiorino (Co-Chairmen), Valarie Benezra (Treasurer), and Melody Kuroda (Secretary). The Chairpersons of the three student chapters during the academic year 1995-1996 were: T.A. Venkatesh (MRS), Laura Giovani (ASM/TMS), and Sara Ransom and Amy Hsio, (Co-Chairs, ACerS). The 1996-1997 officers of aMaSS and the three student chapters will be elected in the fall.

FACULTY NOTES

Faculty members of this department now occupy 14 endowed chairs. The chairholders are: Yet-Ming Chiang, Kyocera Professor of Ceramics; David C. Dunand, AMAX Associate Professor of Materials Engineering; Thomas W. Eagar, POSCO Professor of Materials 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; Anne M. Mayes, Class of '48 Assistant Professor of Polymer Physics; Uday B. Pal, John Chipman Associate 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. Tuller, Sumitomo Electric Industries Professor of Engineering; John B. Vander Sande, Cecil and Ida Green Distinguished Professor; and 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 careers. Faculty from this department currently occupy one such chair; Michael J. Cima, Norton Professor of Ceramics Processing, although The Lord Foundation of Massachusetts has agreed to provide one additional junior term chair for the coming year.

Professor Samuel M. Allen will serve as Vice Chairman of the 1996 Gordon Research Conference on Physical Metallurgy. During this academic year, Professor Gerbrand Ceder was awarded the 1996 Robert Lansing Hardy Award from the TMS. This award is given to a person under 30 years of age who shows exceptional promise for a successful career. Both Professors Joel P. Clark and Donald R. Sadoway were made AT&T Fellows. Professor Emeritus Morris Cohen received the *Acta Metallurgica* J. Herbert Hollomon Award in recognition of his leadership in guiding U.S. national materials policy and the evolution of the multidiscipline of materials science and engineering, as well as his teaching and research contributions.

Professor Thomas W. Eagar was the 1995-1996 Taylor Lecturer at Pennsylvania State University. Professor Lorna Gibson completed a second edition of her book, *Cellular Solids: Structure and Properties*, co-authored with Professor M. F. Ashby of Cambridge University, and was invited to speak at the Frontiers of Engineering meeting sponsored by the National Academy of Engineering. Professor Nicholas J. Grant's membership in TMS was upgraded to Legion of Honor member Grade L, in recognition of his 50 years of membership.

Professor Linn W. Hobbs received the Best Invited Paper Award at the Eighth International Conference on Radiation Effects in Insulators, Catania, Sicily. Professor Klavs Jensen received the Charles M. A. Stine Award of the Materials Engineering and Sciences Division of the American Institute of Chemical Engineers, was AT&T Distinguished Lecturer at the University of Wisconsin, and received the Best Paper Award at the 2nd International Conference on Rapid Thermal Processing.

Professor Lionel C. Kimerling was one of the first two recipients of the MIT Frank E. Perkins Award which is presented for excellence in advising and mentoring of graduate students. In addition, he received the 1995 Electronics Division Award of the Electrochemical Society for his seminal contributions to the understanding of defects in semiconductors and for his leadership in the field of electronic materials, and was awarded a Department of Energy Research Excellence Award. Dr. Robert A. Laudise received the TMS Applications to Practice Award, and the 1995 Nolt Medal from Union College, Schenectady, NY. Professor Heather N. Lechtman was invited by Trinity University to present its Distinguished Scientist Lecture in March 1997.

Dr. James N. Livingston published his book *Driving Force, The Natural Magic of Magnets*, which was inspired by a freshman seminar on "The Magic of Magnets" which he has lead for many years. His goals for writing the book included increasing the public's appreciation of science, particularly "magic magnets," and increasing public recognition of the field of materials science, a discipline that "most freshmen who arrive at MIT have still never heard of." His book has been chosen by the Natural Science Book Club.

Professor Andreas Mortensen was the recipient of the Bourse de Haut Niveau from the French Ministry of Research and Education, for partial support of a sabbatical year at the Ecole des mines de Paris. Dr. Robert C. O'Handley was invited to give two prestigious talks. One was at the conference title, CM³ in Philadelphia, PA, and the other was at the APS Meeting in St. Louis, MO. Professor Uday B. Pal received an ALCOA Foundation Science Support Award. Dr. David I. Paul was chosen as House Fellow to MIT Burton House undergraduate dormitory.

Professor Regis M. N. Pelloux was elected an Honorary Fellow and Life Member of the International Fatigue Congress Series. This honor is in recognition of Professor Pelloux's significant contributions to the understanding of fatigue crack growth mechanisms in metals. Professor Pelloux was formally recognized at the International Fatigue Congress, "Fatigue '96," held in Berlin, Germany.

Professor David V. Ragone's textbook titled, *Thermodynamics of Materials*, was recognized by *Choice Magazine* as one of the Outstanding Academic Books for 1995. Professor Robert M. Rose was appointed Adjunct Professor of Biomechanics in the Department of Surgery, Tufts University School of Veterinary Medicine. Professor Michael F. Rubner was made 1996 MacVicar Fellow for Outstanding Teaching at MIT. Professor Kenneth C. Russell continued as the National President of Alpha Sigma Mu, the Materials Science and Engineering Honorary Fraternity, and assisted in establishing the Massachusetts Alpha chapter.

Both Professor Gerbrand Ceder and Professor Chris Scott received a Faculty Early Career Development (CAREER) Program Award. This is a National Science Foundation award for support of junior faculty within the context of overall career development and combines in a single program the support of quality research and education.

Professor Subra Suresh received several highly distinguished honors during academic year 1995-1996. He was the Shell Distinguished Lecturer in the Department of Materials Science and Engineering at Northwestern University, and the 1996 ASM Sauveur Lecturer. He was elected Fellow of both the American Ceramic Society and of the American Society of Mechanical Engineers. He was invited to be a Midwest Mechanics Lecturer (one of only two selected in the international community by four midwestern universities). In addition, he was invited to deliver the closing Plenary Lecture at the "Fatigue '96" Meeting, and elected Honorary Member of the Materials Research Society of India. Lastly, Professor Suresh was awarded the Swedish National Chair in Engineering by the Swedish Research Council for Engineering Sciences (TFR). He is one of six international scholars from among all branches of engineering and basic sciences to be elected to this National Endowed Visiting Chair 1996-1998. The Swedish National Chair is intended to "bring renowned international scientists to Sweden to work with Swedish colleagues in different areas of engineering sciences."

Professor Edwin L. Thomas received a NSF Creativity Extension Award. Professor Harry L. Tuller was appointed founding Editor-in-Chief of the Journal of Electroceramics published by Kluwer Academic publishers. Professor Ioannis Yannas was awarded the honorable title, "Fellow, Biomaterials Science and Engineering" from the Society for Biomaterials at the Fifth International Biomaterials Congress in Toronto, Canada.

RESEARCH HIGHLIGHTS

During the past year Professor Samuel M. Allen has scaled up his processing for making hardenable injection molding tools by three-dimensional printing (3DP), such that now the largest parts he has made exceed 8 kg. He has also developed a thermodynamic database for use in alloy design of copper-base alloys that undergo spinodal age-hardening reactions, for possible use as infiltrants of 3DP tool materials. Professor Robert W. Balluffi published a major new text titled *Interfaces in Crystalline Materials* with A. P. Sutton of Oxford University. His research on the structure and electrical properties of grain boundaries of ZnO continue. This work is leading to increased understanding of the operation of varistors. Professor Gerd Ceder has done groundbreaking research in the modeling of multicomponent oxide systems. Professor Yet-Ming Chiang has begun new research programs on lithium-ion battery electrodes collaborating with Professors Ceder, Mayes and Sadoway. Professor Michael Cima's research revealed a mechanism by which single crystal-like films formed from ion-beam assisted deposition on amorphous components with computer controlled composition gradients by 3DP, made a major advance in processing for bulk coating of granular material which provided new basic understanding for bulk coating, and developed an extremely sensitive technique to characterize corrosion of aluminum nitride electronic packages. Professor Joel Clark has established a major research program in life cycle analysis of automotive materials and products. Professor David Dunand was promoted to Associate Professor, and has recently received a patent on his studies of transformation superplasticity in composite materials. Professor Eugene Fitzgerald's work on relaxed GeSi layers shows promise for achieving inexpensive optoelectronic components using silicon-based technology.

Professor Merton Flemings has returned to full time teaching, with research in the areas of semi-solid forming, materials recycling and advanced sensing of materials processes. He spent the spring semester of 1996 at Ecole des Mines de Paris. Dr. John Haggerty has developed a novel electronic packaging system for high-powered applications based on reaction bonded silicon nitride and reaction bonded silicon carbide. Professor Lorna Gibson's research on the effect of osteoporosis on the mechanical strength of trabecular bone has indicated that the way in which the bone is lost has a significant impact on the residual strength of the bone. In addition to his work on high temperature oxidation, Professor Linn Hobbs has started a new initiative in biomaterials using the surface oxides of metals as templates for growth of biological ceramics. Professor Lionel Kimerling's study of silicon optoelectronics is the first comprehensive investigation of a silicon compatible optical interconnection technology. Professor Kirk Kolenbrander, working in collaboration with Professor Ceder, has developed the first determinations of a "critical radius" of a coherently supported quantum dot in a lattice mismatched crystalline host. His work on surface passivation of semi-conductor nanocrystallites is establishing a new understanding of the photoluminescence characteristics of these materials. Professor Ronald Latanision is working on photoelectric chemical techniques to study the passive films formed on iron and titanium. This work should lead to the development of better corrosion resistant alloys. Professor Heather Lechtman received a field research grant from the American Philosophical Society for support of her work in Bolivia and Chile during the summer of 1996.

Professor Anne Mayes has developed a new method for preparing stable hydrophilic surfaces on acrylic polymers that is inexpensive and easily adapted to commercial-scale processing. These materials demonstrate excellent resistance to protein adsorption and may be useful for intraocular lenses, among other applications. Professor Frederick McGarry has found a rational way to increase the fracture toughness and fracture energy of rigid silicone resins, without impairing their resistance to heat and/or fire. This will enable their use in structural composites and adhesives-application hitherto not feasible, because of their extreme brittleness. Professor Andreas Mortensen continues his work in reactive infiltration processing, solidification of metal matrix composites, and in-situ plasticity of metals. Dr. Robert O'Handley is developing a novel magneto resistance device using shape memory alloys. This material should have outstanding applications in sensors and transducers. Working with Reading Tube Corporation, Professor Uday Pal is developing a commercial scale method of electrolytic deoxidation of copper. This is a very novel approach and has the potential to improve the quality and reduce the cost of a wide range of copper products.

Professor David Paul has developed theoretical analyses of the magnetization distribution within magnetic thin films. This work is of increasing concern as storage devices used thinner and thinner films. Professor Regis Pelloux has completed a study on the micromechanics of corrosion fatigue crack initiation in aluminum-lithium alloys. Professor Robert Rose has developed an in vivo oxidative degradation model for ultra-high molecular weight polyethylene. Professor David Roylance has completed a text on *Mechanics of Materials*. Professor Michael Rubner has developed light-emitting thin film polymers which may have a number of exciting applications including flat

panel displays. Professor Kenneth Russell has developed theoretical models of nucleation processes which occur in vapor deposited thin films. In addition to a major revision of the freshman elective, 3.091, Introduction to Solid State Chemistry, Professor Donald Sadoway is studying the electrochemical production of tantalum powders.

Professor Chris Scott's research involves study of the compounding of polymer blends. His laboratory has developed the first numerical simulation of phase inversion during compounding. Professor Subra Suresh has developed new theories and computational models for studying the mechanics of multi-layer films which have a wide-range of applications. Professor Edwin Thomas is continuing his outstanding work on understanding the internal surface structures of complex block co-polymers. Professor Harry Tuller's research group has continued its work on developing compatible electrodes/solid electrolyte systems for high temperature fuel cells, and was recently awarded a patent on this technology. Professor August Witt has developed a method of interface stabilization during crystal growth in the vertical Bridgman configuration using multiple sensors. Professor Bernhardt Wuensch has continued reliable measurements of grain-boundary diffusion coefficients in high purity oxide bicrystals of known orientation. Associate Dean John B. Vander Sande has been using high resolution transmission electron microscopy to quantify the structure of soots. This technique, which he calls "soot prints," is being used for soot particulate source assignment. In time he expects to generate a soot encyclopedia, and in this regard he has made excellent progress on the characterization of diesel soots and particulates generated from coal combustion processes.

DEPARTMENTAL AWARDS

Patricia E. Gavagan, Administrative Assistant in the Undergraduate and Graduate Academic Office received the James N. Murphy Award. The award is presented to an employee whose spirited contributions to the Institute family have won a place in the hearts of students. Dr. K. C. Chou, Research Associate in Professor Pal's group was elected to the Chinese Academy of Science.

The initiates during the 1995-1996 academic year for the Massachusetts Beta Chapter of Tau Beta Pi Engineering Honor Society were: Martin J. Gilkes, Marnie L. Harker, Benjamin Hellweg, Neil T. Jenkins, Jiang-Ti Kong, Preston P. Li, Angela Y. Lin, and Sara L. Ransom.

Eight seniors were accepted as associate members in the Society of Sigma Xi, The Scientific Research Society of North America: Danielle R. Chamberlin, Albert Li-Yuan Hsu, Paul J. Kang, Christian Lund, John S. McCloy, Kathleen A. Morse, Luiz A. Ortiz, and Surekha Vajjhala.

Carmen R. Berg and Preston P. Li were awarded ASM International Undergraduate Scholarships. Martin J. Gilkes and Justin L. Sanchez were awarded National Science Foundation Incentives for Excellence Scholarship Prizes. Andrew Gouldstone and Danielle Russell won the 1996 DMSE Best Senior Thesis Awards. Janelle Gunther Greer won the 1996 Wulff Award. Benjamin Hellwig '97 was named an NCAA Division III Coaches Academic All-American for wrestling. Erin B. Lavik won the 1995 DMSE Best Senior Thesis Award. The Best Co-Op Report Award went to Christian Lund. Sara L. Ransom was awarded a Society for Women Engineers (SWE) Scholarship.

Six graduate students were accepted as associate members of the Society of Sigma Xi: Kenneth C. Arndt, Shuba Balasubramanian, Denise M. Foss, Jason E. Grau, Linda K. Molnar and Anthony Nichtawitz. Three graduate students were accepted as full members: Harold D. Ackler, John T.-T. Chen, and Gerd Norga.

John Chen won an MRS Graduate Student Award for excellence in graduate materials science and engineering research. Patrick Tepsch received a graduate student award from the Materials Research Society, and received the DMSE Teaching Award. David Walton was invited to participate in the Japanese Association of Mathematical Sciences Japan-U.S. Seminar to take place during the summer of 1996. Harold Ackler won First Prize at the American Ceramic Society New England Section Student Poster Contest and Erin B. Lavik won Second Prize. Gerd Norga won the Best Student Paper Award of the Journal of Electronic Materials for his paper "Metal Adsorption on Silicon Surfaces from Wet Wafer Cleaning Solutions." Sridhar Seetharaman won the 1995 Best Graduate Student Award in Materials Technology, Royal Institute of Technology, Stockholm, Sweden.

Fellowship Awards for one or more semesters were held during academic year 1995-1996 by 54 students: Axel Van De Walle, American Chemical Society Fellowship; Laura M. Giovane, DOD Fellowship; Ittipon Diewwanit, H. F. Taylor Fellowship; John W. Lum, H. F. Taylor Fellowship; Arvind Sundarajan, H. F. Taylor Fellowship; Jeffrey D. Nystrom, Kurtz Fellowship; Robert W. Hyers, NASA Fellowship; Brian J. Gally, NDSEG Fellowship; Andrew Kim, NDSEG/SCEEE Fellowship; Erika D. Abbas, ONR/SCEEE Fellowship; Valarie I. Benezra, ONR/SCEEE Fellowship; Kevin W. Eberman, ONR/SCEEE Fellowship; Samuel A. Newell, ONR/SCEEE Fellowship; Alice M. Man, ONR/SCEEE Fellowship; Yot Boontongkong, PPST Fellowship; Naomi A. Fried, Rasmussen Foundation Fellowship; Akihiko, Suwa, Rocca Fellowship; Ramabhadra, Ratnagiri, SIDOR Fellowship; Anton F. Van Der Ven,

SIDOR Fellowship; Christian Lund, SIDOR Fellowship; Catherine M. Bambenek, Starr Fellowship; Kevin M. Chen, Starr Fellowship; Matthew T. Currie, Starr Fellowship; Anand J. Reddy, Starr Fellowship; Todd S. Stefanik, Starr Fellowship; Charles W. Rowe, 3M Fellowship; David G. Walton, Petroleum Research Fund Fellowship; Morgan J. Slade, Carl Loeb Fellowship; Nicole Lazo, MPMI Fellowship; Adam Powell, AT&T CRFP Program Fellowship; Isako Hoshino, AT&T GRPW Program Fellowship; Michael Morse, AT&T Ph.D. School Program Fellowship; Eric Werwa, AT&T Ph.D. School Program Fellowship; James E. Neely, DOE Integrated Manufacturing Fellowship; Jeffrey D. Nystrom, DOE Integrated Manufacturing Fellowship; Stephen C. Britten, NDSEG Fellowship; Tracey A. Burr, NDSEG Fellowship; Edison C. Chu, NDSEG Fellowship; Jason A. Gratt, NDSEG Fellowship; Olivera E. Kesler, NDSEG Fellowship; Michael J. Fasolka, NSF Fellowship; Darrell J. Irvine, NSF Fellowship; Erin B. Lavik, NSF Fellowship; Randy J. Logan, NSF Fellowship; Sanjeev Makan, NSF Fellowship; Vanessa Z.-H. Chan, NSF Fellowship; Benita J. Dair, NSF Fellowship; Michael F. Durstock, NSF Fellowship; Michael F. Durstock, NSF Fellowship; R. E. Kirchain, Jr., NSF Fellowship; Aimee L. Smith, Ida M. Green Fellowship; Anil Jain, Cambridge Technology Center Fellowship; Lan Hoang, EIP Graduate Fellowship; Elicia M. Maine, International Motor Vehicle Program Fellowship; Anna M. Lokka International Motor Vehicle Program Fellowship.

CLOSING REMARKS

As noted last year, our challenges for the future include completion of the undergraduate textbook initiative, and the development of our new core graduate curriculum. It is anticipated that we will develop a graduate textbook initiative in future years to compliment the new graduate curriculum. The numerous changes in our faculty provide both a challenge and an opportunity. The challenge is to maintain our educational programs at a consistently high level with a short term reduction of over 20% of our faculty. The opportunity is to reshape the direction of our department through the many new faculty hires which we will need to make during the next few years. We continue to need to strengthen biomaterials, magnetic materials, ceramics manufacturing, and heat and fluid flow within our faculty ranks.

Thomas W. Eagar

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering is a strong department by any measure. It has a strong faculty, outstanding students, strong disciplinary base, active and viable research programs, and strong interactions with industry and government agencies. The Department is still one of the most highly subscribed departments by undergraduate students.

We have undertaken many new initiatives during the last four years to improve undergraduate education, to strengthen research activities, to promote significant interactions with industry, to open new intellectual frontiers, and to enhance the learning and cultural environment for our students.

All of these major new initiatives are now yielding positive results. The Department has implemented a new undergraduate curriculum, which is designed to produce future leaders in engineering, industry, academia, and society at large. To complement this effort, the Department is producing teaching aids through the newly established Hypermedia Teaching Facility. The renovation of our teaching and research facility has been extremely effective in improving the teaching and learning environment of our students. The Department's research volume is growing at a record rate. The funding level in the fields of manufacturing, design, bio-medical engineering, information systems and technology, and combustion and IC engines is high. The Department's faculty has played a major role in establishing the NSF funded Engineering Research Center for Competitive Product Development.

The department is strong in areas where technology can make a difference in society, the nation, and the world. We are, for example, playing a vital role in health and medical care through our research on robotics, automation, and information systems. Our design and manufacturing group is leading the effort in rapid prototyping, axiomatic design, product development, precision engineering, materials processing, manufacturing systems, and flexible automation. As machines and systems become more intelligent, mechanical engineers will play new roles in industry. Information technology will soon affect almost every aspect of mechanical engineering industries. Our research enterprise must be flexible to allow for changes as societal needs change, while at the same time, bearing in mind that scholarly effort requires long term perspectives and should seek opportunities for long lasting contributions.

CHALLENGES AND OPPORTUNITIES

The Department of Mechanical Engineering, like the nation and the world, is in a state of transition. Globalization of industry is one of the contributing factors to this state. We all understand the myriad effects of globalization on industry and the economy. It is changing all aspects of industry ranging from customer base, vendor base, manufacturing facilities, research and development, migration of skilled workers to finance. Those who are not competitive are penalized by the global financial market. Education has not yet been affected by the global economy, but before long, it too will feel the effects of globalization. While it is not clear how universities will change, one can speculate on the possibilities. Some of the many possibilities that may change the role of education in a global economy are the need to generate students who can become societal leaders in a global setting, and the need to create a stronger interaction between MIT and leading technological companies worldwide, distance learning, the use of virtual environments in education, and the pooling of human resources.

The field of mechanical engineering has changed in industry because design and production of products have changed and will continue to undergo greater changes in the future. Few products are all mechanical! The automatic transmission in automobiles, for example, will soon have more software interacting with a smaller number of mechanical parts than ever before. The future growth of many other industries such as the semi-conductor industry will depend on mechanical engineers' ability to make precision mechanical products. Mechanical engineering will soon play a vital role in health and medical industries because human dexterity can no longer perform microsurgical operations and conventional drug delivery systems can not deliver drugs to specific cells and tissues. As machines and systems become more intelligent, mechanical engineers will have to play new roles in industry. Information technology will soon affect almost all aspects of mechanical engineering industries. The Department of Mechanical Engineering must be strong in areas where technology can make a difference in society, the nation, and the world:

- energy related industry will continue to be a large fraction of our GNP

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- health industry is responsible for 16% of GNP
 - manufacturing industry is still responsible for over 18% of GNP
 - defense industry is about 6% of GNP
 - education and research contributes 2.8% to GNP
 - transportation industry is over 12% of GNP
 - telecommunications industry will continue to grow.

These fields will provide opportunities for mechanical engineers.

Traditional mechanical engineering industries are no longer driven by technological changes alone and, for this reason, mechanical engineering education must be broadened. When science or technology are the motivating forces behind a given industry, scientists or technologists are in the driver's seat. Today, non-technological issues have become as important as technological superiority in these industries, in contrast to the biotechnology industry where scientific and technological advances in biology are the driving forces. We may not be able to teach students everything they need to know in every field, but we must provide a perspective on non-technical issues that will affect their careers and help them assume leadership positions. We must do this while providing students with the best engineering education possible.

In addition to these externally driven challenges, we face internal challenges. We must continually renew the Department's intellectual strengths. On the one hand, we must nurture disciplinary core strengths by forming core groups; and, on the other hand, we must resist the temptation to isolate these core groups thereby missing opportunities to create new intellectual frontiers and disciplines through interaction among groups. We must also resist the pressure to simply maintain the status quo. Even in a world of diminishing resources, we must be willing to set aside a fraction of our resources to undertake new activities.

We must seek ways to improve the mentorship of our undergraduate students. Undergraduate education must continue to receive as much attention from our faculty as does graduate education and research. We need to improve graduate education. The current graduate program prepares students interested in teaching and research well. However, it does not well serve the needs of those who aspire to become industrial leaders. We must renovate the learning environment. In addition, we must strengthen the fundamental engineering science efforts, especially in areas where faculty have moved into more applied areas, and must nurture an environment for technology innovation. And, most importantly, we must seek financial resources to meet the basic necessities for vibrant educational and intellectual activities of the Department.

UNDERGRADUATE EDUCATION

One of the major goals of our undergraduate education is to create future leaders in industry, academia, and engineering. An MIT education must provide a "can do" attitude backed by knowledge, perspective, experience and ethics to produce future leaders. The Department of Mechanical Engineering has embarked on four major activities to achieve these broad educational goals:

Curriculum development for Course 2 (the accredited mechanical engineering course) and curricula for Course 2A (non-accredited course for students interested in broader educational background)

Use of new and emerging technology in education -- the development of hypermedia teaching aids and the Hypermedia Teaching Facility

Renovation and endowment of teaching laboratories -- the Pappalardo Laboratories, the AMP Laboratory for Mechanical Behavior of Materials, the Rohsenow Heat and Mass Transfer To Mechanical Laboratory, and the d'Arbeloff Laboratory

Improvement of learning environment outside of the formal class rooms

CURRICULUM FOR COURSE 2

A new curriculum for Course 2 was implemented in September 1995. There are six important goals for the new curriculum. The first goal is to provide broader engineering education, the second is to provide an integrated view

of engineering, the third is to teach synthesis and analysis in all subjects, the fourth is to provide more hands-on experience in design, manufacturing and instrumentation, the fifth goal is to promote active learning, and the sixth is to provide students with a broader perspective on their life and careers.

Several courses are now taught in an integrated manner in a two semester sequence. Among them are: mechanics and materials; thermodynamics, heat transfer and fluid mechanics; and design and manufacturing. Systems, dynamics and control are taught in a three semester sequence to achieve our goals.

All of our undergraduate students are required to take a completely new required course -- 2.670, ME Tools -- during the Independent Activity Period in their sophomore year. They are taught the essential tools needed for mechanical engineering subjects such as the use of CAD (Computer Aided Design) programs and the use of machine tools. Students really like this course. They learn while having fun. It has been very gratifying that the enthusiasm for learning can be readily discerned in the twinkling eyes of our students. The exposure they received while building their Stirling engine will affect their learning experience in all subsequent engineering subjects. Professors Douglas Hart and Kevin Otto, Richard Fenner and his staff, and student assistants should be applauded for a job extremely well done.

CURRICULUM FOR COURSE 2-A

We have also formalized the curricula for non-accredited mechanical engineering, Course 2-A. This curriculum has five tracks: (1) biomedical engineering and pre-medicine, (2) large-scale systems design, (3) technology-policy and pre-law, (4) management and entrepreneurship, and, (5) open track. Its purpose is to actively encourage students to pursue a degree from Course 2-A and to properly guide them. The interdisciplinary committee which revised this curriculum was headed by Professor Thomas Sheridan.

UNDERGRADUATE LABORATORIES

We have renovated the Pappalardo Laboratories, the Rohsenow Laboratory, and the AMP Laboratory. The d'Arbeloff Laboratory for Information Systems and Technology was launched with the promise of creating a new educational and research paradigm. Its goal is to explore the areas where physical systems and information systems converge to make intelligent machines, systems, and processes. Professors Harry Asada and Ian Hunter are the Director and Co-Director of this new laboratory.

TECHNOLOGY IN EDUCATION

Professor Tony Patera, Chair of the Faculty Steering Committee, and Dr. Nish Sonwalkar, managers of The Hypermedia Teaching Facility, and Professor James Fay have generated its first CD-ROM for fluid mechanics. This milestone achievement will significantly improve classroom learning and is available on the World Wide Web for off-site learning. This effort will influence future educational enterprises at MIT. They have created a new paradigm at MIT. We are considering other technologies that can enhance undergraduate education.

ENHANCEMENT OF CULTURAL ENVIRONMENT

Our students need to acquire a broader outlook on life to become well-rounded, successful professionals. A number of activities have been initiated to help them achieve this goal. The Distinguished Alumni Seminar Series is a successful and important means of showing the students how they too can become leaders after they graduate from MIT. Once a term letters are sent to them from the Department Head to let them know that they have what it takes to be successful leaders. Although it may be of minor significance, free newspapers are placed in a lounge area so the students can read them between classes. Much more still needs to be done.

We need to create a different physical environment that can promote mutual cultural and educational exchanges to facilitate greater interactions among our students, faculty and staff.

TEACHING QUALITY

The Department faculty has always been committed to excellence in teaching. Implementation of the new curriculum has rejuvenated our search for pedagogical efficacy and effectiveness. Even during this transition period, our faculty continues to teach at the highest level possible. Teaching performance is considered as one of the most important criterion in promotion and tenure.

STATISTICS

degrees in 2, 2A, and 2B:

September, 1995: 5 degrees, 2 women (1 African-American and 1 Puerto Rican)
February, 1996: 14 degrees, 4 women, 1 male Puerto Rican, 2 male foreign students
June, 1996: 122 degrees, 29 women including 2 African-Americans, 2 Mexican Americans, and 2 foreign students. Minority men included 5 African-Americans, 6 Puerto Ricans, 3 other Hispanics, and 2 foreign students

GRADUATE EDUCATION CURRICULUM

The Department's graduate program is strong and has been emulated by many other universities world-wide. It is rigorous, scholarly, and well administered.

The doctoral program is slanted toward creating academic researchers and professors in contrast to creating industrial leaders. In fact, we are the country's major producer of Mechanical Engineering university professors. Although the program is highly flexible, it does not explicitly encourage students to acquire broad educational experience and thus many doctoral students become narrow and highly specialized. Furthermore, some thesis research topics are removed from those of industrial interest. In short, the current doctoral program is serving the needs of those interested in pursuing the academic career well, but it may not serve the needs of those interested in becoming industrial leaders.

An ad hoc Graduate Education Committee, under the leadership of Professor Ali Argon, was established to review the graduate education program of the Department and make recommendations to the Department. Their charge is to develop graduate programs that educate those graduate students who wish to pursue careers in industry. Our goal is to lead in developing a creative graduate program that can complement and supplement the existing graduate programs for S.M. and Ph.D. degrees.

STRENGTHENING INDUSTRIAL TIES

Concurrent with its effort to review the graduate curriculum, the Department has undertaken a number of projects to strengthen its relationship with industry. We are doing this as a means of promoting greater interaction with industry, making our graduate programs more relevant, increasing opportunities for creative new ideas, and as a way of increasing funding for research.

The Department has a number of industrial consortia on a number of specific topics. This number is increasing. The following is a list of some of the Department's industrial consortia:

- 3-D Printing (Professor Eli Sachs)
- Droplet Based Manufacturing (Professor Jung-Hoon Chun)
- Solidification Front Monitoring in Continuous Casting (Professor Jung-Hoon Chun)
- Hip-Joint Research with Brigham and Women Hospital (Professor Myron Spector and Professor Suh)
- International Medical Imaging Technology (Professor Forbes Dewey)
- Three Automotive Engine Related Consortia in the Sloan Automotive Lab (Professor John Heywood)
- Home and Health Automation (Professors Harry Asada and Ian Hunter)

These consortia bring in over four million dollars of research support into the Department. It is expected that they will grow in number and in support.

The Department, under the auspices of our Manufacturing Institute, has created the MIT-Industry Partnership for Engineering Excellence. Under this arrangement, an industrial firm and MIT sign a two-year rolling contract at a minimum support level of \$ 1 million over the two year period. The idea is to create a long-term relationship which meets the Department's educational goals and the industry's goals as well. MIT has modified its normal patent provisions by granting the industrial firm a five-year, royalty-free exclusive license from the date of filing the patent application. After five years, the industrial firm must choose between the following two options: retain the exclusivity but pay royalty *or* receive a royalty-free, non-exclusive license for the life of the patent. We hope to

have ten Partnerships. MIT-SVG (Silicon Valley Group) Partnership for Engineering Excellence is our first industrial partnership.

The Department of Mechanical Engineering together with the Department of Nuclear Engineering has obtained a five-year, \$ 2.5 million research contract with Korea Electric Power Company (KEPCO). KEPCO is one of the world's largest nuclear utilities. This contract allows us to maintain our strength in the nuclear power field. MIT conducts fundamental research on topics chosen by mutual discussion and accepts visiting engineers from KEPCO.

Research support for single investigator projects is still one of the most important means of supporting graduate students. This means of receiving research support is becoming increasingly difficult as Washington is becoming fiscally more conservative. Competition for research support is more intense as the real dollar for Federal R&D support is expected to decrease by 30 to 50% over the next five years. It is imperative, therefore, that the Department continues to strengthen its relationship with industry. Our goal is to increase industrial support to 60% (or approximately \$12 million) of the Department's research volume.

STATISTICS

September, 1995: 10 Ph.D.s, 7 foreign students
17 Masters, 1 woman, 8 foreign students
February, 1996: 15 Ph.D.s, 1 woman, 8 foreign students
20 Masters, 1 woman, 7 foreign students
June, 1996: 23 Ph.Ds., 1 woman, 2 male Mexican Americans, 10 foreign students
48 Masters, 6 women including 1 African-America and 1 Mexican American, 1 male African-American, 17 foreign students

FACULTY AND STAFF

As of July 1, 1996, there were 59 full-time faculty: 34 professors, 10 associate professors (7 with tenure), 13 assistant professors and 2 TBAs. In addition, the teaching, research, and technical staff fluctuates around 70, more than half of whom are part-time.

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 Ahmed Ghoniem); and Design and Control (Head, Professor Warren Seering). The systems research groups are: manufacturing (Head, Professor Timothy Gutowski); Biomedical Engineering (Head, Professor Roger Kamm); and Information (Head, Professor Haruhiko Asada).

RESEARCH ISSUES

Two years ago, I stressed that in order to make an impact on technology, society and education, our department must emphasize the two ends of the research spectrum and move away from the center of the research spectrum where the bulk of a typical university research is taking place today. The two ends of the research spectrum are: fundamental knowledge which is the basis for future research development and technology, *and* the research that can lead to technology innovation. The Department has been trying to implement this shift by hiring new faculty whose work reflects this shift in attitude, by strengthening our relationship with industry, and by creating new research areas.

STATUS OF RESEARCH

Manufacturing research is well funded primarily because the faculty, who are primarily affiliated with the Laboratory for Manufacturing and Productivity, has generated exciting new ideas and aggressively pursued external funding. The research volume in manufacturing has increased because the Manufacturing Institute has successfully brought in large industrial funding. Research is being conducted in: materials processing (microcellular plastics, composites, metal forming, welding), rapid prototyping (3-D printing, DBM), precision engineering, precision stage design by magnetic levitation, manufacturing systems, production machine design, opto-mechanical devices, and design theory. Three industrial consortia in the field of manufacturing are headed by Professors Chun and Sachs. Other professors and senior research staff in this field include: Gutowski, Hardt, Slocum, Suh, Trumper, Cochran, Sarma, Gershwin, Sharon, and Saka.

Biomedical engineering research is reasonably well funded although some of Professor Hunter's funding is still channeled through McGill University. Efforts by key faculty members (Professors Hogan, Hunter, Kamm, Dewey, Rowell, Yannas, and Dr. Mark Johnson) have improved the funding situation. It appears that the funding level will increase significantly in the near future. One of the tasks is to enhance more collaborative efforts among the department faculty to yield more synergistic research in this field. At this time, the Department is searching for a faculty member who can marry the traditional biomedical engineering research with cell biology.

We hired two faculty members, Professors Seth Lloyd and Sunny Siu, to strengthen the information end of our education and research programs. Professor Lloyd is a quantum mechanics physicist with strong interest in information. He was at Los Alamos Laboratory for three years after spending three years at Caltech as a post-doctoral researcher. Professor Siu is a specialist in the networking area. He was an Assistant Professor of Electrical Engineering at the University of California, Irvine. Professors Asada and Hunter created the Home Automation Consortium which will be located in the new d'Arbeloff Laboratory. They have raised almost \$2 million for the consortium in a relatively short period of time. The professors associated with this new interdisciplinary laboratory are: Asada, Hunter, Lloyd, Rowell, Thomas Sheridan, Siu, Jean-Jacques Slotine, and Kamal Youcef-Toumi.

There are many exciting research projects in the design area. Precision machine design (Professors Alex Slocum and David Trumper), New Products Program (Professor Flowers), axiomatic design and software shell development (Professor Suh), environmentally compatible design (Professor Wallace), design optimization (Professors Otto and Thornton), product development (Professor Seering), mining related design (Professor Peterson), and CAD (Professor Gossard) are some representative projects. Some projects are well funded, others are not. Student interest in design is great and the research funding level in design is not sufficient to support all of the graduate students wishing to work in this area. Professor Seering and colleagues submitted a proposal in the field of product design to the National Science Foundation for an Engineering Research Center award. We hope that we will be granted the ERC award.

Research in energy related areas is done in the field of internal combustion engines (Professors Heywood, Cheng, Hochgreb and Dr. Wong), gas turbines and chemically reacting systems (Professor Ghoniem), research related to nuclear power (Professors Peter Griffith and Neil Todreas), cryogenics and air conditioning (Professors John Brisson, Joseph Smith, Griffith and Gerald Wilson), and heat transfer (Professors Mikic, John Lienhard, and Taiqing Qiu). We need more interdisciplinary research in this field on topics such as portable power source, heat transfer in computers, new power trains for vehicles, etc. Some of the research in this area are extremely well funded, but we need to increase funding for other areas.

Research in materials is strong. Research activities are in fundamental deformation mechanisms of metals and polymers (Professors Anand, Argon, Boyce), fracture (Professor Parks), phase transformation (Professors Abayaratne and Parks), composite materials (Professors Williams and Gutowski), and tribology (Professor Suh and Dr. Saka). Some of these areas are well funded.

Research in systems and control include: robotics, control, man-machine systems, and system design. Research in robotics covers diverse topics and is very strong. It is conducted by Professors Asada, Dubowsky, Hunter, Slotine, Sheridan and Dr. Salisbury. Research is done in microsurgical robots (Professor Hunter), nanoscale displacement devices (Professor Youcef-Toumi), robot for space applications (Professor Dubowsky), self learning adaptive robot (Professor Slotine and Dr. Salisbury), robots for automation (Professor Asada), and modular robot (Professor Dubowsky). Research in man-machine is conducted by Professor Sheridan. Professors Suh and Cochran are conducting research on design of large systems.

There are many exciting research projects in fundamental basic research areas such as numerical computation (Professors Jurgen Bathe, Tony Patera, Ghoniem and Parks), fluid and solid mechanics (Professors Akylas, Abayaratne, Feng, Bathe, Parks, Anand, Patera, Probstein, Kamm and Dewey), combustion (Professors Cheng, Ghoniem, Heywood, and Hochgreb), control (Professors Annaswamy, Slotine, Asada, Sheridan, Dubowsky, Hardt, Hogan, Rowell and Youcef-Toumi), materials (Professors Argon, Boyce, Anand, Gutowski, Parks, and Suh), and design (Professors Suh, Otto, Seering, Thornton, Flowers, and Wallace). The current research volume in some of these fundamental research areas is small. Every effort must be made to strengthen fundamental research areas.

The Department has made attempts to recruit world renowned senior faculty members in mechanics, but for some complex reasons, we have not been successful.

RESOURCE UTILIZATION

Resource utilization is an important issue for the Department and for MIT. The Department needs to generate significant resources to meet all of its teaching and research needs.

FUTURE PROSPECT

I am optimistic about the Department's future. We have invested in new programs which are bearing fruit. We have strong programs in both traditional areas as well as in new areas. Our students are the best humanity can produce. Our interaction with industry is exceptionally strong. We have recruited excellent new faculty members. Our research volume is growing. Our alumni have been very generous in support of our programs.

The Department must continue to raise funds and take intellectual risks in order to meet our aspirations and ambitious goal for education and research. The Department must guard against the temptation to act as a federation of twelve independent tribes rather than a single academic department, since the benefit of having a large department is the intellectual synergism that generates exciting ideas and results. The senior faculty of the Department must continue to look after the intellectual growth of younger colleagues by providing them with opportunities and room for innovation, intellectual experimentation and growth. Most of all, the Department must give its utmost attention to education of our students, both undergraduate and graduate students.

We are the best mechanical engineering department in the world for education, research and public service. We intend to keep it that way.

CONCLUSIONS

The Department has achieved a great deal over the last few years. This could not have been done without the dedication of the faculty and staff. We worked together as a team even when heated discussions preceded the adoption of new programs and policies. I am very grateful to my colleagues and staff.

New Faculty: Sanjay Sarma, Assistant Professor, Design; Kai-Yeung Siu, Assistant Professor, Design; Anna Thornton, Assistant Professor, Design

Promotions: Associate Professor without tenure: Simone Hochgreb, Anuradha Annaswamy, David Trumper; Associate Professor with tenure: Jung Hoon Chun; Full Professor: I. Hunter, E. Sachs.

Retirements: Carl Peterson, Ronald Probststein, Thomas Sheridan.

Nam P. Suh

DEPARTMENT OF NUCLEAR ENGINEERING

This was a successful year for the Department of Nuclear Engineering (NED) — a year that brought new academic programs, new facilities, and new research efforts. The department proposal for the establishment of a Master of Engineering degree was approved by the Institute faculty and will be initiated in the academic year 1996-97. The program aims to attract the students interested in professional leadership in industry. The new degree will offer a more structured education at the master's level than the S.M. degree, to ensure breadth of coverage in systems synthesis as well as disciplinary analysis topics. Two tracks are offered: nuclear systems engineering, and radiological health and industrial engineering.

In recent years the field of nuclear engineering education has evolved to become broadly concerned with technological applications of nuclear and radiation phenomena in biomedical, industrial, and environmental fields, in addition to the technology of power production. The department has been at the forefront of this evolution, with the establishment in 1988 of the graduate level Radiation Science and Technology academic area. In 1991 the undergraduate program was reorganized into two tracks: nuclear energy, and radiation in medicine and industry. The two tracks of the Master of Engineering parallel those of the undergraduate program.

The department was again rated the top department in its field by *US News and World Report*. The consistency of this ranking over many years has reflected the quality of scholarship by students and faculty in the department.

In September 1995 Professor George Apostolakis joined the department. He is a world renowned expert in reliability and risk assessment of engineering systems. His work has involved applications to nuclear power plants, NASA space missions, and chemical and nuclear waste repositories.

The department faculty continue to supervise nearly \$15 million of annual research volume, administered through many interdepartmental centers. About two thirds of this is in the area of plasma fusion engineering which suffered some reduction, but not as much as the national program which was cut by nearly 30 percent. This was somewhat ameliorated by the initiation of the INEL University Research Consortium projects, from which six projects (out of a total of 47) were successfully proposed by department faculty and funded at approximately \$1 million per year.

A multiyear research agreement with Korea Electric Power Corporation that will focus on the technological advancement of the next generation of nuclear power plants in Korea was initiated. The agreement expands the department's research cooperation with Asia/Pacific countries. Additionally, visiting teams were exchanged with Tsinghua University of Beijing, China, to explore cooperation in research on the boron neutron capture therapy (BNCT) approach to cancer treatment.

A new laboratory was added to the research facilities to explore accelerator sources of neutrons for medical applications. Two projects supervised by Professor Jacquelyn Yanch are currently being pursued using a new tandem accelerator with unique capabilities. One project focuses on delivery of neutrons that are suitable for cancer treatment through boron neutron capture therapy. The other project focuses on use of boron capture as an alternative to surgery to treat rheumatoid arthritis. Another notable addition to research facilities was a 600 MHz magnet and spectrometer in the Spatial Nuclear Magnetic Resonance Laboratory of Professor David Cory.

Several administrative duties changed hands this year. Professor Jeffrey Freidberg took over from Professor Allan Henry the chairmanship of the department's Committee on Graduate Students. (Professor Henry, who retired this year, chaired the committee for nearly twenty years.) Professor Sidney Yip became the graduate student financial aid officer. Professor John Meyer continues as the head of the undergraduate education committee.

UNDERGRADUATE PROGRAM

Twenty-one students were enrolled in the undergraduate program during the past year (seven sophomores, five juniors, and nine seniors). Seven students completed requirements for the bachelor's degree in nuclear engineering.

During the fall term 1995, an accreditation visit for evaluation of our undergraduate program occurred. Unofficial results from the Accreditation Board for Engineering and Technology (ABET) indicate that we conform to their guidelines. Their next visit will be in 2001.

GRADUATE PROGRAM

Twenty-eight students were welcomed into the graduate program in September, bringing the total graduate enrollment to 118 students. Of this number, 42 percent were specializing in fission and energy studies, 33 percent in radiation applications in biomedical and other technology, and 25 percent in fusion. An additional student was approved for special student status. During the academic year, 51 students were awarded 56 graduate degrees.

For approximately one and a half years the NED Curriculum Development Committee, chaired by Professor Freidberg, has devoted its efforts towards the creation of a unified, streamlined curriculum for our doctoral program. They have developed a four subject Core program for all NED doctoral students that defines the discipline of Nuclear Engineering. The subjects consist of (1) Applied Nuclear Physics, (2) Engineering Principles of Nuclear Science and Technology, (3) Microscopic Theory of Transport, and (4) Nuclear Engineering Laboratory. The Core curriculum has been approved by the entire NED faculty and will be initiated in the fall 1996 semester.

The Institute approved the department's request to offer a new degree, the Master of Engineering, in September. This intensive fast-paced program will prepare students for productive professional engineering careers by providing additional depth in nuclear-related subjects beyond the bachelor's degree, together with the breadth of perspective necessary for engineering leadership in the field.

FACULTY HONORS, AWARDS, AND ACTIVITIES

The Ruth and Joel Spira Award for Distinguished Teaching was presented to Professor Yip. This award acknowledges the tradition of high quality engineering education at MIT.

The American Nuclear Society (ANS) MIT Student Chapter Outstanding Teaching Award was presented to Dr. Lisa Porter, a postdoctoral associate.

Professor Cory was invited to lecture on nuclear magnetic resonance (NMR) at several conferences during the year. He spoke at the Microscopy Society of America, Kansas City, in August, and also at the International Chemical Congress of Pacific Basin Societies, Honolulu, in December. The Department of Nuclear Engineering at North Carolina State University invited him to give a departmental seminar in February; and in April he gave a tutorial introduction to the physics of medical imaging at the New England Section of the American Physics Society Meeting in Cambridge.

Professor Elias Gyftopoulos was awarded the distinction of Commander of Order of Honor by the President of the Republic of Greece.

Professor Yip chaired an international conference on Multiscale Modeling of Industrial Materials which was cosponsored by the National Science Foundation (NSF) and held at the University of California (UC), Santa Barbara, in January 1996. A follow-up is planned at MIT in 1997.

Professor Mujid Kazimi was a member of a Department of Energy (DOE) Basic Science Research Advisory Group that reviewed the proposed upgrades of national research reactors. He also served as a member of a review group for the Department of Nuclear Engineering at UC, Berkeley. He joined the executive committee of the Nuclear and Radiological Engineering Division of the American Society for Engineering Education (ASEE) for a two-year term.

Professor Apostolakis joined the Advisory Committee on Reactor Safeguards (ACRS) of the Nuclear Regulatory Commission. He chaired an international meeting on Probabilistic Safety Assessment in Crete, Greece, in June 1996.

Dr. Bruce Rosen sponsored and organized the Second International Conference for Human Brain Mapping. Over 1200 participants were in Boston for this event.

Professor Ronald Ballinger has joined a team to review safety of the storage of metallic nuclear fuel in DOE laboratories.

RESEARCH FISSION

Professor Henry and a graduate student investigated an alternative method for describing space-time neutron behavior in a large light water reactor. The procedure (called one-dimensional nodal synthesis) consists of combining at a given reactor elevation a number of precomputed, two-dimensional flux shapes in order to approximate a three-dimensional, time-dependent flux shape. Thus, the coefficients of combination depend on time and axial location.

For test problems simulating a large pressurized water reactor (PWR), acceptable accuracy was achieved. However, at best, the computation time was reduced by a factor of three, while in some cases the synthesized solution took longer to run than a corresponding full, three-dimensional nodal calculation. Thus, the method appears to be of only limited value.

Under the supervision of Professors Neil Todreas, Michael Driscoll, and Michael Golay, a project to achieve enhanced capacity factor performance of light water reactors by adoption of a 48-month operating cycle was initiated. Three tasks were accomplished: (1) a PWR core was designed; (2) the surveillance requirements for both PWRs and boiling water reactors (BWRs) were investigated regarding this cycle length; and (3) required availability levels for components of a key sample PWR system were determined. Professors Todreas and Driscoll have assessed the performance of passive containment cooling systems. New concepts have evolved from this research.

Professor Meyer's research included the development of computer methods for simulation of boiling water reactor conditions that potentially could lead to unstable behavior. He and Dr. John Bernard collaborated to calculate the thermal hydraulic conditions in the MIT Reactor core tank after hypothetical accidents.

Professor Kevin Wenzel heads the Plutonium Group, which includes Professors Driscoll and Todreas and Dr. Marvin Miller, along with three graduate students. The group is exploring methods for disposal of plutonium, particularly excess weapons-grade plutonium from dismantled nuclear weapons. Recent projects include the design of novel fuel forms for deep burning of plutonium in peripheral fuel assemblies of light water reactors, studies of long-term leach rates of plutonium surrogates in borosilicate glass, and experimental studies of the proliferation resistance of glass host forms.

The disposition of the contents of the high level waste tanks at the Hanford reservation has been studied by Professor Kazimi and two graduate students. Conditions were identified for water convection in the porous material in these tanks. That may explain anomalous temperature behavior in tank 106C. Professor Kazimi and his students have also pursued development of a decision analysis method for the immobilization of the radioactivity.

Professor Kenneth Russell has actively pursued international cooperative efforts in nuclear materials research. He has submitted a Civilian Research and Development Foundation (CRDF) proposal on self organizing systems with scientists from the Kiev Institute for Nuclear Research and is pursuing a joint theoretical and experimental study of pressure vessel embrittlement with the Belgian Nuclear Center, SCK-CEN. Both efforts center on Professor Russell's theory for the effects of radiation on precipitate nucleation.

RADIATION SCIENCE AND TECHNOLOGY

Professor Cory has articulated a novel description of spatial aspects of magnetic resonance that focuses attention on spin magnetization gratings. This leads to a more natural description of the dynamics and is useful both in research and in teaching. He has also implemented an improved NMR microscope operating at 600 MHz which is the highest field (and highest resolution) NMR system dedicated to microscopy. He has developed, designed, and implemented a new approach to high resolution NMR of semi-solids based on a combination of magic angle sample spinning and magnetic field gradients. He has implemented a set of paradigms for "NMR computation" based on the interactions of coupled spins. This in many ways parallels the efforts in quantum computing with small spin systems, but remains based on macroscopic phenomena and avoids issues of wave-function collapse.

Professor Xiao-Lin Zhou is conducting research in two areas: neutron reflectometry and applications in the area of neutron scattering spectroscopy, and near-threshold reactions for neutron production in the area of compact neutron sources. In the neutron reflectometry and applications project, a time-of-flight neutron reflectometer has been

designed, and construction work is currently underway at the MIT Research Reactor. In the epithermal neutron production by near-threshold charged particle reactions project, Professor Zhou has completed a study on the reaction data of p-Li and p-Be reactions, as well as a comparison study between the neutron production characteristics of near-threshold reactions with high energy proton reactions, and determined the advantage and feasibility of near-threshold reaction as an alternative epithermal neutron source.

Functional brain mapping is being investigated by Dr. Rosen and his students. This research mapped the earliest brain system responsible for the visual motion after effect. Dr. Rosen and his students have also established the temporal resolution limits of functional activation, and pushed below one second the ability to characterize the temporal orchestration of distinct brain regions.

Professor Yip is supervising several projects on atomic-level materials modeling. They are (1) atomic simulation of thermal properties of irradiated silicon carbide, (2) multiscale materials modeling focused on study of atomistic mechanisms and the electronic effects of plastic deformation in semiconductor crystals, (3) atomistic modeling of SiC fiber composites, and (4) atomistic-continuum hybrid simulation of fluid flow.

Professor Sow-Hsin Chen and a student have found a method to measure average Gaussian and square mean curvatures of interface in a micro-phase separated bicontinuous micro emulsions and phase-separated polymer blends by small angle neutron and x-ray scattering.

FUSION

Under the direction of Professor Ian Hutchinson, the Alcator C-Mod Tokamak project experienced a highly productive year despite the disruption associated with a big drop in the national fusion research budget. Major progress in divertor research included demonstration of record values of the compression of neutrals in the divertor and the documentation of the effects of geometry on divertor detachment. These are both critical ingredients of the proposed power and particle handling solution for the International Thermonuclear Experimental Reactor (ITER) and future reactors. An important development in the core thermal confinement, which showed major improvements, casts some doubt on the current transport scaling. This development demonstrates once again the necessity of high-field compact tokamaks, like Alcator, to address fusion's scientific challenges.

Professor Wenzel is supervising a project to install an Omegatron edge diagnostic on the Alcator C-Mod Tokamak. The diagnostic will provide the first measurement of ion temperature in the edge plasma of the tokamak. He is also supervising a project at Astex to study high-density plasma systems for metal deposition in high aspect ratio features for semiconductor manufacturing.

Professor Freidberg and Dr. Ali Shajii discovered the existence of a new class of low Mach number discontinuous fluid flows. The flows are similar to "standard" contact discontinuities except that they are strongly modified by the presence of a metallic wall. The wall not only introduces new velocity jumps into the flow, but produces a thermal drag that can stabilize the flow against Rayleigh-Taylor instabilities which always destroy the structure of the "standard" contact discontinuity. This phenomenon is important in understanding the propagation of a quench in large, superconducting, fusion magnets.

Professor Freidberg and Dr. Shajii developed a new theoretical model describing low Mach number compressible flow. Such flows occur in long superconducting cables used for fusion magnets. The flow is dominated by friction rather than inertia and because of the long length, compressibility effects are important even though the flow corresponds to low Mach number. A surprising result is that when sufficient external heat is supplied to the fluid, the flow direction actually reverses against the direction of the pumping pressure. This phenomenon has been observed experimentally and cannot occur in an incompressible fluid.

Professor Freidberg and Dr. Shajii derived a theoretical explanation of the phenomenon known as *thermal hydraulic quenchback*. This phenomenon, which occurs in superconducting magnets cooled by super-critical helium, is characterized by a near explosive growth in the velocity of propagation of a quench event. They pointed out that ahead of a standard quench front there is a small compression of the coolant because of the frictional drag. This gives rise to an additional heating of the coolant which, while small, is still sufficient to drive the superconductor normal. This "new" region of superconductor gone normal leads to an enhanced propagation velocity.

Fusion technology and safety research continued under the supervision of Professors Kazimi and Meyer. Limiting heat flux conditions in high velocity water cooled channels were defined. For highly subcooled water, it was found that transition to film boiling would not be deleterious to heat transfer. This should enable the design of components that can remove up to 15 MW per square meter without reaching unacceptably high temperatures. Also, a probabilistic model for the design of the radiological confinements structure for a large tokamak such as ITER was developed based on a combination of event trees and influence diagram.

SYSTEMS AND POLICY

Professor Richard Lester continues his work at the Industrial Performance Center. As Center director, Professor Lester oversees its research on the nature and determinants of successful industrial performance. With the participation of about 30 faculty and more than 50 students from all five Schools at MIT, the center today serves as a listening post on industry, monitoring patterns of organizational and technological practice, interpreting them for its industrial partners, and feeding its observations back into the core disciplines and departments of the Institute.

STUDENT AWARDS AND ACTIVITIES

The MIT American Nuclear Society Student Branch serves as the focal point for extracurricular NED student activities. All activities are planned by students and change from year to year depending on student interests. Past year events include the Monday Afternoon Seminar Series, coordination of the NED Open House for undergraduate students, the orientation session for incoming students, and a host program for international students, in addition to numerous social and athletic events.

The MIT Chapter of the Alpha Nu Sigma Society, a national honor society for students in applied nuclear science and nuclear engineering, recognized 11 outstanding students for their academic achievement. The MIT Health Physics Society Student Branch continues to be active in activities focused on environmental radiation transport, radiobiology, and radiation detection and measurement.

At the annual international dinner/awards ceremony, the Roy Axford award for outstanding academic achievement by a senior in nuclear engineering was given to Seungtaek Choi, and the Irving Kaplan award, which recognizes academic achievement by a junior in nuclear engineering, was given to Jerry Hughes, Jr.

The Manson Benedict Fellowship for 1996-97 was presented to Ju Li, a graduate student from China, in recognition of excellence in academic performance and professional promise. The Theos Thompson Memorial Fellowships were held for the fall term 1995 by Andrew Gnau, Dennis Klein, and Robert McHenry.

Gary Cerefice received the Sherman Knapp Scholarship, funded by Northeast Utilities. National Academy for Nuclear Training Fellowships for 1995-96 were held by Jess Iverson and Sherry Wu.

The Outstanding Service Award for service to the department beyond academic and research achievements was presented to Kathryn Hautanen and Theodore Weber.

An Institute fellowship, the Ida Green Fellowship was held by Tammy Stoops during 1995-96. An incoming student, Heather MacLean, is the recipient of the Ida Green Fellowship for 1996-97.

The MIT Committee on the Writing Requirement awarded Second Prize in the Parke A. and Ann L. Hodges Prize for Phase Two Papers to Seungtaek Choi for his paper entitled, "The Compound Action Potential of the Frog Sciatic Nerve." This prize is given for outstanding undergraduate writing in a student's professional field.

The spring 1995 term project of subject 22.033 Nuclear Systems Design Project received a second place award in the design contest of the Education and Training Division of the American Nuclear Society.

Mujid S. Kazimi

DEPARTMENT OF OCEAN ENGINEERING

The academic year 1995-96 was another excellent year for the department. The research program of the department continued to grow. The faculty continue to engage in research that enjoys national and international recognition. The educational program continues to be strong and vital attracting some of the best students from around the world.

Our faculty body was strengthened by the addition of John J. Leonard. Professor Leonard will be working in the area of marine robotics an area of future growth for the department. John did his graduate work at Oxford and his post graduate training at MIT Sea Grant College Program at the Autonomous Underwater Vehicles Laboratory. Professor J. R. Fricke decided to return to private industry thus resigned from his position in January 1996. Dr. Fricke's contributions will be surely missed especially his involvement in the undergraduate program of our department. He was a gifted teacher well liked by our students.

Six of our senior faculty opted to accept the special retirement offered by the Institute. They are, Professors Carmichael, Dyer, Kerwin, Masubuchi, Newman and Ogilvie. However, Dyer, Kerwin and Masubuchi will continue with their educational and research programs with half time appointments. Professors Carmichael and Ogilvie volunteered their services and will be involved in the teaching and administration of the department for at least one more year. This guarantees that the transition between the retiring faculty and our new faculty will be a smooth one.

The department is continuing initiatives which begun in recent years and is undertaking several new ones. Highlights of these efforts are given below.

UNDERGRADUATE EDUCATION

The Department's new undergraduate program in the Fall of 1993. The new curriculum focuses in five areas:

- Hydrodynamics and Oceanography
- Structures and Materials
- Dynamics and Wave Propagation
- Mathematics and Computation
- Design/Applications/Experience

When we introduced the new undergraduate curriculum in 1993, the Department also introduced a minor in Ocean Engineering. This program is intended for undergraduates who wish to broaden their overall education. This program is specifically recommended to students who eventually plan to practice their major discipline in an ocean related application, or who intend to pursue later graduate education in Ocean Engineering or Naval Architecture.

The Department, in collaboration with the MIT Sea Grant College Program, continues to be very active in the Undergraduate Research Opportunities Program (UROP). The Department feels that the UROP program is an excellent educational vehicle and increased its budget in this area in order to allow more undergraduate students to become exposed to the research conducted in our department.

The Department also continues to add to its experimental facilities used in our undergraduate educational program. This year a new tank was constructed and used in the instruction of our undergraduate design subject. The new tank is especially equipped with laser-induced visualization capability, which would be used by students in the design and development of small autonomous underwater vehicles. Future plans include expanding our educational laboratory space and hiring new staff to oversee activity in this area.

Our faculty and staff continue to stay active in the freshman seminars. The purpose of these seminars are to integrate freshmen into the research life at MIT and make them aware of possible opportunities in the marine field. Professor J.K. Vandiver continues to direct the Edgerton Center for the Institute. The Edgerton Center provides opportunities for students, especially freshmen, to engage in projects in engineering and science.

By investing significant resources to our undergraduate program we have already started reaping some rewards. In particular, the number of undergraduate students interested in marine related education continues to rise. Currently there are seven confirmed sophomores entering in the Fall Term '96. This is almost twice as many as we had the Department of Ocean Engineering

year before. There is also a growing interest in 13.010, Introduction to Ocean Science and Technology. We had 16 registered students ending with a total of 14 students.

The Accreditation Board for Engineering and Technology (ABET) reviewed the Ocean Engineering undergraduate program during the month of October 1-3, 1995. The overall assessment of the three day meeting was a strong endorsement of the department's curriculum and faculty teaching and advising.

GRADUATE EDUCATION

In 1993 our focus shifted from undergraduate to graduate education issues. Our first major initiative was the development of a new professional program leading to a Master of Engineering emphasizing the multidisciplinary nature of the marine environmental problems. The content and structure of the new program combine into a coherent curriculum the key ingredients of marine systems-management, engineering technology and marine science. This program provides professionals with the needed breadth to work in the marine environmental field, from understanding the legal, political and economic context to designing a mitigation system for cleaning up pollution; from designing safe, environmentally friendly ships to developing monitoring systems for studying global climate change or measuring ocean pollution. With a strong emphasis on problem solving, practical applications, and field experience, the program provides a hands-on familiarity with the field. This year saw the completion of the curriculum for this program.

Our current major activity in graduate education involved the revision of our graduate curriculum. Professors Brown, Ogilvie, Vandiver and Schmidt(chair) have been asked to work with the faculty of the department and our colleagues at WHOI to come up with a revised graduate curriculum to reflect recent advances in our field. The same topic was also discussed in a departmental retreat held last January.

The first accomplishment in this area is the development of our new curriculum in ocean acoustics. It builds on the existing curriculum by continuing to emphasize the fundamentals of ocean acoustics. However, it also adds subject matter to expose our students in some of the new areas of Ocean Engineering, some of which were pioneered by our department. These include interchange of information in the ocean environment, navigation of underwater vehicles, simulation of the acoustic environment and the design of marine measurement systems.

We are now working in the area of hydrodynamics curriculum. Again, our new curriculum will be built on the strengths of our existing one. Our new curriculum will streamline our existing subjects and introduce a new theoretical subject addressing viscous and turbulent marine flows. Our hydrodynamics curriculum will be composed of one introductory subject and four basic subjects to introduce our students to the fundamentals of marine hydrodynamics and a number of application subjects to expose our students to the latest developments in hydrodynamics research.

A future area targeted for development is shipbuilding. This will contribute in the national effort of rebuilding commercial shipbuilding in the US. Our first subject has already been developed and introduced in our Naval Construction curriculum. In the coming years we hope to revise and streamline all other areas of our graduate curriculum. As we develop the new curriculum we also continue with the effort we started last year where faculty from our department and other engineering departments share the instructional duties of some of the basic subjects offered in various engineering departments.

RESEARCH

The department's faculty and staff pursued a variety of outstanding research programs, including some that are receiving wide attention inside as well as outside the field of Ocean Engineering. Professor Milgram has completed a twelve year effort on the dynamics of towing systems in large waves at sea. This is one of the few situations of the type which we all seek where procedures based on the most fundamental science give results which are fully applicable in a practical engineering environment and situation. The complete theory and its application are described in a paper by Professor Milgram in the December, 1995, issue of the *Journal of Ship Research*.

When a portion of the work was completed in 1987, the Navy requested use of this work to produce systematic results which formed the basis of the dynamic tension statistics section 1988 U.S. Navy Towing Manual. This document is the "operational bible" of Navy towing salvage ships at sea and of the offshore tow planning done at the

Navy Office of the Supervisor of Salvage. Now that we have developed methods of its practical applications, we have once again been asked by the Navy to run a set of systematic simulations for them. This time the results will be used not only in the next addition of the U.S. Navy Towing Manual, but also in a computer system that will be abroad all Navy towing and salvage ships and running at the related Navy offices.

In January, 1995 the department agreed to collaborate with FastShip Atlantic, Inc. The commercialization of such a technology could lead to a rebound in American competitiveness in shipbuilding and an expanded role in the US in global transportation of high value cargo. MIT has developed a methodology that is being used to analyze hundreds of commodities presently traveling by air and sea across the North Atlantic. This analysis will predict which volume of cargo will be directed to FastShip. Professor Marcus indicates that this methodology and its applications on the North Atlantic will allow us and others to evaluate the role of faster ships to move high value cargo. Professor Sclavounos carried out the hydrodynamics evaluation of the design of the FastShip. In a related effort the department is also assisting Massachusetts Heavy Industries in their effort to reintroduce shipbuilding at the Fall River Shipyard (Quincy Shipyard).

Professor Triantafyllou has continued research on "Rapid Maneuvering of Autonomous Underwater Vehicles through Vorticity Control". The long term objectives are to study experimentally and theoretically the mechanisms of vorticity control that allow very fast starting and rapid maneuvering in fish and to explore ways for technological developments leading to their use in autonomous underwater vehicles.

Our joint research with MIT Sea Grant's Autonomous Underwater Vehicles Laboratory is continuing. The objective of the project is to develop robust and reliable, high resolution navigation concepts, high resolution tomography approaches, and optimal, adaptive sampling strategies for collection of oceanographic and geological data by autonomous underwater vehicles operating in a large aperture sampling network. The Sea Grant effort is led by Dr. James G. Bellingham while the department's effort is led by Professor Henrik Schmidt.

DEPARTMENTAL AWARDS AND ACTIVITIES

Professor Ira Dyer was the recipient of the Gold Medal of the Acoustical Society of America, its highest award, which was awarded in May, 1996 at the Indianapolis meeting of the Society.

The Linnard Prize at the 1995 Annual Meeting of the Society of Naval Architects and Marine Engineers was awarded for a paper entitled "A Coupled Navier-Stokes Potential Flow Method for the Design of Ducted, Multi-stage Propulsors using Generalized Geometry" to Professor Justin Kerwin, Dr. David Keenan and Gregg Digginsad Scott Black graduate students.

Professor Justin Kerwin has been invited to present the Nineteenth Weinblum Memorial Lecture in Bremen, Germany in October, 1996 and at the National Academy of Sciences in April 1997.

Professor Judith T. Kildow was on sabbatical. Her major objective was to complete her book entitled "Environmental Principles and Management Strategies".

Visiting Professor Hiroshi Kagemoto, of the University of Tokyo is working with Professor Dick Yue on research projects in hydrodynamics.

Professor Henry S. Marcus was the third to hold the chair of Matson Distinguished Professor of Travel Industry Management at the University of Hawaii during his 94-95 sabbatical.

Professor Koichi Masubuchi received the "Order of Sacred Treasure, with Gold Rays and a Neck Ribbon". This award was given by the government of Japan following the order by the Emperor.

Professor Nick Newman was on sabbatical. He used his sabbatical to visit some of his research collaborators to exchange ideas and to continue with his own research in hydrodynamics

Visiting Professor Finn Nielsen of the Norwegian Institute of Technology, Trondheim, spent a year at MIT working with Professors Nick Newman and Paul Sclavounos and our other hydrodynamics faculty.

Professor Triantafyllou's paper on Robotuna ("Scientific American, March 95) was named highlight paper of 1995 in the 150th Anniversary Issue of the Scientific American, September 1995.

Lieutenant Commander Mark Welsh was appointed as Associated Professor of Ocean Engineering in July, 1995 and was awarded the Meritorious Service Medal for outstanding leadership and superlative innovation while serving as the Deputy Research and Development Manager and Integrated Product Team for New Attack Submarine program office.

Professor Tomasz Wierzbicki spent his sabbatical primarily in Germany and France. He continued with his research on Tanker Safety and initiated some new research in the area of crashworthiness.

Michael S. Drooker resigned from our department to accept an offer as Senior Consultant with Information Systems here at the Institute.

Dr. Thomas Korsmeyer has been offered a position on the research staff in RLE here at the Institute. This become effective on July 1, 96. Dr. Korsmeyer continues to hold the title of lecturer in our department.

Dr. Seamus Tuohy resigned from the staff of the design laboratory. He accepted an offer to work at The Charles Stark Draper Laboratory in Cambridge, Mass. Seamus is presently holding a title of Lecturer here in the Ocean Engineering Department.

Two graduate students, Beth Lurie and Todd Taylor received the Graduate Student Paper award at the SNAME annual meeting for their paper on sailboat propellers.

Taryn Westberg, Paul Marquardt and Jason Miller (undergraduates) took the initiative to develop a team project, carried out in the Fall of '95 in subject 13.016, *Introduction to Geometric Modeling and Computation*, into a SNAME student paper. This work, which was carried out in January, 1996 during Independent Activities Period, was presented in January, 1996 at the New England Section student paper night. We learned in June that their paper was selected for the national undergraduate student paper award.

ROBERT BRUCE WALLACE PRIZE

The winner of the 1996 Wallace Prize was awarded to Jason E. Miller. Jason was selected from a list of extremely strong candidates.

MARTIN A. ABKOWITZ INTERNATIONAL FELLOWSHIP PROGRAM

Dr. Charles Mazel, of the Department of Ocean Engineering and Edgerton Center, was awarded the Martin A. Abkowitz Fellowship to attend the 8th International Coral Reef Symposium in Panama City, Panama, in June, 1996

T. FRANCIS OGILVIE LECTURESHIP

The T. Francis Ogilvie Lectureship, was awarded to Dr. Alexander Weigand of the California Institute of Technology who gave a presentation on "Quantitative Visualization for Vortical Flow Research", on December 5, 1995.

ALUMNI EVENTS

Alumni Reunion was held at the Hilton Hotel in Washington, D.C. on October 5, 1995. Professor Chryssostomidis addressed the alumni and outlined some of the key initiatives in shipping and shipbuilding that the department is planning to undertake in the foreseeable future.

Chryssostomas Chryssostomidis

ARTIFICIAL INTELLIGENCE LABORATORY

The central goal of the Artificial Intelligence Laboratory is to develop a computational theory of intelligence extending from the manifestation of behavior to operations at the neural level. Current work focuses especially on understanding the role of vision, language, and motor computation in general intelligence.

The Laboratory also seeks to develop high-impact practical applications in areas such as information transportation, enhanced reality, the human-computer interface, modeling and simulation, image understanding, decision analysis and impact prediction, model-based engineering design, medicine, and supporting computing technology.

Professor Patrick H. Winston works on the problem of learning from precedents. Professor Robert C. Berwick studies fundamental issues in natural language, including syntactic and semantic acquisition. Professor Lynn Andrea Stein works on integrated architectures for intelligence. Professor W. Eric L. Grimson, Professor Berthold K. P. Horn, Professor Tomaso A. Poggio, and Professor Paul Viola do research in computer vision. Professor Rodney A. Brooks, Professor Tomas Lozano-Perez, Professor Gill Pratt, 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 computing 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.

The Laboratory's 168 members include 16 faculty members, 24 academic staff, 35 research and support staff, and 93 graduate students active in research activities funded by the Advanced Research Projects Agency, Air Force Office of Sponsored Research, Alphatech, Inc., Army Research Office, Fujitsu, International Business Machines, Jet Propulsion Laboratory, Korean Atomic Energy Research Institute, Loral Systems Company, Mitsubishi, NASA, National Science Foundation, Office of Naval Research, and Sumitomo Metal Industries.

VISION

ENHANCED REALITY AND OBJECT RECOGNITION

Professor Grimson's group has developed a system that performs Image Guided Surgery, by registering video images with information produced by Magnetic Resonance Imaging machines. This reality-enhancing system, developed collaboratively with researchers at the Brigham and Women's Hospital, makes it possible to superimpose previously recorded Magnetic Resonance Imaging information with a current view of the head of a person with a brain tumor. Extensions to the system include a trackable surgical probe, which enables the surgeon to touch points in the operating field and see, in real time, cross-sectional slices of MR data showing the position of the probe. Neurosurgeons at Brigham and Women's are now routinely using this system for intraoperative guidance and navigation. Similar methods are under development for other surgical applications, such as sinus surgery, endoscopic surgery, and surgeries performed under surgical microscopes.

Professor Grimson's group also works on methods for recognizing objects in cluttered, noisy, and unstructured environments. Recent efforts have focused on the role of visual attention in recognition, and on the development of efficient methods 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. Recent thrusts include applying existing methods to automatic target recognition and visual database search. The latter approach involves a novel method for classifying images on the basis of their content, such as "snowy mountain," "field," "waterfall," and so on. This method uses relative photometric relationships between image regions connected in a flexible template, and supports classification and indexing in large databases, independent of illumination, spatial layout, and color shift.

MOTION VISION AND LOW-LEVEL INTEGRATION

Professor Horn and his students work on problems in motion vision. Because recovery of information about the world from a single cue such as motion parallax, binocular stereo disparity, or shading in images tends to be unreliable, Professor Horn works on the integration of information from multiple cues at a low level, building systems that interlace iterations of different schemes for recovering shape. Preliminary results in integrating motion

vision and shape from shading, and in integrating binocular stereo and shape from shading, both show great promise.

On another front, a new special-purpose early-vision analog VLSI chip will be completed soon. This chip determines an image's focus of expansion---that point in the image towards which the camera appears to be moving. It does this without the need to detect 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. Although it has just 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 development of 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.

As part of an effort in the "Intelligent Highway" arena, the focus-of-expansion chip may be adapted to become a component in a time-to-impact warning system. A time-to-impact chip differs from a focus-of-expansion chip in that the focus-of-expansion chip factors out distances and velocities to recover the direction of motion, whereas a time-to-impact chip takes the direction of motion to be of less interest, while distances and velocities are considered significant. The time-to-impact chip will not be able to determine distances to objects or velocities in absolute terms, but it will obtain the ratio of these quantities, which yields the time to impact. Using such a chip, a warning system will be useful particularly in warning drivers of rapidly approaching objects in their so-called blind spot.

IMAGING IN HIGHLY SCATTERING MEDIA

Professor Horn is also exploring diaphanography, the science of recovering the spatial distribution of absorbing material in a highly scattering medium from optical measurements on the surface of a volume. This is a third domain of image understanding, which stands alongside the usual optical domain of opaque objects in a transparent medium (where pin-hole optics rules) and tomography (where the observed quantities are line integral of absorbing density).

In highly scattering media, the directionality of injected photon flux is quickly lost and the situation is best modeled as a diffusional process. The governing equation is Poisson's equation, and convenient physical models include heat flow in a solid and current in a conductive medium that also has leakage paths to ground. Forward analysis---computing how a photon flux will distribute itself given a distribution of absorbing material---is not hard to compute numerically (although computationally expensive). For simple situations, closed form solutions are also available. The inverse problem---recovering the distribution of absorbing material from a surface image---presents a challenge, however. Under certain combinations of scattering constant, average background absorption, and spacial scale, the problem is not well posed mathematically, and Professor Horn is trying to discover under what circumstances the problem is better posed, and how spatial resolution in the reconstruction is likely to vary with depth.

Potential medical applications include mammography and the imaging of testicular cancers, thyroid tumors, and of brain tumors in infants. Also, in some drug manufacturing and vaccine production, the techniques may enable the dermination of whether an egg contains a live embryo. Because imaging using heat-flow analysis is a related problem, other potential applications include flaw detection in aircraft parts and geological mineral exploration.

LANGUAGE

Professor Berwick and his group have concentrated on the problem of learning a lexicon. In particular, they have come up with a general framework for language acquisition in which linguistic parameters like words are built by perturbing a composition of existing parameters and related it to "traditional" coding schemes like Lempel-Ziv. The important idea is to get the *learned* representation to match linguistic intuitions, rather than some arbitrary code. They illustrate the power of the representation can via several examples in text segmentation and compression, acquisition of a lexicon from raw speech, and the acquisition of mappings between text and artificial representations of meaning.

Professor Berwick and his group also have developed a new compression scheme for natural language. The algorithm was also run as a compressor on a lower-case version of the Brown corpus with spaces and punctuation

left in. All bits necessary for exactly reproducing the input were counted. Compression performance is 2.12 bits/char, significantly lower than popular algorithms like *gzip* 2.95 bits/char. This is the best text compression result on this corpus that they are aware of, and should not be confused with lower figures that do not include the cost of parameters. Furthermore, because the compressed text is stored in terms of linguistic units like words, it can be searched, indexed, and parsed without decompression.

Also, Professor Berwick and Dr. Partha Niyogi have been formalizing linguists' intuitions about language change by advancing a dynamical systems model for language change derived from a model for language acquisition. Rather than having to posit a separate model for diachronic change, as is typically done in the diachronic literature by drawing on assumptions from population biology, this new model dispenses with the need for these independent assumptions by showing how the behavior of individual language learners leads to emergent, global population characteristics of linguistic communities over several generations as the end product of two types of learning misconvergence. As the simplest case, they formalize the example of two grammars (languages) differing by exactly one binary parameter, and show that even this situation leads directly to a quadratic (nonlinear) dynamical system, including regions with chaotic behavior.

ROBOTICS

COG

Under the supervision of Professor's Brooks and Stein the humanoid robot COG became provisionally operational during the last year, and graduate students have started carrying out experiments with the hardware.

Mr. Matthew Williamson has installed his six degree of freedom series elastic actuator arm on COG. He has implemented a low level control system to make the joints act like spring muscles, and then on top of this has implemented the first robotic version of equilibrium point control, a theory developed by Professor Emilio Bizzi of the Brain and Cognitive Science department at MIT.

Mr. Brian Scasselati, Mr. Matthew Marjanovic, and Mr. Matthew Williamson have cooperated in building a system which is able to learn how to move COG's arm in reaching motions based on visual feedback.

Ms. Cynthia Ferrell has integrated a system for visual saccades with a head motion system so that COG can look around the room, much like a human does, coordinating eye and head motion to maintain a steady view of the world.

PLANETARY EXPLORATION ROBOTS

Professor Brooks has continued to work with NASA and JPL on developing technology for autonomous exploration of Mars.

Ms. Liana Lorigo took the Pebbles robot out to JPL and successfully tested her visual navigation algorithms in both their indoor Mars facility and their outdoor "Mars yard."

Ms. Chandana Paul implemented a control system for a small manipulator for Pebbles---this manipulator was designed and built the previous year by Mr. Matthew Williamson and makes use of series elastic actuators so that the arm can hammer, pry, and dig. Ms. Yoky Matsuoka built a new end-effector for this arm.

Mr. James McLurkin developed an operational 30 gram micro-rover. He commenced design work on a 15 gram rover, designed to look for evidence of micro fossils on the surface of Mars.

EVOLUTIONARY PROGRAMMING

Professor Brooks and Dr. Una-May O'Reilly worked on evolutionary techniques to develop programs automatically. The first domain in which they are working is face detection. This was chosen because there has been a lot of work done over the last few years in trying to write programs that can do this well, and the results leave a lot to be desired. Thus if progress can be demonstrated with evolutionary techniques it will validate the techniques as being able to succeed on hard problems that have eluded human efforts.

MANIPULATION AND LOCOMOTION

Professor Pratt's group has been working on robotic systems that are specialized for interaction with natural environments. Unlike traditional industrial robots, these robots are far less concerned with positional accuracy and maximal slew rate. Instead, they must have smooth and stable force-controlled interactions with unknown environments, including tolerance to unexpected shock. Such requirements have led Professor Pratt and his students to develop the concept of series-elastic actuators, which differ from conventional actuators in their purposeful placement of mechanical elasticity between the transmission and the load. This has both been shown theoretically, and demonstrated in prototype hardware, to provide a significant improvement in terminal characteristics. Best of all, this series-elastic design methodology may soon allow for an order of magnitude reduction in the cost of high-quality force actuators because inexpensive gear trains may be used. Given the high number of degrees of freedom required for natural robots, this cost reduction is important.

Robots that interact with natural environments also need control systems that differ from those used in industrial robots, and developing such control systems is a second thrust of Professor Pratt's group. Path planning and accuracy are unimportant, as the environment is dynamic and unpredictable. Rather, what is needed is an appropriate behavioral abstraction to reduce control bandwidth and increase smoothness. In much the same way that early vision extracts discrete features from, and lowers the bandwidth of visual information, this "late motor" processing converts discrete behaviors into smooth interactions and expands the bandwidth of information used to modulate motor action. Professor Pratt's research in this area is presently focused on Virtual Model Control, where simulations of physical systems are used as the processing mechanism for control. Recent efforts have shown this method to be superior to conventional inverse kinematics for describing the control of robot posture.

To support experimental work, Professor Pratt and his students have been constructing a bipedal walking robot and an arm for COG.

ROBOTIC HANDS AND HAPTICS

Dr. Salisbury's group focuses on three areas: sensor guided grasping, study of human and robot hands, and the development of haptic (touch) interfaces and rendering techniques.

In conjunction with Professor Slotine from the Department of Mechanical Engineering, Dr. Salisbury's group has developed a system that can grasp stationary and freely moving objects. The system is being applied to NASA efforts to enable remote planetary probes to autonomously collect geological samples.

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 from simple force-sensing fingertips. Work currently is in progress on a new force-controllable multi-finger hand, and on planning algorithms that enable the hand to continuously reorient objects held in its fingertips.

The group's research in the field of haptics has focused on developing algorithms for rendering the feel of movable rigid objects, and for rendering compliant visco-elastic objects, both using the PHANToM Haptic interface. Additional haptic investigations address "palpating in" texture and compliant properties to populate their object representations, and the development of heat flow and vibratory stimulators. Applications currently include Naval training tasks, surgical simulation and robotic reactor maintenance modeling.

ASSOCIATE SYSTEMS THE INTELLIGENT ROOM

The Intelligent Room is a new facility constructed during the past year for work on Human Computer Interaction (HCI). The work aims to develop a computational infrastructure that is aware of people, their actions, and their goals through the use of vision and sound understanding. During the first year, students of Professors Brooks, Lozano-Perez and Stein have developed systems that enables presenters to use speech and gesture to navigate through a presentation prepared on the World Wide Web and to use gesture to assign video sources to monitors. Other software from Dr. Victor Zue's group at the Laboratory for Computer Science and from Jim Hollan's group at University of New Mexico have been integrated into the Room.

SOFTWARE AGENTS

Professor Stein's group also works on software and information agents. Mr. Michael Coen's SodaBot/SodaBotL is a software agent environment and construction system designed to facilitate the rapid prototyping and deployment of personal and application-based software agents, as well as communities of semi-autonomous associate systems.

Prior to SodaBot, building agents has generally involved a multi-layered approach ranging from low-level "system-hacking" (e.g. of mailers, networks, etc.) to high-level application development (e.g., a meeting scheduler), and everything in between. Each layers can require a substantial amount of independent implementation and debugging. Additionally, it can be difficult to distribute new agents: they tend to be site-specific in intricate ways, and disconnecting them from their local dependencies can be technically involved.

Mr. Mark Torrance's "Active Notebook" is a tool that organizes collected information according to a user's personal conceptual taxonomy. Over the next year, Active Notebook will be expanded to better facilitate groupware applications.

INFOLAB

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 Borchart, 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, the core functionality of version 2.0 of the IMPACT system was completed. This system uses the transition space representation to support interactive development, modification and tracking of plans on the basis of real-world observables. Users of IMPACT work with a "spreadsheet for events" which integrates the collection and reconciliation of reports from the field, provides a graphic presentation of that information, propagates constraints, and supplies "what if" reasoning functionality regarding possible events and their consequences.

Work on the IMPACT system forms one component of a larger effort called the Infolab Project, which is focused on the development of systems that help humans solve problems on human terms, interacting through the concentrated use of simple language, images, diagrams, and other modes of expression that are intrinsically meaningful to humans and engage intuitive human problem-solving skills. To this end, Dr. Boris Katz has been developing the START natural language query retrieval system. During the past year, members of Professor Winston's group have assisted Dr. Katz in constructing the START Bosnia Information Server, a World Wide Web resource that provides access to multi-media information in response to natural language questions about the U.S. mission in Bosnia-Herzegovina.

SCIENTIFIC AND ENGINEERING REASONING INTELLIGENT SIMULATION

The research of the 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.

Recently, the group has also demonstrated that intelligent simulation can help in creating dynamically stabilized structures. Such structures will be sensitive and active, incorporating networks of high-performance controllers. They have constructed and demonstrated a prototype column that is actively stabilized by piezo-electric actuators. This column supports 5.6 more load than a passive column of the same size could support. They have also demonstrated a truss bridge that uses actively stabilized members to support greater loads than would be possible without active control.

Over the past four years, five of the group's recent graduates have received National Young Investigator awards, largely based on their work on the development and application of intelligent simulation technology. Professor Jack Wisdom, a collaborator with the group, was awarded a MacArthur Fellowship, partly on the basis of work done here.

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. Their systems reason about how devices work and how they fail 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.

Recent work is focused on understanding how things work in domains that include simple mechanical devices 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.

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. The 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.

COMPUTATIONAL INFRASTRUCTURE SYMBOLIC PARALLEL ARCHITECTURES

The Symbolic Parallel Architecture group, under the direction of Dr. Knight, has been developing technology for the next generation of parallel computer systems. The group is developing, for example, compilers that automatically feed back experience in running code for use in the layout and compilation process. Work on extremely low power computing using reversible logic approaches also continues, with funding in place for implementing the first fully reversible computer system using the group's low power technology. The Abacus SIMD vision processor component has been fabricated, and is undergoing initial testing. Abacus is designed for high-speed processor-per-pixel image handling for early vision applications. Finally, chip-to-chip freespace signaling technologies are under development for use in novel self-assembling arrays of processors. Such processor chip arrays are under

study for applications in sensor and effector systems, as well as for implementing simple, local communication for modeling physical systems.

CONCURRENT VLSI ARCHITECTURE

The Concurrent VLSI Architecture Group, under the direction of Professor Dally, develops techniques for applying VLSI technology to solve information-processing problems. The group has been developing the M-Machine, an experimental parallel computer that tests new concepts for the control of multiple arithmetic units, interprocessor communication, and memory addressing. During the past year, the group has completed most of the register-transfer-level design of the M-Machine's multi-ALU processor (MAP) chip. Circuit design and layout of portions of the chip have been performed in collaboration with the Microelectronics Center of North Carolina (MCNC). With collaborators at the California Institute of Technology, they have been adapting the Multiflow compiler to generate parallel code for the M-Machine, and they have been writing an operating system that provides coherent shared memory in software.

The group has also been developing the Reliable Router, a multicomputer network component. The Reliable Router demonstrates new algorithms for adaptive routing and fault tolerance in interconnection networks. It also demonstrates new circuit techniques for simultaneous bidirectional signalling (sending bits in both directions simultaneously over one wire) and plesiochronous synchronization.

MULTI-AGENT SYSTEMS

The study of participation in Multi-Agent Systems (MAS) can help develop scalable, plural, open information infrastructures, comprised of humans, equipment, and services. Participation in MAS depends on a synergy of interdependent, overlapping, and mutually supporting information infrastructures: availability infrastructures and participatory infrastructures. Availability infrastructures impact development of participatory infrastructures: e.g., mobile wireless infrastructure platforms can be immediately informed on-site about current whereabouts and participation, providing information needed for message screening infrastructures to manage interruptions. Participatory infrastructures impact development of availability infrastructures: e.g., message screening infrastructures reduce unwanted interruptions of the sort that cannot be tolerated in wireless communications.

Availability Infrastructures make information services available, enabling MAS participants. Availability infrastructures provide accessibility, immediacy, responsiveness, and transparency. *Participatory infrastructures* provide services for participating and accounting for participation. They provide services which semantically link activities for operating, predicting, assessing, and planning.

Professor Hewitt's group is developing foundations to address how participation is described and processed using telecomputer services. They call their approach *Participatory Semantics*. Their approach concentrates on *participation* how, when, who, what, where, etc. They take participation as distributed, open (multi-agent) activity. They take semantics of participation broadly: it includes influences on all subsequent participation. Criteria they have identified for participatory semantics are concurrency, scalability, plurality, and openness.

Patrick Henry Winston

BIOTECHNOLOGY PROCESS ENGINEERING CENTER

The Biotechnology Process Engineering Center (BPEC), an interdepartmental 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. The BPEC, through a highly competitive reapplication process, has been awarded an additional 11 years of funds by the NSF effective September 15, 1994 through September 14, 2005.

The mission of the BPEC is to develop advanced manufacturing ideas and technologies, to ensure US 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.

INFRASTRUCTURE

As an interdepartmental center, the BPEC reports to the Dean of Engineering. The center's management consists of the Director, Daniel I.C. Wang, Institute Professor and Professor of Chemical Engineering. In addition to the Director, the management team consists of the Associate Director, Gregory N. Stephanopoulos, Professor of Chemical Engineering, the Assistant Director, Ms. Audrey Jones Childs, and four thrust team leaders. The thrust area leaders meet with the Director once a month to discuss the critical issues in research, financial planning, new research initiatives, and new members to the BPEC. The Thrust I leaders are Anthony J. Sinskey, Professor of Biology, and Gregory N. Stephanopoulos, Professor of Chemical Engineering. The Thrust II leaders are Jonathan A. King, Professor of Biology, and Alex M. Klibanov, Professor of Chemistry. This managerial team is a reflection of several changes that were made during fiscal 1996. The first change was the appointment of Ms. Audrey Jones Childs as Assistant Director for Administration and Operations. The second change was the consolidation of three associate directors into a single Associate Director, Professor Gregory N. Stephanopoulos. The Associate Director oversees the industrial collaborations, technology transfer, and the industrial consortia. A third change in management during fiscal 1996 is the addition of an Industrial Coordinator, Dr. James Leung. Dr. Leung has joined BPEC as a Consultant to coordinate the industrial activities. In addition to these changes, three new faculty members joined the center. These new members are Professor Hermann Steller, Departments of Brain and Cognitive Sciences and the Department of Biology, Professor Martin L. Yarmush, Mass General Hospital, and the Harvard-MIT Health Science and Technology Program, and Daniel Blankschtein, Professor of Chemical Engineering. Dr. Daniel I. C. Wang, Director of the BPEC, was honored with the position of Institute Professor on July 1, 1995.

RESEARCH STRUCTURE

A cross-disciplinary team consisting of biologists, chemists, and chemical engineers executes the research in two thrust areas: 1. Therapeutic Protein Production: Quantity and Quality; and 2. Therapeutic Protein Aggregation, Stability, Formulation and Delivery. Cross-disciplinary educational and research collaborations are especially important components of the center's activities.

A team of 14 faculty members participated in the center's activities from July 1, 1995 through June 30, 1996. They are from the Departments of Chemical Engineering (School of Engineering), Biology, Brain and Cognitive Science, and Chemistry (School of Science), the Mass. General Hospital/MIT's Harvard Science and Technology Program, Department of Chemistry at 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, 355 personnel took part in the center's research activities during fiscal 1996. This figure comprises of the following: 38 MIT Undergraduate Research Opportunities Program students (UROP), eight MIT Undergraduates working on course-related projects; 12 non MIT undergraduates from 12 different Universities who participated in the center's NSF Research Education for Undergraduates Program (REU); 102 graduate students from four departments; four technical assistants; 62 postdoctoral associates/fellows; 46 visiting scientists, engineers, industry researchers, five other administrative personnel and 14 faculty.

Funding sources are explained as follows. The NSF provides the major financial support for BPEC personnel. The National Institutes of Health (NIH-NIGMS) provide additional support for graduate educational activities for the MIT students. In addition, unrestricted funds were secured from outside sources. The center received industrial donations in the form 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 the type of applicants. To assure many applicants for the National Institutes of Health Interdepartmental Training Grant, we have formed a minority recruitment committee. Specifically, recruitment for the BPEC's outreach programs was lead by Ms. Araba Lamoussé-Smith at the National Society of Black Engineering National Conference.

EDUCATIONAL ACTIVITIES

The goal of BPEC's educational programs is to train undergraduates, graduates, post-doctoral and industrial personnel. BPEC's vision in the educational programs is to incorporate biotechnology principles into our existing courses. This is being accomplished through course modifications and interdisciplinary teaching in the areas of chemistry, biology, and chemical engineering. The planning of our educational programs affects all sectors of the student body. To provide an industrial perspective to our students, course contents have been planned to incorporate real problems in biotechnology manufacturing. Invited lecturers from the biotechnology industry expose students to current day research problems.

To meet the goals and objectives of our educational visions, the course curricula for undergraduates, graduates and industrial personnel have continually undergone changes and implemented new initiatives. For example, to integrate biotechnology concepts as well as our research thrusts, several undergraduate courses have met the above challenges. These include "Chemical Kinetics and Reactor Design"; "Biotechnology and Bioengineering"; "Molecular and Engineering Aspects of Biotechnology"; "Chemical Engineering Project Laboratory"; and "Integrated Chemical Engineering." At the graduate level in education, a large number of courses have been modified to incorporate the research thrusts from the BPEC. In addition, new courses have been implemented as a direct result of the presence of the BPEC. The following courses taught by the BPEC faculty, relate directly to the BPEC's research thrusts: "The Folding Problem"; "Principles and Methodologies of Metabolic Engineering"; "Biochemical Engineering"; "Separation Process for Biochemical Products." Several graduate activities and courses that provide both cross-disciplinary principles as well as systems view were also taught by the BPEC faculty. Examples of these course activities are: "Cell Culture Optimization Consortium"; "Macromolecular Structure and Function Seminar"; and "Seminar on Pharmaceutical and Biotechnology Industry Management." To ensure the educational needs of industry are met, the BPEC provided one-week special summer courses. These courses included "Fermentation Technology", "Downstream Processing", "Advances in Controlled Release Technology and Delivery of Pharmaceuticals and Other Agents", and "Management for Physicians, Scientists, and Engineering in the Pharmaceutical and Biotechnology Industry."

The most recent educational initiative is the establishment of the "Metabolic Engineering Laboratory." This laboratory course is in its organizational stage that started in fiscal 1996 is to be tested in fiscal 1997. The National Science Foundation awarded additional administrative funding for the organization of this course.

One of the BPEC's goals is to ensure that the undergraduate students are integrated into the Center's research thrusts. The BPEC provides the initial research experiences to the undergraduates and encourages the students to work in industry as internees. For example, BPEC's industrial coordinators contacted 15 companies associated with BPEC for summer undergraduate internships. A total of 33 BPEC undergraduates was provided to these companies.

The two main BPEC outreach undergraduate programs are the Undergraduate Research Opportunities Program (UROP) and the Research Experience for Undergraduates (REU). The NSF funded REU program supported 12 non-MIT students. It is of interest to note that three REU students applied for graduate studies at MIT. Each student was required to present their research experiences during the center's summer seminar series "UROP and REU Seminar." The students were taught basic research and presentation tools during a "How to Give a Presentation" workshop series. As part of the student's research training, the BPEC instilled cross-disciplinary and

team research in each student. All BPEC students were also invited to participate in the center's seminar series on Scientific Integrity that was lead by academic and industrial speakers.

Outreach activities in fiscal 1996 included participation of faculty from other universities along with their students in the center's research. Outreach activities by the BPEC included tours (i.e., a tour for 19 under-represented minority students and teachers from the Boston and Cambridge, MA schools). Since the BPEC has two Co-PI's (Professor C.S. Lee, Iowa State University and Professor F.E. Regnier, Purdue University) collaborating with our center, these individuals brought their students and postdocs to the BPEC during the fiscal 1996 summer months.

At the graduate level, the center continued to bring interdisciplinary ideas into the course teachings. BPEC successfully completed the seventh 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 and was renewed for an additional five years of funding effective July 1, 1994. 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 chair. The BPEC graduated 24 Ph.D. candidates, four M.S. candidates, and seven B.S. candidates. Nearly 75% of our graduates enter industry. At a time when industrial hiring has decreased in other disciplines, we have not found this to be the case for our graduates because of the training that we have provided in biotechnology process engineering.

To ensure the educational needs of industry are met, the center has provided one-week special summer courses achieved through the Special Summer Course Program at MIT. In fiscal 1996, four special summer courses under the auspices of the BPEC were presented.

CURRENT RESEARCH

The vision of the Biotechnology Process Engineering Center (BPEC) is to establish, through research and education, the advanced manufacturing concepts and processes that will ensure the competitiveness of the US biotechnology industry. To achieve this goal, a strong cross-disciplinary team consisting of biologists, chemists and chemical engineers has been formed to execute its programs. The research thrusts of the BPEC have continued to focus on the original vision: the production of complex therapeutic proteins. However within each thrust new concepts have been added due to the completion of some of the previous goals. BPEC presently has two main thrusts in research education and industrial involvement: Thrust I. Therapeutic Protein Production: Quantity and Quality; and Thrust II. Therapeutic Protein Aggregation, Stability, Formulation and Delivery.

In Thrust I, the increases in the quantity of therapeutic protein production are achieved by addressing nutrition, physiology, and biochemistry of cell metabolism in bioreactors. To improve the protein quality, modern and advanced bioanalytical characterization of glycoproteins in real-time is part of the overall goal. In particular, the BPEC is focused on the underlying reasons for macroheterogeneity (site occupancy) and microheterogeneity (antennary structure). In Thrust Area I, the two sub-thrusts deal with an integrated and systems view of quantity and quality in protein production. A major interface between these sub-thrusts as well as to Thrust Area II involves analytical monitoring and characterization of therapeutic proteins. The research foci contain both knowledge-based and technology-based concepts. For example, medium design and bioreactor control research is driven by principles in biochemistry and metabolism. We have demonstrated proof-of-concept and have improved significant the quantity of protein during production. This milestone allows us to explore technology transfer with industrial partners as a testbed for our achievements. A user-friendly algorithm from this research has been developed to enlarge our circle of testbed sites with multiple industrial partners. During the past year, two concepts were added to address the underlying reasons for cell death. The ultimate goal of this research sub-thrust is to provide the industry with rational and sound process development methodologies and the ability to produce therapeutic proteins with high productivity and in large quantity.

In Thrust II, the objective is to address protein aggregation, stability, formulation and delivery. This is the critical cost factor for therapeutic proteins since this final stage of production is associated with the highest cost. Protein aggregation is important in product stability, protein folding/refolding, disease state (amyloids) and vaccine

virulency. During the past year knowledge-based milestones were achieved which included development of a novel technique to detect protein aggregation in its undenatured state, and demonstration that protein aggregation has specific pathways with multimeric polymerization as the mechanism. These findings are important in several future technological milestones which are the directions for our future programs.

The second sub-thrust focuses on the structure of solid protein formulations and the effects of bioprocessing parameters on protein stability. Our knowledge-based milestone has been demonstrated using FTIR spectra to monitor changes in the (-helical structures of solid proteins during lyophilization. This mechanistic understanding of structure-function relationships allows us to examine possible methods to stabilize proteins through the rational incorporation of excipients. A technology-based milestone has also been achieved, which addresses the lyophilization process parameters that affect protein stability. In addition, the pH history of a protein prior to lyophilization has also been demonstrated to effect protein stability. This finding is an important technological contribution toward protein stabilization. These milestones in protein stability have already been transferred to various industrial collaborators.

It has always been our strategy to affect our Center activities with interdisciplinary and multidisciplinary participants. Furthermore, an integrated approach in research and education is believed to be a major strength of our Center.

INDUSTRIAL COLLABORATIONS AND TECHNOLOGY TRANSFER

The industrial interactions during fiscal 1996 were achieved through both knowledge-based and technology-based advances. Industrial collaborations and technology transfer are important goals of the center. The BPEC's Industrial Advisory Board helps the center reach its goals. The Board consists of members from important sectors of industry and academia. Their function is to assess and plan both long-range and generic issues in research education. The board members are also in a position to forecast the future exciting developments in biotechnology. In addition to this Board, the center's Research Managers have shorter range goals and objectives with specific issues and defined technological barriers within their organization. One of their objectives is to serve as a conduit in identifying specific individuals or groups within a company for the detailed collaboration. As champions for the interactions, these Research Managers serve the important function to secure the necessary financial support for the collaborations.

Since there has been a gradual decline in the BPEC Consortium (38 current members), a new "Cell Culture Process Optimization Consortium" was planned and implemented between January 1995 to June 1995. The consortium was inaugurated in June 1995. The Director of this consortium is Professor Gregory N. Stephanopoulos. Eight BPEC faculty members are part of the consortium. There are presently four affiliate members and 10 companies who are in the process of becoming affiliate members. The BPEC interface with the consortium members is achieved through the consortium coordinator, Dr. James Leung.

Responsibilities of the BPEC's Industrial Consortium Office 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 to serve company needs

In addition to this research consortium, the BPEC also collaborates with industry through other means. There are often very specific collaborations between a given BPEC faculty and a given company. Formal collaborations through these efforts are achieved via grants and contracts directly to the participating faculty. A total of 30 companies collaborates with the BPEC in its two research thrust areas. It should be noted that some companies collaborate on more than one project.

A further indication of the significance of the BPEC to industry is the large number of US companies that have visited the Center. Sixty visits were made this past year and represent the interests of the biotechnology industry to find out the cutting-edge research that we believe is important to the industrial sectors today and tomorrow.

There are several ways in which advances in technology can be reported. The knowledge-based information research represents one facet of technology transfer. This type of information transfer is presented by publications,

presentations, and seminars. Our faculty presented 34 industrial seminars reaching an attendance of 1,875. In addition, the faculty made 125 technology-based presentations to societies, conferences, and symposiums; presented 42 seminars for academia; and published 192 BPEC thrust related publications.

Another example of significant advances in technology transfer is based on patents arising from the research in the Center. Patents represent novel and new concepts and can be considered to be an effective means for transfer technology. Twenty-three patents were filed by the BPEC faculty; five of these patents were granted; and nine patents were licensed during fiscal 1996.

Daniel I. C. Wang

CENTER FOR TECHNOLOGY, POLICY, AND INDUSTRIAL DEVELOPMENT

The Center for Technology, Policy, and Industrial Development was founded in 1985 to foster teaching and research focused on policy issues related to science and technology. The Center was established in response to the realization that as technology proliferates, it effects profound and pervasive changes in our economic system and its component industries, which intensify the fundamental complexity of our lives. That growing complexity challenges us to develop policies that will allow us to enjoy the benefits of these technologies and will at the same time protect us against their harmful side effects. The Center's goal is to understand the effect of technological changes on the development of society and to help formulate policies for an era of intensified international economic competition.

HIGHLIGHTS OF THE PAST YEAR

The Center has appointed Profs. Michael J. Piore and Charles Fine as its Associate Directors. These new positions were made possible by a ten-fold increase in research activity through the 1990s. Now with stronger ties to the Department of Economics and the Sloan School of Management, the Center hopes to involve a broader group of researchers in its interdisciplinary educational and research programs. The appointment of the new Associate Directors came at a time not only of significant growth but also as the CTPID marked its 10th anniversary at MIT.

CURRENT RESEARCH PRIORITIES

The Center for Technology, Policy, and Industrial Development oversees research activities in many disciplines. Several of these activities have a common theme of industry studies. We have found industry studies to be valuable and insightful both in terms of increased understanding and also as a framework for change and innovation.

CTPID's role in industry study projects is to be objective and not advocate any particular policy position. As such, it can serve as a facilitator or "honest broker", bringing together interested and impacted parties who offer different approaches to important issues. Utilizing the knowledge base, it can analyze and evaluate different approaches. The Center can relate independent studies to a common framework and data base and thereby help to sharpen the debate and understand the nature of disputes and disagreements. The industry study programs are a major focus of the Center but by no means the only focus. Below is a highlight of research activities within the Center's individual program groups.

INTERNATIONAL MOTOR VEHICLE PROGRAM

The International Motor Vehicle Program (IMVP) is a multidisciplinary research enterprise that performs comprehensive studies of the automobile industry worldwide, as well as its effect on society. The research follows two courses: One examines automobile manufacturing by identifying the best practices, assessing industry performance standards, and developing international comparisons of assembly plants, suppliers, and distributors. The other research pursuit evaluates how the automobile relates to society in relation to the complicated issues of the environment, regulation, and a variety of cooperative relationships evolving between management and labor and business and government.

In the past year, the IMVP had expanded and continued several benchmarking projects, including Phase 2 of the International Assembly Plant Study (now comprising 21 companies, 86 plants and 20 countries), the International Engine Plant Study and the International Stamping Plant Study. The IMVP also collaborated with the International Car Distribution Programme, based in Great Britain, to expand its research in automobile distribution.

In addition, the IMVP further developed the Auto Case 2000, an interactive software-driven simulation model for predicting the outcomes of different automobile manufacturing strategies. This database is complemented by the Superdatabase project, now in early development and comprising component databases from all aspects of IMVP research. Co-Directors for IMVP are Profs. Daniel Roos and Charles Fine.

LEAN AIRCRAFT INITIATIVE

The Lean Aircraft Initiative (LAI) analyzes how the "lean" paradigm, identified by the International Motor Vehicle Program in the auto industry, can translate into the U.S. defense aircraft industry. This industry now faces monumental challenges in the face of shifting defense priorities, massive spending cuts, and the need for defense

conversion. The industry must become increasingly more competitive and make significant improvements in affordability, quality and productivity to succeed in this difficult, uncertain and fast-changing environment.

The development of the Lean Enterprise Model (LEM) had been a major activity for LAI last year. The LEM is intended to provide an accessible compilation of those principles, practices, metrics and enablers that characterize the lean aircraft business enterprise. The LEM prototype now has three formats: a display chart, a notebook and a computer-electronic version.

Originally conceived as a three-year research project beginning in 1993, the LAI will now enter Phase II, expanding its research agenda another three years, beginning in September 1, 1996. Director for LAI is Prof. Earll Murman.

FAST AND FLEXIBLE COMMUNICATION PROJECTS

The Fast and Flexible Communication Projects, part of an ongoing government initiative to improve U.S. manufacturing capability, analyze product-development in the automotive and aerospace industries, focusing particularly on the relationship between complex assemblies and multiple sources for parts and tooling. Originally designed as a 28-month project in 1994, the research has been extended for an addition two years and now comprises two sections: the Fast and Flexible Communication of Engineering Data in the Aerospace Industry, and the Fast and Flexible Communication Design and Manufacturing Systems for Automotive Components and Sheet Metal Parts.

The projects' research has focused on developing more "agile" or "fast and flexible" communications and processes. A component of its research includes hypothesis testing of agile manufacturing principles, developed by the Agile Manufacturing Forum at Lehigh University. The projects have deployed faculty, staff and site-located graduate students from MIT and Lehigh University at three sites: General Motors Saginaw Steering Division; Vought Aircraft Company Aerospace (now a subsidiary of Northrop Grumman Corp.); and Ford-Louisville Assembly Plant, along with its primary sheet metal supplier, Budd Company. Co-Directors for the projects are Prof. Charles Fine and Dr. Daniel Whitney.

INTERNATIONAL COOPERATIVE MOBILITY RESEARCH PROJECT

The International Cooperative Mobility Research Project's objective is to improve our understanding of world motorization as a phenomenon, help implement policies to alleviate the problems increased motorization may bring, and facilitate the opportunities increased motorization may yield. The Mobility Project provides a new vision of a sustainable multimodal transportation system, analyzing what our mobility needs and choices are through the process of collecting data worldwide and comparing how certain policy and technology approaches have worked in facilitating mobility.

Now in its initial stages, the Mobility Project has begun work in establishing the International Mobility Observatory, an effort to identify, evaluate and document outstanding examples of innovative mobility systems and strategies worldwide. The project team was met twice -- once with sponsors and once with only researchers -- and has produced a compendium of noteworthy mobility initiatives.

RESEARCH PROGRAM ON COMMUNICATIONS POLICY

The Research Program on Communications Policy (RPCP), formerly known as the DOHRS Program, was established at CTPID with the following objectives: To study technical, economic, and policy challenges to open interfaces for scalable digital systems and broadband networks; to facilitate cross-industry, cross-government agency, and cross-academic discipline dialogue on these issues; to disseminate the results of these activities.

Major RPCP projects developed over the past year and continuing into 1996 include: (1) launching the Internet Telephony Interoperability Consortium, a research organization focused on providing interoperability between the Internet and traditional telephony; and (2) investigating the policy implications of an MIT-developed camera, now manufactured by Polaroid, which is capable of shooting 60 frames a second, as opposed to the standard movie format of 24 frames a second, and which could reshape the awaited Federal Communications Commission ruling over a broadcasting standard for high-definition television. Director for RPCP is Dr. Amar Gupta.

MATERIALS SYSTEMS LABORATORY

The Materials Systems Laboratory (MSL) is internationally recognized for its innovative work on the competitive position of materials and products in automotive, aerospace, electronic and environmental applications. It fosters a unique combination of knowledge of design and production processes used in industry with managerial economics.

MSL has been particularly successful in developing an understanding of the cost of using new materials, such as powdered metals and ceramics, in a wide range of applications and contexts. Two continuing research projects for MSL in 1995 had been (1) establishing the impact of automobile technology upon the development of materials and (2) identifying new trends in automobile materials. Director for MSL is Prof. Frank Field III.

TECHNOLOGY, BUSINESS AND ENVIRONMENT PROGRAM

The Technology, Business and Environment Program was founded to help companies meet the dual challenges of achieving environmental excellence and business success. The Program's mission is to elucidate a new preventive environmental management paradigm, centering on business practices and linking technological change with sound environmental management.

Two major projects for TBE in 1995 had been (1) a research initiative to study the ways companies are adopting non-regulatory codes of environmental management; and (2) a set of studies looking at the adoption of tools and guidelines for introducing environmental themes into a company's products and processes. Director for TBE is Dr. John Ehrenfeld

TECHNOLOGY AND LAW PROGRAM

The Technology and Law Program offers a cluster of graduate-level subjects within the Technology and Policy Program at MIT, as well as research opportunities at the interface of law and technology. Research activities in 1995 included the design and evaluation of policies for: encouraging technological change for preventing chemical accidents and pollution through regulation, liability and economic incentives; promoting environmental justice by involving communities in governmental and corporate decisions that affect their health, safety, and environmental concerns; and investigating sustainability, trade and the environment. The Program's director is Nicholas Ashford.

TECHNOLOGY AND POLICY PROGRAM

The Technology and Policy Program educates men and women for leadership on the important technological issues confronting society. TPP prepares its graduates to excel in their technical fields, and to develop and implement effective strategies for dealing with the risks and opportunities associated with those technologies. TPP's primary efforts concentrate on the Master of Science Program that prepares students for practical work in government and industry. With about 140 students on campus and over 500 graduates, it is now the largest of its kind in the world. Students require between one and two years to complete the degree which includes an interdisciplinary thesis focused on a Technology Policy issue.

The Summer Internship Program had been the major innovation in 1995. This program placed 35 graduate students in policy-oriented internships in government agencies and in industry in the United States and abroad. Chairman for TPP Prof. Richard de Neufville.

MIT COMMUNICATIONS FORUM

The Communications Forum is an interdisciplinary seminar series that reviews the full range of communications-related issues. The topics include developments in communication technology, the economics of the telecommunications markets, and regulations in the communication industry -- just to name a few. Sessions are held approximately every two weeks. Director for the Forum is Prof. David Thorburn.

CENTER FOR TECHNOLOGY, POLICY, AND INDUSTRIAL DEVELOPMENT

The Center for Technology, Policy and Industrial Development has an extensive Internet site at "<http://web.mit.edu/ctpid/www>", where one can attain research papers and more information about its program groups and personnel.

Christopher Wanjek

Center for Technology, Policy, and Industrial Development

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CENTER FOR TRANSPORTATION STUDIES

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 and logistics at MIT.

The Center's Web address is <<http://web.mit.edu/cts/www>>. In addition to a wealth of information about the Center and its programs, the site includes descriptions of current research projects in transportation, and a listing of MIT theses in transportation since 1980. Transportation faculty and research staff are also listed with their areas of interest, along with connections to other interesting resources on the Web.

EDUCATION

Because the quality of applications remains consistently high, qualifying for graduate admission for transportation studies is increasingly difficult. This year, 77 applications were received for graduate studies in transportation, and 20 students were enrolled. Funding was found for 80% of the students.

In December, 35 undergraduates from around New England came to MIT to learn about graduate transportation programs at MIT and Harvard and at the Universities of Massachusetts, Connecticut and Rhode Island. The open house event was sponsored by the Region One UTC Program (headquartered at the Center), of which those schools are all a part.

A new course was introduced this spring dealing with reshaping the transportation system and the supporting transportation organizations of eastern Massachusetts. The course design had students working in a team to produce a written and oral report based on background lectures, interviews with principal actors, literature review and their own ideas and insights. In the process, students learned about organizational and institutional issues and about the specifics of transportation in Massachusetts. They also gained experience with working in a team on a simulated high-level consulting project, and had an opportunity to sharpen their oral, written and graphic communication skills.

RESEARCH

During the past academic year, 157 projects were listed in the Center's *Current Research Projects in Transportation at MIT*, 50 of which had been started since last year's listing was printed. Sponsored research volume increased by 14%.

MAJOR NEW PROJECTS

East Japan Railway Company

As part of our research into Intelligent Transportation Systems, we are developing new train control systems which utilize emerging information technologies. The total system design is being studied, as well as key component technologies.

Martin Marietta Energy Systems

The goal of the overall project is to develop a deployable real-time Dynamic Traffic Assignment (DTA) system. The system shall be able to serve as an effective integrator between ATMS and ATIS and shall be deployable in real time in a large and congested network in which recurrent and non-recurrent congestion may occur.

Jet Propulsion Laboratory

This effort is in support of the Traffic Surveillance and Detection Technology Development Program. MIT will design, develop, fabricate, assemble, integrate and test a sensor or sensor system employing color vision technologies designed for vehicle traffic surveillance and detection.

INTEGRATED SUPPLY CHAIN MANAGEMENT PROGRAM

Since its inception last year, the MIT/Industry Integrated Supply Chain Management Program has grown to ten members -- Amoco, Caliber Logistics, CVS, Lucent Technologies, Monsanto, Procter & Gamble, Quelle, Siemens,

Xerox and Volkswagen. To date, ten research projects have been initiated, six quarterly collaboration meetings have been held at sponsor locations, and the first annual executive seminar has been conducted, attracting over 55 senior managers from sponsor companies for a two-day session.

CENTER AWARDS \$50,000 IN SEED FUNDING

The Center awarded \$50,000 in seed funding for new research in 1996. The grants, which were funded by the Center's Corporate and Public Affiliates programs, were designed to support research which was not otherwise funded and which showed the potential to generate significant future research opportunities. The selected proposals were: *Cynthia Barnhart*, Associate Professor of Civil and Environmental Engineering and Mitsui Career Development Professor, for "Real-Time Control of Transportation Systems;" *Carl Martland*, Senior Research Associate, Department of Civil and Environmental Engineering, for "Steady State Cyclical Queues: Development of Approximate Solutions for Use in Transportation Systems Analysis;" and *Paul Carlson*, Research Assistant, Department of Civil and Environmental Engineering, for "Space Transportation."

MAJOR MEETINGS

SYMPOSIUM ON THE PRIVATIZATION OF TRANSPORTATION

Nearly 60 people convened at MIT in November for a two-day symposium entitled "Transportation Privatization: Potential and Reality." The purpose of the meeting was to explore the potential of privatization in the transportation sector and the lessons learned from experiences to date, focusing both on privatizing transportation operations and on privatizing infrastructure design, construction and maintenance for surface transportation systems. Participants in the symposium represented 29 organizations including private carriers; federal agencies; state turnpike, transit, highway and port authorities and departments of transportation; metro transit agencies; finance organizations; Boston's Central Artery/Tunnel Project; Harvard and MIT. The speakers represented public, private and academic organizations from four different states, the District of Columbia, Puerto Rico, Argentina, England and Japan.

EXECUTIVE SEMINAR IN INTEGRATED SUPPLY CHAIN MANAGEMENT

In January, the Integrated Supply Chain Management Program marked its first anniversary with a two-day executive seminar for its sponsors' senior management. Attended by nearly 70 people, the meeting gave senior executives the opportunity to learn what supply chain is all about and to learn about the latest MIT research in the area.

SYMPOSIUM ON ADVANCED BUSINESS CONCEPTS IN TRANSPORTATION AND LOGISTICS

In March, the Center's Corporate Affiliates Program sponsored a two-day symposium at the MIT Faculty Club on "Advanced Business Concepts for Logistics and Transportation." Attended by nearly 80 people, representing 38 public and private organizations, the symposium explored a range of vital business issues and concepts, including advances in manufacturing, team management, buyer-supplier partnerships and supply chain integration. Each session featured leaders from academia and from industry presenting the newest research and exemplary industry practice, and concluded with discussion of the implications of these concepts for the future of logistics and transportation.

SEMINAR ON ADVANCED RESEARCH PROJECTS IN ITS

About 75 people from federal, state and regional government agencies, along with private sector representatives, convened at MIT in April for a seminar on Advanced Projects in Intelligent Transportation Systems. Sponsored by the Center's Public Affiliates Program, established in 1994 to create a critical mass of energy focused on the challenges facing public agencies in transportation, the meeting was held to discuss new research activities here in the areas of Advanced Travel Information Systems and Advanced Traffic Management Systems. In addition to reporting relatively technical results of basic research, panelists also talked about the application of that research.

SEMINAR ON ELECTRONIC COMMERCE FOR LOGISTICS AND TRANSPORTATION

In May, more than 60 people representing 29 shippers, carriers, logistics providers and government agencies, came to MIT for a day-long seminar sponsored by the Center on Electronic Commerce for Logistics and Transportation. The purpose of the meeting was to explore the state of the art in such topics as electronic data interchange, commerce on the Internet, satellite-based tracking systems, etc., and its agenda included proposals for new ventures by MIT student teams. The meeting was held in conjunction with a larger event the day before on Electronic Commerce and Corporate Survival, sponsored by MIT's Industrial Liaison Office and attended by about 20 of the

Center's participants. The night between the two meetings, the Center co-sponsored -- with the MIT Enterprise Forum -- a presentation featuring Tim Berners-Lee, "the man who invented the Web."

SMALLER FUNCTIONS

ANNUAL TRB RECEPTION

As usual, the Center sponsored a reception at the annual Transportation Research Board meeting in Washington in January. In spite of a blizzard which virtually shut the entire capitol down for a week, this year's event was attended by about 50 alumni and friends.

LUNCHEON SEMINAR SERIES

Every semester 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 not only of students and faculty from the Institute, but also of representatives from the Volpe National Transportation Systems Center in nearby Kendall Square, from other universities, and from business and research organizations in the area.

Last fall, the series featured *Sharon Banks*, General Manager of AC Transit, the transit authority of the San Francisco East Bay area; *Richard Doyle*, FTA Regional Administrator for Region One (New England); *Bill Millar*, Executive Director of the Port Authority of Allegheny County; *Lawrence G. Reuter*, General Manager of the Washington DC Metro; and *MIT's Solar Electric Vehicle Team*, winners of Sunrayce '95, with a special presentation on their solar vehicle and their winning race.

The spring series included *Steven Ditmeyer*, Director, Office of Research and Development, Federal Railroad Administration; *George Donohue*, Associate Administrator, Research and Acquisitions, Federal Aviation Administration; *Stephen Gluck*, Manager, Surface Transportation Systems, Raytheon Electronics Systems Division; and *Dharmenda Sharma*, Administrator, Research and Special Programs Administration, US DOT.

RESEARCH SEMINAR SERIES

A new series of luncheon seminars was introduced this spring featuring MIT faculty and research staff presenting their current work for discussion and feedback. Participants in the series were: *Richard de Neufville*, Professor, Civil and Environmental Engineering; *Dr. Frannie Humplick* of the World Bank (PhD'91); *Rabi Mishalani*, MIT Research Associate, and *Tony Hotz*, Project Manager, Lincoln Laboratories; *Don Rosenfield*, Senior Lecturer, Sloan School of Management; *Sergio Jara-Diaz*, Visiting Professor, Civil and Environmental Engineering; *Ralph Gakenheimer*, Professor, Urban Studies and Planning and Civil and Environmental Engineering; *Cindy Barnhart*, Associate Professor, Civil and Environmental Engineering; *Arnold Barnett*, Professor, Sloan School of Management; and *Joe Sussman*, JR East Professor, Civil and Environmental Engineering.

CORPORATE AFFILIATES PROGRAM

The Corporate Affiliates Program welcomed several new members this year, bringing the current total membership to 39. The new members are Cummins Engine, General Electric, Home Depot, Lily Transportation, Monsanto, and Trism. Continuing members are AT&T; Bose; British Airways; British Railways; Burlington Northern Sante Fe; Caliber Systems; Canadian National; Caterpillar; Chemical Leaman Tank Lines; Conrail; CP Rail; CSX Transportation; Digital Equipment; DuPont; Federal Express; Gillette; Goodyear; Honda; IBM; LogiCorp; Mars; Norfolk Southern; NYK Line; Procter & Gamble; Ryder System; Sea-Land; The 3M Company; Unilever; Union Pacific; UPS; US Postal Service; Volkswagen; and Yellow.

AFFILIATES DAY AT BRITISH AIRWAYS

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. This year's meeting was hosted by British Airways World Cargo at Ascot, about 15 miles from Heathrow where British Airways is headquartered. Attended by more than 60 people -- half from America, half from Europe -- it was the first Affiliates Day in the history of the program to be hosted by a non-American firm, a sign of the increasing internationalization of the program. (About 20% of the membership is now from outside the US.)

PROFESSIONAL EDUCATION

Every summer for the past eleven years, the Center has offered an intensive week-long seminar on Logistics Analysis for Carriers and Shippers. Attended by representatives of carriers, shippers and third-party logistics providers, the course is structured around a series of lectures and case studies and involves intensive interaction among the participants. This year the course was attended by 39 participants.

PERSONNEL CHANGES

The Center will lose a key contributor and professional leader this summer when Senior Research Associate Tom Humphrey retires. Tom has been with the Center for over 18 years, having served previously in state and federal government leadership positions. At MIT, he was responsible for numerous initiatives in research and industry/government outreach, as well as teaching. Tom led the effort that established MIT as the leader of the consortium of seven New England universities in the University Transportation Center Program for Region One of the US Department of Transportation, successfully directing the program for nine years and leaving us with a very strong program to continue: it has brought millions of dollars of transportation research and student aid to MIT. Tom's other contributions include establishing the New England Transportation Consortium, setting up and directing the Center's Public Affiliates Program, teaching core courses in public transportation, and advising many students, both undergraduate and graduate. We hope to continue to benefit from his advice and goodwill in his new position in Washington DC. He leaves big shoes to fill.

RECOGNITION

In an attempt to measure the contributions of educational programs to the practice of operations research and the management sciences, a survey was recently conducted by *Interfaces, an International Journal of the Institute for Operations Research and the Management Sciences* which ranked MIT first for the most contributions to the practice literature from 1988 to 1994. Developing and applying advances in OR and management science to transportation and logistics is a particular strength of the Center.

MIT alumnus Damian Kulash was appointed president of the Eno Transportation Foundation. Previously assistant operating officer at the National Research Council, where he had been for thirteen years, Kulash holds a BS degree in industrial management ('66) and a PhD in civil engineering ('71) from MIT.

Six MIT students were winners of graduate fellowships from the Dwight David Eisenhower Transportation Fellowship Program in the last two years. The graduate fellowship is specifically designed to enable students to pursue masters degrees or doctorates in transportation-related fields. The recipients were John Bowman, Edward Lovelace, Paul Schimek, Clare Anne Epstein, Brian Perreault and Scott Ramming.

Daniel Roth, who earned the MST degree at MIT in 1994, received the Charley Wootan Award from the Council of University Transportation Centers for his thesis *Incremental High-Speed Rail in the US: Economic and Institutional Issues*. Roth currently works at Price Waterhouse in Washington DC.

Jeffrey Chapman, a senior at MIT, was awarded a \$1500 undergraduate scholarship in January by the New England Roundtable of the Council of Logistics Management. Chapman is majoring in civil and environmental engineering with a concentration in transportation. As part of the MIT Rail Group he has performed extensive research into the economic effects of heavy axle loads and has also acquired work experience with the Canadian National Railroad in intermodal logistics and with Burlington Northern Railroad in maintenance planning and scheduling.

PhD candidate John Bowman was named the winner of the 1995 UTC National Student Award for Region One. He was chosen on the basis of his academic record and on his papers entitled "Travel Demand Model System for the Information Era" and "Activity Based Disaggregate Travel Demand Model System with Daily Activity Schedules." He received a \$1000 cash prize.

Jung Soo Yu was awarded the Effective Teaching Assistant Award in the Department of Civil and Environmental Engineering for his work in *Introduction to Computers and Engineering Problem Solving*.

Ken Kruckemeyer, one of the Center's research associate on MIT's UPR/Tren Urbano project, was presented with the World Habitat Award at a ceremony in Curitiba, Brazil. Kruckemeyer is a founder and now director of Tent Center for Transportation Studies

City Corporation, a 269-unit mixed income housing complex in Boston's South End. The award, which honors innovative and replicable affordable housing developments worldwide, was made at a four-day international conference sponsored by the United Nations Center for Human Settlements.

Jeff Sriver won a \$2000 scholarship from the George Krambles Transit Scholarship Fund for the second year in a row. Sriver (MST'95) finished his master's thesis on factors influencing land development around 55 rail transit stations in the cities of Atlanta, Boston, Miami, Toronto and Washington. The lessons and implications of his research are applied to the case of the proposed Tren Urbano light rail system in San Juan, Puerto Rico.

Yossi Sheffi

CONCOURSE

Concourse is a highly structured and integrated program for freshmen covering the standard core curriculum in mathematics, physics, chemistry, and humanities. The structure of Concourse follows that of the standard curriculum with scheduled lectures, recitations, problem sets and quizzes. Small class size (limited to 64 students) and extensive personal interaction with senior faculty and tutors provide students with the intimate atmosphere of a small school while retaining all of the excitement and resources of a large institution like MIT.

ENROLLMENT

Fifty-eight freshmen enrolled in Concourse for fall term which represented a 9% decline from the fall of 1994. Spring term's enrollment was 47, a 42% increase from the spring of 1995. Registration for IAP was limited to nine students who participated in Concourse's twelve-unit course on problem solving.

HIGHLIGHTS

Two brand-new courses: SP330, "The Meeting of Art and Science Through Method" was offered for the first time, as was SP344, "Problems in Electricity and Magnetism." "Problems in Electricity and Magnetism" was made possible by an award from the Class of 1951 Excellence in Education Fund, and enriches the 8.02/8.022 offered in Concourse by a series of problems with the same flavor (and origins) as SP345, "Problems in Science and Technology." Our second new offering, "The Meeting of Art and Science Through Method," a HASS-D course, is limited to Concourse students only. It is a *tour de force* of mythology, visual arts, natural history and neurology as only Dr. Lettvin can teach.

We also received some public recognition: "The Chicken From Minsk," a book based on SP345, received favorable mention in the April 22 issue of *U.S. News and World Report* (page 79).

FACULTY AND STAFF

Members of the Concourse faculty for 1995-96 were: Professor Robert M. Rose and Dr. David Paul, Department of Materials Science and Engineering; Professor Judah L. Schwartz, School of Engineering and Harvard School of Education; Lior Pachter and Harry L. Wolfgang, Department of Mathematics; Dr. Gregg E. Solomon, Department of Brain and Cognitive Science; Dr. Yuri Chernyak, Harvard-MIT Division of Health Sciences and Technology; Roberta Brawer, Program in Science, Technology and Society; Dr. Christopher Sawyer-Laucanno, Program in Writing and Humanistic Studies; Dr. Jerome Y. Lettvin, Department of Electrical Engineering and Computer Science; Dr. Kevin Rhoads and Cheryl Butters, School of Engineering. Sixteen MIT undergraduates in the fall, three undergraduates over IAP and seven undergraduates in the spring were employed as teaching assistants for recitations, tutorials, and grading.

The Concourse Program was overseen by Robert M. Rose as Director and by Cheryl A. Butters as Program Coordinator.

Robert M. Rose

INDUSTRIAL PERFORMANCE CENTER

The MIT Industrial Performance Center is dedicated to the study of industries in the US and in other advanced economies. The Center brings together the intellectual resources of the Institute in a search for fresh insights into the nature and origins of successful industrial performance, and seeks to develop practical new approaches for strengthening public policies, business strategies, and engineering practices concerning these important issues. With the participation of about 30 faculty and more than 50 students from all five Schools at MIT, the Center today serves as a listening post on industry, monitoring patterns of organizational and technological practice, interpreting them for our industrial partners, and feeding our observations back into the core disciplines and departments of the Institute.

In March, the Industrial Performance Center (along with the MIT International Science and Technology Initiative/China program) received a major grant from industrial, trade and government organizations in Hong Kong to conduct a research project entitled *Made By Hong Kong*. The specific objectives of the study are to analyze the role of industry in the future development of the Hong Kong economy and to formulate recommendations for government, industry, and academia based on this analysis. More broadly, the research seeks to understand how a society with a strong manufacturing past can develop new strengths and new activities; how industries operating in the larger China region can utilize the advantages presented by the proximity of a large market, low-cost labor, and access to emergent strengths in advanced technology; and how economic capabilities, employment, and social well-being can be maintained even as many of society's production facilities move outside domestic territory. These are the challenges that Hong Kong confronts over the next decade; they are, as well, problems that all advanced industrial countries face today. The project leaders are Suzanne Berger, Professor of Political Science and Director of the MISTI/China program and Dr. Richard K. Lester, Professor of Nuclear Engineering and Director of the Industrial Performance Center.

During this past year the Center continued to develop its role as a significant contributor to the interdisciplinary intellectual life of the Institute, and the group of faculty that regularly participates in its activities continues to grow. The center continues to sponsor the IPC Faculty Seminar. This seminar continues to play an effective role in strengthening the sense of community among a diverse group of faculty already working on industrial performance-related research, and has also attracted other faculty with a more general interest in these problems. Currently, thirty faculty from all five of the Institute's Schools are active participants in this series.

RESEARCH

The Center's research program continues to be organized around three broad themes: (1) new approaches to organizational integration, (2) the international configuration of production, and (3) technology, skills and wages. Several research projects addressing specific topics under these themes are underway.

Professor Charlie Fine and his students continued their studies of technology supply chains in the automobile and microelectronics industries. Professors Richard Lester and Michael Piore and their students continued their research on alternative conceptual approaches to the organization of design and product development activities. During the past year their primary focus was on product development in the cellular telephone sector. Visiting Professor Maryellen Kelley continued her research on the introduction of programmable automation technologies and the impact of alternative approaches to employee participation on performance in the durable manufacturing goods industries. In related work, Doctoral Fellow Rose Batt studied the influence of self-managed teams as well as off-line problem-solving groups on the performance of a major regional Bell telecoms corporation. Professor Kelley also continued her research on the evolution of supplier relations and contracting practices in the defense industry. Professor Erik Brynjolfsson and his students made significant progress in their research on the productivity impacts of information technology. Professors Suzanne Berger and Ron Dore completed a major project on the nature and extent of convergence of national industrial policies and institutions caused by the globalization of capital markets and the expansion of world trade. As part of a larger investigation of the effects of new technologies on skill requirements and wages, Professor Frank Levy and Professor Richard Murnane began a study of changing occupational structures and skill requirements in a major local financial services institution. Finally, researchers at the Center are assembling a comprehensive database of industrial performance indicators covering the United States and other advanced industrial societies at a detailed industry level.

EDUCATION

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. In addition, in recent years faculty associated with the IPC have initiated five new graduate courses based substantially on the results of their research at the Center: Information Technology as an Integrating Force in Manufacturing (Prof. Brynjolfsson); Technology, Productivity, and Industrial Competition (Prof. Lester); Managing People and Organizations in a Changing World Economy (Prof. Locke); The Massachusetts Economy and Economic Development (Prof. Levy) and Domestic Politics of Trade and Integration (Prof. Berger, with Professor Peter Hall of Harvard).

The Center continues to sponsor a Doctoral Fellowship program that provides opportunities for highly qualified doctoral students to pursue independent thesis research in fields related to the Center's mission. Candidates are selected on a competitive basis and are drawn from across the Institute. To date, 13 fellowships have been awarded.

OTHER ACTIVITIES

The Center continues to play an important role in helping to develop intellectual connections and research collaborations among the Sloan Foundation's national network of Industry Studies, now ten in number. The Center is responsible for the Sloan Human Resources Network, which was created to support research and to encourage communications among those doing human resources-related research with the Industry Studies. During the past year, the Network organized a conference jointly with the National Center for the Workplace on the results of the Industry Studies to date in this area. The HR Network also formed a working group on white collar employment issues. This group organized a conference in July 1994 and the resulting papers will be published by Oxford during the coming year. Finally, the Network also organized the second conference for Ph.D. students affiliated with the Industry Studies. This was held at MIT in June 1995. The second HR Network meeting was held in San Francisco in January 1996. It was organized by Frank Levy and Tom Kochan. The focus was on what the industry studies can contribute to our understanding of economy-wide earnings trends - related in particular to the declining demand for semi-skilled labor driven by technological change and international trade.

Richard K. Lester

INTEGRATED STUDIES PROGRAM

The Integrated Studies Program (ISP) offers a curriculum for first-year students built around the study of a variety of technologies practiced in different cultures and historical periods. ISP promotes a form of education that seeks to show students the interrelatedness of ideas and processes in the sciences, humanities and social sciences. Hands-on learning is emphasized as a complement to the theoretical work that is a typical component of the first-year curriculum. ISP's overarching goal is to provide students the academic and social foundation for success at MIT and beyond by creating a community devoted to team-work, inquiry, and life-long learning.

HIGHLIGHTS OF THE YEAR

Formerly housed administratively in the School of Humanities and Social Sciences, ISP is now under the joint sponsorship of SHSS and the School of Engineering. The program has also reorganized administratively so that students take an increasingly greater responsibility in running the workshops connected to our HASS-D subjects on technologies. We have also begun offering two seminars jointly with the Experimental Studies Group (ESG). The first is a student-taught seminar on Robotics, which stresses concepts encountered in 8.01; it includes 'brown bag robotics kits' for each student. The second, the Art of Color, is taught by Dr. Peter Dourmashkin, who is on the staffs of both ESG and ISP; it is a studio course which explores the interactions of colors.

The two semester HASS-D subjects on technologies that form the core of ISP were once again marked by hard work, creativity and enthusiasm of the students. The primary responsibility for these subjects lies with Peter Dourmashkin and Professor Arthur Steinberg. In a desire to further improve these offerings and their delivery, we instituted a number of changes including smaller weekly discussion groups, a very successful project on team-constructed business plans for new textile mills in the 19th century Merrimack Valley, and a unit on constructing and running remote-control cars. Besides these HASS-D subjects we offer recitations in some of the science and math core subjects, and tutorials for students who request them.

We will miss the following staff members who left us this year: Dr. Betsey Price, Christopher Craig, and Wilfredo Sanchez. We welcome a new member, Frederica Steinberg, Lecturer in Writing.

STUDENT ENROLLMENT

In order to increase participation by members of underrepresented minority groups and women, ISP hosted an open house during Campus Preview Weekend for pre-frosh, and students enrolled in Interphase were invited to a luncheon. Of the 41 students enrolling in the fall, 22 were members of underrepresented minority groups (12 male; 10 female). In spring, of the 40 who enrolled, 13 were members of underrepresented minority groups (6 male; 7 female). These enrollment figures represent ISP's most successful recruitment among the minority community and a goal for 1996-1997 is to develop a closer working relationship with the Office of Minority Education to identify unique needs of this group.

WRITING CURRICULUM

ISP introduced a writing component under the leadership of Ms. Steinberg. This writing program is built around short, developmentally effective writing assignments integrated within ISP's fall and spring HASS-D subjects. Students also worked on writing through a variety of activities including journals, peer conferences and brainstorming sessions, and workshops devoted to specific topics. Students received quick feedback on their papers from a group of upperclass graders, so that improvements could be incorporated in a timely fashion on subsequent assignments.

ISP is overseen by Arthur Steinberg, Director, and Debra Aczel, Program Coordinator.

Arthur Steinberg

LABORATORY FOR COMPUTER SCIENCE

The MIT Laboratory for Computer Science (LCS) is an interdepartmental laboratory whose principal goal is research in information science and technology toward a better life for all people.

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 chess.

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 via the ARPANET. 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. 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. This research also led to the X Window System, a computer intercommunication and user interface system, 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 goals of these four categories are as follows:

In the areas of *Information Infrastructure and Distributed Systems*, we wish to understand principles and pursue technologies for the architecture and use of highly scaleable information infrastructures from the organizational to the international level. Transactions among such distributed systems are likely to involve beyond conventional electronic mail and file transfer, the purchase and sale of information and information services (electronic commerce), electronic shopping, health care, education, groupwork across space and time, automation of computer-to-computer actions and many more.. This research is expected to have a broad impact on future systems because virtually every machine will be connected to some information infrastructure and such infrastructures are expected to last for a very long time..

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 the use of advanced graphics and interactive spoken dialogue between people and machines. This area also includes programs that reason about clinical issues and help in clinical decision making and health care.

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 computationally intense systems define the Laboratory's overarching goal: development, understanding and better human communication with tomorrow's information systems.

In the Laboratory's fourth category of research, *Theory*, we strive to discover and understand 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:

The World Wide Web (W3): The Laboratory has founded a W3 Consortium similar to the X Consortium. As of this report, 146 organizations have joined this consortium in order to participate in and contribute to the orderly evolution of the World Wide Web (W3). That process, and the consortium, are directed by Mr. Tim Berners-Lee, the inventor of W3. A team of researchers and developers has been assembled at LCS and at our European affiliate INRIA (France), to staff the consortium effort. The team currently is very close to its planned size of some 15 full-time equivalents at each site, plus students. We are currently exploring a relationship in Japan similar to that with INRIA so that we may have Asian contributions to the evolution of W3. We are proud to be involved in the continued development of W3, which is widely used by millions of people and which enhances and is enhanced by the pursuit of our objectives in understanding and building scaleable international information infrastructures.

Curl : A New Distributed Environment : Professor Stephen Ward and his research group (Computer Architecture Group) have embarked on a very ambitious effort--the development of a new language system, called Curl, which is aimed to become for future distributed systems what languages and operating systems are to today's individual computer systems. Curl is a gentle slope system (GSS) meaning that incremental human effort results in incrementally greater functionality, without major discontinuities. Curl should make possible for non-programmers and programmers alike the tailoring of distributed systems to their needs.

Multiprocessor Architectures: Professor Arvind's group is currently engaged in building the StarT family of parallel computers. The group has recently entered into a joint research agreement with IBM based on StarT-Voyager technology. In addition, the group is involved in the construction and evaluation of StarT-jr. -- a tightly-coupled network of workstations built using existing technologies. The computation nodes are Pentium/Pentium Pro workstations donated by Intel running Linux. An important role of StarT-jr is to serve as a development platform for StarT-Voyager software. The group is also active in all aspects of parallel software research through exploration of implicitly parallel programming languages (like pH and Id) and the development of applications in these languages through collaborations with physical scientists.

Spoken Language Systems: Our Spoken Language Systems Group has expanded and strengthened its capabilities through continued development of its constituent component technologies. The speech recognizer was modified to incorporate a novel probabilistic framework which learns from both positive and negative examples. Research in multilingual language processing continues, with new emphasis on Mandarin. Research in dialogue modeling was conducted in the area of "displayless" human-computer interactions. Remote access to the worldwide web has been introduced using telephone-based speech recognition, and a new knowledge domain of detailed restaurant information has been developed.

Advanced Graphics: A new effort has begun at LCS under the leadership of Professor Seth Teller. It involves the automatic digitization of large physical environments, such as the City of Cambridge, through use of vehicular cameras that travel the streets of the city. The Synthetic Imagery Group is also investigating strategies for rendering visually the contents of immense datasets, and interactive teaching techniques for undergraduates. We are currently in the process of expanding this important area of research with additional faculty. We aspire to complement our spoken language systems with advanced visual approaches toward a more integrated and more natural human machine interaction.

Novel Operating System Approaches : Research by Professor Frans Kaashoek and his research group (Parallel and Distributed Operating Systems Group) has led to a new approach for constructing tomorrow's operating systems.

Called Exokernels, this approach entails a very efficient and “thin” operating system aimed at high performance and a library of desirable functions which are available to applications, as needed. Performance improvements of more than an order of magnitude have been measured using this approach.

During this reporting period, the Laboratory's Distinguished Lecturer Series included presentations by Professor John Ousterhout, Distinguished Engineer, University of California at Berkeley, Dr. Andrew J. Viterbi, Chief Technical Officer, Qualcomm, Incorporated, Dr. James Clark, Chairman and CEO, Netscape, Dr. Arati Prabhakar, Director of the Nation Institute of Standards and Technology, Dr. Robert Metcalfe, Executive Correspondent, Infoworld and Mr. Bill Gates, Chairman and CEO, Microsoft.

The Laboratory is organized into 18 research groups, an administrative unit, and a computer service support unit. The Laboratory's membership comprises a total of 443 people, including 84 faculty and research staff, 142 graduate students, 116 undergraduate students, 65 visitors, affiliates, and postdoctoral associates and fellows, and 36 support staff. The academic affiliation of most of the Laboratory's faculty and students is with the Department of Electrical Engineering and Computer Science (EECS).

About 70 percent of the Laboratory's funding comes from the US Government's Defense Advanced Research Projects Agency (DARPA). 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 the World Wide Web, and joint studies on research areas of common concern.

Michael L. Dertouzos

LABORATORY FOR ELECTROMAGNETIC AND ELECTRONIC SYSTEMS

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 10 faculty from EECS, 2 Senior Research Engineers, 7 research staff, and approximately 50 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) and the Energy Laboratory. LEES is also an active participant in the Leaders for Manufacturing Program, the New Products Program, and the Program in Technology Management and Policy. During the past year the laboratory has experienced a continued expansion of its automotive related research, very positive results from its research on gel polymer actuators and sensors, and major advances in power system control and modeling.

AUTOMOTIVE ELECTRONICS AND ELECTRICAL SYSTEMS

Professor John G. Kassakian, Dr. Richard D. Tabors, and graduate students Khurram Afridi and Vahe Caliskan, with funding from Mercedes-Benz, have enhanced the multi-attribute trade-off analysis tool, MAESTrO, and made it available to 9 automotive supplier and OEM companies. They have also developed a computer based tool for simulating the energetic performance of automobile electrical systems.

Professor Steven B. Leeb, with graduate students Deron Jackson, Aaron Schultz and Ahmed Mitwalli, has developed a 2800 W electric vehicle battery charging system employing a non-contacting magnetically coupled connector system. Field testing of the prototype will begin this year. A bidirectional version of the system is under development. Its ability to discharge as well as charge a battery is essential for insuring maximum battery life.

Professor Jeffrey Lang and graduate student John Ofori have continued their development of high torque, low mass motors for automotive applications. The direct drive wheel motor and its controlling electronics have been constructed and tested separately. They are now undergoing combined system tests. A new project started this year is the design and evaluation of a combined starter/alternator/drive-assist motor to operate in parallel with a diesel engine. The new motor/engine system is expected to offer a propulsion system that is smoother and quieter than the conventional gasoline engine.

Under the direction of Professor Kassakian, the laboratory has initiated a Consortium on Advanced Automotive Electrical and Electronic Systems. The purpose of the consortium is to support high-risk research on advanced concepts, provide members access to the laboratory's research results, and to make available to members the trade-off analysis tool MAESTrO and support its continued development. It presently has 9 members from the US, Europe and Japan. The consortium is an outgrowth of the workshops on automotive electrical systems that the laboratory has hosted for the past two years. The work of this group has been completed, and its results will be presented in both Detroit and Germany in the fall.

PERFORMANCE BASED MONITORING AND CONTROL OF POWER SYSTEMS

Utility industry restructuring has placed an intense focus on achieving economically optimal system operation by employing new and more sophisticated control and monitoring strategies. LEES has been making significant contributions to the solutions of problems of economic control, modeling, and apparatus monitoring.

MODELING AND CONTROL

Professor Bernard Lesieutre and his students have been encouraged by their theoretical results in developing load models for use in power system studies. They are now pursuing methods by which to estimate power system load composition in an on-line environment. With Professor Leeb, they are analyzing harmonic components of current

waveforms to identify certain load components. The results of this research, funded by the National Science Foundation, will allow a greater understanding and enable more precise control of power system dynamics.

Professor George C. Verghese, with Professor Lesieutre and researchers from Electricité de France, have continued their work on large-scale power system model reduction using the Synchronic Modal Equivalencing framework. Tests over the past year have resulted in a well defined procedure for accurate model reduction of intermediate size power systems. They are now pursuing the expansion to very large power system models.

Dr. Marija Ilic and her students have continued their investigation of power system operation and planning problems created by the deregulation of the electric utility industry. Dr. Ilic and former Ph.D. student Shell Liu have recently published a research monograph, *Hierarchical Power Systems Control: Its Value in a Changing Industry*, summarizing the results of this work. Under sponsorship of the U.S. Department of Energy, Dr. Ilic is studying the operating fundamentals of the distributed utility of the future – a power system that is comprised of many distributed small-scale, potentially clean, electric energy sources.

LEES will be hosting the North American Power Symposium in September 1996. This conference has a twenty-year history, and has traditionally had high academic participation, with a strongly student-oriented focus. Professors Lesieutre and Verghese, and Dr. Ilic, comprise the organizing committee of the conference.

ADAPTIVE MONITORING OF TRANSFORMERS

Under funding from the Boston Edison Company, Professor James L. Kirtley, Professor Lesieutre, Mr. Wayne Hagman and Mr. Paul Warren have developed a system of monitors for continuous real-time surveillance of operating power transformers. Five transformers on the Boston Edison system are now being monitored. The ability of this system to provide detailed information about transformer operation has allowed the system to be operated closer to its real capacity. An evaluation by Boston Edison indicates operational savings in excess of \$2.5 million in the first year of monitoring activity.

As part of the transformer monitoring project, Professors Lesieutre and Kirtley, Mr. Hagman and students have developed new nonlinear models to describe important thermal and dissolved-gas-in-oil dynamics in large power transformers. These physically based models are essential components of the adaptive on-line monitoring and diagnostic system. Their studies have resulted in a significantly improved transformer thermal model that facilitates the detection and diagnosis of certain transformer problems and allows better evaluation of the present condition for purposes of dynamic loading.

NON-INTRUSIVE LOAD MONITORING

Professor Leeb, in collaboration with Professor Leslie K. Norford of the Department of Architecture, and with graduate student Steven R. Shaw, has been developing techniques to permit the parallel processing Non Intrusive Load Monitor (NILM) demonstrated last year to serve as a platform for performing critical load diagnostics and power quality monitoring. Preliminary experiments conducted in LEES and in MIT buildings E25 and E40 have indicated that it is possible to non-intrusively diagnose the condition of critical motors in building ventilation systems and industrial manufacturing facilities. This ability provides an inexpensive means to schedule preventive maintenance in critical path electrical loads. An early version of the NILM intended for residential monitoring has been commercialized and is under beta test with 10 utilities around the country.

ELECTROMECHANICS

Micro-Electromechanics

Professor Lang, Professor Martin A. Schmidt of the MTL, and graduate student Jo-Ey Wong have continued their development of the micromechanical relay for power switching in automotive applications. This work has been performed in parallel with a fundamental study of micromechanical relay contacts. To date, the study has demonstrated that micromechanical relay contacts can stand off hundreds of volts when open, and appear capable of exhibiting contact resistance as low as several milliohms when closed. Based on the results of the study, a fully functional relay has been designed, and its fabrication is now in progress.

Professor Lang and graduate student Steven Nagle, in collaboration with other faculty in the School of Engineering, are developing a micromechanical compressor/combustor/turbine/generator which promises to produce electric

power with a power density near 100 W/cm³. The LEES work has focused on the design of the generator and its power electronics, and a proof-of-concept model is now under construction. When successful, the overall project will represent a major advancement in portable electric power supplies.

Electrical Machines

The Novice Design Assistant, a computer aided tool for designing three-phase induction motors developed by Professor Kirtley and graduate student Ujjwal Sinha, has been extended by Professor Kirtley and graduate student Mark Thomas to the design of large, multi-disk wound field and permanent magnet machines for ship propulsion. The tool is being modified to make it applicable to the design of ac generators and single-phase induction motors.

Professor Lang and graduate student Ed Lovelace have completed the design, construction and testing of a controller for the variable-reluctance motor which operates without the usual rotor position sensor and shaft encoder. Instead, the controller estimates rotor position from the information contained in sparse measurements of phase voltages and currents, thus making a more economical and rugged system.

Gel Polymer Actuators

Professor Leeb, in collaboration with Professor Toyochi Tanaka of the Center for Materials Science and Engineering, and with graduate students Ahmed Mitwalli, Deron Jackson and Changnan Wang, have developed a technique for incorporating 10 to 100 micron diameter metal flakes in aqueous solvent polymer gels. The presence of transition metals was found, in general, to inhibit the free-radical polymerization process through which gels are formed. It has been found that the process will occur if the metal particles are first coated with high molecular weight polyvinyl alcohol before the assembly of the pre-gel solution. The resulting interpenetrating polymer network (IPN) permanently entrains the metal flakes. This gel can be triggered to exhibit a volume phase transition by applying an ac magnetic field which induction heats the flakes. Because solvent can leave and enter IPN gels without removing the induction targets (unlike the ferrofluid solvent gels developed last year), the IPN gels could serve as the basis for the development of a variety of non-invasively triggered industrial and medical chemical release applications.

Also demonstrated this year by Professor Leeb and his students was a thermo-optical sensor employing a gel formed from an interpenetrating polymer network of polyvinyl alcohol and a copolymer of N-isopropylacrylamide and acrylic acid. This gel exhibits a continuous volume-phase transition that is strongly dependent on the presence of polyvalent metal ions in the gel solvent. A sensor apparatus has been constructed that estimates the transition temperature of a gel. When this sensor is loaded with a gel sensitive to metal ions, it can be used to detect the presence and identity of those ions in solutions. Any thermally responsive gel whose transition characteristics are affected by an environmental parameter of interest could be used in this sensor. Work is underway to develop gels whose phase transition characteristics are strongly affected by the presence or absence of specific target molecules.

Biological Electromechanics

Professor Martha Gray and her group continue their work on the use of magnetic resonance (NMR) for measuring composition and functional integrity of cartilage. The fixed charge density of cartilage is one of the most important factors in reflecting the mechanical integrity of cartilage. They have used NMR methods to exploit the fact that there is a quantitative relationship between the concentration of fixed and mobile charges. With this approach they have been able to identify focal lesions in intact joints and small explants of cartilage, and to obtain near histological three-dimensional resolutions of fixed charge density. Recent pilot studies suggest that this method may be feasible clinically and in animal models.

POWER ELECTRONICS

Professor Kassakian, with graduate students David Perreault and Robert Selders, have further demonstrated the practicality and advantages of the cellular architecture for power electronic systems. A low-power prototype system has been built to evaluate the current sharing control schemes developed last year. Results have been excellent, and new funding from the Office of Naval Research has been obtained to support continued development of the concept.

Professor Anantha Chandrakasan and his students have been developing strategies for energy efficient computing to minimize the energy dissipated per data sample in systems where the computational workload varies with time. They are using a technique that adaptively minimizes the power supply voltage for each sample. The idea is to lower

the supply voltage and clock frequency during reduced computational workload periods instead of working at a fixed high voltage and allowing the processor to idle. A factor of 5 improvement is expected in some applications. A chip has been fabricated and tested to verify stability and the functionality of static and dynamic logic circuits. They are currently building an MPEG-2 video decoder with an embedded power supply to test the idea in a large system.

HIGH VOLTAGE AND INSULATION RESEARCH

Professor Markus Zahn and graduate student Afsin Üstündag have developed a mathematical formulation that allows reconstruction of an applied electric field from light intensity measurements using electric field induced birefringence (Kerr effect) even when the magnitude and direction of the electric field varies along the light path. Graduate student Tza-Jing Gung has performed confirming experiments using needle/plane electrodes stressed by high voltages.

Graduate student Darrell Schlicker, working with Professor Zahn, has greatly improved the MIT Couette Facility used to study the electrification of oil due to flow in power transformers. The beneficial effects of lowering flow electrification using the anti-static additive benzotriazole (BTA) has been confirmed and continuing experiments are comparing the behavior of new oils with used oils taken from operating transformers.

As part of a new NSF/EPRI supported research program on sensors for power systems, graduate student Alexander Mamishev, working with Professors Zahn and Lesieutre, has greatly improved the MIT developed three-wavelength dielectrometry sensor to maximize signal to noise and to minimize cross-coupling effects between wavelengths. Such sensors are being applied by graduate student Yanqing Du to study the absorption and diffusion of moisture and anti-static additives, particularly in power transformers.

John G. Kassakian

LABORATORY FOR INFORMATION AND DECISION SYSTEMS

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 programs.

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 in technologically important areas.

As an interdepartmental laboratory, LIDS reports to the Dean of the School of Engineering, Professor Robert A. Brown. The Co-Directors of the laboratory are Professors Robert G. Gallager, Sanjoy K. Mitter, and John N. Tsitsiklis (Acting Co-Director).

The Center for Intelligent Control Systems, 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 made.

Financial support is provided by the National Science Foundation, NASA, the University Research Initiative Program (Army Research Office), Advanced Research Projects Agency (ARPA), Siemens, IBM, C.S. Draper Laboratory, the Office of Naval Research, and the Air Force Office of Scientific Research.

NEW RESEARCH INITIATIVES

To complement a recently initiated effort in Automatic Target Recognition useful for synthetic aperture Radar and such, Prof. Willsky and Dr. Krim have started a new research initiative in Representation theory for recognition which accounts for physical morphology of target objects. The theoretical effort is paralleled with its direct application on many aspects of their other research.

A joint project with Microsystems Technology Laboratory (MTL), supported by ARPA, involves constructing a low power wireless sensor that operates efficiently over a wide range of powers and bit rates, from 1 Mb/s for full-motion video to 1 b/s for temperature sensing. One goal of the project is to characterize how constraints on device technology interact with information theoretic limits to determine the best architecture for low power communication. As an example, for indoor line-of-sight communication, radiated RF power is swamped by the power cost of computation. This work is being carried out by Professor Trott and his students in LIDS together with Professors Sodini, Schlecht, Chandrakasan, Lee and their students in MTL.

CURRENT RESEARCH COMMUNICATION AND CODING

Modern advances in computation have greatly relaxed the complexity constraints that apply to error-correction codes designed for voice-band modems, cable modems, and satellite channels. This has fueled the demand for powerful coding techniques and design methodologies which closely approach the information-theoretic upper bounds on performance. Professors Trott and Lapidoth, together with Dr. G. David Forney, Jr. of Motorola, have begun to develop new methods for constructing and evaluating high-performance codes and decoding methods. Research has also begun on the design universal codes that perform optimally over a broad class of channels. This work is supported by NSF and Motorola.

CONSORTIUM ON WIDEBAND ALL OPTICAL NETWORKS

Researchers from LIDS, RLE, Lincoln 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 research 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. An operational test bed is now in place and a node has been installed at LIDS. 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. Professor Gallager, Dr. Steve Finn, and a number of their graduate students are involved in this research.

CONTROL OF HYBRID SYSTEMS

Hybrid systems are those containing mixtures of logic and continuous dynamics, e.g., digital computers and subsystems modeled as finite automata, coupled with controllers and plants modeled by differential or difference equations. A mathematical model of such systems, based on interacting collections of dynamical systems has been developed. This model is consistent with the theory of optimal control of hybrid systems developed in our lab by Professor Sanjoy K. Mitter in collaboration with Dr. Michael Branicky and Professor Vivek Borkar, a visitor from the Indian Institute of Science. Further, since this model builds on the rich theory of dynamical systems, extensions of that theory have been developed. For example, we have extended Lyapunov's stability theory to hybrid systems by developing a theory of multiple Lyapunov functions. Possible applications include programmable logic controllers and power-switching electronics. These analysis tools were also the basis of a collaboration begun with Dr. Branicky and Professor Nancy Lynch of MIT's Laboratory for Computer Science on the formal verification of hybrid systems. LIDS' Professor Dahleh and doctoral candidate Jorge Goncalves have also shown interest in this effort. Finally, Dr. Branicky was recently a visitor at the Department of Automatic Control, Lund Institute of Technology, Sweden (DAC), where he created some tools for the simulation of hybrid systems. These tools were developed within existing DAC software (Omola/Omsim) and will be ported to LIDS computers for future simulation/experimentation work.

PERCEPTUAL SYSTEMS AND MACHINE LEARNING

Problems of speech recognition (speaker-independent), handwritten character recognition (on and off-line), and robust vision system design have turned out to be much more difficult than originally thought, owing to the richness and variability of the data and the resulting complexity of the problem of representation. Professor Sanjoy K. Mitter and his team have recently worked on two different approaches to compute useful representations. The top-down approach, inspired by the work of Grenander, is based on deformable templates and has been applied to character recognition. The bottom-up or compositional approach emphasizes computational efficiency and has been applied to edge detection. Shared by both approaches is the idea that uncertainties and ambiguities must be represented properly and resolved in the right context. This leads naturally to multi-layered representations where the lower levels contain local and data-driven information and the higher levels contain more global and goal-oriented information. Current research efforts attempt to exploit the synergies of the bottom-up and top-down approaches by using feedback mechanisms.

DETERMINISTIC AND STOCHASTIC NONLINEAR DYNAMICAL SYSTEMS

The theory of nonlinear systems, both deterministic and stochastic, has developed rapidly over 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 Athans, Mitter, Tsitsiklis, Verghese, 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 communications networks, control theory, power systems, computer-aided manufacturing, and other areas. Currently, in addition to traditional subjects

in nonlinear and dynamic programming, there is emphasis on solution of large scale problems involving network flows as well as in the application of decomposition methods. The thrust is two-fold: 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 collection points to a computation center. This gives rise to fundamental issues involving the synchronization of computation and communication that are as yet only partially resolved. Professors Bertsekas and Tsitsiklis and their students perform this work.

DATA COMMUNICATION NETWORKS

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 and local networks, both high speed and low speed networks, and both point-to-point and broadcast channels are of concern. One of the major topics of current interest is how to meet quality of service requirements at the internet layer through the diverse types of services that can be provided by highly heterogeneous underlying networks. The growth of both high speed optical networks and low speed wireless networks is making the problem critical. Another topic is finding the fundamental tradeoffs between fairness (i.e., multiple quality of service guarantees) and efficiency in high latency networks. This work is conducted by Professors Bertsekas, Gallager, Dr. Finn and their students.

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, 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. It aims at developing a deterministic theory for system identification that can directly deal with finite data. Applications involving non-stationary time series will be considered (e.g., feature extraction from EEG Data).

INFORMATION TRANSFER AND RETRIEVAL

Research on information transfer and 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 makes 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 estimate number of relevant documents not yet received and reformulation of the search strategy to retrieve those missing nuggets. Experiments with a precursor to the expert system have already demonstrated retrieval effectiveness in terms of relevant documents found, equivalent to that achievable by a human information specialist acting as a search assistant. Partly based on this research, a series of operational and retrieval assistant systems have been developed and a new object-oriented expert system with a graphic user interface is now being tested.

MULTIRESOLUTION STATISTICAL SIGNAL PROCESSING

Over the last few years, the multiresolution models on trees that Prof. Willsky and researchers at INRIA (France) have developed have received tremendous international attention from the research community. Prof. Willsky, Dr. Krim and their students have successfully applied this framework to dramatically reduce high computational complexity and greatly improve performance in a wide array of problems ranging from remote sensing in oceanography to image segmentation, classification in SAR imaging.

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 Professor Michael Athans, Professor Munther Dahleh, Professor Sanjoy Mitter, Professor 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 that 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.

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 that 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 problems involve multidimensional complex systems that, although easy to simulate, are difficult 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.

NONLINEAR CONTROL DESIGN

This research aims at developing systematic, computable methods for designing nonlinear controllers for classes of nonlinear systems that are provably stabilizing in the presence of uncertainty. Part of the research focuses on characterizing classes of nonlinear systems that, on one hand, cover a wide range of applications and on the other hand, are amenable to computations. This research is carried out by Profs Munther Dahleh, Mike Athans, Gunter Stein and Sanjoy Mitter.

PHOTONIC NETWORKS AND DATA FUSION

Professors Robert Gallager, Sanjoy Mitter, Dimitri Bertsekas, John Tsitsiklis, and Drs. Steve Finn and Hamid Krim have initiated a major project investigating the use of heterogeneous networks, particularly optical networks, in large scale distributed fusion problems. This will provide an important application area for the testbed constructed by the consortium on wide band, all-optical networks. It also presents a challenge to the architectures needed to meet quality of service requirements in large distributed systems operating over internetworks of heterogeneous networks. Finally, it provides a focus for work on routing, congestion control, and image fusion and compression. The work is funded by ARO.

ROBUST CONTROL IN INTELLIGENT MANUFACTURING OF MATERIAL

This is a new application area led by Professor Dahleh and his students. By utilizing feedback, a process for developing material such as semi-conductor films can be controlled to meet accurate specifications with only simplified models of the process. This research is being conducted in collaboration with Prof. Kolodziejcki from EECS and local industry.

TOMOGRAPHY AND INVERSE PROBLEMS

The interest in imaging in general and medical applications in particular has greatly grown over the last few years. Prof. Willsky, Dr. Krim and their students, have used to great advantage the inherent multiscale features in images, to progressively retrieve significant cues important for enhancement, identification/classification and ultimately diagnosis. This multiscale framework further provides one with tremendous computational advantages for image reconstruction known for its high computational demand. Their work is referenced in numerous journals, and gotten international attention, for its innovative ideas and provision of a novel fresh look at what is considered a very important problem.

WIRELESS COMMUNICATION

Research in the communications area, carried out by Professors Gallager, Lapidotoh, and Trott and their students, has focused on four areas: determining fundamental limits on communication over time-varying channels, the use of multiple antennas to improve communication efficiency, joint source and channel coding, and network

issues. Progress has been made in all four areas. For example, in audio and video broadcast applications, it has been shown that an integrated data compression and channel coding scheme can outperform any system employing separate compression and coding. As another example, it has been demonstrated that spreading in frequency, using uniform energy allocation over all degrees of freedom, is only beneficial up to a certain limit. This work is supported by the NSF and the ARO.

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 systems 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 in 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.

Speakers in the Colloquium and Seminar Series included: Dr. Jorma Rissanen of the IBM Research Division, Prof. Vwani Roychowdhury of Purdue University, Prof. Allen Tannenbaum of the University of Minnesota, Prof. Karl J. Aström of Lund Institute, Prof. Jean-Jacques Slotine of MIT, Dr. Alan Weiss of Bell Labs, Prof. Roger Brockett of Harvard University, Mr. John T. Preston of MIT, Prof. Frank Kelly of the University of Cambridge, UK, Dr. Irwin Mark Jacobs of Qualcomm, Prof. Jaime Peraire of MIT, Prof. Steven Shreve of Carnegie Mellon University, and Dr. Paul Warbos of the NSF.

VISITORS TO THE LABORATORY

Visitors to the Laboratory for Information and Decision Systems included: Professor Karl Aström of the Lund Institute of Technology, Sweden; Dr. Vivek Borkar, Professor of Electrical Engineering, Indian Institute of Science; Professor Meir Feder, Tel Aviv University, Israel; Dr. James Mills, Tellabs Operations, Indiana; Professor James Modestino, RPI, New York; Dr. Charles Rohrs, Tellabs, Indiana; and Professor Allen Tannenbaum, Electrical Engineering, University of Minnesota.

HIGHLIGHTS

Professor Michael Athans received an honorary doctorate from the National Technical University of Athens, Greece on July 1, 1996, "for outstanding contributions to teaching and research in the field of control theory and systems engineering." He was also elected to the Board of Governors of the IEEE Control Systems Society for the three-year period 1997-2000. Alexander Megretski has been appointed to the LIDS faculty. Professor Sanjoy Mitter presented an invited talk on Problems and Issues in Image Processing at the International Congress on Industrial and Applied Mathematics in Hamburg, Germany, July, 1995. He also presented a plenary lecture, "The Role of Hidden Markov Models and Nonlinear Filtering in Signal Analysis" at the August, 1995 Conference on Signal Processing and Communication at the Indian Institute of Science, Bangalore, India.

Robert G. Gallager
Sanjoy K. Mitter

LABORATORY FOR MANUFACTURING AND PRODUCTIVITY

The Laboratory for Manufacturing and Productivity (LMP) is an interdepartmental laboratory in the School of Engineering directed by Prof. Timothy G. Gutowski (Mechanical Engineering). It 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.

The mission of the Laboratory for Manufacturing and Productivity is to be a leader in the development and application of manufacturing technology to improve the manufacturing enterprise. The key intellectual components of this mission are developed through a coordinated program of teaching and research in the following areas: development of new process technology; integration of process knowledge into product design; and integration of the process into manufacturing system design and operation.

The outputs of the laboratory are engineering leaders for industry and academia, as well as new technologies, methodologies and knowledge for the improvement of the manufacturing enterprise.

The faculty of the LMP work closely with industry, primarily through industrial consortia and project. These include the Precision Engineering Group, the 3-D Printing Consortium, the Reconfigurable Tooling Program, the Droplet-Based Manufacturing Consortium, the Tribology Program, the Microcellular Plastics Program, the Composites Manufacturing Program, the Leaders for Manufacturing Program (Research Group 5 -- Design and Operation of Manufacturing Systems), and the Lean Aircraft Initiative. There are various projects with individual companies. A significant portion of the lab's research is funded by the U.S. Government (DOD, NSF, NASA, DOE), often with an industrial consortium.

HIGHLIGHTS OF THE YEAR

In terms of research dollars, the Laboratory for Manufacturing and Productivity enjoyed its best year ever last year with a research volume of \$3.3 M. This growth was made possible by the combined efforts of the thirteen faculty and staff of the lab. A few projects contributed disproportionately to this increase. These included the work of Professor Ely Sachs (3D Printing), Professor Alex Slocum (Precision Engineering), and Professor David Hardt (Reconfigurable Tooling). Continued growth in these areas and others indicates that we will top last year's figure during the current year.

HONORS AND AWARDS

The research efforts of the LMP faculty have again been recognized nationally. Professor Alex Slocum once again won the prestigious R&D 100 Award. This award, given for the 100 most technologically significant products developed in 1995, was bestowed upon Slocum for his "self compensating hydrostatic bearings". Last year the faculty of the LMP won two of these awards. These were given to Professor Alex Slocum for his "replicated internal shear damper" and to Professor Emanuel Sachs for his invention of the three-dimensional printing process.

This year one of our students, David Levy, won the highly esteemed Lemelson Prize for invention.

PROGRAM HIGHLIGHTS

In the past year several significant new and/or continuing programs were funded:

Professor Jung-Hoon Chun started a new program on Continuous Casting Monitoring; (this is based on a significant new gamma ray attenuation technique), and he has received several new awards in the area of his uniform metal droplet process.

Professor David Cochran has started the "Lean Production Facility" within the LMP to study and demonstrate the principles of manufacturing cell design. This effort is taking advantage of the new renovations in the lab and new machine tools which the LMP has received and will be receiving in the near future. Professor Cochran has also received several new awards to support this work.

Professor Alex Slocum received a significant grant from the U.S. Naval Research Lab to study Lean and Agile Precision Machining.

Professor Ely Sachs has started several new efforts related to 3D Printing and solid free form fabrication.

Professor David Hardt has received a significant award for reconfigurable tooling for rapid response forming of aerospace structures.

Professor David Trumper has received several new grants in the area of precision lithography.

Professor Kamal Youcef-Toumi has received several new awards in the area of atomic precision positioning.

Professor Timothy Gutowski has received a new award in the area of advanced composites forming.

Dr. Stanley Gershwin has received a new award in the area of design and operation of manufacturing systems.

Dr. Don Clausing has received a new award from Ford Motor Co. in the area of strategic reusability planning and management.

Some new machines which we have recently acquired through the efforts of our faculty are: a Coordinate Measuring Machine, a Water Jet Cutting Machine, a Bridgeport Manual/CNC Lathe, a Thermoforming Machine, a new Teleconferencing Station, and a state-of-the-art Eight Axis Hexel Hexapod Milling Machine (acquired through an NSF Instrumentation Grant).

The Laboratory has established a web page at the following address: <http://web.mit.edu/lmp/www/>.

PERSONNEL

Dr. Stanley B. Gershwin has been appointed Associate Director of the Laboratory for Manufacturing and Productivity. He will assist in the development of new programs, in Laboratory administration, and in developing the LMP Collegium. This position is now funded by an allocated expense account, which was created by the Laboratory faculty; future funding will come from Collegium fees.

Professor Don Clausing was named a Xerox Fellow in Competitive Product Development.

Professor David Hardt was appointed Co-Director of the Leaders for Manufacturing Program.

FUTURE PLANS

RESEARCH AND FUNDING AREAS

A significant portion of the LMP funding is from the federal government (about 58% of \$3.3 M in FY '95). In particular, the faculty of the LMP have been quite successful at winning ARPA type contracts. We also have significant NSF and DOD support. If these types of funds were to go away, there would be a significant impact on the LMP.

On the other hand, the LMP projects at these agencies tend to be relatively small (usually under \$1M) and diverse. Furthermore, many of these projects address those particular issues which are of concern during tight budget times. Much of our work will lead to lower cost processing. And some of our projects are specifically intended to save money, (e.g. cell redesign, rapid and agile manufacturing etc.). In addition, several new and potentially significant programs are in the initial stages of development. These are related to our two most recently hired faculty members, Professor David Cochran (Cell and Factory Design) Professor Sanjay Sarma, (Machine Control and Telemachining).

Hence, while there is concern, there is also reason for optimism that the LMP is doing what is needed in these economically difficult times. Furthermore, because of our diverse nature, the LMP is much more flexible than some organizations and can better respond to changes in funding patterns.

EDUCATIONAL INITIATIVES

The long-term goal for the Laboratory for Manufacturing and Productivity is to maximize its impact on manufacturing industry. This can be done primarily in the area of education. The research conducted in the

laboratory will support educational activities. Many of the new research projects in the LMP are "proactive" with a strong design and build component which is often done in teams. Future plans for the laboratory are to emphasize the development of the building concept (in teams) as an educational and research experience for both graduates and people from industry.

In one idea under consideration, participants will actually design and build a manufacturing cell in the lab. This type of project will require significant resources for equipment, space and technical personnel. The first embodiment of this idea will be through the existing graduate manufacturing course 2.810 and will use the LMP's "Lean Production Facility." Future versions will lead to a stand alone course for students and then a version for industry. Trial discussions with industry have been very well received. We believe that such integrative projects will provide a significant vehicle for unifying the work of the various faculty in the lab and provide a result which is truly greater than the sum of the parts.

Service to the Institute and Industry

The Laboratory for Manufacturing and Productivity plays two roles; one as an interdepartmental research lab, and the other as the manufacturing teaching lab for the Department of Mechanical Engineering. In recent years, to accommodate budget restrictions, the support provided by the Department of Mechanical Engineering for technical instructors has been reduced and that in turn has placed serious strains on the Laboratory for Manufacturing and Productivity. We believe that the long term solution to this problem involves the LMP becoming the manufacturing teaching laboratory for other departments. Recently, for example, we assisted with the CAD/CAM teaching for the Aero-Astro graduate course (16.870 Aerospace Product Design). The laboratory would like to develop a closer relationship with the Aero-Astro department, as well as other groups (e.g. the School of Architecture's Design Studio) and develop a strategy to share CAD/CAM, shop and fabrication facilities. In general we believe that the trend in engineering education is toward a new emphasis on practice and design. Given the LMP's significant facilities and knowledge in these areas, we are optimistic about the future and our ability to meet the needs of both industry and MIT.

We will be expanding our contacts with industry in various ways. We plan to devote significant efforts to the expansion of our Collegium. For that purpose, a major meeting is planned on October 15-16, 1996. This meeting will not only be a presentation of our recent research; a "best practices" workshop will provide industry people an opportunity to learn from each other, and we will learn from them. In addition, we will continue to offer our popular Summer Session short course, 2.85s, "New Developments in Manufacturing Process Technology."

Timothy G. Gutowski
Stanley B. Gershwin

LEADERS FOR MANUFACTURING PROGRAM

A progress report for 1995–96 on the eight Leaders for Manufacturing (LFM) Program “products” follows. The program focused on research and knowledge transfer through “learning tools” such as manufacturing case studies. A highlight was LFM’s and MIT’s assuming a leadership role in the National Science Foundation-sponsored Next Generation Manufacturing Project, as described in the *Implementation and Leadership* section, following.

CONTINUOUS IMPROVEMENT

To document progress and improvement opportunities, the Leaders Program this past year surveyed constituents and issued a two-year report draft, whose results the LFM co-directors will interpret for issuance in the final report.

COLLABORATION

LFM’s partnership is growing and diversifying. The program enters “Phase III” engaging the energies and resources of three new limited corporate partners, six small and medium enterprises, and 14 university partners in the National Coalition for Manufacturing Leadership, as well as 12 of the original 13 LFM managing industry partners.

Each of the three new “limited partners” benefits, for an annual fee, from opportunities to sponsor two employees as LFM fellows, host at its facilities two LFM internships, and participate in other LFM research, educational offerings including curricula and LFM-generated manufacturing case studies, and selected events such as student recruiting.

Leaders Program-supported research continues to increase the partners’ manufacturing competitiveness and understanding. For example, at Eastman Kodak, a team headed by Michael Carnette ’96 reduced average printed circuit board delivery and replacement time from four weeks to three days in a pilot project, and reduced inventory from a six-month to a three-month supply. In another project, a team headed by Pavel Zamudio-Ramirez ’96 determined that, unless major technological improvements in automobile recycling occur, the economic-driven infrastructure might need the help of regulation to deal with future automobile disposal.

The LFM Governing Board meeting format continues to emphasize ample opportunity for the governors to provide program direction, interact with one another, and exchange ideas on major manufacturing issues. This past year, meetings were hosted by United Technologies and by Ford.

GRADUATES/CAREERS

The Leaders Program supported 88 fellows during 1995–96; including the new class the program welcomed in June, the total number of fellows since the program’s inception has reached 349. Among incoming LFM students this year, two received Robert N. Noyce fellowships and two received fellowships from the National Science Foundation.

This past June, 43 LFM fellows graduated. Of 42 ’96 fellows who had confirmed their plans in early June, 88 percent assumed positions in US manufacturing companies. Nonsponsored students chose from an average of 5.5 job offers each (based on their 26 responses). Most-cited reasons for job decisions had to do with growth potential, potential for impact, and “good people fit.”

Leaders graduates (now 264, including those research assistants who conducted internships) organized and hosted in San Francisco this spring a two-day workshop for LFM alumni/ae to meet and exchange information relevant to leadership, manufacturing, business, management, and technology, including sessions on product development, project management, theory of constraints, collaboration, career development, and dissemination of LFM knowledge. Approximately 50 attendees participated in presentations, case studies, and breakout sessions led by industry experts and leaders in the business community.

In addition, this past year, a series of workshops attended by LFM students as well as partner companies developed from a Boeing-led study of how better to utilize LFM-calibre graduates.

From 408 applications received this past spring, 55 were accepted into the LFM Fellows Program; 48 students (all with work experience) enrolled. The new fellows average 28 years in age with 4.2 years of work experience.

Included are six women, four members of minority groups underrepresented within MIT, and 15 partner-sponsored students. The number of women in the program thus dropped sharply this year. The program's recruiting strategy is being further developed to better reach these individuals nationwide. LFM's Diversity Committee, now in its second year, continues to raise within the program diversity awareness relevant to business/management issues. The scope of work is initially within the program at MIT, with plans to possibly expand later into Sloan and other MIT departments as well. The committee continues to explore avenues for incorporating diversity issues into the LFM leadership curriculum and providing interactive learning experiences for all LFM stakeholders.

CURRICULA

LFM faculty report that in 1995 they introduced six courses and revised one.

The LFM Learning Tools Committee (established in 1995 to enhance LFM learning transfer to faculty, alumni, industry, and other universities) motivated '96 fellows to develop six cases based on their internships. Twelve cases in total have thus been prepared to date, including two that have been presented to industry for use and eight that have either been used as teaching tools in LFM classes or are being planned to be used.

The LFM Program piloted an Industry Leaders course in November 1995 to expose industry personnel to key LFM concepts during a single week. The course as offered to LFM partner company executives (who report to vice presidents of manufacturing, head manufacturing education, or otherwise lead manufacturing-related efforts) received mixed reviews. A substantially revised version will be offered in the fall of 1996.

MANUFACTURING FACULTY

The Leaders Program actively involved approximately 80 faculty and research staff in 1995–96. During this time, one LFM faculty member received tenure. Despite this success, faculty especially valuable to industry are not generally being properly rewarded or recognized. Responding to industry partners' concerns about this over the years, LFM co-directors and partner company representatives met with the deans of the two schools to discuss the tenure issue.

Faculty developed the pilot extended-education, one-week minicourse described under *Curricula*, above.

One former faculty member, Robert Thomas, received the 1995 C. Wright Mills Award (given to the outstanding book written by a sociologist during the past year) from the Society for the Study of Social Problems for his book, *What Machines Can't Do*.

INTERDISCIPLINARY RESEARCH

Nearly 200 LFM industry partner and faculty researchers collaborated under the direction of Drs. Eugene Meieran of Intel and James Dyer of Polaroid (retired). The program held its second "Research Assault" in October 1995. It also distributed a second issue of the *LFM Research Program Contacts and Manufacturing Science and Technology Research Database*, and updated its *Research Directory* to facilitate networking.

The Leaders Research Program has consolidated its original nine research programs into seven Research Groups: Product and Process Life Cycle; Scheduling and Logistics Control; Variation Reduction; Design and Operation of Manufacturing Systems; Integrated Analysis and Development; Culture, Learning, and Organizational Change; and Next Generation Manufacturing. The Research Program this past year supported 25 research assistants' projects. The industry-directed Research Groups have also served as "umbrellas" for many LFM fellows' internship work. LFM Working Papers, which include student theses, now number approximately 500 titles.

Government funding through the federal Technology Reinvestment Program (TRP) partially supports LFM's placement of two or three interns per year through FY98 in small and medium-sized enterprises. LFM students have now interned at Bay Networks, Inc.; Instron Corporation; MPM Corporation; PictureTel; Quantum Corporation; Reading Tube Corporation; and Teradyne, Inc.

IMPLEMENTATION AND LEADERSHIP

The Leaders Program and MIT assumed a leadership role this year in the National Science Foundation-sponsored Next Generation Manufacturing Project, which seeks to develop an industry-based view of the future and develop specific examples of new business practices and technologies that begin to build the needed attributes of a Next Generation Enterprise. Companies will be able to tailor the plan for action that these examples represent for their own use to help plan, achieve, and sustain world-class manufacturing. The Leaders Program's involvement in NGM has greatly enhanced the program's visibility and influence within the government agencies, and has sparked interest within the LFM companies, focusing the program on longer-term issues.

The LFM co-directors participated in many visits with government and university leaders this past year, broadening dialogue for university/industry/government partnerships to improve manufacturing. The National Coalition for Manufacturing Leadership (NCML) that LFM spearheaded a few years ago to advance a national agenda of revitalizing US manufacturing now meets regularly to share developments in curricula and research collaborations, establish a common position on influencing federal policy and funding decisions, and engage the voice of the customer—industry—through regional meetings. The Decision Sciences Institute, at its conference in Boston during November 1995, offered a session on the NCML. The NCML was also involved in the Manufacturing Recruiting Forum at the University of Michigan the same month. The Coalition currently comprises 14 members, including those universities listed in last year's Reports to the President as well as University of California/San Diego and Northwestern, which joined this past year. Monterey Tech, Mexico, is also considering joining, and MIT has developed a much closer working relationship with Stanford, including joint research. Having helped establish the dual-degree manufacturing programs at Michigan and Obispo, MIT continues to assist Arizona, Georgia Tech, New Mexico, Penn State, and Pomona in setting up their own programs.

In addition to these evidences of program leadership, LFM's Industry co-director, Bill Hanson, was appointed in November 1995 to the National Research Council's Board on Manufacturing and Engineering Design, on which he is serving a three-year term.

1995-96 brought the LFM Program five significant personnel transitions:

- James Dyer of Polaroid (retired) assumed directorship of the LFM Research Program, sharing the role with Eugene Meieran of Intel.
- Paul Gallagher, LFM '95, was hired by MIT to serve as the Next Generation Manufacturing Project Integration Team research leader. His position is funded by the National Science Foundation.
- Karin Janson-Strasswimmer was hired as senior program assistant.
- Nancy Upper, formerly LFM's senior communications assistant, left the program but continues to participate as an independent contractor.
- Hilary Sheldon resigned as manager of partner relations; through program restructuring, existing staff have assumed a portion of this position's responsibilities.

Stephen C. Graves
William C. Hanson
David E. Hardt

MATERIALS PROCESSING CENTER

The mission of the Materials Processing Center is to provide an environment where students and professionals from industry, government, and academia collaborate to identify and address pivotal multidisciplinary issues in materials processing and manufacturing in a way that (1) creates new knowledge, (2) produces knowledgeable people, and (3) promotes exchange of information in the service of our nation in the context of a global community.

The Materials Processing Center is an interdisciplinary center within MIT's School of Engineering in response to a recognized national need to improve the materials processing knowledge base and streamline the process of translating materials research results into industrial innovations and applications. Center research covers a broad range of materials and processes and focuses on six basic industrial sectors: electronics, transportation, energy, biomaterials, primary materials, and construction. Our metric for the value of this research is impact in applications. The MPC has a 40-member Industrial Collegium of domestic and international companies that provide a window on the state-of-the-art in materials processes and an outlet for our research results.

Because of the interdisciplinary nature of the field of materials processing, faculty and research staff affiliated with the Center come from a range of fields beyond the traditional materials science and engineering group. Significant contributions are being made by specialists in chemical engineering, electrical engineering, mechanical engineering, physics, aeronautical and astronautical engineering, civil and environmental engineering, chemistry, nuclear engineering, and ocean engineering. Center research involves over 150 faculty, research staff, visiting scientists, and graduate and undergraduate students.

The MPC builds upon MIT's history of close ties with industry. The Collegium further strengthens this link between university research and industrial innovation. Our strategy is to leverage core federal funding into expanded industrial collaborations. MPC Industry support currently stands at 42% of our total budget.

HIGHLIGHTS CENTER INITIATIVES

Over the past year the MPC has initiated several programs designed to enhance the intellectual vitality of the materials processing community at MIT. By measuring the value of these initiatives in terms of the intellectual core they create, we hope to define our community strengths, collaborate in new and creative ways, and pursue the most meaningful research. In 1996 we began a series of Vision Workshops, designed to explore issues and generate priorities for emerging fields of materials-related research. The first series of Vision Workshops, in Automotive Processing and Manufacturing Needs, was held early in 1996. Two other Vision workshops, focused on Optoelectronics and Biomaterials are planned for later this year.

In 1995, the MPC instituted three new research funding initiatives: (1) the MPC Visiting Scholar Program, (2) the MPC Young Faculty Seed Program, and (3) the MPC Research Seed Program. The first MPC Visiting Scholar is Dr. Ilan Blech, who is working with Profs. Suresh, Thompson, and Kimerling in the area of micromechanics of thin film metals and laminates. Prof. Chris Scott received the first Young Faculty Seed award, to develop an industrially funded program in the cellular automata computation technique for simulation of droplet breakup and coalescence in polymer compounding flows. MIT's High Temperature Electronic Systems (HTES) group, under the direction of Dr. John Haggerty, received the first Research Seed award, to develop a research plan for a new high temperature-power-frequency electronics and packaging technology based on wide bandgap materials such as SiC.

The MPC has also instituted a number of new information distribution services over the past year. The MPC Short Course Library, which was compiled and published in February 1996, is a listing of short technical seminars led by MIT faculty and senior research staff. This Library, which we hope will grow in scope with future editions, offers MIT's industrial partners a concise and focused guide to the expertise of MIT's materials processing community, spanning several School of Engineering departments. Over the past year, the MPC has also instituted a materials subject-related scan of the *Commerce Business Daily*, which is available electronically through MIT's Office of Sponsored Programs. Since its inception last summer, this wholly electronic service has alerted our faculty to important federal research funding opportunities. The MPC has also begun the Materials Abstract Distribution service (MAD), which helps MIT students and faculty stay abreast of their colleagues' work across the wide spectrum of Center research projects.

Other highlights from the past year include nearly \$1M in new industrial research support initiated by the MPC in FY96, as well as an additional six new members for the MPC Industry Collegium.

RESEARCH

Research highlights from the past year are too numerous to report in detail here. A sampling of some of the important breakthroughs achieved by our faculty, research staff, and students follows.

- Prof. Michael Cima's research group revealed the mechanism by which single crystal-like films form from ion-beam assisted deposition on amorphous substrates. His group also demonstrated complex-shaped ceramic and metal components with computer controlled composition gradients by three-dimensional printing (3DP) and the first drug delivery devices made by 3DP.
- Professor Keith Nelson's research group patented and began commercialization of their device for noncontact measurement of thin film thickness, mechanical, thermal transport, and adhesion properties.
- Professor Harry Tuller's research group continued its work on developing compatible electrode/solid electrolyte systems for high temperature fuel cells and was awarded a patent on this technology (US 5,403,461). The group was also awarded a second patent on their novel method of photo-assisted micromachining of semiconductors including silicon (US 5,464,509).
- Prof. Jackie Ying's research group developed a novel Cu-CeO_{2-x} nanocomposite for catalyzing SO₂ reduction and CO oxidation. Her group also recently synthesized the first family of transition metal oxide molecular sieves with hexagonally packed cylindrical pore structure.
- Prof. Uday Pal was granted a patent on galvanic deoxidation of molten metal, and the technology is being implemented industrially at Reading Tube Corporation (in PA) at their copper casting facility.
- Professors Yet-Ming Chiang and Jackie Ying are co-chairing a Research Needs Assessment study for the U.S. Department of Energy on "Energy Applications of Nanofabricated Materials."
- Prof. Chris Scott's research group developed a computer program for simulation of the twin screw extrusion process.
- Prof. Dietmar Seyferth and Dr. Pawel Czubarow were granted a patent (US 5,455,000) on "Pre-ceramic Polymers as Binders for Metal/Ceramic Powder in Preparation of Functionally Graded Materials."
- Prof. Thomas Eagar's research group invented a new method of liquid infiltration of powders in order to rapidly manufacture metal parts.
- Prof. Lionel Kimerling's program in silicon photovoltaics yielded several important defect control discoveries, including a predictive model for contamination during etching to guide specification of chemical purity and an in-situ monitor of process and materials quality.

NEW INDUSTRIAL PROJECTS

While the foundation of the materials processing community at MIT has been established with federal research support, our future success will be measured by our ability to leverage this knowledge base into industrially relevant applications. Our 40-member Industry Collegium provides the MPC with the necessary gateway to industry. The staff of the MPC works closely with both our Collegium and Industrial Advisory Board members to understand their needs and match these with the expertise of our faculty. During the past year, these activities were directly responsible for the addition of nearly \$1 million in industrial research support from a total of six companies. This includes the continuing support by Master Builders Corporation for Prof. Edwin Thomas' development of block copolymers which exhibit anisotropic mechanical properties. These materials are ideal as cement joint compounds, as well as floor and roof barrier coatings. A funded visiting scientist from Finland, working with Dr. Robert O'Handley, has demonstrated a novel shape memory effect. Guest researchers represent an effective technology

transfer function for their companies. Prof. Uday Pal has also launched a two-year program with Griffin Pipe Products Company to explore novel cupola metal refining techniques. Prof. Michael Cima's research group has made a major advance in processing for bulk coating of granular materials, which has been rapidly implemented by the sponsor, saving more than \$500K in raw materials cost annually. In addition, our initiative with small companies continues to expand. Prof. Eugene Fitzgerald's SBIR project on integrated optoelectronics with Discovery Semiconductors has moved into an expanded Phase II program.

NEW INDUSTRIAL INITIATIVES

The MPC provides an active industrial outreach function for the broad, interdepartmental materials community at MIT, using the Collegium to expand our relationships with industry and capitalize on the link between university research and industrial innovation. Our success is reflected by increased industrial research volume in the face of increasing academic and industrial competition for shrinking federal research support. Given that research is 75% of graduate education, the health of our academic community is dependent upon our ability to work effectively with and in a manner that is profitable to industry. Downsized U.S. companies are increasingly dependent upon out-sourced solutions to current problems and are actively seeking future growth opportunities via longer term exploration of new products, processes, and directions. Our challenge is to reach directly into industrial operating units where timely solutions are needed and ideas become innovations.

An effort is underway to leverage an initial proof-of-process effort with Millipore into an expanded consortium of chemical, equipment, and electronic OEM companies to develop and commercialize an innovative wafer monitoring device and ultraclean manufacturing process monitor based on radio frequency photoconductance decay (RFPCD). This process monitor is being developed for introduction into next-generation semiconductor processing and fabrication equipment.

The MPC is also working with the Department of Chemical Engineering to develop a fundamental basis for predicting texture development in polymers. Professors Thomas, Armstrong, Rutledge, and Scott pool their collective molecular, morphological, and rheological modeling and processing expertise in this coordinated multidisciplinary approach. Hoechst Celanese anticipates that increased insight into the hierarchical nature of texture development during formation processes will lead to the production of novel extrudate morphologies with significantly improved performance profiles. This project is an excellent example of how our fundamental knowledge and research can lead directly and efficiently to industrial innovation. Personnel exchanges between MIT and Hoechst Celanese will provide a rapid knowledge and technology transfer vehicle.

Additional initiatives are also underway that leverage the industrial access provided by our Industry Collegium. One example is an initiative with PPG to appoint one of their senior research and product development professionals as a full-time visiting scientist within the MPC. While industrial visiting scientists are certainly not new to MIT, this visit explores the depth and breadth of our research, how we conduct research, what may be of interest to PPG, and how and where we might work together in the future. In short, PPG uses this opportunity to explore how best to utilize MIT as both an intellectual and technological resource.

Internally, we are structured to focus on establishing specific research program areas based on strong external industrial partnerships. Some of these initiatives are described above. It should also be noted that this approach has expanded our direct interaction with other MIT labs, centers, and departments including LEES, the OR Center, LFM, the Manufacturing Institute, Plasma Fusion Center, and the Chemical Engineering, Electrical Engineering, and Physics Departments.

Our overall research objective is to add at least an additional \$1M in industrial support in FY97. This target is clearly obtainable with currently identified industrial partnership opportunities.

ACADEMIC INITIATIVES

The Materials Processing and Manufacturing Institute, launched in partnership with the Department of Materials Science and Engineering, had a total of six students enrolled in the Program for FY96. This program provides both MIT faculty and students with the opportunity to participate in high priority, proprietary industrial site projects. Students receive the combined benefits of an MIT academic experience and industrial research practice. This

program provides the additional opportunity to have significant impact in the real world while educating the faculty-student teams to this goal.

The MPC continues its Summer Research Internship with the Center for Materials Science and Engineering. This 13th class includes nine undergraduates, eight from other universities. The program provides the faculty with much needed seed support for exploratory projects and continues to meet its goal of providing undergraduates with an array of multidisciplinary research opportunities in materials.

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

MPC is one of few, and by far the largest, university research centers with a materials processing emphasis. Our Collegium represents the strongest industry research interface at MIT. The MPC is ideally positioned to take advantage of the national shift in emphasis to engineering practice and cooperative research. We have restructured internally to identify Research Program Areas and externally with stronger partnerships. We are successful if we (1) maintain a strong, dedicated Industry Collegium; (2) motivate faculty and students to address pivotal issues in materials processing and manufacturing; (3) involve women and minority faculty and students; and (4) continue to increase the research throughput of the Center in the next year.

Lionel C. Kimerling

PROGRAM FOR ENVIRONMENTAL ENGINEERING EDUCATION AND RESEARCH

The Program for Environmental Engineering Education and Research (PEEER) has now completed its fifth year of operation. The Program functions as a virtual center with the mission of coordinating and focusing research and education on the intersection between technology and 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, at all levels from local concerns to issues of international concern and transboundary effects. The objective of the program is to establish multidisciplinary 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, Civil and Environmental Engineering
Professor Nicholas A. Ashford, School of Engineering

Program in Business, Technology and the Environment
Dr. John Ehrenfeld, Chemical Engineering and CTPID

MIT/EPA Center for Airborne Toxins
Professor Adel Sarofim, Chemical Engineering

MIT/EPA Center for Environmental Remediation
Professor Dennis McLaughlin, Civil and Environmental Engineering

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, Civil and Environmental Engineering
Professor Philip A. Gschwend, Civil and Environmental Engineering

Department of Urban Studies and Planning
Professor Larry Susskind
Professor Lawrence Bacow
Professor Vicki Norberg-Bohm

Department of Aeronautics and Astronautics
Professor Ian Waitz

Department of Chemistry
Professor Jeffrey I. Steinfeld

Department of Nuclear Engineering
Professor George Apostolakis
Professor Michael Golay

Department of Chemical Engineering
Professor Gregory McRae

Department of Materials Science and Engineering
Professor Donald Sadoway

Department of Ocean Engineering
Professor Alan Brown
Professor Judith Kildow

Department of Electrical Engineering and Computer Science
Professor Rafael Reif

Department of Mechanical Engineering
Professor David Wallace

Division of Toxicology
Professor Stephen Tannenbaum

EVOLVING AREAS OF RESEARCH IN ENVIRONMENTAL ENGINEERING

This year, the PEEER research agenda has been focused on expanding its established long-term goals. 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.

A large volume of research in traditional disciplines is underway at MIT in the area of environmental sciences, technology, and engineering. This research, and its educational components, have kept the Institute in the forefront of international research into environmentally relevant science and technology.

The PEEER perspective represents a new phase of environmental study at MIT, both internally and in international leadership. The Program is designed to stimulate and support 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. In 1995-96, PEEER faculty members have extended the Program's interdisciplinary focus into a major international collaboration on issues of sustainable development. The Alliance for Global Sustainability, described below, has completed its first year of activities, and has embarked upon a research and educational agenda of global scope.

PRO-ACTIVE ENVIRONMENTAL STRATEGIES

PEEER is supporting the formation of consortia 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. Two meetings developed during the year and presented in spring of 1996 furthered this effort:

Proactive Environmental Strategies for Industry

In May, PEEER in collaboration with the Industrial Liaison Program, presented a conference on "Proactive Environmental Strategies for Industry: Anticipating the Future in Environmental and Sustainability Driven Problems." The meeting showcased MIT research and educational work in this area. Speakers outline the ways in which industry is moving away from a reactive stance to command-and-control regulation towards proactive strategies, emphasizing the anticipation and avoidance of problems. Participants, including MIT faculty members, senior corporate executives, public interest group representatives, and high-level government administrators discussed:

- What is sustainability and what does it mean to business?
- What issues will drive new technology development?
- Who will have the ability to compete internationally and at what cost?
- What changes in organizational structure are indicated?
- How are industries responding both technically and strategically?

Managing the Future Uses of Chlorine

On June 12-13, 1996, PEEER sponsored a conference entitled, "The Future Uses of Chlorine: Issues in Education, Research, and Policy." The meeting capped the third and final year of the MIT Chlorine Project, which supported interdisciplinary education and research into the management of chlorine in the environment. The project was part of the MIT Initiative in Environmental Leadership. A central theme of the meeting, convened by Professor Marks, was that complex environmental problems, such as managing chlorine, require collaboration among multiple academic disciplines as well as diverse stakeholder groups. The conference featured plenary sessions and research workshops which addressed the toxicology of organochlorines, public concerns about their use, and how industry is responding. One conclusion of the meeting was that working independently, researchers may fail to grasp the full dimensions of environmental problems that are huge—global—in scope. Environmental impacts may be more profound at the global level than at the local level.

TECHNOLOGY, BUSINESS AND THE ENVIRONMENT PROGRAM

The Technology, Business, and Environment Program focuses upon the new demands of sustainability and the cultural changes taking place in firms as they move toward greater environmental awareness. Research examines tools and strategies that can speed up learning and change in corporations. One project probes the question of whether industry-initiated "codes of environmental management" such as the Responsible Care initiative and ISO 14000 are moving firms in the direction of environmentally sustainable practices. A second study examines the adoption and implementation of design for environment methodologies. Research also looks at European environmental management, for example, how the Netherlands' use of voluntary agreements between government and industry impacts its goal of achieving sustainable development in one generation. An additional research focus is industrial ecology, specifically, the historic development of closely coupled industrial communities, such as Kalundborg, Denmark, where energy and materials from each industrial plant are used efficiently by others.

AUTOMOBILE AND THE ENVIRONMENT

PEEER is part of a confederation of MIT groups working on how automobiles interact with the environment in every phase of their production and use. 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 combustion. 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.

In July, 1996, a symposium on Advanced Instrumentation for Air Quality Measurements was held at Endicott House. The meeting was organized by Center on Airborne Organics directed by Professor Adel F. Sarofim. The Center is a joint enterprise of MIT, the New Jersey Institute of Technology, and California Institute of Technology. The symposium explored how recent and ongoing advances in trace gas and aerosol measurement technology might benefit the urban and regional air quality community as it grapples with issues of photochemical oxidant and airborne aerosol pollution.

ENVIRONMENTAL STRATEGIES FOR THE ELECTRONICS INDUSTRY

Microelectronics and Computer Technology Corporation (MCC) and Semitech are collaborating on 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. Professors Rafael Reif (Electrical Engineering and Computer Science) and Donald Sadoway are building a full-scale pilot chip production chip facility in the Micro Systems Technology Laboratory. The work is addressing issues of pollution prevention, particularly the use and emission of toxic and hazardous chemicals in the manufacturing process.

ENVIRONMENTALLY CONSCIOUS MANUFACTURING AND DESIGN

Members of the Design Group in the Department of Mechanical Engineering studying environmentally-conscious design view the interest in design-for -the-environment as part of a trend toward system-oriented product design. They are developing integrated product system models to account for complex interactions when designing to simultaneously meet manufacturing, in-use performance, and environmental goals. The group is led by Professor David Wallace.

TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

PEEER faculty and affiliates continue to look for a way to describe and define the intersection between technology and sustainable development. Research teams 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. To build new environmental remediation technologies and tools, the E-Lab group 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. This PEEER-sponsored project, under the leadership of Professor Gregory 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. The group, funded through the Lee and Geraldine Martin Foundation, is developing strategies to implement the 1990 Clean Air Act Amendments in the northeast United States.

AWARDS

PEEER also awards a fellowship made possible by the Martin Foundation. This year's recipient was Jennifer Howard, a student in the Technology, Management and Policy doctoral program whose "home" department is Civil and Environmental Engineering. She is working in the area of industrial ecology, and is studying the chemical industry and the organizational and management changes required by their "Responsible Care" initiative (a non-regulatory code of environmental practices developed by the industry). She is particularly interested in the organizational changes demanded by practices directed towards environmental sustainability. Ms. Howard's advisor is Dr. John Ehrenfeld; other members of her doctoral committee are Professors Maureen Scully (Sloan), Michael Piore (Economics) and Leo Marx (Science, Technology and Society).

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) While promoting these programs, PEEER faculty are also focusing on 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.

CHEMICALS IN THE ENVIRONMENT

PEEER has created a four-subject graduate sequence in Chemicals in the Environment 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 work place. 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); Chemicals in the Environment: Policy and Management (Urban Studies and Planning). In 1991, this series received the MIT Sizer Award for outstanding contribution to education at MIT.

AT&T INDUSTRIAL ECOLOGY CURRICULUM DEVELOPMENT GRANT

The AT&T Foundation has awarded grants to six academic institutions for research and educational development in 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.

In funding this project, AT&T has named Professors Clark, Richard de Neufville, Marks, Sadoway, and Dr. Ehrenfeld 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, a module of industrial ecology subjects has been developed to support the new industrial ecology option of the new professional masters degree in the Department of Materials Science and Engineering, as described below. The industrial ecology project group is working toward integration of this module into other degree programs.

LEADERS FOR MANUFACTURING: ENVIRONMENTAL EDUCATION

A three-day Environmental Boot Camp has been developed by Professor Marks and Dr. Ehrenfeld for students in the Leaders for Manufacturing Program (LFM). The subject covers environmental issues that confront those working in industry and the regulatory context for environmental management. It addresses questions most often asked by former LFM graduates. Subsequently, Dr. Ehrenfeld also leads a group interested in product life-cycle concerns for the LFM. Dr. Ehrenfeld and Professor Marks are serving as advisors for a new group of environment-oriented LFM students.

ENVIRONMENTAL LITERACY SUBJECTS AT THE

PEEER is committed to integrating environmental awareness into the educations of all MIT students. To this end, the program has encouraged the creation of several subject designed to provide "environmental literacy" for non-majors. In addition to the Chemicals in the Environment and Industrial Ecology subjects described above, such offerings now include 1.01J, 10.271J Environment and Technology (Professor Philip Gschwend and Dr. Ehrenfeld); 16.542 Environmental Aerospace Engineering (Professor Ian Waitz); and 1.782 Environmental Remediation Engineering (Professor Marks in conjunction with a local consulting firm), and a new course on technology and the environment initiated by Professor Vicki Norberg-Bohm (DUSP). Of the three MIT subjects currently explicitly addressing issues of sustainable development, three are taught by PEEER faculty.

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, and 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 MINOR IN ENVIRONMENTAL STUDIES

A minor program in environmental engineering is offered through the Department of Civil and Environmental Engineering. The program specifies six sets of approved subjects that MIT will recognize as an official environmental minors to be so recorded on transcripts and diplomas. Professor Gschwend is directing environmental minor program.

TRAINEESHIPS

Led by Professor J. I. Steinfeld, a Traineeship Program funded by the National Science Foundation and located in the Department of Chemistry, focuses on the Chemistry of the Environment. Nine faculty members are carrying out research in diverse areas relating to the production, dispersion, and removal of chemical species in the natural environment, and their interactions with biological systems. A central integrating component of the program is an interdisciplinary Seminar in Environmental Chemistry, which is required of the trainees but is open to all graduate and undergraduate students. The seminar addresses technical, economic, political, and environmental aspects of problems involving the intersection of chemistry and society.

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.

PUBLICATIONS

PEEER is responsible for the publication of a monthly newsletter *Environmental Calendar*, edited by Dr. Teresa Hill (PEEER and DUSP). The newsletter includes details of upcoming events and synopses of research, editorial comment by faculty members, announcements, and other news of environmental studies at MIT. Special issues of both these publications distribute information about environmental subject offerings each term and for IAP.

ALLIANCE FOR GLOBAL SUSTAINABILITY

The Alliance for Global Sustainability (AGS), an international partnership focused on issues critical to ensuring the sustainability of the global environment, has just completed a very successful first year of activities. PEEER faculty members are active in the research being developed collaboratively through the Alliance. Three major science and technology institutions, the MIT, the Swiss Federal Institutes of Technology, and the University of Tokyo are the founding members of AGS. With concerns growing world wide to find pathways to future economic and social development that will be harmonious with protection of the environment, and the future of its vital ecosystems, the partners seek to apply scientific and economic disciplines to define new approaches to a sustainable civilization.

In January 1996, researchers affiliated with the AGS met in Tokyo to begin forming consortia of multidisciplinary research projects designed to address issues in ten thematic areas. The project areas are: Mobility, Energy, Health, Regional Sustainability (watershed scale), Global Change, Environmentally Conscious Design and Manufacturing, Cities of the Future, Regulatory Harmonization and Trade, Framing Sustainability, and Monitoring. Researchers in each thematic area subsequently met throughout the year to discuss and coordinate their work. Several of these workshops and planned activities, in the areas of energy, global change, cleaner technologies, and cities of the future are taking place during the summer and fall of 1996. Alliance projects are designed to benefit from the differing geographic perspectives of the three institutions' faculties and participants from all continents. Environmental issues of particular significance to developing nations are an additional focus of AGS research. Projects are being structured so that they can achieve maximum synergy among the partner institutions, have major contact with all stakeholders in each decision-making process, and promote world-wide education and communication.

The next annual meeting of the AGS will be held at MIT Jan. 22-25, 1997. In addition to the meetings of affiliated faculty from the three founding universities and presentation of ongoing research, the meeting will include the first meeting of the recently appointed AGS International Advisory Board. Stephan Schmidheiny, Swiss industrialist and author of *Changing Course* and *Financing Change* about the role industry can play in promoting a sustainable future, will serve as the first Chairman of this Board.

Professor Marks is coordinating Alliance activities at MIT. The work of the Alliance projects onto the international stage PEEER's founding principles of knowledge-sharing between all sectors; interdisciplinary approaches to complex environmental issues; and the continuing interplay of research and curricula development.

David H. Marks

TECHNOLOGY, MANAGEMENT AND POLICY PROGRAM

The Technology, Management and Policy Program (TMP), established in 1992, is a multidisciplinary doctoral program focusing on research to improve methods in defining and implementing policies for the intelligent use of technology. Currently with 22 doctoral candidates, the Program brings together and coordinates several MIT research centers and educational programs in technology, management and policy issues linked to large-scale systems.

Together with its master's program, the Technology and Policy Program, doctoral program involves over 40 faculty and research staff, US \$10 million of annual research funding, and about 200 graduate students. Graduates from this program go on to work for industry or government from Tokyo to Paris to Washington, D.C.

The participants in this Ph.D. Program share a common vision. Each emphasizes dual competency, in a technical area and in management and policy, as the basis for effective design of large-scale systems. Together they are developing a new paradigm of engineering systems planning and design that blends technical expertise with competence in economics, management and policy, to achieve better adaptation of technology to societal goals. A primary purpose of TMP is to diffuse throughout the education and practice in engineering the expertise in systems technology and policy that has been developed in the individual centers involved in the Program.

The centers and laboratories that constitute the Program have each achieved considerable worldwide recognition in their specialized fields over the past 20 years. By working together, they can pursue research on large-scale systems, and establish interdisciplinary curricula, more easily than they could do individually.

The Program's objectives include:

- Participating in major research projects, in close cooperation with major national laboratories and international organizations;
- Establishment of a significant team of faculty and staff working closely together in technology, management and policy;
- Creation of new educational opportunities in large-scale systems, by building on the existing capabilities of the Technology and Policy Program.

CENTERS AND LABORATORIES

Center for Technology, Policy and Industrial Development: The name of the CTPID was selected to underscore the important linkages between technology, policy and industrial development. The central objective of the Center is to define these linkages and to develop policy alternatives that meet pressing social concerns.

Center for Construction Research and Education: CCRE was established at MIT in 1982 to: provide a research environment conducive to development and application of innovative construction technologies and management principles; to offer graduate programs in construction engineering and management; and to act as a facilitator and catalyst for improving the productivity and competitiveness of the engineering and construction industry and to enhance its contribution to the economy and society in general.

Center for Transportation Studies: CTS was established in 1973 to develop and coordinate a 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. The interchange of information, ideas and inspiration among the faculty, students and research staff makes it one of the most dynamic centers of activity in the transportation field.

The Materials Systems Laboratory: MSL is internationally recognized for its innovative work on the competitive position of materials and products in automotive, aerospace, electronic and environmental applications. It fosters a unique combination of knowledge of design and production processes used in industry with managerial economics.

Program for Environmental Engineering Education and Research: PEEER explores the relationship between technology and a sustainable environment. This new initiative builds upon MIT's extensive strengths in environmentally oriented education and research activities.

Christopher Wanjek

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

The School of Humanities and Social Science (SHSS) continues to focus its efforts on affirmative action, fund-raising, and faculty recruitment in departments and sections which are experiencing retirements and resignations, in particular Linguistics & Philosophy, Political Science and Economics. The faculty within the School received a number of honors and awards, and some important administrative changes within the School have occurred.

UNDERGRADUATE EDUCATION

The three-year experimental change to the HASS-D Requirement, as described in last year's Report, has been monitored this year to determine what, if any, impact it has had on the enrollments in HASS-D Categories 1 and 2, roughly the Humanities. Evidence is inconclusive at this point; we will continue to monitor enrollments for the remainder of the three-year period.

The HASS Guide is now available electronically, on the World Wide Web. The electronic version is currently being revised to make information more easily accessible and useful to students. The improvements are based partially on the report and recommendations of students who took the Writing Course, "Communicating in Cyberspace" in Spring 1996 and chose the electronic HASS Guide as their group project.

NEW INITIATIVES

Various new initiatives within the School are underway, some of which were launched in the previous two years. The Writing Initiative, which is a collaborative project between the School of Humanities and Social Science and the School of Engineering, has received new funding from its main external source, the Barker Foundation. It has attracted the attention of the Committee on the Undergraduate Program, and it may yet become one of the cornerstones of a reinvigorated MIT Writing Requirement; a full discussion of the Requirement will take place in FY97.

The Mind Articulation Project in the Department of Linguistics and Philosophy received this year a \$1.8 million grant from the Research and Development Corporation of Japan. This project offers new and exciting research opportunities at the intersection of linguistics and neuroscience. It will also help to support graduate students pursuing the NSF Research Training Grant program between Linguistics and Cognitive Science at MIT.

The Media Studies Committee, chaired by Associate Professor Henry Jenkins, submitted its proposal for a new graduate program in Media Studies in the fall. This followed on the heels of a major conference in October, sponsored by the Dean's Office, on "The Future of Media Studies." The conference included presentations by fifteen leading scholars in the area of film and media studies in the United States, and over one-hundred people attended the two day event. Ten of these scholars met independently with faculty in MIT's Film and Media Studies Program to advise on how to design a graduate program for MIT focused on the new media. These scholars concluded that no American university is better suited than MIT to develop graduate studies focused on the new media, owing to MIT's reputation as the pre-eminent university of science and technology and to faculty strength in the Humanities and elsewhere at MIT in the area of cultural criticism.

In spring systematic discussions on the subject of graduate education in the new media continued on a variety of levels. Faculty in the Department of Architecture and in the Media Arts and Sciences Program joined faculty in the Humanities for a series of brown-bag lunch meetings, which focused on the nature and organization of a graduate studies curriculum. The Deans of Humanities and Social Science and Architecture and Planning participated in monthly meetings focused on issues of programmatic coordination and financial support. It is expected that a strategic plan for the implementation of a new graduate program in media studies will be submitted for faculty approval in FY97 or FY98.

AFFIRMATIVE ACTION

The affirmative action record of SHSS continues to appear strong relative to the rest of the Institute, but this is 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 1995-96 there were 36 women faculty, which represents 24 percent of the total. Of these 23 are tenured (22 percent of the tenured faculty). Over the past five years, the total number of women faculty has steadily increased (30 in 1990-91), and the School is making every effort to continue this trend. We were successful in recruiting four women to the faculty for next year (two in Political Science, one in Linguistics and Philosophy, and one in

Economics), and were successful in our efforts to appoint a fifth to a faculty position in Literature. Of the 13 senior faculty in the School who elected to retire, only one is a woman. The number of women faculty in 1996-97 will be 40.

The School's record with respect to minority faculty is less satisfactory than it is with respect to women, although we appear to be making steady progress. Our efforts toward increasing the minority representation on the faculty has led to the successful recruitment of a male Afro-Caribbean (Haitain) linguist currently at the University of Michigan, who will become an assistant professor in the Department of Linguistics and Philosophy next year; the appointment of a black male from Uganda as assistant professor in the Music and Theater Arts section; and the appointment of a black woman as assistant professor in the Department of Economics. SHSS also continues to pursue non-traditional methods in the hope that they will lead to faculty appointments, such as the appointment of an African-American male in Music and Theater Arts, hired last year as an instructor, while working to complete his Ph.D. It is expected that he will join the faculty as an assistant professor sometime in 1996-97. The total number of minority faculty in the School this year, including Asian Americans, was 17 (11%); next year (1996-97) the number will increase to 20 (14%).

The School's record with respect to minority administrative staff members is better, with five minorities of a total of 20 (25%). SHSS has reduced the number of administrative staff positions by two in the last three years (from 22 to 20) owing to the transfer of the Integrated Studies Program (ISP), effective July 1, 1995, to the School of Engineering, and the administrative reorganization of the Programs in Anthropology/Archaeology and Science, Technology and Society (STS). The School remains committed to further 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 George Boolos of the Department of Linguistics and Philosophy would have become the third person to hold the Rockefeller Professorship in Philosophy and would also been awarded a Guggenheim Fellowship for the 1996-97 Academic Year, if not for his untimely death due to cancer. The Department of Economics' Professor Paul Joskow received the Edward A. Hewitt Prize by the American Association for the Advancement of Slavic Studies and was named as the Elizabeth and James Killian Professor; Professor James Poterba was elected a Fellow of the American Academy of Arts and Sciences and named Mitsui Professor of Economics and Management; and Institute Professor Paul Samuelson received the National Medal of Science. Professor Alan Lightman of the Program in Writing and Humanistic Studies won the 1996 American Institute of Physics Andrew Germant Award for contributions to the public understanding of science and was also elected to the American Academy of Arts and Sciences. Among the History faculty, Professor John Dower was named the first holder of the Elting E. Morison Chair in Humanities; Professor Peter Perdue won the Wade Award for Innovation; Assistant Professor Elizabeth Wood won the Levitan Prize; and Associate Professor Anne McCants won the Edgerton Award for outstanding research, teaching, and service to the Institute. Assistant Professor James Buzard of the Literature Section was awarded the Class of 1956 Career Development Professorship. The Department of Political Science's Professor Richard Samuels was awarded the 1996 John Whitney Hall Prize of the Association for Asian Studies and the 1996 Hiromi Arisawa Prize for the Association of American University Presses, both for his book *Rich Nation, Strong Army*; and Associate Professor Stephen Ansolabehere was awarded the Goldsmith Book Prize for his book *Going Negative*, cited as the best book on mass media, politics, and public policy. Professor Martin Diskin of the Program in Anthropology accepted the first Human Rights Award of the Ignacio Martin-Baro Fund for Mental Health and Human Rights. The Program in Science, Technology and Society's Assistant Professor Evelyn Hammonds was awarded the Class of 1947 Career Development Chair. Assistant Professor Janet Sonenberg won the Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching.

FUNDRAISING

1996 Highlights include novel achievements in a number of departments and programs through an incredible technological period of transition which saw an explosion of growth on the Internet reflected in the classroom. SHSS continues to secure money from foundations. Foundation support came in for new technologies, while additional monies came in to honor stellar faculty and scholarship.

This spring, MIT announced the formation of the Geneviève McMillan and Reba Stewart Professorship in the Study of Women in the Developing World. The professorship, located in the School, was established with a gift from Geneviève McMillan in honor of Mrs. McMillan's friend, the late Reba Stewart. Ms. Stewart was an

arts educator and an accomplished painter. Mrs. McMillan is herself a prominent art collector with a long-time interest in Africa and the Middle East.

Emblematic of the continuing developments and new application of technologies in the School of Humanities and Social Science, this past year the Department of Economics received a National Science Foundation grant to purchase new computer systems. This enhancing and enabling technology will insure the Department's ability to maintain its superior position without being hindered by insufficient or obsolete computer equipment.

The Program with the most varied use of new technologies requiring support from foundations and corporations alike is the Foreign Languages and Literatures Section (FL&L). This past year in FL&L, six faculty members received funding from the Language Consortium for their work in utilizing interactive multimedia technology in language acquisition. Professor Shigeru Miyagawa received funding from the Department of Education for the JP-Net Project "Networking Secondary School Teachers of Japanese." Chinese language studies received a \$500,000 pledge this year from a friend of the School and Institute in Indonesia. This same donor completed in December payments on a previous pledge of \$500,000.

Continuing the School's development in pioneering new applications of technology in the Humanities, Professor Peter Donaldson and Senior Research Scientist Janet Murray received a grant from the National Endowment for the Humanities for the Shakespeare Electronic Archive project. This grant will make it possible to digitize the entire collection of quarto editions of Shakespeare plays at the Henry E. Huntington Library and, in addition, extend the work of the Shakespeare Electronic Archive group to the World Wide Web. Associate Professor Henry Jenkins and Senior Research Scientist Murray are the recipients of the new NEH Teaching with Technology program. Their project, The Virtual Screening Room: A Multimedia Textbook for Film Analysis, is designed to produce a fully interactive digital "textbook" (i.e., a hypermedia learning environment) for use for teaching film analysis.

The Department of Political Science secured contributions in excess of a half million dollars from individual supporters. These contributions come in large part from the Department's aggressive outreach in reconnecting with its alumni/ae. Portions of these funds help to support the new Washington Internship Program which has yet to be fully endowed.

The Department of Linguistics and Philosophy this year established the Morris Halle Fellowship Fund and the George Boolos Memorial Fellowship Fund, both of which are in the early stages of contributions towards full endowment. Finally, in keeping with the School's direction in exploiting technology, the Department received funding for the MIT Linguistics-Tokyo University Mind Articulation Project, funded by JRDC (Research and Development Corporation of Japan).

ADMINISTRATIVE CHANGES, RETIREMENTS

This has been a year of transition for the faculty in SHSS, resulting in thirteen retirements (due, primarily, to the early retirement incentive), one death, three resignations, one returning senior faculty member after a two-year absence, and twelve new faculty appointments within the School. Retirements in SHSS have resulted in the loss of Institute Professor Morris Halle and Professor James Harris of the Department of Linguistics and Philosophy; Professors Willard Johnson, George Rathjens, Eugene Skolnikoff, and Myron Weiner of the Department of Political Science; Professor Richard Eckaus of the Department of Economics; Professors Arthur Kaledin and David Ralston of the History Section; Professor and Dean for Undergraduate Academic Affairs Travis Merritt, Professor Albert Gurney, and Professor Irene Tayler of the Literature Section; and Professor Charles Weiner of the Program in Science, Technology and Society. Several will remain with part-time appointments; we wish them all great success in all their future endeavors as emeriti professors of MIT. The School saw three resignations this year, including one due to the denial of tenure and two senior faculty members. Two faculty were promoted to tenure, effective July 1, 1996: Stephen Ansolabehere of the Department of Political Science and Richard Locke, who holds a joint appointment in the Sloan School of Management and the Department of Political Science.

The School was successful in recruiting twelve new members to the faculty effective 1996-97. They include three new hires (two assistant professors and one associate professor with tenure) and one returning professor in the Department of Economics, three (assistant professors) in the Department of Political Science, three (two assistant professors and one professor) in the Department of Linguistics and Philosophy, one (associate professor without tenure) in the Literature Section, one (assistant professor) in the Music and Theater Arts Section, and one (assistant professor) in the Program in Science, Technology and Society.

Next year the History Section will have Professor Pauline Maier return as Acting Head for the Fall term, while the current Head (Professor Peter Perdue) is on Sabbatical; he will return as Head for the Spring term. Professor Peter Child will become the next Head of Music and Theater Arts, replacing Institute Professor John Harbison, who stepped in as Acting Head this Spring term when Professor Alan Brody was appointed as Associate Provost for the Arts; the former Associate Provost for the Arts, Professor Ellen Harris, will return full-time to the Section after a leave. Professor Suzanne Flynn replaces Professor Isabelle de Courtivron as Head of the Foreign Languages and Literatures Section, and Professor Michael Fischer replaces Professor Merritt Roe Smith as Director of the Program in Science, Technology and Society. We will miss the insights and administrative wisdom of Professors Harbison, de Courtivron, and Smith, and wish them well as they return to professional lives focused on full-time scholarship and teaching.

Sadly, we report the loss of two valued colleagues in the Department of Linguistics and Philosophy: Professor George Boolos, an internationally renowned logician, on May 27, 1996, and Emeritus Professor Thomas Kuhn, the pre-eminent philosopher of science of his generation, on June 17, 1996.

Philip S. Khoury

HUMANITIES, ARTS, AND SOCIAL SCIENCE OFFICE

Continuing the effort to make the HASS-D Selection System as efficient as possible, and to ensure that the highest possible percentage of students receive their first-choice HASS-D subject, the HASS Office, in conjunction with Information Systems, upgraded the system to a new version of Powerbuilder. This office also undertook the revision of the electronic version of *The HASS Guide*, based on the results of a student group project for 21W 785, "Communicating in Cyberspace". The purpose of the revision, to be published Fall 1996, is to make *The Guide* more accessible and useful for students. The procedure for receiving data from the Registrar's Office has been streamlined, with one step eliminated, thus facilitating the production of statistics for the SHSS Dean's Office.

In addition, the HASS Office has 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* (hard copy and electronic versions) each term. This office also continued to record proposals and completion forms for HASS Concentrations and Minors in MITSIS, on behalf of the Registrar's Office, in addition to maintaining a HASS Minor data base and paper files. Petitions for HASS credit for subjects which are not so coded in MITSIS, including 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, served as staff to the HASS-D Overview Committee, chaired by Professor James Paradis.

HASS ENROLLMENT STATISTICS BY FIELD AND SUBJECT - RECENT TRENDS

The number of HASS subjects offered rose slightly, from 443 in 1994-95 to 459 this year. The number of autonomous sections decreased very slightly, from 609 to 598. The number of HASS-Distribution subjects offered was almost exactly the same as last year--113, compared with 111 in 1994-95. The largest overall enrollments were in the same fields as last year, in exactly the same order: 1800 in Economics, 1594 in Foreign Languages and Literatures, and 1000 in Literature, followed by 923 in Writing and 859 in Music. (Six-unit music performance subjects are not included in these statistics.) The following fields showed the greatest increases over last year, in terms of percentage: Visual Arts (from 184 to 221) and Women's Studies (from 72 to 82).

HASS CONCENTRATIONS: PATTERNS OF POPULARITY

Once again, Economics and Foreign Languages had by far the largest number of completed HASS Concentrations: in 1995-96, 316 (compared to 273 last year) students completed concentrations in Economics, and 260 (compared to 243 last year) completed concentrations in Foreign Languages & Literatures. (For a breakdown by languages, see Table II.) The next two most popular HASS Concentration fields are Music, with 107 completed concentrations, and Psychology, with 94. Writing (71) and History (70) were nearly tied for fifth place.

HASS MINOR PROGRAMS

The number of HASS Minors dropped this year to 416 from 476 in 1994-95. The two most popular fields in terms of applications filed were the same as last year: Economics (128) and Music (55). These were closely followed by Foreign Languages, with a total of 54 (12 in French, 18 in German, and 24 in Spanish). Other popular HASS Minors, in order, were Writing (42), Political Science (24), and Psychology (18). The number of HASS Minors received by the Class of 1996 was 170, compared to 201 in 1995 and 171 in 1994.

HARVARD CROSS REGISTRATION

The number of MIT undergraduates cross-registering for courses at Harvard increased considerably in 1995-96, to the highest level since the all-time high in 1990-91. In 1995-96, 199 MIT undergraduates took 214 subjects at Harvard, compared to 150 students enrolled in 174 subjects in 1994-95. Once again, more MIT undergraduates chose to study foreign languages at Harvard than anything else. Ninety-five of the 214 subjects were in 17 different foreign languages. The two most popular languages were Chinese (25) and Korean (17); enrollments in other languages were spread fairly evenly. The most popular fields outside foreign languages were Economics (17) and Philosophy (15).

S.B. DEGREES GRANTED IN SHSS

In Course 14, Economics, 46 students received the S.B. Degree, while 11 students received degrees in Political Science, Course 17. During the same time period, September 1995 through June 1996, a total of 35 students completed the S.B. Degree in Humanities, Course 21. Of these, seven received joint degrees, three in 21-E and four in 21-S. Another 19 received degrees in a specified field within Course 21. Nine undesignated Humanities degrees (for "Major Departures" in several fields and German) were granted. Three students received the S.B. in Philosophy.

UNDERGRADUATE MAJORS IN SHSS

The Economic Department has 101 undergraduate majors, whereas 19 undergraduate students are majoring in Political Science. (These figures represent only first degrees.) There were 75 Humanities majors in 1995-96; 49 of these were first degrees. Of the 75, 25 were joint majors (12 in 21-E and 13 in 21-S.) Music had the most majors (19), followed by Literature (16) and Writing (14). Six undergraduates have officially declared a major in Philosophy.

HONORS AND AWARDS GRANTED TO UNDERGRADUATE MAJORS IN SHSS

Among the more notable honors achieved by SHSS majors this year were:

Boit Manuscript Prize:	Ivana Komercevic, '96, First Prize (fiction); Todd Boutin, '96, Second Prize (fiction); and Charlotte Iverson, '96, First Prize (poetry)
Robert A. Boit Writing Prize:	Charlotte Iverson, '96, Honorable Mention
Burchard Scholars:	Martin Calles, '97; Lin-Ann Ching, '98; Teresa Huang, '97; Ryan Kershner, '98; Vassiliki Koumandou, '97; Don Lacey, '98; Richard Lee, '97; Kevin Simmons, '98; Mayukh Sukatme, '97; Wilson Tai, '97; and Cindy Tom, '97
Peter J. Eloranta Award:	Ivana Komercevic, '96
Joseph D. Everingham Award:	Monica Gomi, '96
Philip Loew Memorial Award:	Leonard H. Kim, '96
MIT Alumnae Award:	Julia Ogrydziak, '96
Phi Beta Kappa:	Grace Cheng, '96; Michael Cho, '96; Shane Crotty, '96; and Ivana Komercevic, '96
Louis Sudler Prize:	Jeff Morrow, '96
Gregory Tucker Memorial Prize:	Leonard H. Kim, '96
Laya Wiesner Award:	Alan Pierson, '96; Marivi Acuna, '96

Bette Davis

TABLE I: ENROLLMENT IN HUMANITIES, ARTS, AND SOCIAL SCIENCE SUBJECTS: 1995-96

Field	Elective Subjects			HASS-Distribution			Total Enrollment		
	#Subjects	(#Sections)	#Students	#Subjects	(#Sections)	#Students	#Subjects	(#Sections)	#Students
Anthropology	11	(13)	140	6	(14)	207	17	(27)	347
Archaeology	5	(5)	105	1	(2)	26	6	(7)	131
Economics	22	(44)	1,751	2	(2)	49	24	(46)	1,800
Foreign Languages & Literature	58	(90)	988	22	(36)	606	80	(126)	1,594
History	34	(34)	365	15	(15)	356	49	(49)	721
History of Art & Architecture	0	(0)	0	3	(3)	94	3	(3)	94
Linguistics	5	(5)	45	0	(0)	0	5	(5)	45
Literature	36	(36)	370	19	(30)	630	55	(66)	1,000
Music*	21	(27)	378	9	(14)	481	30	(41)	859
Philosophy	13	(13)	131	5	(5)	286	18	(18)	417
Political Science	27	(29)	288	8	(8)	221	35	(37)	509
Psychology	9	(10)	355	1	(1)	315	10	(11)	670
STS	16	(16)	113	4	(4)	98	20	(20)	211
Theater Arts*	18	(24)	218	3	(3)	39	21	(27)	257
Urban Studies	15	(15)	235	1	(1)	20	16	(16)	255
Visual Arts	10	(11)	86	3	(6)	135	13	(17)	221
Women's Studies	9	(9)	35	5	(5)	47	14	(14)	82
Writing	29	(51)	819	3	(6)	104	32	(57)	923
Other Subjects	8	(8)	76	3	(3)	135	11	(11)	211
Totals	346	(440)	6,498	113	(158)	3,849	459	(598)	10,347

Notes:

1. - Figures were obtained from the MITSIS system, 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.

TABLE II: CONCENTRATION IN ALL FIELDS OF HUMANITIES, ARTS, AND SOCIAL SCIENCES

Fields of Concentration	Class of 1999		Class of 1998		Class of 1997		Class of 1996		Totals in Fields	
American Studies	(0)	0	(0)	0	(2)	0	(15)	15	(17)	15
Ancient & Medieval	(0)	0	(1)	0	(4)	0	(8)	8	(13)	8
Anthropology	(1)	0	(13)	2	(22)	7	(28)	25	(64)	34
Archaeology	(0)	0	(1)	0	(10)	3	(6)	4	(17)	7
Black Studies	(0)	0	(1)	1	(4)	0	(4)	2	(9)	3
East Asian Studies	(0)	0	(2)	0	(18)	6	(38)	35	(58)	41
Economics	(1)	0	(40)	6	(190)	77	(260)	233	(491)	316
Ethnic Studies	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
Film & Media Studies	(0)	0	(2)	0	(12)	1	(14)	14	(28)	15
Foreign Languages**	(6)	0	(75)	9	(164)	53	(242)	198	(487)	260
History	(0)	0	(10)	1	(27)	6	(68)	63	(105)	70
History of Art and Architecture	(0)	0	(4)	0	(2)	0	(9)	7	(15)	7
Labor in Industrial Society	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
Latin American Studies	(0)	0	(0)	0	(3)	0	(3)	3	(6)	3
Linguistics	(0)	0	(3)	0	(2)	0	(5)	5	(10)	5
Literature	(1)	0	(9)	0	(21)	8	(59)	50	(90)	58
Middle Eastern Studies	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
Music	(0)	0	(18)	0	(75)	10	(115)	97	(208)	107
Philosophy	(0)	0	(2)	0	(16)	8	(50)	45	(68)	53
Political Science	(0)	0	(1)	0	(26)	0	(40)	32	(67)	32
Psychology	(0)	0	(14)	0	(52)	18	(87)	76	(153)	94
Religion	(0)	0	(0)	0	(2)	1	(7)	6	(9)	7
Russian Studies	(0)	0	(1)	0	(0)	0	(1)	1	(2)	1
Science, Technology, & Society	(3)	0	(0)	0	(20)	4	(29)	26	(52)	30
Theater Arts	(1)	0	(7)	1	(16)	1	(31)	23	(55)	25
Urban Studies	(0)	0	(5)	1	(6)	0	(22)	21	(33)	22
Visual Arts & Design	(0)	0	(1)	0	(3)	0	(3)	2	(7)	2
Women's Studies	(0)	0	(4)	0	(9)	0	(9)	9	(22)	9
Writing	(0)	0	(3)	0	(41)	1	(86)	70	(130)	71
Special Concentrations	(0)	0	(0)	0	(1)	0	(2)	2	(3)	2
TOTALS	(13)	0	(217)	21	(748)	204	(1241)	1072	(2219)	1297

* The parenthetic 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 are below:

Chinese	(0)	0	(7)	0	(12)	3	(20)	16	(39)	19
ESL	(0)	0	(2)	0	(0)	0	(2)	0	(4)	0
French	(3)	0	(25)	4	(37)	11	(46)	40	(111)	55
German	(2)	0	(15)	1	(17)	5	(31)	22	(65)	28
Japanese	(0)	0	(7)	2	(46)	20	(56)	47	(109)	69
Other Languages	(0)	0	(4)	1	(8)	6	(19)	17	(31)	24
Spanish	(1)	0	(14)	1	(43)	7	(65)	53	(123)	61
SILC	(0)	0	(1)	0	(1)	1	(3)	3	(5)	4
Totals	(6)	0	(75)	9	(164)	53	(242)	198	(487)	260

TABLE III

UNDERGRADUATE MAJORS

<u>Year</u>	<u>Economics</u>	<u>Humanities*</u>	<u>Philosophy</u>	<u>Political Science</u>	<u>Total</u>
1986-87	49	57	7	21	134
1987-88	76	77	9	40	202
1988-89	103	52	11	43	209
1989-90	111	51	13	54	229
1990-91	115	64	13	44	236
1991-92	81	75	12	35	203
1992-93	75	64	5	41	185
1993-94	79	58	5	38	180
1994-95	81	56	8	40	185
1995-96	101	49	6	19	175

*These figures do not include double majors who registered first in a course other than Humanities. (If you include double majors, the figure is 75.)

TABLE IV

GRADUATE STUDENTS

<u>Year</u>	<u>Economics</u>	<u>Hist & Soc Study of Sci & Tech</u>	<u>Linguistics & Philosophy</u>	<u>Poli Sci</u>	<u>Total</u>
1986-87	105	-	55	115	275
1987-88	120	-	72	157	349
1988-89	127	4	67	118	316
1989-90	132	9	77	154	372
1990-91	134	13	61	154	362
1991-92	139	17	53	160	369
1992-93	149	21	57	154	381
1993-94	143	24	50	138	355
1994-95	130	29	65	122	346
1995-96	138	27	63	107	335

TABLE V: HASS MINOR APPLICANTS FOR CLASSES OF 1996, 1997, 1998 AND 1999

FIELD	TOTAL APPLICATIONS
Anthropology/Archaeology	8
Economics	128
Film and Media Studies	7
Foreign Languages	
French	12
German	18
Spanish	24
History	12
History of Art & Architecture	1
Linguistics	6
Literature	15
Music	55
Philosophy	4
Political Science	24
Psychology	18
Regional Studies Minor Programs	
African & African Diaspora	3
East Asian Studies	13
European Studies	1
Latin American Studies	2
Middle Eastern Studies	0
Russian Studies	2
Science, Technology & Society	7
Theater Arts	6
Urban Studies and Planning	7
Women's Studies	1
Writing	42
Total Minor Applications	416

DEPARTMENT OF ECONOMICS

The goal of the MIT Department of Economics is to be the best economics department in the world. To achieve this goal, we strive to maintain both the best Ph.D. program in economics and an outstanding faculty of research leaders. We also endeavor to provide an outstanding education in economics for MIT undergraduates and to encourage our faculty to continue their active and successful public service activities in the United States and abroad.

HIGHLIGHTS OF THE YEAR

The scientific and academic activities of the Economics Department continued at a strong pace during the year. We have made two senior appointments in the areas of international economics and labor economics. In addition, we have made two junior appointments in the areas of contract theory and information economics. The Department continues to search for one senior appointment in the area of economic theory.

Once again, the Department competed aggressively with Stanford, Harvard, and Princeton, for the AY 96-97 crop of new Ph.D. students. We were successful in attracting an excellent class for the fall 1996 term.

The Department has received an NSF (ARI) equipment grant to expand and upgrade the existing graduate student computer cluster and to add an undergraduate computer cluster. Receiving this grant was a major coup for the Department and will ensure that the Department is able to keep pace with the technology used by economists for education and research for at least the next few years. Having graduate and undergraduate computer clusters with state-of-the-art computer equipment will keep the MIT Department of Economics competitive with other top economics departments.

HONORS AND AWARDS

Assistant Professors Daron Acemoglu and Susan Athey both received new NSF awards. Assistant Professor Andrew Bernard served as a Session Chair for the Econometric Society Winter Meetings and the American Economic Association Meetings, Assistant Professor Alberto Bisin received the EEC Human Capital and Development Fellowship, Professor Olivier Blanchard was named Vice President of the American Economic Association, Assistant Professor Dora Costa received the National Institute on Aging Fellowship, Professor Peter Diamond was named the President of the National Academy of Social Insurance and was invited to give the Tjalling Koopmans Memorial Lecture at Yale University, Associate Professor Glenn Ellison was awarded the Sloan Faculty Research Fellowship, Associate Professor Jonathan Gruber received the National Science Foundation Presidential Faculty Fellowship, Professor Bengt Holmström was elected Research Associate at NBER, Professor Paul Joskow received the Edward A. Hewett Prize by the American Association for the Advancement of Slavic Studies and was named as the Elizabeth and James Killian Professor, Assistant Professor Michael Kremer was named the NBER Health and Aging Fellow, Professor Michael Piore was a finalist in the Los Angeles Times Book Prize for his book *Beyond Individualism*, Professor James Poterba was elected a Fellow of the American Academy of Arts and Sciences and named Mitsui Professor of Economics and Management, Professor Peter Temin was elected the President of the Economic History Association, and Institute Professor Paul Samuelson received the National Medal of Science.

PROGRAM HIGHLIGHTS

This year's entering class of 24 Ph.D. students will include 15 international students (several of whom have undergraduate degrees from U.S. universities) and 4 women (17%). Seventeen percent of our entering class have National Science Foundations Fellowships to begin their graduate studies in economics.

Undergraduate enrollment increased again last year. The department has experienced a continued increase in enrollment for undergraduates with a total increase of 36% over the last ten years. There were 130 undergraduate majors in economics (29 of whom are double majors), 128 undergraduate minors and 316 concentrations completed in economics last year.

Our Class of 1996 job market candidates did very well this year, with 36% receiving assistant professorships in top ten economics departments. A total of 71% of our graduate accepted academic positions, 16% accepted government positions, 10% obtained positions in the private sector and 3% took positions in non-profit research institutions.

RESEARCH ACHIEVEMENTS

Faculty research continues to be intense and highly productive. Assistant Professor Acemoglu is working on "Changes in Unemployment and Wage Inequality: An Alternative Theory and Some Evidence"; Assistant Professor Athey has just published "Product and Process Flexibility in an Innovative Environment" in the *Rand Journal of Economics*; Assistant Professor Bai has just published "Testing For Parameter Constancy in Linear Regressions: An Empirical Distribution Function Approach" in *Econometrica*; Professor Banerjee is working on "Contractual Choice and Productivity: Theory and Evidence"; Assistant Professor Bernard has a paper forthcoming in the *American Economic Review*: "Comparing Apples and Oranges: Productivity Convergence and Measurement Across Industries and Countries"; Professor Blanchard has two books forthcoming this year: *The Economics of Transition*, Clarendon Lectures, from Oxford University Press, and *Macroeconomics*, Prentice Hall; Professor Caballero has "The Cleansing Effect of Recessions" forthcoming in the *American Economic Review*, Papers and Proceedings; Assistant Professor Costa has just published "Health and Labor Force Participation of Older Men, 1900-1991" in the *Journal of Economic History*; Professor Diamond has just published "Discussion of the conceptual underpinnings of the contingent valuation method by A.C. Fisher" in *The Contingent Valuation of Environmental Resources: Methodological Issues and Research Needs*, from Edward Elgar Publishing; Professor Dornbusch has just published "Currency Collapses" in the *Brookings Papers*; Professor Eckaus is continuing his research on energy policy and greenhouse gas emissions in China; Associate Professor Ellison is working on "Basins of Attraction, Long-Run Equilibria and the Speed of Step-by-Step Evolution"; Professor Fisher is working on *The Economic Theory of Production Prices Indexes* which is forthcoming from Cambridge University Press; Associate Professor Genesove is working on "Trade Mechanisms in the New England Fish Industry"; Associate Professor Gruber has the paper "Saving Babies: The Efficacy and Cost of Recent Expansions of Medicaid Eligibility for Pregnant Women" forthcoming in the *Journal of Political Economy*; Associate Professor Harris has just published "Cigarette Smoke Components and Disease: Cigarette Smoke is Far More Than a Triad of 'Tar' Nicotine, and Carbon Monoxide," in the *National Cancer Institute Monographs*; Professor Hausman has just published "Market Definition Under Price Discrimination," in the *Antitrust Law Journal*; Professor Holmstrom has just published "Internal Labor Market: Too Many Theories, Too Few Facts" in the *American Economic Review*; Professor Joskow has just published "Privatization in Russia: What Should Be A Firm?" in the *International Journal of the Economics of Business*; Associate Professor Kremer has the paper "Integrating Behavioral Choice into Epidemiological Models of the AIDS Epidemic" forthcoming in the *Quarterly Journal of Economics*; Professor Newey has just published "Nonparametric Estimation of Exact Consumer Surplus and Deadweight Loss" in *Econometrica*; Professor Piore has just published the chapter "Local Development on the Progressive Political Agenda" in the book *Reinventing Collective Action: From the Global to the Local*, from Blackwell Publishing; Assistant Professor Pischke has published the chapter "A Comparison of East and West German Labor Markets Before and After Unification" in the book *Differences and Changes in Wage Structures*, from the Chicago University Press; Professor Poterba has just published "Environmental Taxes on Intermediate and Final Goods When Both Can Be Imported" in *International Tax and Public Finance*; Associate Professor Smith just published "Necessary and Sufficient Conditions for the Perfect Finite-Horizon Folk Theorem" in *Econometrica*; Professor Temin has just published "Introducing Competition into Local Exchange Markets" in *Telecommunications Policy*; Assistant Professor Ventura is working on "A Representative Consumer Theory of Distribution"; and Professor Wheaton has the paper "The Cyclic Behavior of the Greater London Office Market" forthcoming in the *Journal of Real Estate Finance and Economics*.

PERSONNEL

Professor Paul Krugman will be rejoining the faculty effective September 1, 1996 after a two year absence. Professor Krugman specializes in international economics and is the leading economist of his generation. Professor Joshua Angrist, who was a Visiting Professor in AY 95-96, has accepted a position as Associate Professor with tenure. His areas of research are labor, applied econometrics and empirical microeconomics. Assistant Professors Robin Wells and David Spector will be joining the faculty effective July 1, 1996. Professor Wells' interests are in the area of organization theory, contract theory, theoretical and empirical corporate finance. Professor Spector received his Ph.D. in a new, joint program between the LSE and DELTA, and was the most sought after candidate on the job market this year. Professor Spector's interests are in contract theory, information economics and political economy.

Professor Richard Eckaus has formally retired, effective June 30, 1996.

Associate Professor Abhijit Banerjee, was approved for promotion to the rank of Professor, effective July 1, 1996. Assistant Professors Michael Kremer, David Genesove, Lones Smith and Thomas Piketty were all approved for promotion to the rank of untenured Associate Professor, effective July 1, 1996.

Assistant Professor Dora Costa was on leave as the Aging Fellow at the NBER. Associate Professor Jonathan Gruber was also on leave at the NBER and Professor Michael Piore was on leave for the academic year to more aggressively pursue his research.

There were eight visiting faculty for all or part of the 1995-96 academic year. Professor Jean Tirole, of the University of Toulouse, taught a topics course in industrial organization. Assistant Professor John DiNardo taught two courses in the labor economics sequence. Assistant Professor Ilya Segal, currently at Berkeley, taught Principles of Microeconomics. Assistant Professor Sara Ellison, formerly of the NBER, taught Statistics and Econometrics in the fall and Statistics in the spring. Professor John Geanakoplos of Yale, taught General Equilibrium and Topics in Economic Theory in the spring. Professor Robert Porter of Northwestern, Professor Paul Milgrom of Stanford University and Professor Therese McGuire of University of Illinois were visitors to the Department for Fall 1995. Although they did not teach, Professors Porter, Milgrom, and McGuire participated in workshops and worked with students during their visits.

The Department maintains its concern with increasing the representation of women and minorities in the economics profession. All search committees have been instructed to make a special effort to identify outstanding women and minority candidates as an integral component of their search process. To this end, Robin Wells (a minority woman) was aggressively recruited when it became known that she was willing to move from Stanford. As part of the regular recruitment process for junior faculty, the Department solicited/received 224 CVs. Of those, 31 were women. After the first screening, 32 files were retained for a more intensive review. After a second screening, 25 candidates (3 of whom were women) were selected for interviews. All candidates were interviewed by at least two members of the faculty. Subsequently, 4 candidates were invited to come to MIT and present a seminar. As a result of this exhaustive process, one offer was made and accepted.

FUTURE PLANS

We must continue to rebuild the faculty. We have made two of the three senior appointments authorized by the Dean and the Provost. We have a search committee reviewing candidates for the third position and hope to make an appointment this year. Almost 50% of the Department is now made up of junior faculty. This situation presents us with opportunities to bring fine new scholars into the senior ranks of the department. It also places an enormous mentoring burden on the active senior faculty in the Department. Providing competitive compensation arrangements and research funding continues to be a major challenge for retaining and attracting the best faculty.

We must maintain the strength of our graduate program. MIT is widely known to have the best Ph.D. program in the world. With the loss of several senior faculty a few years ago, our ability to recruit the best graduate students slipped for a year. We had a much better yield of the best graduate students applying for admission in AY 95-96. We did even better for AY 96-97. The end of the EB pool, the end of the Javits Fellowship Program, and a declining number of NSF fellowships presents a very difficult financial challenge to sustaining our graduate program.

Paul L. Joskow

ANTHROPOLOGY PROGRAM

As of 1995-1996, the Anthropology-Archaeology Program has a new name and a new focus. During 1995, Program faculty enthusiastically designed a curriculum centered on cultural anthropology, with emphasis on the contemporary world, its dislocations and transformations, and on technology and technical change in social context. As before, course offerings will cover the culture history of various regions, but they will not include subjects devoted primarily to prehistory or technical archaeology.

1995-96 has been an unsettled year, as the Program has adjusted to recent changes in personnel, administration and academic direction, as well as to an upcoming move from dilapidated but comfortable quarters in Building 20. For most of the year, moreover, the Program has had to make do with temporary administrative assistants. Concentrations and overall enrollments, on the other hand, have remained strong, and the new administrative arrangements are working well. Professor James Howe, after a year on leave, has resumed the headship of the Program, with a term continuing to 1999, while Arthur Steinberg continues as Head of the Integrated Studies Program.

HONORS AND AWARDS

Two faculty members received well deserved recognition during the academic year. On November 30th, at an evening of personal tributes and music, Professor Martin Diskin accepted the first Human Rights Award of the Ignacio Martín-Baró Fund for Mental Health and Human Rights. Anthropology Program members were delighted to see Professor Diskin's years of scholarship and advocacy for the people of Central America receive the public tribute they deserve. The Program was also very pleased that Hugh Gusterson was promoted to the rank of untenured Associate Professor of Anthropology and Science Studies.

PROGRAM CONTRIBUTIONS

Anthropologists and the discipline of anthropology continue to play an important part in the doctoral program in the History and Social Study of Science and Technology. As of July first, Professor Michael Fischer will become head of the STS Program, and Professors Jean Jackson, Howe, Gusterson, and Fischer are all involved in the radical revision of the HSSST graduate curriculum that got underway in June of 1996.

The Program's seminar series, "Peoples and States: Ethnic Identity and Conflict," co-sponsored by the Center for International Studies (CIS), finished a seventh successful year.

RESEARCH AND PUBLICATION

Every member of the Program is working on the advanced stages of a book manuscript---Professor Steinberg an experimental historical novel about Venice; Professor Jackson an ethnographic study of a chronic pain center; and Professor Diskin a monograph on land tenure and economic change in El Salvador. One book by Professor Howe was accepted by the Smithsonian Institution Press, while another is in the final stages of editing at the University of Oklahoma Press. Professor Gusterson's book, *Nuclear Rites: A Weapons Laboratory at the End of the Cold War*, is in page proofs at the University of California Press and will appear in the Fall of 1996.

Among the articles and chapters published this year by Program members are Professor Diskin's "Distilled Conclusions: The Disappearance of the Agrarian Question in El Salvador" (*Latin American Research Review*); Professor Gusterson's "Becoming a Weapons Scientist" (in *Technoscientific Imaginaries*); Professor Jackson's "Preserving Indian Culture: Shaman Schools and Ethno-education in the Vaupés, Colombia" (*American Ethnologist*); and "La lucha por la tierra en la costa de San Blas (Panamá)" (*Mesoamérica*) by Professor Howe.

Professor Gusterson has also been collaborating with three political scientists in a series of workshops sponsored by the MacArthur Foundation to consider the field of security studies from a cultural and social constructivist perspective. They have completed the manuscript of a volume entitled *Constructing Insecurity*. Professor Howe is collaborating with tribal authorities in Panama on a project to rescue endangered historical documents, and he is contributing to a special exhibit and edited volume to appear at UCLA's Fowler Museum in the Fall of 1997.

Members of the Program gave talks and attended conferences at locations across the United States and abroad. In June, Professor Gusterson spent three weeks in Tomsk, Siberia, where he interviewed scientists and environmental activists and attended a conference entitled "Radioactivity and Radioactive Elements in the Environment."

James Howe

FOREIGN LANGUAGES AND LITERATURES

During the academic year 1996-97, 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. Several members of the section were recognized by colleagues in their fields and educational institutions. Suzanne Flynn, Professor of Linguistics and Second Language Acquisition, has been named Section Head of FL&L, succeeding Isabelle de Courtivron, Professor of French Studies. Professor Flynn was also honored with the Balliol College Fellowship, an exchange program for faculty at MIT and Balliol College, England, in addition to being recognized by the University of Puerto Rico for her work on educational and linguistic issues relevant to Puerto Rico. Margery Resnick, Associate Professor of Hispanic Studies, and Lecturer in Spanish Margarita Ribas Groeger's project received funding from the Class of '51 Fund for Excellence in Education and the Class of '55 Fund for Excellence in Teaching. María Gonzalez Aguilar, Lecturer in Spanish, received, for the second consecutive year, the Whiting Foundation Fellowship to pursue a project in her field. Professors Edward Turk (French Studies), James Harris (Spanish and Linguistics), Shigeru Miyagawa (Linguistics and Japanese) and Professor Resnick were on leave during the Fall term, and Professor Flynn and Bernd Widdig, Assistant Professor of German Studies, were on leave during the Spring term.

FL&L faculty and lecturers, working with colleagues in the Laboratory for Advanced Technology in the Humanities (LATH) and the Language Learning and Resource Center (LLARC), have been researching and developing materials and new technology to enhance the teaching of foreign languages and culture. Award-winning work on interactive video projects include: *No recuerdo*, an interactive narrative documentary for the Spanish language (Douglas Morgenstern, Senior Lecturer in Spanish, Principal Investigator, PI); *Dans le Quartier St. Gervais*, a French language learning interactive video (Gilberte Furstenberg, Senior Lecturer in French, PI); *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 Dr. Janet Murray, Senior Research Scientist and Director of the LATH; *Star Festival*, an interactive CD-ROM for Japanese language and culture learning (Professor Miyagawa, PI); *Paradoja*, a CD ROM that explores the problems and obstacles women face in Latin America (Lecturers Ribas Groeger and Gonzalez Aguilar, co-PI's); and *Berliner sehen*, an interactive documentary for German language learning (Ellen Crocker, Lecturer in German, and Associate Researcher Kurt Fendt, co-PI's). The LATH is also in the final stages of a joint project with Lincoln Labs for advanced conversation-based language learning systems. The Department of Education demonstrated its support for the interactive video projects with a new grant for JP NET, a global information service for Japanese language and culture instruction. The Consortium for Foreign Language Teaching and Learning remains a strong supporter of various FL&L projects, providing continued funding for an interactive archive of German Jewish survivors of the Holocaust; and the development of an interactive film subtitling program to facilitate the use of language materials in the classroom. Professor Miyagawa is the PI for the Japanese/English Lexicon Project, a major new initiative for the research and application of lexical structures for linguistics, machine translation, and Japanese Language Education. A grant proposal for the project is now pending from Fujitsu Limited.

Research in the areas of literary and cultural studies, linguistics and language pedagogy continues to be of the highest caliber, with articles published in internationally respected journals. Professor de Courtivron's "Notes from a Department in Progress" appeared in the *Consortium News*, as did Lecturers Ribas Groeger and Gonzalez Aguilar's jointly authored "Paradoja, from Documentary Film to Interactive CD-ROM." Senior Lecturer Morgenstern's "Tracking the Missing Biologist" appeared in *Humanities* and Martin Roberts, Assistant Professor of French Studies, published his article "Self in the Other: Ethnographic Film, Surrealism, Politics" in *Visual Anthropology*. Research Associate Fendt's article "Interactive Reading: Hypertext and Literary Studies" was published in *SIMA*. A number of faculty authored chapters in books this year, as well. Professor Harris published a chapter entitled "The Morphology of Spanish Clitics" in *Evolution and Revolution in Linguistic Theory*. "Toward Theory-Driven Language Pedagogy," co-authored by Professor Flynn appeared in *Second Language Acquisition Theory and Pedagogy*. Reviews by faculty members appeared in a number of journals, including *The French Review*, the *New York Times Book Review*, the *Washington Post*, and *German Quarterly*.

This year, two FL&L faculty members were offered Visiting Professorships - Professor Flynn, at Ortega y Gasset in Madrid, Spain; and Professor Harris at the Universidad Nacional del Comahue in Argentina. In addition to these

appointments, FL&L faculty were invited to several conferences in the U.S. and around the world and thus had opportunities to present their research to international audiences. Among them, Lecturer Crocker spoke at Universität München on New Media Technologies, while Senior Lecturer Furstenberg attended a conference on Multimedia and French as a Foreign Language at the University of Lille, France. She also gave a workshop about multimedia design and its application for foreign language teachers at the University of British Columbia. Professor Miyagawa gave the inaugural lecture entitled "Information Deficit and the Need for Japanese Language Education" at the Kochi-MIT International Exchange Program in Kochi, Japan; Professor Resnick participated in FIONA - the European Community teleconference/conference in Barcelona; and Elizabeth Garrels, Associate Professor of Hispanic Studies, participated in the Latin American Studies Association conference in Washington, D.C. Professor Flynn was the keynote speaker at the University of Puerto Rico at Humacao on "The Role of Technology in the Language Classroom." Professor Harris was invited as plenary session speaker at the University of Amsterdam's conference "Going Romance 95" and also at the "Langues et Grammaire" conference at the Université de Paris. Nicolás Wey Gómez, Assistant Professor of Hispanic Studies presented two papers, "El origen histórico y literario de la conformidad y la monstruosidad en el Caribe Colonial" and "Visiones del mundo: la cosmografía escolástica en los siglos XV-XVI" at the Universidad Autónoma, Madrid, Spain. Professor Wey Gómez was also invited to UCLA to present his work entitled "Jealousy, Paranoia, and Homosexuality in Cervantes' Fiction" and Professor Widdig spoke on "Masses of Money: *Dr. Mabuse, the Gamer* and the Experience of Inflation" at the 19th annual German Studies conference in Chicago. Jane Dunphy and Mary Christie, Lecturers in ESL, each presented their work at the Languages and Communication for World Business and the Professions conference in Michigan. Takako Aikawa, Assistant Professor of Japanese, co-authored "Two Types of Zi-Verbs in Japanese" that she presented at the 10th New England Pedagogy Workshop for Teachers of Japanese Language held at Harvard University. Professor Resnick spoke on Women's Equality Day at the Veteran Administration Women's Labor Bureau in Washington, D.C. Shoggy Waryn, Lecturer in French, gave a paper entitled "French Television and the Age of Globalization" at the University of Iowa, and Professor Turk presented his work "Carné: A Life in French Film" at Boston College. Faculty members also gave talks at: the University of Zaragoza, Spain, New York University, Cornell University, the Goethe Institute, Brown University, and the NEH Summer Institute, among other institutions.

There have been a number of cultural and educational events that our faculty have planned and participated in both locally and at MIT. The ESL Program, under the direction of Professor Flynn and in conjunction with the Sloan School of Management, is in the second year of its highly successful summer intensive for incoming MIT MBA students. The program is designed to immerse students not only in written and spoken English, but also in American culture, through social and educational activities in and around Boston and MIT. Lecturer Gonzalez Aguilar organized the Hispanic Month movie festival; Monika Totten, Lecturer in German in conjunction with the Goethe Institute, co-sponsored a poetry reading by prize winning German author Holger Teschke. Professor Miyagawa organized and planned a workshop that brought members of the NorthEast Association of Teachers of Japanese together with staff of JP NET in order to establish an information and pedagogy exchange among secondary teachers of Japanese around the world via the World Wide Web. Professor Aikawa, and Tomoko Graham, Lecturer in Japanese, participated in the conference as well. Yih-jian Tai, Visiting Lecturer in Chinese, co-produced and performed in the production *Within the Forbidden City* as part of Boston's Asia Pacific month. Professor Widdig organized meetings with German government officials as part of his participation and leadership in the new MIT-Germany program. This initiative, modeled after the MIT-Japan Program, will give students the opportunity to combine their knowledge of German language and culture with their expertise in the field of engineering and science by working with business and research interests in Germany.

Members of the FL&L faculty also contribute to MIT through their service on a number of Institute-wide committees: The Institute Nominations Committee, Equal Opportunity Committee, Regional Minors Committee, HASS-D Overview Committee, Edgerton Award Committee, Committee on the Writing Requirement, Women's Studies Steering Committee, Phi Beta Kappa Selection Committee, Corporation's Joint Advisory Committee on Institute Wide Affairs, Committee on Academic Performance, Sub-Committees for Undergraduate Programs and the Committee on Curricula, among others.

FL&L has maintained its commitment to making full-time appointments and to attracting qualified candidates from minority groups. In order to achieve those goals, FL&L has targeted historically black colleges and universities and has advertised in journals focusing on the minority community.

While the number of majors in FL&L remains low at three, the number of minors (60) has been steadily increasing and the number of concentrators (499) has remained stable. Spanish continues to have the largest enrollments at 511; followed by French, 377; Japanese, 351; German 214; English as a Second Language, 220; Chinese 186; and Russian (Literature), 17. Enrollments in Studies in International Literatures and Cultures (cross-cultural language and culture subjects taught in English) are subsumed under the language group to which the instructor belongs. FL&L subjects also make up an important component of the Regional Minors Program. There are currently 21 students who are pursuing minors in one of the Regional Studies programs.

MIT alumni have continued their support and efforts to expand the East Asian language program. In response to overwhelming interest in East Asian languages and cultures, the section is aggressively recruiting a scholar to head our Chinese Program. It is hoped that a professor of Chinese Studies will join the section by AY 1998.

Isabelle De Courtivron

HISTORY

Most of the History faculty continued work on their large-scale research manuscripts during the year, in addition to keeping active in teaching and Institute service. Professor John Dower appeared frequently in the U.S. and Japanese media in connection with the fiftieth-year anniversary commemorations of the end of World War II.

ACADEMIC PROGRAMS

Associate Professor Christian Appy; William R. Kenan, Jr. Professor Pauline Maier; Professor Bruce Mazlish; Professor Peter C. Perdue; Associate Professor Douglas J. Forsyth; and Assistant Professors Heather Cox Richardson and Elizabeth Wood 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. Luce Professor John W. Dower and Dean Philip S. Khoury advised advanced graduate students at Harvard in Japanese and Middle Eastern history, respectively.

Enrollments in history courses were 474 in Fall, 1995 and 493 in Spring, 1996. 6 students majored and eleven students minored in history. The most popular subjects included: 21H102 Emergence of Modern America (34), 21H116J Civil War and Reconstruction (37), 21H301 Ancient World: Greece (61), 21H302 Ancient World: Rome (68), 21H433 The Age of Reason (48), 21H522 Japan in the Age of the Samurai (35), 21H546 World War II in Asia (33), 21H921J Ideas of the World Order (50).

Freshman advisor seminars were taught by Professor Appy on "National Insecurity," Associate Professor Arthur D. Kaledin on "The End of the World," and Professor Khoury on "Conflict and Peace in the Middle East." Associate Professor William B. Watson, Professor Appy, Associate Professor Anne E. C. McCants, and Professor Perdue supervised UROP projects.

Visiting Lecturer Emma Jinhua Teng began two new subjects in Asian-American History and Asian-American Women's Studies that drew substantial student interest; we plan to continue to offer subjects in this field in the future.

Five students wrote senior theses in History: Thomas M. Callaghan, on "Hitachi Corporation, July 1937 to April 1952"; Jonora K. Jones, on "Creoles of Color in Louisiana during the Late Eighteenth and Early Nineteenth Centuries"; Ximena Leroux, on "Chiapas: Structural Conditions of Peasant Rebellion"; Justin E. Manley, on "A Characterization of Romano-Celtic Religion: Religious Interaction in Roman Britain"; Scott W. Seago, on "The Development of Uniformity and Roman Use in Early Anglo-Saxon Liturgy".

HONORS AND AWARDS

Professor McCants won the Edgerton Award of 1996 for outstanding research, teaching, and service to the Institute by a junior faculty member. The History Faculty is very proud of her achievement. In addition to her highly regarded research and teaching, she has served as Housemaster of Green Hall and chaired the Truman Fellowship competition.

Professor Dower will become the first holder of the Elting E. Morison Chair in the Humanities on July 1, 1996. The professorship recognizes outstanding contributions of distinguished faculty members in the Humanities at MIT. Professor Perdue won the Wade Award for innovation to support his new project developing a video internet archive of materials on modern Chinese history. Associate Professor Jon E. (Ted) Lendon was nominated for the Carnegie Foundation for the Advancement of Teaching 1996 U.S. Professors of the Year Program.

PROMOTIONS AND RETIREMENTS

Professor Wood was promoted to Associate Professor on the basis of her forthcoming manuscript discussing the role of gender in the early period of the Russian Revolution, and she won the Levitan Prize for her new project examining the impact of agitation trial literature on the formation of early Bolshevik culture. She also organized a conference at MIT which gathered younger scholars in the field of Soviet history together to present papers on their new research.

Associate Professors Kaledin and David Ralston were promoted to Full Professor and retired after over thirty years of active service to the MIT community. Professor Kaledin will continue working on his long-standing interest, the Thought of Alexis de Tocqueville. Professor Ralston has published several books in European and comparative military history, and he plans to remain active in his field. Friends and colleagues join in expressing their appreciation for all they have done for the History Faculty and the Institute.

RESEARCH AND PUBLICATIONS

Dean Philip S. Khoury published several articles, including "The Muslim Brotherhood in Syria". He also chairs the McMillan-Stewart committee in the Study of Women in the Developing World, which has interviewed several senior scholars of the Middle East for a possible appointment next year. Professor Maier has begun to write her chapters for the Sloan Foundation History of the United States, a major project funded by the Sloan Foundation, which will produce an American History that incorporates the history of science and technology.. Professor Merritt Roe Smith is the project's director; the other participants are Professors Daniel Kevles of California Institute of Technology and Alex Keyssar of Duke University. Professor Maier completed her manuscript currently titled "Sacred Scriptures: Making the Declaration of Independence". Professor Bruce Mazlish coedited with Leo Marx a volume entitled *Progress: Fact or Illusion*, and organized a panel on "Global History: A New Perspective", at the American Historical Association meeting in Atlanta. Associate Professor Anne McCants published "Fertility, Marriage, and Decline: Demographic Processes among Norwegian Immigrants to the Rural Middle West" and "Meeting Needs and Suppressing Desire: Consumer Choice Models and Historical Data." Professor Harriet Ritvo published "Border Trouble: Shifting the Line between People and Other Animals", "Barring the Cross: Miscegenation and Purity in 18th and 19th Century Britain", and "The Natural Order: Constructing the Collections of Victorian Zoos."

INSTITUTE COMMITTEES AND SERVICE

Associate Professors Ted Lendon and Anne McCants served on the Committee on the Undergraduate Program; Associate Professor Christian Appy served on the Committee on Curricula; Professor Peter C. Perdue served on the new MIT International Council and the Committee on Undergraduate Admissions and Financial Aid; Professor John Dower served on the Library Committee.

OTHER ACTIVITIES

Professor Richardson directed the Kenan Sahin lecture series, which presented talks "From Civil War to Civil Rights: The First and Second Reconstructions in American History" by Professor Eric Foner of Columbia University and "'Americans Must Rule America: Anti-immigrant Sentiment in American History" by Assistant Professor Tyler Anbinder of George Washington University. Professor Mazlish again jointly ran the History and Literature Workshop series, and Dean Khoury directed the Bustani Middle Eastern Seminar.

The History Faculty will continue to make every effort to increase its representation of women and minorities especially as it embarks next year on three tenure-track searches for European and American historians.

Professor Pauline Maier will serve as Acting Head during the Fall term of 1996, while Professor Perdue is on sabbatical leave.

Peter C. Perdue

LITERATURE

1995-96 was a productive and active year for the Literature Faculty, in which two new faculty members joined the Section and several retired or announced their intention to retire (See Personnel). Three books by members of the faculty and teaching staff were published: Associate Professor Diana Henderson's *Passion Made Public: Elizabethan Lyric, Gender and Performance* (University of Illinois Press); Associate Professor Mary Fuller's *Voyages in Print: English Travel to America, 1576-1674* (Cambridge University Press); and Lecturer Wyn Kelley's *Melville's City: Literary and Urban Form in Nineteenth-Century New York* (Cambridge University Press). Other highlights of the year include the award of two NEH Fellowships and an ACLS Fellowship to members of the faculty, the award of a fifth major grant to the Shakespeare Electronic Archive team, the appointment of Diana Henderson as Associate Professor of Literature, and the promotion of Assistant Professor James Buzard to Associate Professor and his appointment to the the Class of 1956 Career Development Professorship.

ACADEMIC PROGRAM AND STUDENT ENROLLMENT

During the past year, 1,126 students enrolled in Literature subjects, 16 were registered as Literature majors, 16 as minors, and 90 as concentrators in Literature for the HASS requirement. In addition, 8 students were enrolled as majors in the new Film and Media Studies major departure. Film and Media Studies, an interdisciplinary program, is headed by Professor Jenkins and administered by Literature. The first graduate level subject in the critical and historical study of film and media was offered in 1995-6: Professor Jenkins' Media, Culture and Society (21L907).

RESEARCH AND PUBLICATION

Professor Peter Donaldson continues to work at the juncture of literary study and emerging technologies as director of the Shakespeare Electronic Archive and is working on a series of essays on the construction of a global Shakespeare information space and its theoretical and cultural implications. Professor Alvin Kibel is editing a volume based on the international conference on "The End of the Twentieth Century" held at the Library of Congress, which he organized. Professor David Thorburn is working on a history of prime time television narrative. Professor Ruth Perry published several essays in the field of Eighteenth Century Studies and feminist criticism in *Transformation, Profession 95* and elsewhere, and is completing her book on the family in eighteenth-century English literature. Professor Hildebidle is conducting research on the Field Day and published several poems and essays. Professor Stephen Tapscott published several essays and poems in *The Breadloaf Anthology, PN Review, Epoch* and *The Atlantic Monthly*. Professor Jenkins has completed several chapters of a book on shifts in the discourse and culture of childhood and childrearing in post-War American literature, film and media, and is preparing a CD-ROM film textbook in collaboration with Senior Research Scientist Janet Murray. Professor Fuller published her book *Voyages in Print: English Travel to America, 1576-1674* and is working on her second book on the cultural and literary implications of English travel to the New World in the Early Modern Period. Professor Henderson published her book *Passion Made Public* and is working on a series of studies of modes literary collaboration. Professor Buzard published an essay on "Translation and Tourism: Scott's Waverly and the Rendering of Culture" in the *Yale Journal of Criticism* as part of his work toward a book on literature, culture and ethnography in 19th-century England. Professor Shankar Raman is completing a book on Renaissance Literature and European travel to and images of India and "the East."

CONFERENCES AND INVITED ADDRESSES

Members of the faculty have also presented their work at a number of conferences including meetings of the World Shakespeare Congress, Society for Cinema Studies, The Modern Language Association, the Northeast Modern Language Association, The Society for the Study of Narrative Literature, The Forum for European Expansion and Global Interaction, Connotations-Symposium (Cologne, Germany, The Berkshire Conference on the History of Women (Chapel Hill, N.C.), Console-ing Passions: Feminism and Television Conference. Literature faculty have also delivered public lectures and presentations at Clemson University, University of California, Santa Cruz, University of Hartford, Yale Center for British Art, University of Burgogne (France), University of Aberystwyth (Wales), The John Carter Brown Library, Victoria College, University of Toronto, Seikei University (Tokyo), Northeastern University, The University of Salerno (Italy), The University of Lille (France), Vassar College, University of Massachusetts, Amherst, and Wellesley College.

SERVICE, GRANTS AND AWARDS

The Shakespeare Electronic Archive project, headed by Professor Donaldson, and Dr. Janet H. Murray, Director of the Laboratory for Advanced Technology in the Humanities, received a major grant from the National Endowment for the Humanities. The award, which provides \$118,000 in direct support and \$100,00 in potential matched funds, will make it possible to digitize the entire collection of quarto editions of Shakespeare plays at the Henry E. Huntington Library and, in addition, extend the work of the Shakespeare Electronic Archive group to the World Wide Web. The Shakespeare Electronic Archive is also supported by the Andrew W. Mellon Foundation, who have provided a direct grant for the creation of an on-site archive at the Folger Shakespeare Library and matching funds for NEH grants. Professor Donaldson chaired the Library Advisory Committee, charged with conducting the search for a new MIT Director of Libraries which resulted in the appointment of Ann Wolpert to the position, and served as a member of the Council on Educational Technologies. Professor Perry held the Fellowship of the American Council of Learned Societies in the Spring Term and also 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 Fuller held two National Endowment for the Humanities Fellowships, one for study at the John Carter Brown Library in Providence and a second for study at the Folger Shakespeare Library in Washington, D.C. Professor Raman was appointed Research Fellow of the Literary Anthropology Research Project at the University of Konstanz, Germany. Professor Buzard was appointed to MIT's Class of 1956 Career Development Chair.

PERSONNEL

Professor A.R. Gurney Jr. retired and Professor David M. Halperin resigned as of June 30, 1996. Professors Irene Tayler and Travis Merritt announced their decisions to accept the faculty retirement incentive plan effective in FY 97. Professor Emeritus Louis Kampf, who had held the position of Senior Lecturer following his retirement from the faculty in 1994, retired from active service at the end of the academic year.

AFFIRMATIVE ACTION

Professor Henderson's appointment increased the representation of women on the regular faculty for the year, and Professor Raman's appointment following last year's search marked the first appointment of a faculty member of Asian nationality in Literature. The retirement of Professor Tayler, effective in FY97, will offset the gain in the representation of women in the short term, but it is our expectation that through active searches for unfilled positions and presentation of appropriate proposals for target of opportunity appointments, we will increase the representation of women and minority faculty by at least one in each category in the next two years.

Peter S. Donaldson

MUSIC AND THEATER ARTS

Music and Theater Arts continues to afford students at MIT the opportunity to experience the unique language and process of the arts in their integrity. The social and moral contexts of human experience also informs all our curricular and co-curricular offerings. Faculty and teaching staff help students understand art's particular demand for rigor and discipline, its non-quantitative standards of excellence and beauty. A strong, comprehensive program in both Music and Theater Arts, encompassing history, theory and performance--taught by a faculty and staff of the highest caliber whose ongoing professional activities inform their teaching--has been and will continue to be our hallmark. Because it is comprehensive, the academic program serves as a base for those who have the talent and desire to continue their education in Music or Theater beyond the undergraduate level. The Section also affirms its commitment to diversity within its disciplines and among its staff.

HIGHLIGHTS OF THE YEAR

If one word were used to describe the Section during the past year, that word would be change, and leadership changes were among the most significant. The Section had a different temporary head each term as a rare turn of events saw Section Head, Professor Alan Brody, elevated to the position of Associate Provost for the Arts upon his return from sabbatical leave on January 1, 1996. Professor Marcus Thompson led the Section during the fall term, while Institute Professor John Harbison served as temporary Head during the spring term. Senior Lecturer, John Oliver, conductor of the Tanglewood Festival Chorus for the Boston Symphony Orchestra and long-time head of the choral program within the Section, chose to take early retirement, as did our Administrative Officer of thirteen years, Nancy Cavanagh. In addition, Assistant Professor Janet Sonenberg became Acting Director of Theater Arts. The MIT concert season featured the debut performance of a new chamber ensemble, SONOS, comprised of Bayla Keyes, violin; Professor Thompson, viola; Andrés Díaz, 'cello; and Senior Lecturer David Deveau, piano. Their performance received a glowing review by *The Boston Globe* music critic, Richard Buell. The MIT Brass Ensemble journeyed to France during the spring break, performing concerts in St. Lô, St. Pair, Caen, Rouen, and Paris. This tour was the second part of an exchange with the *Ensemble de Cuivres de Saint-Lô*, who visited MIT last spring and performed with the Brass Ensemble in Kresge Auditorium. The first in a series of exchange concerts with the music faculty of Emory University in Atlanta featured seven members of the Emory Chamber Music Society in a performance of "New Music from Emory" at Kresge Auditorium.

HONORS AND AWARDS

Professor Sonenberg was presented the Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching at the annual Awards Convocation in May. This is the second year in a row that a member of the Section has won the award. Last year's recipient was Lecturer in Music Elena Ruehr. The major Institute student awards in the Arts were also captured by Music or Theater Majors. Alan Pierson '96 (Music) and Marivi Acuna '96 (Theater Arts) each received a Wiesner Award, while Jeffrey Morrow '96 (Music) was awarded the Louis Sudler Prize. Pierson and Morrow will continue their music education in graduate programs at U. Cal. Berkeley and the Eastman School of Music.

PROGRAM HIGHLIGHTS

Enrollments in Music subjects climbed to their highest level yet at 1343, and Theater Arts leveled off at 306 for a total of 1649. Through the generosity of Mr. and Mrs. Cherry Emerson and Mr. and Mrs. G. Robert Klein, three fine, used grand pianos were purchased for our practice rooms. Seven of the eight rooms are now equipped with pianos, six with small practice grands, and one with a new upright that is moved into 4-270 each Monday for use in the large lecture for the Introduction to Western Music subject. The Section also sold two concert grand pianos and, again with help from the Emersons, was able to realize its long-planned-for goal to purchase another Steinway concert grand for Kresge Auditorium. The Roy Lamson Memorial Concert in September featured new works by MIT composers Associate Professor Evan Ziporyn, Senior Lecturer Edward Cohen, and Lecturer Elena Ruehr, all commissioned by the Council for the Arts. Guest Artist residencies that include a public performance, coachings, and lectures or lecture/demonstrations have become an important tool in providing an expanded perspective and innovative approach to both traditional and 20th century musics. Residencies by the prize-winning St. Lawrence String Quartet and the Rova Saxophone Quartet were extremely well received by students and very successful. The MIT Symphony under the direction of Professor Emeritus and Senior Lecturer David Epstein had a noteworthy season of concerts featuring MIT student soloists and the music of MIT student composers. In a concert that sold

out several days in advance, Dr. William Cutter, Lecturer in Music, conducted both the MIT Symphony and the MIT Concert Choir in a moving performance of the Mozart *Requiem* and *Cantata 118* by Bach.

Theater Arts faculty were very much in evidence as directors of major student productions. Associate Provost for the Arts Alan Brody directed Playwrights in Performance--two evenings of one-act plays by MIT student playwrights; Professor Sonenberg directed the Dramashop's *Escape from Happiness* in February, while Lecturer Michael Ouellette directed the same group's performance of *Medea*. In a performance that combined the talents of student musicians and actors, Gamelan Galak Tika, our Balinese percussion orchestra, provided the music for theater arts' Shakespeare Ensemble in a strikingly original version of Shakespeare's *The Tempest*.

ACHIEVEMENTS

Prodigious productivity marked the activities of our faculty this year, but none was more productive than Professor Harbison who premiered five of his compositions in locations around the world, one of which--*San Antonio*, a Sonata for Alto Saxophone and Piano--was premiered in 77 locations at the same time. In addition, 6 CDs of his music were released under 5 different labels; four compositions were published; four commissions awarded, including one from the Metropolitan Opera for a full-length opera; and he was appointed President of the prestigious Copland Fund and a member of the Advisory board of the National Young Composers Competition. Professor Brody's play *The Housewives of Mannheim* won the Best Play of 1995 award from the Live Oak Theater Festival in Austin, Texas, and he was also invited to conduct acting workshops at the fourth Annual Festival of European Schools of Theater. Professor Lowell Lindgren delivered a major paper and chaired the closing 18th-century session of *Relazioni musicali tra Italia e Germania nell'eta barocca* at the Six th International Convention, Antiquae Musicae Italicae Studiosi of Como. His book, *Fifteen Violoncello Sonatas by Antonio Maria Bononcini*, was published by A-R Editions, and he also completed six review essays for a number of publications. Associate Professor Martin Marks chaired sessions at the Annual Meetings of the Sonneck society for American Music and the American Musicological Society. He continued to be in great demand as a Lecturer/Performer at screenings of silent films at the Harvard Film Archive, Boston University, and Brandeis University. Professor Sonenberg's book *The Actor Speaks*, an exploration of the creative process, was published by Crown Publishers, Inc. Instructor Thomas DeFrantz had his feature article, "The Black Body in Question" published by *Village Voice*, and he presented papers at the Congress on Research in Dance in Miami, the Performance Studies Conference at Northwestern University and the Congress on Research in Dance Special Topics Conference at Champaign-Urbana.

PERSONNEL

The Section continued its commitment to diversity of faculty and programs with the hiring of James K. Makubuya as Assistant Professor of Music. Professor Makubuya is a specialist in the music of his native Uganda and will expand an ethnomusicology program that already includes musics of India and Indonesia when he comes on board next fall. Peter Child was promoted to Full Professor and will serve as Section Head for the next three years; Professor Sonenberg was appointed Director of Theater Arts, replacing Professor Brody; Pamela S. Wood was appointed Senior Lecturer in Music; and John H. Lyons will become the Section Administrative Officer, all as of July 1. Lecturer in Theater Arts Kermit Dunkleberg, who has served as Director of the Shakespeare Ensemble for the past several years, leaves to complete his Ph.D.; and the Section bid farewell to Administrative Assistant Jane White who left to become Professor Brody's Assistant in the Provost's Office.

John Harbison

PROGRAM IN WRITING AND HUMANISTIC STUDIES

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.

In addition to its curriculum, the Program offers a number of cultural and literary activities to the MIT community. Pulitzer-Prize winning novelist E. Annie Proulx spoke in our Writers Series this year. Poets Alan Dugan, Sharona Ben-Tov, Lloyd Schwartz, Christopher Jane Corkery, Lavinia Greenlaw, Celia Gilbert, Steve Kelen, Charles Wright, and Carl Phillips spoke in our Poetry at MIT series.

In research and writing, Professor Kenneth Manning continues to increase and document his large data base on black physicians in his project on "Blacks in American Medicine, 1860-1980". Professor James Paradis continues his work on Samuel Butler. Professor Elzbieta Ettinger Chodakowska published her book, *Hannah Arendt - Martin Heidegger*, which was widely reviewed, and continues her biography of Hannah Arendt. Professor Cynthia Wolff continues work on slave narratives and primary research for a biography of Willa Cather. Assistant Professor Susanne Klingenstein has completed a draft of her new book, *Enlarging America: The Cultural Work of Jewish Literary Scholars, 1930-1990*. Senior Lecturer Edward Barrett continues his work on the *Electronic Multimedia Online Textbook in Engineering* and has begun a new series of books at the MIT Press on digital communication. Professor Alan Lightman published a collection of essays, *Dance for Two*.

On other activities and honors of the faculty, Professor Anita Desai's recent novel, *Journey to Ithaca*, received a long and favorable review in *The New York Review of Books* in the context of her entire body of work. Professor Wolff gave a major address at the Austrian American Studies Association meeting in Vienna. Professor Lightman won the 1996 American Institute of Physics Andrew Gemant Award for contributions to the public understanding of science and was also elected to the American Academy of Arts and Sciences.

In Institute service, Professor Paradis completed his first year as chair of the HASS-D Committee. Professor Lightman chaired a CUP subcommittee to evaluate the Writing Requirement and has helped develop a new initiative to substantially deepen and broaden the requirement to a new Undergraduate Communication Requirement.

The Program has initiated a major expansion in the area of digital communication. To this end, Senior Lecturer Barrett has developed a new subject, Communicating in Cyberspace, which he team taught with Visiting Scholar Marie Redmond for the first time this past spring. We have also begun a national search for a new assistant professorship in this area.

We had 50 percent women on our total staff and 55 percent women in our core faculty. We have two underrepresented minorities in our teaching staff.

Alan Lightman

DEPARTMENT OF LINGUISTICS AND PHILOSOPHY

The Department of Linguistics and Philosophy consists of two sections, twenty-four faculty members (five of them jointly appointed), sixty graduate students, two dozen or so visiting scientists and scholars, and a staff of seven. Each section operates quite independently of the other; 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. In the most recent National Research Council rating of graduate programs in the United States, Linguistics and Philosophy were ranked first and tenth, respectively--on faculty quality; second and seventh, respectively--on program effectiveness.

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, sometimes complementary 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 syntax, semantics, morphology, phonology, and on the interfaces between these modules of the grammar of natural language by MIT graduate students, faculty, and visitors.

Neurolinguistic research, in addition to rapidly developing work on language growth and use, is now a central piece of Linguistics research at MIT, and has led directly to the [Mind Articulation] Project, a five-year, joint MIT Linguistics/Tokyo University Physiology project supported by the Research and Development Corporation of Japan.

RESEARCH: PHILOSOPHY

Research in philosophy is not so neatly programmatic as it is in linguistics; thus it is best simply to list the wide range of topics pursued in current research in philosophy at MIT, including but not exhausted by the following: the philosophy of phonology and morphology; theories of consciousness and the mind-body problem; causation and laws of nature; the analysis of fundamental metaphysical concepts: substance, attribute, essence, set, identity, etc.; problems at the intersection of ethics and historical sociology; foundational questions of quantum physics; the analysis of natural laws and their role within scientific theories; applied aesthetics; the foundations of "possible worlds" semantics for modal and conditional logics; the ontology of events; the identity across time of people and other physical objects; the principles of rationality governing ethical reasoning; and the role of evaluative thoughts in practical reasoning.

PUBLICATIONS

As in the past, the faculty on both sides of the Department gave--in the course of the year--a very large number of colloquium presentations, keynote talks at conferences, and workshops in various parts of the United States and the world, while publishing an equally large number of journal articles, chapters in books, and reviews. In addition, the following books appeared during the year: Institute Professor Noam Chomsky's *The Minimalist Program* (MIT Press) and his *Powers and Prospects: Reflections on human nature and the social order* (Allen & Unwin and the South End Press); Professor Joshua Cohen's *Associations and Democracy*, with Wisconsin's Professor Joel Rogers (Verso); and Professor Judith Thompson's *Moral Relativism and Moral Objectivity*, with Princeton's Professor Gilbert Harman (Blackwell).

HONORS AND AWARDS

Who's Who in America judged Professor Chomsky, together with various sports figures and Elie Wiesel, to be among its "50 Great Americans". A "nice desk clock" (in Professor Chomsky's well-chosen words) accompanied this designation.

LEAVES OF ABSENCE

A number of faculty members were on leave during the year: Professor Ned Block spent the year in Paris at the CNRS; Professor James Harris lectured in Argentina (Río Negro), Paris, and Amsterdam during the fall term; Professor David Pesetsky devoted much of his fall term leave to completing the second of his two volumes on syntactic theory and to the important educational policy issues at the nexus of linguistics and reading; and Professor Judith Thompson spent the spring term as Fellow at the Centre for Advanced Study (Oslo), during which time she also addressed the Norwegian Academy of Science and Letters and delivered the Hagerstrom Lectures at the University of Uppsala (Sweden).

PERSONNEL

It is with sadness that we report the deaths this spring of Professor George Boolos and of Thomas S. Kuhn, Laurance S. Rockefeller Professor of Philosophy and History of Science, Emeritus. Professor Boolos, the first MIT graduate of the Institute's PhD program in Philosophy, was to have become the third person to hold the Rockefeller Professorship in Philosophy, and had also been awarded a Guggenheim Fellowship for the academic year 1996-97.

Three persons have retired from the faculty. Institute Professor Morris Halle (who, with Professor Chomsky, founded MIT's graduate program in linguistics in 1961); Professor Harris--at the Institute since 1964 and on the faculty since 1967; and Professor Emeritus Richard Cartwright, who has retired again, this time from teaching--having continued as a Senior Lecturer on Philosophy for the two years since his "first" retirement.

It is with pleasure that we note the promotion of Alec Marantz to the rank of Professor, and with regret, the resignation of Professor Block of Philosophy (at the Institute since 1971), to take up a faculty position at New York University. In turn, we welcome Vann McGee as Professor of Philosophy, and two new Assistant Professors of Linguistics: Michel DeGraff and Cheryl Zoll.

With the appointment of Cheryl Zoll, the affirmative-action goal of the Department, to increase the representation of women on the faculty to at least four from the present two, moves a step closer to realization. Moreover, progress in another affirmative-action direction is made with the arrival of Michel DeGraff, appointed under the Provost's program to increase the number of minority members on the MIT faculty.

Wayne O'Neil

DEPARTMENT OF POLITICAL SCIENCE

The 1995-96 academic year has been marked by many new and exciting developments in the Department of Political Science. Three junior faculty appointments were made in the areas of comparative politics and political theory. The Department continues its search to fill several positions that remain open. The Department competed aggressively this year for a new class of Ph.D. students and was successful in attracting an excellent class for the fall 1996 term.

EDUCATIONAL INITIATIVES

The MIT Washington Internship Program, under the direction of Associate Professor Charles H. Stewart III, enjoyed a second very successful year. During the past two years, this program has placed 20 undergraduates from across the Institute in public and private sector assignments in Washington, D.C. as summer interns. This program brings scientists and engineers into closer contact with policy makers whose decisions affect, or are affected by, scientific and technological change. This year, the Program worked with the Technology and Policy Program to add a series of policy seminars during the spring in the areas of ozone depletion, nuclear waste disposal, and the telecommunications policy. One graduate of the Program has already graduated to work as a legislative assistant for a member of Congress, specializing in science policy.

Professor Suzanne Berger developed a new internship program under the umbrella of the Provost's MIT International Science and Technology Initiative (MISTI). Modeled after the MIT Japan Program, MISTI students are trained in Chinese language and culture before being placed in internships in companies located in China. The Program has plans to expand to Germany and Latin America as well.

Our graduate students, for their part, organized a very successful forum on non-academic careers, in which a number of our alumni/ae participated in April. Alumni/ae returned to campus to share their insights on the ways in which the analytic training of political science has served them in the worlds of business, public administration, corporate management, and consulting.

Many new subjects were developed this past year on both the graduate and undergraduate level. Working with Professor Peter Hall at Harvard, Professor Berger developed a new subject: "Domestic Politics of Trade and Integration" taught jointly at the Center for European Studies at Harvard. Assistant Professor Zhiyuan Cui developed a new subject, "New Currents in Social Theory." Assistant Professor Daniel Kryder offered a new "Field Seminar in American Politics" for graduate students. Next fall, Associate Professor Richard Locke will offer a new Political Science-Urban Studies joint seminar, with Professor Judith Tendler: "Government Policy, Secondary Associations, and Economic Development." Associate Professors Kenneth Oye and Stephen Van Evera, and Professor Myron Weiner secured funding from the MacArthur Foundation to establish a Research and Training Program on Transnational Security Issues at the Center for International Studies at MIT. Professors Barry Posen and Van Evera developed and presented a popular new IAP subject, "Counter Insurgency on the Silver Screen." Professor Harvey Sapolsky led the effort to create 17.40s, the latest venture by the Defense and Arms Control Studies program into professional education, a summer course focused on corporate and national strategies for defense. Finally, Assistant Professor David Woodruff developed two new subjects, "Philosophy of Science and the Methodology of Comparative Politics," and "Soviet and Post-Soviet Politics and Political Economy."

The Department has also been aggressively pursuing funds to establish an endowment that will provide graduate fellowships in honor of Professors Emeriti Lucian W. Pye, Lincoln P. Bloomfield, and Department founder Ithiel deSola Pool. Since 1992, the Department has received gifts and pledges of \$2,000,000 from alumni, friends, and foundations for graduate fellowships, and this year will mark the first that a fully endowed fellowship will be awarded to a graduate student.

STUDENT RECRUITMENT, ENROLLMENT, AND PLACEMENT

The Department continued to compete successfully with other major departments in the recruitment of graduate students. We attracted an excellent class of incoming Ph.D. students. Of the 21 students who accepted our offer of admission, ten are female (47%), three are international students, and five are minorities. The Department will also enroll six Masters students in September 1996.

Undergraduate enrollments went up 7% (from 756 in 1994-95 to 808 in 1995-96) although undergraduate majors decreased by 25% (from 40 in 1994-95 to 30). The number of minors also decreased. There were 126 graduate students enrolled in 1995-96.

Our graduating doctoral students continued to find positions at leading research universities such as The Johns Hopkins University, Harvard University, Brigham Young University, Georgia Institute of Technology, Georgetown University, Princeton University, and leading institutions in Europe and Asia.

FACULTY PERSONNEL

Richard A. Joseph, from Emory University, was named the first Martin Luther King, Jr. Visiting Professor, a two year appointment effective July 1, 1995. His teaching and research interests are African Politics and Comparative Democratization.

David M. Woodruff, from U.C. Berkeley, joined the Department as Assistant Professor, effective July 1, 1995. His main interest lies in the Political Economy of the post-Socialist countries, especially Russia. Other interests include the history of the social sciences, as well as philosophy and methodology of social science.

The Department conducted several searches to fill positions at the junior and senior levels during the past year. We are delighted that Delia Boylan, Susan Giaimo, and Stuart White will join the Department as Assistant Professors, effective July 1, 1996. Professor Boylan will come to us from Stanford University in the field of Latin American Politics; Susan Giaimo will come from the University of Wisconsin in the field of German Politics and Comparative Social Policy; and Stuart White, from Oxford and Princeton Universities, will join the Department in the field of Political Theory.

Associate Professor Richard M. Locke, who holds a joint appointment with the Sloan School of Management, and specializes in Industrial Relations and Political Economy, was awarded tenure, effective July 1, 1996. Assistant Professor Stephen D. Ansolabehere, who specializes in American Political Behavior and Elections, was promoted to Associate Professor with tenure, effective July 1, 1996. Professor Joshua Cohen, who holds a joint appointment with the Department of Linguistics and Philosophy (where he serves as Section Head), and who specializes in Political Theory, was awarded the Arthur and Ruth Sloan Professorship, effective November 1, 1995. Professor Michael J. Piore, David W. Skinner Professor of Political Economy, a specialist in Labor Economics and Industrial Relations, will hold a joint appointment with the Department of Economics, effective July 1, 1996.

Despite these appointments and promotions, our "steady state" has not dramatically changed, since four faculty colleagues of long-standing elected to retire under the Institute's special retirement option this year. Professor Willard Johnson, a specialist in African Politics, and Professor George Rathjens, a specialist in Defense and Arms Control, will continue to be active in their research and writing, and will hold the title Professor Emeritus. Professor Eugene Skolnikoff, who specializes in the field of Technology and Public Policy, and Professor Myron Weiner, a leader in the field of International Migration and Political Development in the Third World, will each hold the position of Professor without tenure and will continue to teach half-time.

Increasing the presence of minorities and women in the Department remains a major concern. All four search committees made special efforts to identify outstanding women and minority candidates as an integral part of their searches. The Department received and reviewed a total of 760 applications for four open positions. Of those, 198 were women and 24 were minorities. The Department interviewed 20 candidates, of whom 8 were women. Out of the 15 finalists who were invited to present seminars, 6 were women. Three assistant professors were hired, two of the them women.

Search committees in the areas of Asia-Pacific Security Studies, International Relations, and American Politics and Public Policy have formed and will evaluate potential candidates at both the junior and senior level during the next academic year.

RESEARCH

Faculty research activities include:

- “Campaign Finance and Political Representation in the U.S.,” “Candidate Quality in Congressional Elections,” and “Valence versus Position Politics in American National Elections” (Professor Ansolabehere)
- “Made by Hong Kong” (Professor Berger, with Professor Richard Lester of Nuclear Engineering and the Industrial Performance Center)
- “Global Accords for Sustainable Development” (Professor Nazli Choucri)
- “Political Economy of Reform In China since 1978,” and “Chinese Environmental Policy” (Professor Cui)
- “Democratization in Africa,” “State-Building and Erosion in Africa,” and Armed Conflict and Peacemaking in Africa: The Case of Liberia” (Professor Joseph)
- “Emerging and Future U.S. Foreign Policy Priorities Concerning Africa” (Professor Johnson)
- “War Mobilization, Racial Conflict, and State Response in the U.S., 1941-45,” and “Presidents and the Transition from Reform to War in the Twentieth Century U.S.: a comparative study of Wilson, FDR, Truman, and LBJ” (Professor Kryder)
- “Becoming One?: The Political Economy of German Unification,” and “Struggling to Change: Organizational Innovation and Its Limits in the American Union Movement” (Professor Locke)
- “Development of Truth Commissions After the Departure of Repressive Political Regimes” (Assistant Professor Melissa Nobles)
- “Underprovision of Compensation,” “Trade and the Environment,” (Professor Oye)
- “Nationalism and War,” (Professor Posen)
- “Armor Breakthrough Operations, 1944” (Professor Posen with graduate students in the DACS Conventional Forces Working Group)
- “Comparative Political Economic History of Japan and Italy” and “Japanese Foreign Policy” (Professor Richard Samuels)
- “Anti-Submarine Warfare (ASW) after the Second World War” (Professor Sapolsky)
- “History of the Congressional Committee System, 1789-1946,” and “The Rational Congress,” (Professor Stewart)
- “Demokaraasi in Africa” (Assistant Professor Frederic Schaffer)
- “Implementation and Effectiveness of International Environmental Agreements,” (Professor Skolnikoff)
- “Money, Elections, and Candidate Quality” (Associate Professor James Snyder, with Professor Ansolabehere); “Politics of Monetary Consolidation in Russia” (Professor Woodruff)

FACULTY PUBLICATIONS

Political Science faculty continue to be prolific publishers of books and articles. Here we can list only a few. Professor Ansolabehere co-authored *Going Negative: How Political Advertisements Shrink and Polarize the Electorate*, published by the Free Press. He also wrote articles that appeared in *Legislative Studies Quarterly*, and *International Journal of Press/Politics*. Professor Berger edited (with Ronald Dore) the book *National Diversity and Global Capitalism*, Cornell University Press. Professor Choucri wrote several articles and co-authored *Global System for Sustainable Development (G.S.S.D.): Theory, Policy, Practice*, MIT Press. Professor Cohen edited (with Archon Fung) *Constitution, Democracy, State Power: The Institutions of Justice*, a collection of four volumes, Edward Elgar Press. He was also editor of *For Love of Country*, Beacon Press. Professor Cui edited *Selected Works of Roberto Unger*, Verso.

Professor Joseph co-authored a chapter in *Comparative Politics at the Crossroads*, D.C. Heath & Co. He also wrote an article for *Current History*. An essay by Professor Kryder appeared in *Studies in American Political Development*. In addition to writing several journal articles Professor Locke co-edited (with T. Kochan and M. Piore) *Employment Relations in a Changing World Economy*, MIT Press, and is co-editing *The Shifting Boundaries of Labor Politics: New Directions for Comparative Research and Theory*, MIT Press. Professor Oye wrote a chapter in *The End of the Cold War & International Relations Theory*, Columbia. Professor Posen’s work appeared in *Political Science Quarterly* and in *Eagle Adrift: American Foreign Policy at the End of the Century*, Harpercollins.

Professor Rathjens wrote a chapter in *Racism, Xenophobia and Ethnic Conflict*, Indicator Press, and a chapter in *The Nuclear Proliferation Regime: Prospects for the Twentyfirst Century*, Macmillan. A Korean translation of Professor Samuels’ book *Rich Nation, Strong Army* (originally published by Cornell University Press) was

published in 1996. Professor Samuels also co-authored a chapter forthcoming in *Realism and International Relations after the Cold War*. Professor Sapolsky wrote "The Truly Endless Frontier," which appeared in *Technology Review*. Professor Snyder published several articles in *Legislative Quarterly* and *Journal of Public Economics*. Professor Weiner's latest book, *Threatened Peoples, Threatened Borders: Migration and U.S. Policy*, was published this year.

FACULTY AWARDS AND HONORS

Our faculty once again garnered many awards and honors. Professor Ansolabehere was awarded The Goldsmith Book Prize for his book *Going Negative*, cited as the best book on mass media, politics, and public policy. The book has also been widely cited and reviewed in popular discussion of the 1996 presidential campaign. Reviews include national columns by David Broder and Max Frankel and in *US News and World Report*, book reviews in *The New York Times*, *The Washington Post*, and *The New Yorker*, and broadcast interviews on ABC News "Primetime Live," CNBC "Equal Time" and "Washington Journal," and National Public Radio "All Things Considered."

Professor Cohen was named Wesson Lecturer at Stanford University, and Wade Lecturer at St. Louis University.

Professor Nobles was awarded the 1995 Best Dissertation Prize from the New England Council of Latin American Studies.

Professor Oye was elected to membership on the Council on Foreign Relations.

Professor Samuels was awarded the 1996 John Whitney Hall Prize of the Association for Asian Studies, and the 1996 Hiromi Arisawa Prize of the Association of American University Presses, both for his book *Rich Nation, Strong Army*. He was also named Distinguished Lecturer by the Association of Asian Studies.

FACULTY PROFESSIONAL AND PUBLIC ACTIVITIES

The Department's faculty continue to give many invited lectures, appear at conferences, serve on boards of professional organizations and editorial boards, in addition to acting as advisors for government, private, and international organizations and agencies. Professor Berger became Vice-President of the American Political Science Association. Professor Choucri was Special Advisor to the Administrator of the United Nations Development Program, and also Advisor to the Executive Director, UNEP and Under-Secretary General of the United Nations. Professor Samuels is Vice-Chairman, Committee on Japan of the National Research Council, and External Assessor: Division of Public Administration, Faculty of Economic and Administration at the University of Malaysia, as well as External Examiner: Department of Politics and Administrative Studies, also at the University of Malaysia. Professor Weiner gave the keynote address at the International Research and Advisory Panel Conference on Forced Migration, in Kenya in April 1996. He was appointed by the American Academy of Arts and Sciences as Delegate to the American Council of Learned Societies, and is also the International Consultant to the newly formed Centre for Development and Enterprise, in Johannesburg, South Africa.

Richard J. Samuels

PROGRAM IN SCIENCE, TECHNOLOGY, AND SOCIETY

The 1995-96 academic year marks the end of a decade of leadership by Professors Kenneth Keniston and Merritt Roe Smith. Professor Keniston served as Director of the Program in Science, Technology, and Society (STS) from 1986 to 1992. During that period Professor Smith became the first Director of Graduate Studies. In January 1992, Professor Smith became Director of STS and Professor Keniston became Director of Graduate Studies. Under their leadership, the STS Program redefined its mission within the MIT community and established the Doctoral Program for the History and Social Study of Science and Technology (HSSST) in concert with the History and Anthropology faculties. During the same period, the STS Program played an instrumental role in attracting the Dibner Institute for the History of Science and Technology to the MIT campus. The presence of the Dibner Institute, coupled with strong faculty interest in graduate studies and the recruitment of first-rate graduate students, has resulted in making the Doctoral Program the best of its type in the world. Beginning July 1, 1996, the new Director of STS will be Professor Michael Fischer. He will be joined by Associate Professor Deborah Fitzgerald as Director of Graduate Studies. The Program's faculty search for the Frances and David Dibner Assistant (or Associate) Professor of the History of Engineering and Manufacturing was brought to a successful close with the appointment of Dr. David A. Mindell. Dr. Mindell was unanimously recommended by the selection committee after they reviewed the dossiers of thirty-five candidates and intensively interviewed the top four prospects. The Doctoral Program graduated its fifth student this June when Dr. Mindell received his Ph.D.

DOCTORAL PROGRAM

In its eighth year, the HSSST Doctoral Program (a collaborative venture of STS, the History Faculty, and the Anthropology Program) continued to develop in a satisfactory way. Present and incoming students received a variety of grants and fellowships, including Dibner, Javits, Ida Green, National Science Foundation (NSF), and the Social Science and Humanities Research Council of Canada. The HSSST Doctoral Program received 76 applications for the 1996-97 academic year. Six of the seven students offered admission to the HSSST Doctoral Program have accepted and will be joining the program this fall. Important roles in the program were played by Professors Keniston (Director of Graduate Studies; STS), James Howe (Anthropology Program), and Peter Perdue (History Faculty), all of whom were members of the Doctoral Program Steering Committee. As Director of the STS Program, Professor Smith also served on the Doctoral Program Steering Committee.

PROJECTS, GRANTS, AND INITIATIVES

Professor Keniston, Professor Emeritus Leo Marx, and Visiting Professor Jill Conway received a grant of \$50,000 from the John D. and Catherine T. MacArthur Foundation to support a seminar and workshop series on environmental issues viewed from cultural and humanistic perspectives. This grant, "Humanistic Perspectives on the Environment," will extend through the next two academic years. Work continued on the history textbook project, "Integrating the American Past: A New Narrative History of the United States," which is funded by the Alfred P. Sloan Foundation (grant total: \$1.754 million over eight years). The project is headed by Professor Smith and includes Professors Pauline Maier (MIT), Dan Kevles (California Institute of Technology), and Alex Keyssar (Duke University) as primary authors.

EDUCATIONAL ACTIVITIES

The STS Program's educational work continued at both the undergraduate and the graduate levels. In all, the Program offered 25 undergraduate subjects and 28 graduate subjects during the past academic year. Undergraduate enrollments totaled 393 (fall: 172; spring: 221). STS offered one new undergraduate subject, "Ethics and the Law on the Electronic Frontier" (Professors Harold Abelson and Fischer). On the graduate level, two new seminars were introduced: "Objectivity, Truth, and Scientific Rationality," (Professors Jed Buchwald and Edward Hall) and "Integrative Seminar in the Social, Cultural, and Historical Studies of Science and Technology" (Professors Fischer and Sherry Turkle). During the 1995-96 academic year there were 5 majors, 7 minors, and 50 concentrators (classes of 1996-2000) in STS. In addition to our course offerings, STS organized three undergraduate events during the 1995-96 academic year: an Open House during the Independent Activities Period (IAP) to give MIT students the opportunity to talk with some of our STS faculty and graduate students; the sponsorship, in collaboration with Political Science, of a film showing of "Brazil"; and an undergraduate dinner for majors, minors, and concentrators in STS was organized in April by Professor Fitzgerald, Undergraduate Academic Officer. Professor Rosalind Williams, Dean for Undergraduate Education at MIT, was the featured speaker at this dinner; Mr. Atsushi Akera,

MIT alumnus in Course VI who is now a graduate student in the History and Sociology of Science Department at the University of Pennsylvania, also addressed the group.

SPECIAL EVENTS

The 1995 Siegel Prize for the best work by an MIT student in science, technology, and society was shared by two students this year. Ms. Diane Greco, a third-year doctoral student in HSSST, was a co-winner of the prize for her paper, "From the Field to the Laboratory: Terrestrial Magnetism at Göttingen, 1833-1839." Ms. Mona Mourshed, a graduate student in the Department of Urban Studies and Planning was a co-winner for her paper, "Rethinking Irrigation Technology Adoption: Lessons from the Egyptian Desert." Both winners received prizes of \$1,000. The 9th Annual Arthur Miller Lecture on Science and Ethics was held on September 18, 1995. Dr. Renée Fox, Annenberg Professor of the Social Sciences at the University of Pennsylvania and a sociologist of medicine for more than 40 years, was this year's speaker. Her talk, "After Thoughts: Continuing Sociological Reflections on Organ Transplantation," dealt with developments in the field of organ transplantation from a social and ethical point of view. The STS Program organized a symposium to honor the life and work of Professor Elting Morison and to commemorate his contributions to the history of technology and to MIT. Morison, who died in April 1995, was one of America's most distinguished historians, a founder of the field of the history of technology and, for most of his life, a member of the MIT faculty. With Professors Walter Rosenblith and Jerome Wiesner, he created the STS Program, which he directed and in which he taught. The symposium proceedings have been published as part of the STS Working Paper Series. The paper, "From Know-How to History: Symposium in Honor of Elting Morison," includes a forward by Professor Keniston and the entire program text of the symposium. On May 9, twelve members of the STS faculty, along with the directors of the Dibner Institute at MIT, attended a dinner meeting with faculty members from Harvard's History of Science Department. Professor Peter Galison, Chairman of Harvard's History of Science Department, organized this dinner meeting to give the faculty of all three groups the opportunity to discuss ways in which the three organizations can collaborate in the future. A follow-up meeting, hosted by STS faculty, is being planned for the fall.

COLLOQUIA, WORKSHOPS, AND LECTURES

In its sixth year, the STS Colloquia Series, headed this year by Professors Fischer and Turkle, continued to be a core activity of the HSSST Doctoral Program. The series brought 21 speakers to MIT from such institutions as Ecole Nationale Supérieure des Mines de Paris, Harvard Medical School, Princeton, Rice, and the Xerox Palo Alto Research Center. Beginning in February, 1996, five HSSST graduate students (Ms. Rebecca Herzig, Mr. Christopher Kelty, Ms. Hannah Landecker, Mr. Ted Metcalfe, and Mr. Heinrich Schwarz) organized seven workshops testing various interventions of cultural studies into technoscience, with emphasis on the study and practice of work, medicine, design, and technology. The topics discussed included race, sexuality, performance, global economic culture, colonialism, and work practices. The workshops served several purposes: to generate discussion about the various approaches to studying science and technology; to give the presenters feedback and questions about their specific projects; and to network across disciplines and schools. In addition to these regularly scheduled talks, the STS Program organized six special lectures throughout the year. Professor Smith arranged three special events for some of our HSSST doctoral students. He arranged for Professors Robert Friedel (University of Maryland) and Robert Post (Smithsonian Institution) (both Visiting Fellows at the Dibner Institute) to meet and discuss their research in an informal way with our students. He also arranged a meeting with our HSSST doctoral students and Professor John Staudenmaier (University of Detroit Mercy and Editor, *Technology and Culture*) to discuss how to get published in the history of technology. This spring he arranged for a group of our students to visit the Museum of American Textile History in Lowell to review an exhibit.

OTHER ACTIVITIES

The Program continued a number of activities that had been initiated in earlier years. The *STS Newsletter*, ably produced biannually by staff member Ms. Sarah Trautmann, 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 their fourteenth 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. The fourteenth class of Fellows includes

six journalists from the United States and reporters from both Germany and Japan. During their nine months on campus, Fellows attend some 60 seminars with faculty, which are specially organized for them, as well as other seminars and workshops devoted to science and technology and their wider impacts. The Fellowships are supported by an endowment contributed by the John S. and James L. Knight Foundation of Miami and by alumni and foundation gifts. Senior Research Associate Victor McElheny, an experienced science journalist who has been Director of the Knight Science Journalism Program from its inception, continued writing a biography of Edwin Land, the inventor of instant photography (deceased 1991), who was for nearly 40 years a Visiting Institute Professor at MIT.

FACULTY ACTIVITIES

Professor Buchwald, Director of the Dibner Institute for the History of Science and Technology and a MacArthur Prize Fellow, chaired MIT's Committee on Discipline, and served on a tenure review committee and a faculty search committee. He also organized MIT's 1996 Physics Colloquium on "The Origin of Electric Waves." In addition to writing several articles, he edited *Scientific Practice. Theories and Stories of Doing Physics* (Chicago, 1995), and contributed two chapters. Professor Buchwald gave lectures at several universities, including the Max Planck Institute in Berlin, and Utrecht University in Holland. He also became the co-editor (with Henk Bos) of the *Archive for History of Exact Sciences* (Springer). Professor Michael Fischer was named the new Director of the Program in Science, Technology, and Society effective July 1, 1996. He served on several STS and Institute committees, including a faculty search committee, a tenure review committee, HSSST Admissions Committee, and Film and Media Studies Planning Committee. Professor Fischer was Chair, Self-Study (Visiting Committee) for Institute for Liberal Arts at Emory University, and was the Editorial Co-convenor of *Late Editions* annual workshop at Rice University. Professor Fischer organized and was co-convenor of the 1995-96 STS Colloquia Series. He published four articles in journals and contributed to two volumes that are not yet published. Professor Fitzgerald was Undergraduate Advisor at STS during the spring term. She was named the new Director of Graduate Studies for the HSSST Doctoral Program effective July 1, 1996. She was a member of the Schuman Prize Committee of the History of Science Society and is Chair of the Program Committee of the Society for the History of Technology. Professor Fitzgerald is co-editor of the Johns Hopkins Press series on agricultural history.

Professor Loren Graham served on several Committees at MIT including the Search Committee (Director, MIT Libraries) and Search Committee (Dibner Professor in History of Technology and Manufacturing). At MIT, he chaired the Tenure Committee for Associate Professor Lily Kay and the Promotion Committee for Assistant Professor Elizabeth Wood. He administers grants from the Sloan Foundation, MacArthur Foundation, and National Endowment for the Humanities. In addition to other professional activities, he serves on the Executive Board of the International Science Foundation, the Executive Committee of the National Council on Soviet and East European Studies, and Chairs the Selection Committee of the John D. and Catherine T. MacArthur Foundation, Initiative in Former Soviet Union. His article "Palchinsky's Travels: A Russian Engineer's Adventures Among Gigantic Projects and Small Minds," was published in June in *Proceedings of the American Philosophical Society*. He has four works in progress, including *Bibliography of the History of Russian and Soviet Science* (edited with Dr. Paul Josephson and Mr. Vyacheslav Gerovitch) under contract with Garland Publishers, and *What Have We Learned About Science and Technology from the Soviet Experience*, Stanford University Press.

Assistant Professor Evelyn Hammonds served on the HSSST Admissions Committee and the Siegel Prize Committee. She was awarded the Class of 1947 Career Development Chair. Her book manuscript *The Search for Perfect Control: A Social History of Diphtheria: 1880-1930* is currently under review by the Johns Hopkins University Press. Professor Hammonds was co-editor of *Gender and Scientific Authority* (forthcoming, University of Chicago Press). She also wrote "When the Margin is the Center: Black Feminism(s) and 'Difference'," in Joan Scott and Cora Kaplan, eds., *Transitions, Environments, Translations*, forthcoming, Routledge. She was Chair, Committee on Women, History of Science Society, and a member of the Program Committee for the Organization of American Historians. She attended the United Nations Fourth World Conference on Women held in Beijing, China, August 29-September 8, 1995 under the auspices of the Ford Foundation. In January, Professor Hammonds was nominated by MIT and honored at the Black Achievers banquet in Boston for her research, scholarship and teaching, and for her organization of the Black Women in the Academy Conference.

Professor Kay served on MIT's Committee on Graduate Studies and Policy (CGSP) during the fall 1995 term. She also Chaired the STS Curriculum Committee for academic year 1995-96. She was a member of the Advisory

Committee on Selection of the Dean of the Graduate School. She was invited to give lectures at several universities and attended annual meetings of the History of Science Society and the American Anthropological Association. Among her most recent publications are "Who Wrote the Book of Life? Information and the Transformation of Molecular Biology, 1945-55," in *Science in Context* (1995); "Problematizing Basic Research in Molecular Biology" in *Private Science: Biotechnology and the Rise of Molecular Sciences* (1996); and "A Book of Life? How a Genetic Code Became a Language" in *Philosophical and Ethical Perspectives on the Human Genome Project* (1996).

Professor Keniston served on several Institute and Program committees. He was Chair, HSSST Admissions Committee; Chair, HSSST Doctoral Program Steering Committee; Member, STS Curriculum Committee; Member, Committee on Graduate School Policy; STS representative on the MIT Women Faculty Initiative and the MIT Minority Faculty Initiative; Member, Killian Award Committee, Chair, Siegel Prize Committee; and Coordinator, MIT Rhodes Scholarship Committee. He gave lectures to the MIT Club of Boston and the MIT Experimental Study Group. He served as Principal Investigator of the MacArthur Foundation Grant for "Humanistic Perspectives on the Environment," and was a consultant for the Guggenheim Foundation, the Costa Rican Ministry of Public Education, and the Curriculum Integration of Humanities and Technology, Polytechnico of Turin, Italy.

Professor Theodore Postol's article, "The Gulf War Performance of Patriot and Future Issues for Theater Missile Defenses," will appear in *Security Studies*. He continues to serve on the editorial boards of *International Security* and *Science and Global Security*. This year's lecture list includes the Department of Energy, University of Pennsylvania, Princeton University, University of Maryland, the Army War College (Carlisle Barracks), Harvard University, and the National Press Club (Washington, D.C.). He also received grants from the Ploughshares Fund, W. Alton Jones Foundation, Carnegie Corporation of New York, and the MacArthur Foundation.

Professor Smith is stepping down as director of the STS Program to devote full time research to the Sloan American History Textbook Project, which he is heading. He continues to serve as editor of the Johns Hopkins Studies in the History of Technology series at The Johns Hopkins University Press and as senior advisor to WGBH's acclaimed television series, "The American Experience." He was appointed to the Editorial Advisory Board of the Thomas A. Edison Papers (NHPRC/Rutgers University). In addition to giving the inaugural Richmond Lecture at Williams College, he also spoke to groups at the University of Detroit-Mercy, Boston University, the Armor and Arms Club of the New York Metropolitan Museum, and MIT Alumni Clubs in Boston, Cleveland, Ohio, and Columbus, Ohio. An essay on "Samuel Colt" will appear in the *Oxford Companion to American Military History*.

Professor Turkle's most recent publications include her book, *Life on the Screen: Identity in the Age of the Internet* (1995), and articles on "Virtuality and Its Discontents" in *The American Prospect* (1996); and "The Ghost in the Machine" in *The Sciences* (1995). She continues to serve as an advisory editor to *Science, Technology and Human Values* and on the boards of *Harvard Magazine* and Computer Professionals for Social Responsibility. She gave numerous lectures during the past year, including keynote addresses at Simmons College, the Council of Independent Colleges, and the Advertising Research Foundation and conferences at Princeton University, the Eastern Sociological Society Annual Meeting, and the Annual Meeting of the American Association for the Advancement of Science.

FUTURE PLANS

Under the leadership of Professors Fischer and Fitzgerald, the STS Program is undertaking a review of its graduate curriculum with an eye to refining the Doctoral Program's offerings and achieving a closer integration of the historical and cultural studies components of the curriculum. With the support of Dean Philip Khoury, a two-day faculty retreat was held in May to discuss the graduate curriculum and to consider revising and reorienting at least two of the four required introductory proseminars that comprise the core of the graduate program. A planning document is currently being prepared by Professors Fischer and Fitzgerald and the first of the curricular changes is scheduled to occur in the fall of 1996. Once issues concerning the graduate curriculum are addressed, members of the STS faculty anticipate undertaking a similar review and revision of the program's undergraduate offerings. This seems particularly appropriate, given the existence of the Sloan American History Textbook Project and its objective of more closely integrating science and technology into general American history survey courses and, beyond that, into courses treating world history and civilizations.

Merritt Roe

CENTER FOR INTERNATIONAL STUDIES

The Center International Studies continues to support doctoral student training and faculty research in the areas of democratization, transnational security, technology policy, and trade and environment. These issues are supported through seminars and workshops, fellowships, conferences and publications, all of which are discussed below. They are consistent with the Center's ongoing efforts to respond to global changes and set new intellectual agendas which reflect the political and economic transformations of the 1990s.

DEFENSE AND ARMS CONTROL STUDY PROGRAM

The MIT Defense and Arms Control Studies Program (DACS) analyzes security alternatives available to the United States and other major and regional powers. Of great interest to the program is the role the United States will play in the world scene no longer dominated by the Cold War confrontation. The program also is examining the extent to which perceived economic and environmental problems are likely to affect 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 with special emphasis on nationalism-driven conflicts. A fourth, led by Professor Sapolsky, has been concerned with the impact the end of the Cold War will have on aerospace, shipbuilding, and research and development. A fifth, directed by Professor Theodore Postol, explores defense technology issues, most recently on the future of the ABM Treaty. A sixth, also led by Professor Sapolsky, has been examining the environmental legacies of the Cold War. A seventh, jointly directed by Professors George Rathjens and Jack Ruina, has been exploring American national strategy and force requirements in a world filled with ethnic turmoil and failed states. An eighth, led by Professor Richard Samuels and offered in conjunction with the MIT Japan Program, looks at security issues in Asia. A ninth, led by Dr. Marvin Miller, studies proliferation problems. In addition, the program sponsors several seminar series including the DACS seminars, the Future of War seminars, and the Defense Star seminars. Three major conferences were held: Organizational Issues in the DOE/DOD Cleanup Efforts; Force Projection Capabilities and Policies, and; The Second General Doolittle Workshop -- Airpower after the Gulf War.

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 education activities. Among the Program publications are *Breakthroughs*, a research journal now in its fifth year; *DACS Facts*, the program's newsletter, and; *DACS Seminars*, reports on current topics. A working paper series has also been restarted. Dr. George Lewis became the Program Assistant Director. Major sponsors have been the Carnegie, Ford, and MacArthur Foundations. In addition to ten faculty members, thirty-five graduate students, eight post-doctoral visitors and scholars and three military fellows were affiliated with the program this year. And most pleasing to all of us, Professor Stephen Van Evera has indicated he will be joining our program and will soon move to our warren.

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 1995-96 by Professor Jean Jackson (Anthropology), examined issues of the creation of ethnic and nationalist identities in relation to the state; the Ford Development Seminar, a workshop funded by the Ford Foundation, explored 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 Jorge Domínguez (Harvard University), dealt in its 31st year with the theme of The Rise and Decline of the Centralized State in the Third World; the Bustani Middle East Seminar, organized by Dean 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 Weiner, concentrates on the themes of security implications of refugee flows and consequences of migration for the labor force. The Migration Seminar put out a working paper series this past year with articles from several recent migration conferences. Finally a new Program in Transnational Security, run jointly with the Center for International Affairs at Harvard and supported by the John D. and Catherine T. MacArthur Foundation, sponsors two new working groups. The first deals with issues of economic insecurity generated by internationalization and increased trade to be discussed in the next section; the second is concerned with intergroup conflict, secession, human rights and refugees, and the insecurity produced by changing borders and ethnic and nationalist tensions.

ACTIVITIES IN POLITICAL ECONOMY

Research and training activities in political economy continued to expand dramatically, with work clustering in two major areas. One set of projects centers on national adaptations to an increasingly global economy. These projects examine the economic and political consequences of increasing integration of markets for goods, technology, and capital.

- Faculty Associates Professor Suzanne Berger and Ronald Dore are publishing their symposium on *Convergence Or Diversity*. The contributors to this book examine national political economies in a global economy, examining the prospects for persistence of diverse national models of production and distribution and for convergence toward a common best practice.
- A working group supported by the MacArthur Foundation centers on issues of economic insecurity associated with rising trade and investment. This MIT-Harvard group reviewed econometric and formal evidence on trade and income distribution and analyzed national strategies of adaptation in Eastern Europe, Mexico, and Japan.

A second set of projects centered on energy and environmental issues. These projects examine ways in which energy security and environmental externalities may be addressed efficiently.

- **Asian Energy and Environment:** This area is the focus of two major initiatives. First, Japan Program Director Professor Samuels and Research Associate Michael Lynch launched an initiative on Asian energy security issues which include such topics as high economic growth rates, rising oil imports from the Middle East, tensions over offshore areas believed to contain oil deposits, and growing oil deposits. The Working Group on Asian Energy and Security is considering military and defense issues as well as energy and economic policies. Second, two groups are examining the efficiency and environmental performance of coal combustion in China. Household coal use is the focus of an NSF supported study by Faculty Associate Karen Polenske. Industrial coal combustion is the focus of a new joint project with Tsinghua University, Tokyo University, and ETH Zurich. This project is lead by Professor Adel Sarofim (Chemical Engineering), Assistant Professor Zhiyuan Cui and Associate Professor Kenneth Oye (Political Science).
- **Regulatory Costs and Harmonization:** This area is the focus of several projects. First, Professor Meyer continues his study of the economic costs of heterogeneous environmental regulations in the 50 American states. Second, Professor Oye continues studies of responses to heterogeneous national environmental regulations within the European Union and North America. Third, in an International Motor Vehicle Project, Professor Oye and CIS Visiting Fellow James Maxwell assessed enterprise and plant level responses to heterogeneous regulations in the automotive industry.
- **Sustainable Development:** Faculty Associate Professor Nazli Choucri organizes the Global Forum on Sustainable Development which focuses on technology, policy, and strategy dimensions of evolving global accords on environment and sustainable development. It is a collaborative initiative between international institutions, business and industry, and MIT as the lead institution of science and technology.

MIT JAPAN PROGRAM

In 1991, the MIT Japan Program was named by the Air Force Office of Scientific Research as one of the first four United States-Japan Industry and Technology Management Training (JITMT) Centers in the nation. This grant was renewed two years later and again in 1995, reflecting the high level of the Program's accomplishments. With funding from this award as well as from the Ayukawa Foundation, the Japan-United States Friendship Commission, the Starr Foundation, and its Corporate Consortium, the Program continues to be the largest, most comprehensive, and most widely copied center of applied Japanese studies in the world. Dissemination of the Program's accumulated knowledge and experience is pursued through three sets of coordinated activities: education, research, and outreach.

Education is central, with placement of MIT science, engineering, and management students as interns in Japan at the core. Educational activities during the period under review were as follows:

- The Program placed 42 interns.
- The Program's two summer courses in technical Japanese, one for computer science and electrical engineering and the other for materials science and related engineering, are in their ninth year of successful operation.

- The Program is continuing to work closely with the MIT International Science and Technology Initiative (MISTI), which was established by the Institute's former provost Mark S. Wrighton, to help place interns in the Pacific Rim.
- The Program is also active in curriculum development and training. The Japan Effectiveness Training (JET) course was offered for the fifth consecutive summer this year; the Program's sponsor retreat last November was attended by 25 individuals from industry and government; 12 Target Seminars were given during the period under review; and the Program's Video Series currently contains 40 titles (12 added in the past year) and are an important tool for dissemination of information to individuals with time and/or budget constraints.

In research, the Program undertook the following projects during the period under review:

- The Re-emergence of Great Power Politics in East Asia: Is Japan Balancing China?, under the supervision of Program Director Professor Samuels.
- Maximizing U.S. Interests With Japan in Science and Technology," also under the direction of Professor Samuels. "Manufacturing Competitiveness, Worker Skills, and Learning Strategies in the U.S. and Japan," undertaken by Dori Digenti, the Program's Director of Training.
- The Changing Role of the Japan Technology Operations: Restructuring at Home and Expanding Abroad," a study headed by Professor D. Eleanor Westney of the MIT Sloan School of Management and E. Keith Henry, the Program's Tokyo Officer.
- The Working Group on Asian Energy and Security," under the direction of Michael C. Lynch, Visiting Scholar at the Center for International Studies.

Japan-related research findings are also disseminated through the Program's Working Paper series. During the period under review, a record number of 29 working papers have been published.

Significant outreach activities during the period under review have included:

- MIT-Keidanren Workshop on the Long-term Future of U.S.-Japan Defense Industrial Cooperation.
- Thinking About China: Lessons from Successes and Failures (the first in a series of workshops).
- East Asia Symposium: The Regional Operations of Multinationals in East Asia
- The Changing Nature of the Japan Operation: Restructuring at Home and Abroad (workshop held in Tokyo).
- Continued publication of The MIT Japan Program Science, Technology & Management Report.
- Japan Science and Technology Databases.
- Continued cooperation with the Institute's Department of Foreign Languages and Literatures on the JPNET (Japanese Network) Project to build a virtual community for Japanese specialists.
- Continued cooperation with the MIT Libraries on the Japanese Scientific and Technical Information Project to create a national resource for Japanese scientific and technical information.
- Continuation of the program's dinner series, technology forum lectures, informal talks, IAP events, weekly Japanese lunch table with Japanese cultural activities, and Japanese film showings.

The Program's Corporate Consortium now has 18 members, all of them large American multinationals--and the list of Japanese host organizations continues to grow.

MIT INTERNATIONAL SCIENCE AND TECHNOLOGY INITIATIVE

MIT International Science and Technology Initiative (MISTI) is a major new program, directed by Professor Berger and administered through CIS, to internationalize education and research at the Institute. With the main goal of the Program to teach MIT students to do research in an international context, MISTI will work with MIT faculty to develop collaborative research projects. The first geographical focus is China with attention to the issues of sustainable development and the environment. Components of the initiative include the following:

- an internship program which, in 1995, sent four students to China, Hong Kong, and Taiwan. MISTI plans to send 15-20 students to China in 1996.
- a speaker series on China designed to educate the MIT community about the culture, economy and politics of China. Since starting in March, there have been six talks on such diverse issues as Chinese politics; innovation in Chinese manufacturing; environment, energy and population; and US Chinese relations.
- co-sponsorship of an International Conference on Sustainable Development, held in Beijing, China in July, 1995. The Conference, sponsored jointly by MIT, the State Science and Technology Commission and Tsinghua University, had, as MIT participants, Provost Joel Moses, twelve MIT professors, each accompanied by a graduate student. Plans are currently underway to expand the Program to Germany.

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 and economic policy communities. Conducted under the auspices of CIS, Seminar XXI recently completed its tenth year and continues to enjoy great success. Professors Oye, Posen, and Weiner (Political Science) serve as Co-Directors, while founder Professor Berger remains 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 meets 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: different frames of interpretation through which societies are understood yield fundamentally different answers to the questions policy makers must ask and resolve. By considering the politics of each country through different frameworks of analysis, the range of possible explanations for these countries' behaviors is widened, as is the range of US policy options which can be considered systematically. Each of the nine sessions bring together distinguished faculty from US and foreign institutions.

KALKER WORKSHOPS ON AMERICAN DIPLOMACY AND WORLD POLITICS

As an off-shoot of the Seminar XXI Program, the Center runs a parallel program at the State Department's Foreign Service Institute in Washington in which American diplomatic trainees of varying rank participate in a series of workshops dealing with salient issues in global affairs. This series, also bringing together government officials and distinguished faculty and other experts from American and foreign institutions explores American strategies appropriate to a contemporary global environment. Workshops are led by Professor emeritus Lincoln P. Bloomfield (Political Science). They are funded by a generous contribution of alumnus Harry Kalker.

FELLOWSHIPS

Two new fellowship programs provide funding for doctoral students and faculty seed research. The Program in Transnational Security, supported by the MacArthur Foundation is operated collaboratively with the Center for International Affairs at Harvard. Support is provided for research on (a) transnational economic security and (b) intergroup conflicts, human rights and refugees. Funding is available to doctoral students for academic year and summer support and to faculty for seed research support.

The National Science Foundation Traineeship in Democratization provides five fellowships annually for five years to support doctoral student training. Doctoral students from all social science departments at MIT are eligible to apply.

The International Energy Policy Research Grant competition continues to provide funding to faculty, researchers, and advanced doctoral students working on any aspect of international energy, environment and related technology policy. In 1995-96 five awards were given to students from the Departments of Political Science and Urban Studies and Planning.

OTHER ACTIVITIES

During 1995-96 CIS was host to visiting scholars from China, Russia, Israel, Brazil, Austria and Japan. In addition to the publications of the DACS and Japan Programs, the Center publishes a bi-annual newsletter, *PréCIS*, and four working paper series. They are 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). In addition the Center publishes the Migration Working Paper Series and the MacArthur Transnational Security Working Papers.

The Center draws its members from the MIT faculty and student body and its support staff through the MIT Personnel Department and our pool reflects the commitment of MIT to affirmative action. General funds presently support part of the salaries of four people, two of whom are women, including our Executive Director. The Director of the Center is an Asian American and the Managing Director of the MIT Japan Program is a woman.

Elizabeth Leeds
Kenneth Oye

PROGRAM IN WOMEN'S STUDIES

Women's Studies redresses the invisibility of women and gender in the construction of knowledge and reminds us that women as well as men have experiences and perceptions to contribute to understanding the world. The inclusion of women's studies subjects in the curriculum of an MIT student helps to produce an engineer, scientist, or business executive who is better-equipped to contribute fully and participate effectively in the work of teams of men and women.

PROGRAM ADMINISTRATION

The program is co-directed by Philip Khoury, Professor of History, and Dean of the School of Humanities and Social Science, and the Women's Studies Steering Committee. During academic year 1995-96, the Women's Studies Steering Committee consists of Professor Isabelle de Courtivron (FL&L), Assistant Professor Evelyn Hammonds (STS), Associate Professor Diana Henderson (Literature), Professor Jean Jackson (Anthropology), Associate Professor Henry Jenkins (Literature and Film & Media Studies), Professor Evelyn Fox Keller (STS), Lecturer Helen Elaine Lee (Writing and Humanistic Studies), Women's Studies Research Librarian Marlene Manoff (Humanities Library), Professor Ruth Perry (Literature), Associate Professor Margery Resnick (FL&L), and Assistant Professor Elizabeth Wood (History). Under the leadership of Professor Resnick, a subset of this core group serve on the Curriculum Committee which reviews and vets the syllabi and teaching the subjects we offer.

HIGHLIGHTS OF THE YEAR

The newly-established Geneviève McMillan-Reba Stewart Chair in the Study of Women in the Developing World is historic not only for MIT, but for the field of women's studies. Candidates for this chair are known for their scholarship on the study of women and gender in the Middle East and/or North Africa and for their familiarity with comparative and interdisciplinary approaches to the study of women and gender. It is expected that the holder of the new chair will teach subjects in his or her specific department and in the MIT Women's Studies Program. Professor Isabelle de Courtivron (FL&L), Professor Michael Fischer (STS), Professor Jean Jackson (Anthropology), and Dean Khoury (Professor of History) are serving on the search committee for the McMillan-Stewart Chair in the Study of Women in the Developing World.

CURRICULUM

The Program in Women's Studies offers an undergraduate curriculum through core classes and crosslisting subjects with cooperative departments. Students may concentrate, minor and petition for a major departure in Women's Studies. The Program in Women's Studies offered nineteen subjects during the academic year 1995-96, with 290 students enrolled. The program continues to be an active contributing member of the Graduate Consortium in Women's Studies (GCWS), a pioneering effort by faculty at six degree-granting institutions in the Boston area and Radcliffe College to advance women's studies scholarship in a series of team-taught interdisciplinary graduate seminars. This year, the program co-sponsored three graduate level courses through the GCWS, in which one MIT student enrolled.

HONORS AND AWARDS

Women's Studies is pleased to announce that Marwan Kazimi '96 is the first recipient of the joint writing prize between The Program in Writing and Humanistic Studies and the Program in Women's Studies: The Louis Kampf Writing Prize in Women's and Gender Studies. This prize honors both Professor Emeritus Louis Kampf's contributions to Women's Studies at MIT and rewards high quality undergraduate writing in women's and gender studies. The Prize is sponsored by Women's Studies and included among the annual writing prizes given by the Program in Writing and Humanistic Studies. The Prize is judged by faculty from Writing and Humanistic Studies and Women's Studies. Kazimi's winning submission was on Gender and Depression.

PROGRAM HIGHLIGHTS

- *Virtue & Virtuality: Gender, Law and Cyberspace*, a conference sponsored by Women's Studies and the Deans of Engineering and Humanities and Social Science, and content organized by STS Ph.D. candidate Jennifer Mnookin (Yale Law '95).

- IAP talks and films on mixed race identity, cosponsored by Women's Studies, List Visual Arts Center, and the Office of the Arts.
- IAP three-evening session on women's mysteries, led by Dean Ayida Mthembu and coordinated by Michèle Oshima.
- 1996 series of readings designed to showcase local authors, included Bunting Fellow Dubravka Ugresic, a writer from the former Yugoslavia, the Writing Program's Lecturer Lee, novelist Jill McCorkle, and several contributors to the *Sojourner* anthology, and co-sponsored by the Humanities Library, Women's Studies and New Words bookstore.
- A four-evening series of films by and about Asian Americans (funded by the Race Relations Committee), cosponsored by the List Visual Arts Center, Women's Studies, Film & Media Studies, complemented both the LVAC exhibit and our subject on Race and Gender in Asian America.
- A series in Women's International Human Rights included talks by International Human Rights Lawyer Seble Dawit (Female Genital Mutilation), Clark University Professor Cynthia Enloe (When American Soldiers Rape: Feminist Human Rights Implications of the Okinawa Case), and Wellesley Professor Salem Mekuria (screening of *Deluge* on the tyranny in Ethiopia), was planned to complement the subject on Women's International Human Rights taught by Lecturer Margaret Burnham (Political Science), and was underwritten by the Center for International Studies and Political Science and cosponsored by Women's Studies and Amnesty International
- The First Annual Off-Line Poetry Slam, funded by Theater Arts and the Dean of Humanities and Social Science, appealed to a whole new constituency of MIT. (A poetry slam is a competitive performance poetry contest with judges chosen randomly from the audience.)
- A Reading, "Resetting the Margins: National Reading Tour of South Asian, Filipino and Southeast Asian American Writers," sponsored four ways among Women's Studies, Writing and Humanistic Studies, the MIT Filipino Student Association and South Asian Women for Action.

RESEARCH, PUBLICATIONS, AND SERVICE

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 Perry (Literature, on leave) delivered the following lectures: "Good Girls and Fallen Women: Representations of Prostitutes in Eighteenth-Century English Fiction" (Conference on Representations of Criminality in the Early Modern Period, University of Salerno, Italy, Oct., 1995), "Feminist Pedagogy" (Feminist Theory Colloquium Series, Northeastern University, Nov., 1995), "What (Younger) Feminist Scholars Want" American Society for Eighteenth-Century Studies, Austin, Texas, March, 1996), "Am I My Sister's Keeper? Intellectual Siblings in Eighteenth-Century England" Conference on Education des Femmes, University of Lille, France, April, 1996, and "Reflections on Interdisciplinarity in the Graduate Consortium in Women's Studies at Radcliffe" (Berkshire Conference on the History of Women, Chapel Hill, North Carolina, June, 1996). She chaired the conference session, "Prostitution: Cultural Meanings and Material Conditions" (Modern Language Association, Chicago, Illinois, December, 1995). She reviewed *Companions Without Vows: Relationships Among Eighteenth-Century Women* by Betty Rizzo in *Eighteenth-Century Studies*. She published the paper "I Brake for Feminists" in *Concerns*, publication of the Women's Caucus of the MLA, and in *Transformations* (Spring, 1996). "Feminist Pedagogy" is being published by *Northeastern Working Papers*. "Good Girls and Fallen Women: Representations of Prostitutes in Eighteenth-Century English Fiction" is being published in a volume forthcoming from the University of Salerno on Representations of Criminality in Early English Fiction. "Building a Feminist Institution: An Informal History of the Graduate Consortium in Women's Studies" will be in the *NWSA Journal* (publication of the National Women's Studies Association). She has reviewed Catherine Gallagher's *Nobody's Story*, Edward Copeland's *Women Writing About Money*, and Claudia Johnson's *Equivocal Beings*, for *Modern Language Quarterly*, and T.G.A. Nelson's *Children, Parents, and the Rise of the Novel*, for *Eighteenth-Century Fiction*. Women's Studies is pleased to have a new addition in Literature, Professor Henderson. She published *Passion Made Public: Elizabethan Lyric, Gender and Performance* (Urbana, University of Illinois Press). She published the following article: "A Woman Killed with Kindness and Domesticity, False or True: A Response to Lisa Hopkins" in

Connotations 5.1, 1995/96. In addition, she gave a talk, "Rend(er)ing Gender: Mutilated Men in *The Duchess of Malfi* and *The Changeling*" for the meeting of the Group for Early Modern Culture Studies in Dallas, Texas, Oct., 1995 and at a special session of the MLA, Chicago, Illinois, Dec., 1995, and participated in a workshop on feminist pedagogy for the World Shakespeare Conference in Los Angeles, California, April, 1996.

Professor Fox Keller (STS) had a 10th Anniversary Edition of *Reflections on Gender and Science* (Yale Press). She co-edited *Feminism and Science* (Oxford University Press) with Helen Longino. Both Professors Keller and Sherry Turkle (STS) talked about Gender and Cyberspace for the Virtue & Virtuality: Gender, Law and Cyberspace conference held in April by the MIT Program in Women's Studies. Professor Turkle gave a talk "Gender and the Net" at Cyber-Identity Conference held by Princeton in March. Professor Hammonds (STS) co-edited *Gender and Scientific Authority* (University of Chicago Press) with Barbara Laslett, Sally Kohlstedt, and Helen Longino, and contributed "When the Margin is the Center: Black Feminism(s) and 'Difference'," to the forthcoming *Transitions, Environments, Translations* (Routledge). She is the Chair of the Committee on Women for the History of Science Society. Additionally Professor Hammonds attended the UN 4th World Conference on Women in Beijing, China, Aug. 29-Sep. 8, 1996 under the auspices of the Ford Foundation. Professor Hammonds oversees the Black Women in the Academy database project which is housed in the Women's Studies headquarters. Professor Jackson (Anthropology) has a chapter, "Coping with the Dilemmas of Affinity and Female Sexuality: Male Rebirth in the Central Northwest Amazon" in the forthcoming *Denying Biology: Essays on Pseudo-Procreation*. She gave a talk, "Gender in the Northwest Amazon: Research Dilemmas" at Tufts in March.

Professor Resnick (FL&L) remains active in the Executive Committee of the International Institute in Spain, where she annually helps coordinate their international conference on Spanish women. This year she moderated the colloquium held in June, 1995. She wrote a chapter on Carme Riera for the book *Proyecciones de la Novela* (Ediciones del Norte). In addition, she gave a talk on Women's Equality Day at the Veteran's Administration for the Women's Labor Bureau, US Government. Professor de Courtivron (FL&L) co-presented "Mosaicos de la Vida Feminina: La Memoria y Ficción" with Carme Riera at the June, 1996 colloquium of the International Institute in Spain. She reviewed *Einstein's Wife* in the December, 1995 issue of *Women's Review of Books*. She presented "Memoir of a Bilingual Daughter" at Colby College, October, 1995.

Mary Brown Parlee, Visiting Professor of Humanities, led a discussion group on gender summer through fall 1995. This dialogue grew out of an IAP course, Gender Outlaw, which explored issues of transgendered and transsexual identity.

Philosophy Ph.D. candidate Jennifer Noonan is leading an ongoing feminist philosophy discussion group, which started this spring. This intellectual forum has discussed such diverse topics as Objectification, Feminist Metaphysics, and Political Liberalism: Justice and Gender.

The program houses several UROPs. Professor Resnick continues to oversee the Margaret MacVicar/AMITA Oral History Project. The women who have attended MIT are a fascinating group of individuals whose unique stories form an integral part of MIT's history as an institution. Most of these graduates went on in their fields and the record of their endeavors provides new insights into the complicated questions surrounding gender and science and technology. In this project, undergraduate students are paired with female MIT graduates in similar fields. The students complete research on the interviewee and they are taught interviewing techniques. After the interview the transcript is edited by the student and the alumna for permanent deposit in the MIT archives. These archives are available to the public and are of interest to all of those interested in the evolution of MIT as an institution and the question of gender in scientific and technological fields. Additionally, a UROP under Professor Fox Keller's supervision, completed a web page on women in developmental biology which is linked to the MIT Women's Studies web page.

This year, Women's Studies had three visiting scholars: Petra Lucht, a doctoral student from the University of Hamburg in Germany (gender and physics), Dr. Poonam Pillai, faculty member of Ohio State University (feminist postcolonial theory), and Dr. Rodica Mihaila, professor of the University of Bucharest and founder of American Studies (contemporary American women's poetry).

Our publication, *Women's Studies Around Boston*, continues to be sent quarterly to our mailing list of over 2,500 individuals. 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 sponsored a comedy night fundraiser for *Sojourner*. This event featured a Latina and two Black comedienne and served to reach out to the feminist community and assist the feminist newspaper which was started at MIT 20 years ago.

FUTURE PLANS

As of July 1, 1996, Ruth Perry, Professor of Literature and Founder of the Program in Women's Studies will assume the directorship for two years. Dean Khoury will reestablish the Women's Studies Advisory Committee comprised of faculty from across the Institute.

Philip S. Khoury

SLOAN SCHOOL OF MANAGEMENT

This year marks the completion of the third year of our five-year plan for preeminence. We continue to revise and innovate in the areas of curriculum, facilities, productivity, research, development, and public awareness.

HIGHLIGHTS

- Completed and formally dedicated the Tang Center for Management Education, the first building designed expressly for the Sloan School, which provides 40,000 square feet of new space, with state-of-the-art videoconferencing, network, and Internet capabilities.
- Launched a collaborative program of faculty exchange and curricular development with Fudan and Tsinghua Universities (People's Republic of China) to establish the mutual understanding that will lead to the successful integration of China into the world economy and provide Sloan with the opportunity to research this emerging economy.
- Completion of the \$3.5 million trading room, the first fully-equipped "real-world" facility ever built on a university campus, for use in teaching and research.
- Continue to build the MIT Entrepreneurship Center, hiring a managing director and strengthening the Institute's commitment to this vital area of research and education.
- Finalized deal with PictureTel Corp. to investigate innovative ways to pursue distance learning through the Systems Design and Management (SDM) Program.

Glen L. Urban

ADMINISTRATION AND SERVICES

FACULTY CHANGES

Promotions

Full professor: Dimitris Bertsimas, Nancy Rose, Eleanor Westney

Associate professor: Erik Brynjolfsson

New Faculty

John Core, Accounting; Elizabeth Eccher, Accounting; Denis Gromb, Finance; Sandy Jap, Marketing; Scott Stern, Management of Technology and Innovation; Nader Tavassoli, Marketing

Professorships

Erik Brynjolfsson, Douglas Drane Career Development Associate Professor of Management

Steven Graves, Abraham Siegel Professor of Management

Donald Lessard, Epoch Foundation Professor of Management

Paul Healy, Nanyang Technical University Professor of Management

Don May, Nanyang Technical University Career Development Assistant Professor of Management

Tenure

Rebecca Henderson

Visiting Faculty

Edward Bowman, Visiting Professor of Management, Wharton School, University of Pennsylvania

Anirudh Dhebar, Visiting Professor of Marketing, Harvard Graduate School of Business

Alan Marcus, Visiting Professor of Finance, Boston College

Philip Parker, Visiting Professor of Marketing, INSEAD, France

Jay Ritter, Visiting Professor of Finance, University of Illinois

Michael Tushman, Visiting Professor of Management, Columbia University

James Hines, Visiting Associate Professor

Janice Klein, Visiting Associate Professor

Kevin Rock, Visiting Associate Professor

G. Peter Wilson, Visiting Associate Professor

On Sabbatical

Dimitris Bertsimas, John Hauser, Robert McKersie, Edward Roberts, David Scharfstein

Returning from Sabbatical

Deborah Ancona, Michael Cusumano, Lawrence Wein, Paul Healy

Professional/Personal Leave

Julio Rotemberg

Terminations

Professors Anantaram Balakrishnan, Ella Edmondson Bell, S. Lael Brainard, John Core, Paul Resnick, Karl Ulrich

ADMINISTRATION CHANGES

Donna Behmer promoted to Senior Associate Dean, Finance and Administration

Anne Drazen promoted to Assistant Dean and Chief Technology Officer

Hillary DeBaun, formerly associate director of the Undergraduate Program, left Sloan to become Team Leader for MIT Student Services Center

David Weber, formerly director of Educational Services, left Sloan to join the MIT Reengineering Team

Lucinda Hill, formerly deputy director of the Master's Program, now director of Educational Services

Robert Halperin, formerly executive director of the Center for Coordination Science, now director of Executive Education

New Hires

Ellen Corwin, systems analyst, Sloan Technology Center

Patrice Diaz-Migoyo, systems analyst, Educational Services

Susan Funke, manager, Corporate Resource Center

Karen Harnett Gribbell, assistant director, Master's Program

Anita Killian, associate director, Resource Development

Melissa LaBarge, project manager, Lemelson-MIT Prize Program

Paul Michelman, director of publications, Office of Communication

Roanne Neuwirth, assistant director, 21st Century Initiative

Laurie Pass, circulation manager, Sloan Management Review

Susan Petrie, business manager, Sloan Management Review

Scott Street, senior project manager, Sloan Technology Center

Marjorie Tyler

ADMISSIONS OFFICE

Each year the Admissions Office aims to find and recruit the best, most innovative leaders of the future from across the U.S. and around the world. The complex challenges of the next generation will demand a wide variety of skills; as a result, we recruit the most diverse class possible.

HIGHLIGHTS

- Highest number of applicants in Sloan history—3,000+
- Highest yield—82%
- 30% women
- 15% underrepresented minorities
- 24% minority (includes Asians)

NEW INITIATIVES

Continue to emphasize recruitment of women and under represented minorities

Reengineer admissions procedures to more effectively and efficiently meet growing demand

Increase presence on World Wide Web

Rod Garcia

Meg Manderson

ALUMNI RELATIONS

To enhance the goodwill of Sloan alumni by enabling them to stay connected to each other, the School, and ongoing opportunities for professional and personal development.

HIGHLIGHTS

- Alumni/ae Worldwide: 15,826, representing over 80 countries
- New Sloan Alumni Interactive web site received over 4,000 hits since May 1 launch
- Interactive videoconferenced club events
- Expanded career management services
- Record alumni turnout for the 1995 Executive Education Convocation and the 1996 Master's Program Reunion
- 20% of alumni/ae population participated in club activities this year
- Published an updated alumni directory

NEW INITIATIVES

Development of a new Alumni Advisory Board

Continued development of new fee-based services and revenue generation activities, including a memorabilia business and on-line alumni courses

Enhancement of web-based programs and services

Carmon Cunningham

CAREER DEVELOPMENT OFFICE

HIGHLIGHTS

- Interviews scheduled: Over 2000
- On-campus recruiting: 203 companies (52 new to Sloan)
- New Corporate Resource Center, staffed with a professional librarian specializing in business information systems
- Addition of materials and resources to Web site
- Increased subscriptions to electronic career search and business information services

New Recruiting Events

High Tech Career Fair (Sloan Resource Center): 10 companies and 70 students

Banking Day (New York, NY): 15 banks and 100 students

Continuing Recruiting Events

Career Development Seminars

Industry-specific Career Options Seminars

Class Of '96 Placement

Average Number of Interviews: 12

Average Number of Offers: 3.4

Median Total Compensation: \$102,500

Median Starting Base Salary: \$78,000

Median Starting Base Salary - Consulting: \$85,000

Median Starting Base Salary - Manufacturing: \$71,200

Top Industries Selected

Consulting: 43%

Manufacturing: 31%

Investment Banking: 17%

Top Job Functions Selected

Consulting: 43%

Operations/Project Management: 17%

Finance: 26%

Top Hiring Firms

McKinsey: 18

Booz-Allen & Hamilton: 9

Boston Consulting Group: 8

Intel: 8

NEW INITIATIVES

Implement fall recruiting for the first time

Work with Career Tracks and student clubs on the development of CDO services while managing continued growth in the size of the student body

Continue outreach to new companies

Organize additional industry-focused career fairs

Ilse Evans

CLIENT PARTNERSHIPS AND RESOURCE DEVELOPMENT HIGHLIGHTS

- Gifts, pledge payments & new pledges up 18%
- Cash receipts up 6%
- More than \$3,000,000 in new pledges recorded
- 68 major gifts and new pledges in the \$25,000-\$1,000,000 range recorded

NEW INITIATIVES

Increase the marketing of the School's resources and leveraging off the Institute

Strengthen existing partnerships with the Graduate Alumni/ae Program, undergraduate reunion giving, and regional staff

Continue to develop closer working relationships with corporate development and Industrial Liaison offices

Increase Sloan's interaction with the foundation relations office around joint strategies. We believe there is growing potential support from foundations for business education that has not yet been tapped.

Ronald Thomann

EDUCATIONAL SERVICES

Educational Services manages the infrastructure of the academic process, providing operational support for students and faculty, producing materials for program management and classroom teaching, managing information systems for student enrollment and registration, and facilitating communication between students and faculty.

HIGHLIGHTS

- Successfully implemented the computerized course prioritization system. Accessible via the World Wide Web, the Sloan bidding system ensures students fair access to courses and supports faculty by managing course enrollment as the student population rises.
- Published a student photobook and directory of all programs, encouraging student interaction through common personal, academic, and career interests.
- Played a key role in the successful integration of a greatly increased master's student body and providing increased levels of high-quality support to the growing Custom Executive Programs.
- Worked on the pilot corporate database project.

NEW INITIATIVES

As MIT moves to electronic course registration, the Educational Services team will work with the Registrar to guarantee that systems for both work well in tandem.

Support for Executive Education will open new fronts as distance learning is explored.

Focus will remain on streamlining student services, as the student population again increases; goal is to find new ways to provide even higher quality service to a larger client base.

Cindy Hill

LEMELSON-MIT PRIZE PROGRAM

The Lemelson-MIT Prize Program raises awareness of and encourages young people to pursue careers in invention, innovation, and entrepreneurship through the presentation of the annual Lemelson-MIT Prizes and a comprehensive public education program.

HIGHLIGHTS

- Public education and awareness activities included: launching the "Invention Dimension" Web site; conducting a survey probing the American public's perceptions of inventions and inventors; sponsoring demonstrations by MIT students with middle-school students; creating an interactive exhibit about inventors at Epcot Center; and spotlighting contemporary American innovators.
- Drs. Herbert Boyer and Stanley Cohen were co-recipients of the \$500,000 Lemelson-MIT Prize; Dr. Wilson Greatbatch received the honorary Lifetime Achievement Award, and David Levy, a doctoral student in the Department of Mechanical Engineering, received the \$30,000 Lemelson-MIT Student Prize.

Annemarie Amparo

OFFICE OF COMMUNICATION

The goal of Sloan's Office of Communication is to clarify, coordinate, and broadcast key messages that demonstrate the preeminence of the School. Innovating the form, content, and processes of communication for stronger impact, better coordination, and greater cost effectiveness, the Office made progress on a number of fronts last year:

HIGHLIGHTS/NEW INITIATIVES

- Conceived, developed, and produced the first issue of *MIT Sloan R.O.I.*, a sophisticated new multimedia periodical that provides a single, concise, and highly visual summary of substantive news and information about Sloan.
- Revamped and expanded Sloan's web site to provide easy access to the full range of information about the School. The updated web site has received national recognition for its quality and completeness.
- Developed and implemented a system for managing the conception and production of school publications and related web sites.
- Promoted coverage of Sloan faculty and activities in the press, including the *Boston Globe*, *Wall Street Journal*, *U.S. News & World Report*, the *Financial Times*, and a host of other print and electronic media.

David Lampe

SLOAN MANAGEMENT REVIEW

Sloan Management Review, the business school's quarterly peer-reviewed journal, has had a successful year:

HIGHLIGHTS

- Impact. Circulation is over 19,500, up 1,500 from last year at this time. SMR's citation and impact ratings were higher than ever before in SSCI's 1995 journal ranking.
- Editorial. SMR published 5 MIT articles from 5 separate functional areas and research centers. Seventy-one percent of the academically generated articles were from top-20 business schools. Several articles were discussed at length in *The Economist* and the *Financial Times*.
- Profitability. SMR had its best year ever, contributing more than \$325,000 to the School, after expenses. Profit margins were around 35 percent.

Sarah Cliffe

SLOAN TECHNOLOGY CENTER

To create a partnership of faculty, staff, students and corporations dedicated to the support of a changing infrastructure, the teaching of the best information technology practices; and innovating, planning, analyzing, implementing, and promoting lifelong technology learning within our electronic community.

HIGHLIGHTS

- Construction and opening of the Sloan Trading Room
- Web-based course and interview bidding systems; Sloan is the first business school to have students bidding for courses and job interviews on the Web
- Major thrust into distance learning with Systems Design and Manufacturing program, and marketing course
- First alumni/ae meeting and multi-business school meetings via videoconferencing

NEW INITIATIVES

All Master's Program/MBA students are now required to have a personal computer. Students with laptops can plug into classrooms, lounges, breakout rooms and common areas around Sloan.

Increasing Sloan's presence in videoconferencing through broadcasts of campus speakers, increased classroom use, alumni/ae meetings, and lunches with faculty members.

Increased usage of technology in management education (TIME) with web-based groupware and administrative systems.

Development of custom classes delivered as a combination of live Web-based material, discussions, tapes, CDs and videoconferences.

Anne Drazen

EDUCATIONAL PROGRAMS

UNDERGRADUATE PROGRAM

44 seniors majoring in management science graduated, with the options:

Finance: 19

Information Technologies: 13

Marketing Research: 7

Operations Research: 4

Behavioral Science: 1

Undergraduate Program graduates also receiving bachelor and master of engineering degrees from:

Department of Electrical Engineering and Computer Science: 11

Department of Chemical Engineering: 2

Economics: 2

Mathematics: 1

Graduates simultaneously awarded SB degrees in Management Science and:

Master of Engineering degrees in Electrical Engineering and Computer Science: 6

Bachelor's degree in Electrical Science and Engineering: 3

Bachelor's degree in Electrical Engineering and Computer Science: 2

Bachelor's degree in Chemical Engineering: 2

Bachelor's degree in Economics: 2

Bachelor's degree in Mathematics with Computer Science: 1

Spring 1996 enrollment: 139

Total students with declared options: 115

Finance: 49

Information Technologies: 41

Marketing Research: 17

Operations Research: 5

Behavioral Science: 2

System Dynamics: 1

Students with management science as their second SB department: 39

Undergraduate enrollments in management subjects: 784 (98 FTEs)

Hillary De Baun

LEADERS FOR MANUFACTURING PROGRAM STATISTICS

1995 applications: 408 (55 admitted, 48 enrolled)

Average age: 28

Average work experience: 4.2 years

Women: 6

Minorities: 4

Sloan School of Management

MIT Reports to the President 1995-96 – 375

Partner-sponsored students: 15

Total 1995–96 enrollment: 88

1995–96 graduates: 43

Employed in U.S. manufacturing companies: 88%

Number of job offers (unsponsored students): 5.5

EVENTS

Alumni/ae Workshop, Spring 1996, San Francisco

Industry Leaders executive education course (pilot program), November 1995

LEADERSHIP

Learning Tools Committee has developed 12 cases which are used by industry and in classes.

The Leaders Program and MIT assumed a leadership role in the National Science Foundation-sponsored Next Generation Manufacturing Project (NGM), which seeks to develop an industry-based view of the future and specific examples of new business practices and technologies.

The LFM-spearheaded National Coalition for Manufacturing Leadership (NCML) has 14 members, including new members University of California/San Diego and Northwestern. Having helped establish dual-degree manufacturing programs at Michigan and Obispo, MIT continues to assist Arizona, Georgia Tech, New Mexico, Penn State, and Pomona in their programs.

Stephen C. Graves

William C. Hanson

David E. Hardt

MASTER'S PROGRAM

To create and deliver a small MBA program based upon collegiality and teamwork, an international focus and a diversity of cultures and interests. The innovative and integrative curriculum aims to provide a strong analytical foundation to management, encourages the interplay of ideas and their practical application, and allows students to design an individualized educational program exposing them to leading edge research and practice.

HIGHLIGHTS

- Ranked #2 by *U.S. News & World Report* in its 1996 annual survey of graduate business schools.
- Received over 3000 applications for admission in 1996, an increase of nearly 30% from 1995 (2300 applications) and 80% from 1994 (1670 applications).
- An incoming class of 300 in the Master's Program and 48 in Leaders for Manufacturing.
- Expanded its two-year enrollment in 1996 to over 700 students, including LFM.
- Nine graduating students received merit scholarships in recognition of their outstanding leadership and contributions to the Sloan community.
- 84% of students in the program planned to receive the MBA; 19% planned to write a thesis.
- 91% of students rated their Sloan Master's Program experience as a 7 or higher out of 10.
- 94% of the students rated their satisfaction with faculty expertise in course material as a 7 or higher out of 10.
- 90% of students stated that they would recommend the program to potential candidates.

NEW INITIATIVES

Establishment of a peer tutoring and advising program to promote student-to-student mentoring.

Initiating community service projects and seminars in which students participate in various volunteer activities in the Boston/Cambridge area.

Coordination of six international study trips and academic seminars during the spring term of the academic year.

Continued inviting corporate and industry leaders to work with students through the career management track activities and through interaction with many of the Sloan student organizations such as the Leaders Club, Finance Club, Marketing Club and New Ventures Association.

Project Team, a student organization focusing on team-building skills, organized several successful seminars for fellow students.

Lawrence Abeln

MANAGEMENT OF TECHNOLOGY PROGRAM

The Management of Technology (MOT) Program prepares executives to shape the role of technology in industry and government. The goal is to provide students with solid disciplinary foundations and integrative experiences, expanding their skills as change agents and problem-solvers.

HIGHLIGHTS

- Graduated 41 students from 16 countries
- Trip to Germany and Hungary
- Guest speaker James Ross, former CEO of Cable & Wireless, in Seminar in Management
- Joined Sloan Fellows class for two new courses, "Managing Manufacturing" and "Service Operations"
- Increase in sponsored students
- Program rated "outstanding" in student survey

NEW INITIATIVES

Incoming class largest ever (52) with the most women enrolled (8)

More company visits to be arranged

International trip will be to Beijing, Hong Kong, and Taipei

Closer collaboration with LFM sponsors will allow more senior executives to enroll

One videoconferenced Seminar in Management (guest speaker) to be arranged

Rochelle Weichman

SYSTEM DESIGN AND MANAGEMENT PROGRAM

To educate future technical leaders in systems engineering/architecture and the conception and design of complex products and systems, preparing them for careers as the technically grounded senior managers of their enterprises. The program is a joint offering of the School of Engineering and the Sloan School of Management, leading to a Master of Science in Engineering and Management.

HIGHLIGHTS

- Approval by the MIT faculty to offer the System Design and Management program as an independent, interdepartmental degree program.
- Successful delivery of four courses to distance-learning students using videoconferencing, the world wide web, and other communication technologies (desktop videoconferencing, electronic mail, fax).
- The conception of a 14-course curriculum including three new core courses (Systems Architecture, Systems Engineering, and System and Project Management).
- Commitment by several companies to enroll students and to join the program as sustaining enterprises.
- Because it fills a gap in the educational track for professional engineers, potential applicant interest is high.

NEW INITIATIVES

Beginning January 1997, the program will offer two tracks: one 13-month on-campus program and one 24-month program with a hybrid of on-campus and off-campus instruction.

Thomas Magnanti
Edward Crawley

EXECUTIVE EDUCATION

To be the preeminent provider of high-quality programs for senior managers and executives in the United States and around the world.

HIGHLIGHTS

- Both the Management of Technology and Sloan Fellows Programs successfully recruited large classes for 1996-1997, indicating continuing strong demand for these mid-career management degrees.

-
- Five executive short courses were successfully offered in May and June.
 - Responding to the demand for more customized programs, we increased Sloan's executive education programs for individual companies.

NEW INITIATIVES

Short Courses—We are creating a richer variety of short courses targeted to the specific needs we see emerging in industry, particularly in the areas of organizational learning, product development, and corporate finance.

Distance Learning—We are completing a state-of-the-art distance learning facility on campus. Our goal is to use this interactive medium to leverage the worldwide impact of our faculty and extensive contacts with industry.

Research—Industry tells us that one of Sloan's key advantages in the educational marketplace is the future-oriented perspective provided by its research programs. Thus, we have reaffirmed our commitment to maintaining and expanding our research base as a means of adding value to our educational programs.

Links to other parts of MIT—Current joint programs (Management of Technology, Systems Design, and Leaders for Manufacturing) serve as a foundation for additional cross-campus collaborations.

Robert Halperin

PHD PROGRAM

1995 applicants: 372

Admitted: 27 (33% from U.S.; foreign applicants from 53 countries, the majority from China, India, Korea, Taiwan, Canada, and Italy)

Enrolled: 12 (9 men, 3 women), in the following areas:

Behavioral & Policy Sciences: 3

Finance & Accounting: 2

Management Science: 7

Majority of graduates pursue academic careers at Harvard, Cornell, and the University of Pennsylvania

Birger Wernerfelt
Sharon Cayley

VISITING FELLOWS

The MIT Sloan Visiting Fellows Program provides the opportunity to pursue full-time, non-degree studies tailored to individual goals and interests. Each Visiting Fellow's program of study, usually for one or two semesters, is designed in consultation with a faculty adviser to meet individual professional needs and interests.

HIGHLIGHTS AND NEW INITIATIVES

This program has in the past enrolled four to six participants a semester. However, demand for the program has increased over the past two years, with enrollment almost doubling each year. Regular sponsors of participants include Schlumberger and The Bank of Tokyo-Mitsubishi, Ltd.

Eleanor Chin

RESEARCH CENTERS AND INITIATIVES

CENTER FOR COORDINATION SCIENCE

Coordination science and technology draws upon a variety of fields including economics, computer science, organizational theory, information systems, management science, and psychology. The Center for Coordination Science conducts multi-disciplinary research aimed at improving the coordination and integration of work performed by people, firms, and computers.

HIGHLIGHTS/NEW INITIATIVES

- 23 theses
- 3 working papers
- 4 published papers:
- 1 book edited

-
- 3 refereed articles published
 - 2 conference proceedings published
 - Made significant progress on Process Handbook project: Major new funding, major progress on software tools and information content

Thomas Malone

CENTER FOR ENERGY AND ENVIRONMENTAL POLICY RESEARCH

CEEPR conducts policy-related research in energy and environmental economics, drawing on faculty and student resources from the Sloan School, the Department of Economics, and the Energy Laboratory. An important component of CEEPR is the Joint Program on the Science and Policy of Global Change, jointly conducted with MIT's Center for Global Change Research.

HIGHLIGHTS

- Research conducted by the Joint Program has received increasing recognition worldwide. Sponsorship is up, as are invitations to present the results of analysis to organizations with an interest in global warming, such as the Second Conference of the Parties held in Geneva in July 1996.
- CEEPR is currently involved in an extensive *ex post* evaluation of the largest public policy experiment in emissions trading to date, the 50% reduction in SO₂ emissions mandated by the 1990 Clean Air Act Amendments. Research into the causes of low allowance prices has received widespread notice and citation in a number of press articles on this experience with emissions trading.
- CEEPR has created a unique mine level database for the U.S. coal industry that will permit continuing research into the micro-economic bases of observed productivity change and related phenomenon of declining price and apparent chronic over-capacity.

NEW INITIATIVES

With the help of a three-year grant from the National Science Foundation, the Joint Program has initiated a new research effort on the interaction of local and global pollution. This research is driven by the recognition that local pollution will be acted upon much sooner than greenhouse gas emissions and that local pollution is a significant contributor, positively and negatively, to global warming.

Continue to expand the four current thrusts of our research: global warming, emissions trading, productivity change in the supply of energy, and electric utility restructuring.

Initiate preliminary research on the use of vertically and horizontally related futures in the crack spread in petroleum and in what is anticipated to become the "spark" spread in electricity markets.

A. Denny Ellerman

CENTER FOR INFORMATION SYSTEMS RESEARCH

Established in 1974, CISR investigates critical issues concerning the management and use of information technology in complex and dynamic organizations. Faculty associated with the Center have conducted pioneering research in such areas as decision support systems, critical success factors, database systems, strategic IS planning, end user computing, executive support systems, and coordination technology.

HIGHLIGHTS/NEW INITIATIVES

- 14 working papers
- 4 theses
- Developed case studies for a new Executive Education short course on the management of the IT network infrastructure
- Held several seminars for sponsors
- Held the 21st Annual CISR Summer Session conference

John Rockart

FINANCE RESEARCH CENTER

Originally established as the International Financial Services Research Center in 1988, the FRC provides its partners with access to MIT faculty to discuss specific finance issues relevant to their businesses. It also encourages involvement in faculty research on topics of mutual interest, as well as in educational programs on financial

management and engineering. The Center also hosts conferences on current financial issues in finance and underwrites a Discussion Paper series for sponsors. The Center has been extremely successful in providing value to sponsor firms through discussions with faculty and focused research relationships.

Research and educational programs focus on:

Corporate Finance—Includes capital budgeting, optimal financial policy, tax strategies, corporate risk management and hedging strategies, corporate disclosure strategies, and investor communications.

Risk Management—Includes financial modeling, statistical analysis, data management, and organizational aspects of risk assessment and control.

Paul Healey
Michael Siegel

INVENTING THE ORGANIZATIONS OF THE 21ST CENTURY

Working with today's innovative managers, we seek to invent the way successful businesses will be organized in the next century. The Initiative is a joint project of the Center for Coordination Science, the Center for Information Systems Research, and the Organizational Learning Center.

HIGHLIGHTS/NEW INITIATIVES

- Added five new sponsors, hired new assistant director and research associate, organized several major sponsor meetings, formed several faculty working groups and began to formulate research agenda.
- Continue to develop research agenda and sponsor base.

Thomas Malone

MIT CENTER FOR ORGANIZATIONAL LEARNING

The MIT Center for Organizational Learning, established in 1991 as a sponsored research center at the Sloan School, is a consortium of organizations working to advance the state-of-the-art in building learning organizations.

HIGHLIGHTS

- Participation in the 21st Century Initiative (along with CCS and CISR)
- The OLC is growing and has a waiting list of companies wanting to be sponsors
- Center associates published eight working papers, four articles/papers, and four chapters in edited books

NEW INITIATIVES

Redesign process guided by all major stakeholders of the Center, including Consortium CEOs, Liaison Officers, MIT faculty, and OLC staff

The implementation of a public Web site in July 1996 (<http://learning.mit.edu>)

Peter Senge

OPERATIONS RESEARCH CENTER

The ORC provides educational and research opportunities for students and faculty interested in the interdisciplinary field of operations research, which draws upon ideas from engineering, management, mathematics, and psychology to apply scientific methods to decision-making.

HIGHLIGHTS

- Three faculty members joined Center
- 21 theses
- 16 working papers
- 2 technical reports
- INFORMS Erlang Prize awarded to OR faculty member Dimitras Bertsimas
- SIAM Activity Group on Optimization Prize awarded to OR faculty members Michael Goemans and Dimitras Bertsimas
- Dantzig Prize awarded to recent OR graduate S. Raghavan
- INFORMS Nicholson Prize awarded to OR graduates Gina Mourtzinou and Chung-Piaw Teo

-
- Sloan professor Robert Freund appointed co-director of ORC

NEW INITIATIVES

Finalize revisions to OR doctoral program

Initiate new fundraising venture

Organize 1 to 2 day OR seminars as fundraising projects

Thomas Magnanti

PROGRAM ON THE PHARMACEUTICAL INDUSTRY

The MIT Program on the Pharmaceutical Industry (POPI) was founded in 1991 as a research and education program focused on understanding the structure and dynamics of the global pharmaceutical industry: the pharmaceutical firms, their suppliers, customers and regulators. POPI seeks to improve the performance of the pharmaceutical industry and reduce the cost of healthcare by lowering product costs and decreasing the time it takes to bring new products to patients.

HIGHLIGHTS

- Exploring the role of publicly funded research in private sector pharmaceutical innovation
- Pharmaceutical R&D in the new environment
- The role of combinatorial chemistry in drug discovery
- The changing dynamics of industry competition
- Technology transfer between universities and large pharmaceutical firms
- Pharmaceutical manufacturing: Does it have a strategic role?
- Evaluating welfare gains from pharmaceutical innovation

NEW INITIATIVES

MIT has begun a major manufacturing technology initiative in collaboration with Purdue University, the Sigel division of Jacobs Engineering, and several pharmaceutical companies. This industry/university Consortium for the Advancement of Manufacturing in Pharmaceuticals (CAMP) is dedicated to the identification, research, and development of new manufacturing technologies. Its objective is to improve healthcare delivery by lowering product cost and decreasing time it takes to get new products to patients. At this time, four major pharmaceutical firms have committed to join CAMP; discussions are underway with others.

Stan Finkelstein

SYSTEM DYNAMICS GROUP

System dynamics is a method for studying the world by looking at things as a whole—understanding how all the objects in a system interact with one another. System dynamics generates behavior as observed in an actual economy from the interactions of local structures and decision-making policies, building a bridge that joins microstructure with macrobehavior.

HIGHLIGHTS/NEW INITIATIVES

- National Science Foundation grant approved for its second year of funding.
- National Model Project continues research on how the U.S. economy works
- System Dynamics in Education Project produces the “Road Maps” workbook for learning system dynamics; maintains comprehensive web site at <http://sysdyn.mit.edu/>
- The Improvement Paradox: Designing Sustainable Quality Improvement Programs continues its research into TQM; web site launched (<http://web.mit.edu/jsterman/www/>)

John Sterman

SCHOOL OF SCIENCE

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 1995 Nobel Prize in Chemistry by Mario J. Molina Professor of EAPS and Chemistry. This is the first Nobel Prize in Chemistry awarded to one of our faculty. The 1995 NRC study of Research Doctorate Programs in the United States showed that our graduate programs quite broadly are ranked among the top few in the Nation. The one exception is neuroscience where we are in a building phase. 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. Mathematics has extensively revised introductory calculus 18.01 and has introduced an "intermediate difficulty" freshman calculus sequence 18.01A and 18.02A. Biology has been successfully introduced into the core curriculum and is continuing quite successfully. One result of adding Biology to the core is a dramatic increase in the number of Biology majors over the past two years. Physics introduced a major change in the structure of 8.01 with most of the teaching taking place in small sections of ~ 20 students. Further refinement of this novel approach is underway. EAPS is revamping its educational program, especially at the graduate level, with an emphasis on a systems approach. In particular, EAPS is in the process of introducing a professional masters degree in Geosystems. BCS has revamped its Cognitive Science major dividing it into four core areas and is designing a neuroscience major to be introduced in FY1997. Overall, after EECS, the departments with the largest number of undergraduate student contact hours at MIT are, in order, Mathematics, Physics, Biology and Chemistry. Thus, the School of Science continues to carry a major part of the undergraduate teaching responsibility at MIT.

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 1996 winner of this award was Professor Marcia McNutt of EAPS. The School of Science Teaching Prize for Undergraduate Education was won by John Essigmann of Chemistry and Toxicology. Two School of Science faculty were chosen as MacVicar fellows in FY96; they are Rick Danheiser and Bob Silbey.

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 including especially women and underrepresented minorities. In 1995-96 seven new faculty joined the School as assistant professors; one as an associate professor; and two additional faculty were appointed as full professors. We also have had to stave off an unprecedented number of outside offers to our most distinguished faculty.

One of the most significant events of the recent past was the formation of the Committee on Women Faculty in the School of Science. This committee was created as the result of an initiative which involved all of the senior women in the School of Science. The committee has multiple purposes and responsibilities. First, the committee has collected data to be used in assessing the status and equitable treatment of women faculty in the School of Science. Second, the committee is facilitating communications between the women faculty and the dean and department heads. Third, the committee is acting as a resource for the Dean of Science and the department heads. Finally, the committee is also serving as a resource to the MIT community as a whole to provide advice about issues of concern to women faculty at MIT. The committee's first official report is due shortly.

There are many new research initiatives in the School of Science. One of the most significant is our newly established partnership with the Carnegie Institution, the Harvard Smithsonian, the University of Michigan and the University of Arizona in the Magellan Project; this involves the design and construction of twin 6.5m telescopes at Los Campanas in Chile. In addition, the Alpha Magnetic Spectrometer (AMS) is scheduled to be one of the premier scientific experiments on the International Space Station to be launched in 2001. The AMS project, which involves an international consortium, will look for anti-matter and dark matter candidates above the Earth's atmosphere. MIT, in partnership with the Whitehead Institute, continues to play a leading role in genome research. A new three-year 26 million dollar program to begin sequencing specific portions of the human genome has begun.

ACADEMIC PROGRAMS

There were 913 undergraduates in the School of Science during the past academic year, a 1.44% increase from the previous year. The number of minority students at the undergraduate level changed as follows:

Blacks	Increased from 25 to 37 (48.00% increase)
Hispanics	No change (48)
Native Americans	Increased from 7 to 8 (14.29% increase)
Asian Americans	Increased from 276 to 289 (4.71% increase)

The female undergraduate population increased from 372 to 418 (12.37%). Twenty percent of the Institute's upperclass undergraduates were enrolled in the School of Science.

Graduate enrollments in science decreased from 1,084 to 1,059. The total enrollment represents 20 percent of the graduate population at MIT. The number of minority students at the graduate level changed as follows:

Blacks	No change
Hispanics	Increased from 14 to 19 (35.71% increase)
Native Americans	No change
Asian Americans	Increased from 47 to 51 (8.51% increase)

The number of female graduate students increased from 245 to 316 (28.98%).

There were 277 faculty members in the School this past year. This represents a slight increase 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 FY96 research volume was \$123 million, a 2% decline over the FY95 research volume.

Robert J. Birgeneau

DEPARTMENT OF BIOLOGY

The Biology Department currently has 55 active faculty members of whom 11 are located in the Whitehead Institute, 12 are located in the Center for Cancer Research, 3 are joint appointees with the Department of Brain and Cognitive Sciences, 1 is joint with Chemistry and 1 is joint with the Department of Civil and Environmental Engineering. Including active Emeriti faculty, 4 of the faculty are Nobel laureates, 23 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 432. We now have the second largest number of majors following electrical engineering. The Bachelor of Sciences in Biology degree was awarded to 151 students this past year: 133 in the regular Course VII Program, 18 in the VII-A Program.

A number of Biology majors received awards in 1996. The 1996 Whitehead Undergraduate Prize, given to an undergraduate majoring in Biology, who shows outstanding promise for a career in biological research as demonstrated by academic scholarship and contributions to research and to the MIT community, was awarded to Jason J. Cherry. The recipients of the 1995-96 John L. Asinari Award were Arash Komeili and Kenneth S. Song in recognition of outstanding undergraduate research in the field of life sciences. Jonathan Hsiao was the recipient of the Salvador E. Luria Prize honoring outstanding scholarship and research of publication quality. The two recipients of the Ned Holt Prize were Maromi K. Sakurai and Shane Crotty to recognize biology majors who demonstrate excellence in scholarship and service to the MIT community. Tomas Perez was the recipient of the National Science Foundation Incentives for Excellence Scholarship Prize. Jennifer Boyle was jointly named the winner of the Malcom Kispert Award as the outstanding senior scholar/athlete of the year. Jennifer L. Tsuei was the recipient of an Edward S. Darna Award, honoring substantial contributions to the life of the theater at MIT. The Laya W. Wiesner Award recognizing the undergraduate woman who has most enhanced community life went to Jennifer Yang. Shelly-Ann Davidson was a recipient of a Ronald E. McNair Scholarship. Elizabeth A. Stoehr received the Joseph D. Everingham Award in recognition of a single creative accomplishment in theater arts. The S. Klein Prize in Science and Technical Writing went to August Change and Marwan Kazimi received the Louis Kampf Prize in Women's and Gender Studies. The following students were elected to Phi Beta Kappa: Rodney K. Chan, Grace M. Cheng, Michael Cho, Shane Crotty, Steven Gunzler, Patricia Kao, Eric Lo, Kazuhiro Ninomiya, Ashish Patel, Maromi Sakurai, Mary Saleeb, Arnold Seto, Stanley Shyn, and Michelle Sonu.

This past Fall a new course consisting of small seminars for advanced undergraduates was offered. Organized by Professor David Baltimore, the topics for these courses included human genetics, plant development, cell cycle control, among others.

GRADUATE PROGRAM

During the period from July 1, 1995 to June 30, 1996, 45 Ph.D. degrees were awarded in the Department; and 4 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 1995-1996 was 212, with another 34 in the Joint Program. The entering class in 1995, including 5 in the Joint Program, was 42. The class arriving in September, 1996 will be 24 students.

Three new graduate courses were offered this past Spring: 7.97, Topics in Evolution, 7.98J, Neural Plasticity in Learning and Development, and 7.99, Disease Intervention through Biotechnology.

RESEARCH

The research activities of the department are in the areas of biochemistry, genetics, microbiology, cell and developmental biology, immunology, neurobiology, and virology. The FY96 total direct cost of research in the department (including the Center for Cancer Research and the Whitehead Institute) was approximately \$35.6

million, \$16.5 million of which was at the Whitehead Institute. MIT overhead on the funding in the department and the Cancer Center was approximately \$8 million.

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) and on the World-Wide Web at <http://web.mit.edu/biology/www/>. There were, however, several significant advances in the areas of human health and disease. Professor Monty Krieger and collaborators reported an exciting discovery of a cell receptor for HDL, the "good cholesterol". This finding may ultimately help explain how HDL works to lower the risk of atherosclerosis. Professor David Housman reported in *Nature Genetics* on his laboratory's molecular characterization of a chromosomal translocation causing a form of leukemia. His laboratory, together with their collaborators, identified the genes that are disrupted by the translocation by first identifying the sites where the chromosomes broke. This work will allow development of rapid tests for monitoring the progression, therapy, remission and relapse of acute myeloid leukemia and should provide valuable insights into the development of leukemia. Professor Hermann Steller's laboratory has made significant strides in their research on Programmed Cell Death (PCD), also known as cell suicide. Because of its myriad implications, PCD, the genetics of which were established by Professor H. Robert Horvitz, has recently become a hot topic, attracting the attention of researchers from all biological fields. In December scientists at the Whitehead Institute completed a comprehensive map of the human genome and in March they reached a major genome goal when they reported the first comprehensive genetic map of the mouse genome. There is a high probability that any disease-related genes identified in mice will play a role in the same biological process in human disease. In addition, the Whitehead/MIT Center for Genome Research, directed by Professor Eric Lander, received a 3 year \$26 million grant from NIH to begin sequencing specific portions of the human genome. Professor Gobind Khorana recently reported that misfolded proteins in certain cells of the eye may be responsible for one form of blindness. The defective proteins are the consequence of genetic mutations associated with the disease retinitis pigmentosa. Their findings may help doctors understand certain clinical observations associated with retinitis pigmentosa.

PERSONNEL

Professors William Quinn and Hermann Steller were promoted to full Professor, effective July 1, 1996. Professors Chris Kaiser and Hazel Sive were promoted to Associate Professor.

We are pleased to report that four new faculty members have accepted positions in the Department.

Drs. David Bartel and Andrew Chess will join the Whitehead Institute and Department of Biology as Assistant Professors this Summer. Dr. Bartel plans to focus on understanding the catalytic abilities of RNA and ribonucleoprotein. He received his Ph.D. from Harvard University and then became a Whitehead Fellow.

Dr. Chess plans to study the mechanisms controlling olfactory receptor gene expression. He received his M.D. from Columbia University where he is now conducting postdoctoral work.

Dr. Sylvia Sanders will also join the Department as an Assistant Professor during the next academic year. She received her Ph.D. from the University of California, Berkeley and is currently doing postdoctoral studies at UCSF. At MIT Dr. Sanders will continue her studies on the molecular basis of cell polarity and cell asymmetry.

Dr. Guosong Liu 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. Liu received his Ph.D. from UCLA and is doing postdoctoral work at Stanford University. Dr. Liu will study the mechanism of synaptic transmission, synaptic interaction and activity dependent regulation of gene expression.

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.

Two faculty members left the Department this year. Dr. Ruth Lehmann assumed a faculty position at the Skirball Institute, New York University Medical Center. Dr. Richard Mulligan accepted a position at Children's Hospital, Boston. We wish them both well in their new positions.

HONORS AND AWARDS TO THE FACULTY

It is a pleasure to report the following honors and awards to Biology faculty during the past year:

Stephen Bell received a Rita Allen Award and a Searle Scholars Award.

Sallie Chisholm was elected a Fellow of the American Geophysical Union.

Arnold Demain received the Waksman Outstanding Teacher Award and honorary membership in the Society for Actinomycetes, Japan.

Nancy Hopkins was named a Class of 1960 Fellow in recognition of outstanding teaching and course development.

H. Robert Horvitz received the Charles A. Dana Award for Pioneering Achievements in Health.

David Housman was named the Ciba-Geigy Professor of Biology.

Richard Hynes was elected to the Institute of Medicine and to the National Academy of Sciences.

Rudolf Jaenisch received the Molecular Bioanalytic Prize from the Boehringer Mannheim Group.

Gobind Khorana was elected honorary foreign member of the Korean Academy for Science and Technology and also to the Japanese Biochemical Society. He also received an Honorary Doctor of Science degree from the University of Bergen Senate, Norway.

Eric Lander was named a Class of 1960 Fellow in recognition of outstanding teaching and course development.

Jacqueline Lees was named the first Helen and Irwin Sizer Career Development Assistant Professor.

Mary Lou Pardue was named the first holder of the Boris Magasanik Professorship.

Alexander Rich received the National Medal of Science.

Robert Rosenberg received the Distinguished Alumni Award from George Washington School of Medicine.

Robert Sauer was elected to the National Academy of Sciences and was elected President of the Protein Society.

Paul Schimmel received an Honorary Doctor of Science degree from Ohio Wesleyan University.

Phillip Sharp received Honorary Doctor of Science degrees from Bowdoin College, from the University of Tel Aviv and from Albright College. He was the recipient of the Lord Foundation Award for Leadership in Advancing the Application of Science and Technology.

Anthony Sinskey was named a Fellow of the Molecular Medicine Society and a Fellow of the American Institute for Medical and Biological Engineering.

Peter Sorger was named the Howard and Linda Stern Career Development Assistant Professor.

JoAnne Stubbe was named the Ciba-Geigy Professor of Chemistry. She also received the Theodore William Richards Medal for 1996.

Robert Weinberg received the William Johnson Walker Prize from the Museum of Science and the G.H.A. Clowes Memorial Award from the American Association for Cancer Research.

Richard Young was named a Charter Fellow of the Molecular Medicine Society.

OTHER

The Department of Biology is proud of the establishment of two new Chairs. A professorship in honor of Boris Magasanik was established. Professor Magasanik, who is a pioneer in cellular biology, helped shape the development of the department. Professor Emeritus Irwin W. Sizer and his wife, Helen Sizer, established a career development professorship in the Department of Biology. Professor Sizer, a former department head, played a major role in the evolution of the department from a classical program to the modern molecular biology program that it is today. These resources will enrich scholarship in the Department of Biology and we are appreciative.

Phillip A. Sharp

DEPARTMENT OF BRAIN AND COGNITIVE SCIENCES

RESEARCH

NEW FACULTY RESEARCH DEVELOPMENTS

Several of our new junior faculty members who recently established their laboratories have already established exciting research programs.

Earl Miller has discovered properties of neurons that provide insight into the functional organization of the prefrontal cortex, a region critical for high-order cognitive functions. His laboratory examined the prevalent hypothesis that disparate types of sensory information are processed in separate modules in prefrontal cortex by recording the activity of neurons in monkeys performing specific behavioral tasks. Contrary to the prevalent hypothesis, he found that many neurons contribute to representing and integrating several types of information. These neurons may provide a substrate for combining sensory information into a unified whole that is our perceptual experience.

Bart Anderson has made a series of empirical discoveries that will require major modifications to existing theories of binocular vision. Current theories of stereopsis all depend on matching features in the two eyes that correspond to the projection of a common surface patch. The assumption is that a given image feature has a unique disparity that determines its relative depth from the observer. However, Professor Anderson has discovered a large class of patterns for which this assumption does not hold.

Matt Wilson has set up a laboratory for recoding simultaneously the activity of large numbers of neurons in the hippocampus and cerebral cortex. His experiments demonstrate that during rapid eye movement (REM) sleep, the neocortex reactivates cortical memory representations. These findings offer the first glimpse into the previously hidden domain of sleep and the content of dream states as related to learning and memory.

Peter Dayan has developed new theoretical approaches to understanding unsupervised learning, including models based on temporal difference learning rules and analytical characterization of learning algorithms. He and his colleagues developed a novel learning architecture called the "helmholtz machine." His findings have important implications for the formation of connections during brain development.

NEW APPROACHES TO NEURAL COMPUTATION

Our faculty group in neural computation continues to lead the field in theoretical work related to learning, visual processing, and motor control.

Michael Jordan's laboratory has published findings on a range of topics, including motor learning, speech production, and learning theory and reasoning. These include papers related to internal models of motor control, theory of local linear classification, visuomotor control, and mean field theory for belief networks.

Tomaso Poggio's group in the Center for Biological and Computational Learning has made important advances in proposing new theories of learning and in understanding learning in vision and graphics.

Ted Adelson has developed a new framework for understanding brightness in visual illusions. He has proposed that the visual system estimates a two-parameter "atmosphere" at every point in an image, and this atmosphere provides a mapping between luminance and brightness.

NEW PRODUCTS

Dexfenfluramine ("Redux"), a drug invented by Richard and Judith Wurtman and patented by MIT, is now available for use on a prescription basis in the United States. It is the first drug ever indicated for weight maintenance, and the first anti-obesity drug to be approved for long-term use. It works by increasing serotonin-mediated brain transmission; this accelerates the onset of satiety and selectively decreases the overeating of snacks rich in carbohydrates and fats.

EDUCATION

GRADUATE

Of the fourteen Ph.D.s granted in the last year, two recipients have accepted assistant professorships at the University of Connecticut and Northeastern University; ten have accepted postdoctoral fellowships; one will be completing the M.D./Ph.D. training in medical school, and the last has accepted a research position in industry.

The pool from which we are drawing new students is strong in quantity and quality, and fourteen new students will begin the Ph.D. program in the Fall. We are also very pleased to report that the competing renewal of our main training grant was exceptionally well received by the National Institute of General Medical Sciences during a late Spring site visit, virtually guaranteeing five more years of this graduate student support.

UNDERGRADUATE

The former major in cognitive science has been replaced by a newly formulated major comprising four core areas: language, experimental cognitive science, systems neuroscience and computation. A neuroscience laboratory is being constructed to accommodate the new program; several new courses, including a Laboratory in Neuroscience and Methods in Neural Modeling, have been added; and either the revised Introduction to Psychology course or the Animal Behavior course may serve as the introductory course for the new major.

FACULTY HONORS AND AWARDS

Barton Anderson:	James H. Ferry, Jr. Fund Grant for Innovation in Research Education
Suzanne Corkin:	David Wallace Medal from the Australian Association of Gerontology
Ann Graybiel:	Javits Award Elected President of the International Basal Ganglia Society
Earl Miller:	Alfred P. Sloan Foundation Faculty Fellowship Award Pew Scholars Award McKnight Scholars Award
Steven Pinker:	Elected Fellow of the Neuroscience's Research Program Linguistics, Language and the Public Interest Award from the Linguistics Society of America
Tomaso Poggio:	Member of the Kuratorium of the Max Planck Society of Tubingen
Mriganka Sur:	Appointed Chief Editor of the "Journal of Neural Transplantation and Plasticity"
Matthew Wilson:	ONR Young Investigator Award Seaver Institute Faculty Award John Merck Scholar Edward J. Poitras Assistant Professorship in Human Biology & Experimental Medicine
Emilio Bizzi, M.D.	

DEPARTMENT OF CHEMISTRY

In the 1995-1996 academic year, the Chemistry Department continued its strong program in undergraduate and graduate education and research. The department currently has 31 active faculty, over 100 postdoctoral researchers, 226 graduate students and 113 undergraduate majors.

The Chemistry Department has initiated a major program to renovate space in all buildings. This plan, entitled "Chemistry Campaign 2000", aims to bring the department's research space up to the standards of the 1990's. Our goal is to raise \$15M over three years and to complete the renovations by the year 2000. This schedule includes time to develop detailed renovation plans and to program temporary space available for staging areas. So far, with help from the central administration, the Department has raised/pledged \$6M.

HIGHLIGHT OF THE YEAR

Professor Mario Molina shared the Nobel Prize in Chemistry for his contributions to the pioneering work in environmental science which determined that chlorofluorocarbon (CFC) gases can rise into the upper atmosphere and deplete the ozone layer.

HONORS AND AWARDS

Professor Klaus Biemann was the recipient of the Beckman Award for work in the application of mass spectrometry

Professor Sylvia Ceyer was appointed to the John C. Sheehan Chair of Chemistry

Professor Christopher "Kit" Cummins won a 3-M Innovation Award as well as a David and Lucile Packard Foundation Fellowship

Professors Rick Danheiser and Bob Silbey were named as MacVicar Faculty Scholars

Professor John Essigmann was awarded CaP Cure, the Association for the Cure of Cancer of the Prostate

Professor Robert Field won the prestigious Meggers Award From the Optical Society of America

Professor Gregory Fu was named a Research Corporation Cottrell Scholar

Professor Stephen J. Lippard was elected a foreign member of the Italian Chemical Society

Professor Mario J. Molina was awarded the Nobel Prize in Chemistry for his work in ozone depletion.

Professor Richard Schrock was awarded the American Chemical Society award in Inorganic Chemistry

Professor Dietmar Seyferth garnered the American Chemical Society award for Organometallic Chemistry

Professor JoAnne Stubbe was awarded the prestigious Theodore William Richards Medal and was appointed as the Ciba-Geigy Professor of Chemistry;

Professor Bruce Tidor was awarded the Cook Development Professorship

Professor Jamie Williamson was awarded a Camille and Henry Dreyfus Teacher/Scholar Award

MOST SIGNIFICANT RESEARCH ACHIEVEMENT

Professor Alan Davison and his colleagues have developed a new brain-imaging agent which may lead to earlier and more accurate diagnosis of Parkinson's disease as well as other conditions affecting older people, i.e., depression and attention deficit disorder. Technepine binds to dopamine transporters in the brain's striatum and carries the brain chemical to receptors.

PERSONNEL

Professors Christopher "Kit" Cummins and Mounji Bawendi were promoted to Full Professor.

One new faculty member was appointed as Full Professor - Professor Timothy Swager of the University of Pennsylvania who received his Ph.D. from Cal Tech in 1988 and was a postdoctoral fellow at MIT from July 1988 to July, 1990.

Professors Klaus Biemann Carl Garland, Irwin Oppenheim and John Waugh announced their intentions to retire this year. Professor Biemann has been with the Department for 42 years, as has both Professors Garland and Waugh, while Professor Oppenheim has served the Department for 34. Retirements of Chemistry staff were also announced: Bob DiGiacomo, the glassblower; the Director of the Spectrometry Laboratory, Jim Simms; and Les Whitaker the Director of Undergraduate Laboratories. In addition, the Director of the Undergraduate Programs, Ms. Melinda Cerny accepted a position with MIT's Student Services/ Re-engineering.

DISTINGUISHED VISITORS AND LECTURERS

The Chemistry Department was privileged to host distinguished scientists in endowed lectureships during the past academic year:

- Professor Andrew G. Myers from California Institute of Technology was the George Büchi Visiting Lecturer in Organic Chemistry in October 1995;
- Professor Dennis Curran of the University of Pittsburgh was the Karl Pfister Visiting Professor in Organic Chemistry in February of 1996;
- Professor Richard Holm of Harvard University was the A.D. Little Lecturer in Inorganic Chemistry in May, 1996;
- and Professor Peter Schultz from the University of California, Berkeley was the T.Y. Shen Distinguished Lecturer in Biological Chemistry in October of 1995.
- The first annual Siemens/MIT Symposium on Crystallographic Chemical Analysis was held in January to celebrate the use of x-ray diffraction as a first resort analytical tool for the elucidation of chemical structure.
- The Women in Chemistry Conference was held in October and welcomed prominent women in the scientific community who led a two-day event focusing on the challenges and successes of women in chemistry.

STUDENT ACTIVITIES

In the Fall of 1995, the Department admitted 37 students to the graduate program. From September of 1995 to June of 1996 the Department awarded, 9 Masters and 43 Ph.D degrees. A forum was held in March with graduate students meeting with faculty to offer input on possible changes to the Chemistry Graduate program. At the Senior Recognition Dinner in May, twelve awards in chemistry were announced at the Department's Senior Recognition Award in May of 1996. In all thirty-five seniors were members of the graduating class of 1996. Also congratulations go out to the following seniors who are recipients of **1996 Undergraduate Chemistry Awards**: **The Alpha Chi Sigma Award** for recognition of academic achievement and contributions in research and/or service to the department was awarded to Jonathan Katz and Annita Zhong. **The American Institute of Chemists Award**, presented in recognition of a demonstrated record of ability, leadership, and professional promise was awarded to Marcus Sarofim, **Barry M. Goldwater Scholarship** given each year in recognition of outstanding scholarship and research. was awarded to Raylene Sanchez, '97, **The Merck Index Award** was presented to three seniors in recognition of outstanding academic achievement: Danika LeDuc, Michelle Nee and Juanita Wickham. **The Chemistry Undergraduate Research Award** was given to Matthias Scholl and Donald Lucas. **The Chemistry Undergraduate Service Award** awarded in recognition of outstanding service to the field of Chemistry and to the department went to Jason Deich. **The Undergraduate Teaching Award** for outstanding teaching in the field of chemistry by an undergraduate went to Steve Brunelli and Victor H. van Berkel.

OTHER STUDENT AWARDS

Catherine Leatherdale of the Bawendi Group was selected as the NEC Graduate Fellowship in Advanced Materials; Ms. Lillian Chong was selected as the 1996 CACS Scholar of the Chinese American Chemical Society; Dr. Bing Ji won the University of Iowa's D.C. Spriestersbach Dissertation Prize for 1995; Natashi M. Kablaoui won a graduate fellowship from the American Chemical Society's Division of Organic Chemistry and the Roche Award for Excellence in Organic Chemistry. James Boiani was awarded the Hypercube Scholar Award.

FUTURE PLANS

The Department of Chemistry is recruiting faculty in all areas to ensure the continued growth and success of chemistry at MIT. We expect to add two junior organic and one senior inorganic chemist in the next 12 months. In addition, curricular changes are being studied at both the undergraduate and graduate levels.

Industrial Internship Program: Beginning in July 1996, the M.I.T. Chemistry Department will initiate a program to encourage graduate students to spend a brief period in the laboratory of an industrial collaborator. Graduate students and faculty supervisors will have the choice of a number of companies and projects from which to choose, and individual faculty and students are particularly encouraged to propose additional possibilities based on their interactions with specific companies. A typical internship assignment would be three months during the Summer semester, although other times and durations may be considered.

Stephen J. Lippard

DEPARTMENT OF EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

Research and education within the Department of Earth, Atmospheric and Planetary Sciences (EAPS) engage a broad array of scientific disciplines: geology, geophysics, geochemistry, physical and chemical oceanography, meteorology, atmospheric chemistry, and planetary sciences. Particular emphasis is placed on the study of the complex geosystems in the Earth's atmosphere, ocean, crust, and deep interior and the similar systems on other planets. The Department comprises 42 faculty, including one with a primary appointment in Civil and Environmental Engineering, 215 graduate and undergraduate students, and 97 permanent research staff, postdoctoral appointments and visiting scholars.

EDUCATIONAL ACTIVITIES

GRADUATE

During the past academic year, 175 graduate students were registered in the Department (Course 12) and the MIT-Woods Hole Oceanographic Institution (WHOI) Joint Program (Course 12W). The EAPS graduate program currently focuses on the Ph.D. degree, which is the goal of over 90% of its graduate students. There is a growing need, however, for professionals trained at the master's level who can solve geoscience problems in a broad, systems-oriented context. In response to this need, EAPS has proposed a new degree, Master of Science in Geosystems, which was approved during this academic year by the Science Council, the Faculty Policy Committee, and the Committee on Graduate School Policy. Plans are underway to open the new program for matriculation in September, 1997. This S.M. degree is designed to appeal to students seeking careers in industry as professional geoscientists, as well as working professionals who wish to expand their knowledge and opportunities in geoscience. It will prepare students for scientific and management careers in the environmental, natural resources, and technical consulting industries by providing skills in computer simulation and modeling of complex natural systems, as well as in scientific inference based on field observations and numerical modeling.

A second initiative, the Graduate Program in Atmospheres, Oceans, and Climate, is also being developed. Climate problems and other issues related to global environmental change are notable for their scientific difficulty and societal importance. This program will take advantage of the breadth of EAPS faculty expertise in these areas. Elements of the new Ph.D. curriculum will be put in place next semester.

UNDERGRADUATE

EAPS is continuing efforts to improve the quality and scope of its undergraduate program. The bachelor of science curriculum has been reorganized to include three areas of concentration: geoscience, physics of atmospheres and oceans, and planetary science and astronomy. Each concentration encompasses a set of required courses, a sequence of field and/or laboratory subjects, and independent study or thesis preparation. An undergraduate minor degree program has also been developed to complement degrees in other disciplines, providing a foundation for careers that incorporate areas of geoscience. The Department has expanded its Independent Activities Program (IAP), and EAPS now offers more IAP courses for credit than any other MIT department. The Department continues to increase its participation in freshman advising seminars: this past year, EAPS faculty advised approximately 10% of the freshman class. EAPS has maintained a strong Undergraduate Research Opportunities Program (UROP), despite changes in federal regulations that have increased the cost of UROPs to grants and contracts.

FACULTY

Three new faculty joined EAPS this year. Kelin Whipple, a geologist specializing in the study of surface processes, was appointed Assistant Professor in July, 1995. His experience encompasses field work, laboratory experimentation, and numerical modeling across a broad range of geomorphological, transport, and tectonic problems. Maria Zuber, a planetary scientist who specializes in the structure and dynamics of planetary lithospheres, was appointed as a full Professor in November. Among her many accomplishments, Dr. Zuber was a key participant in the Clementine mission, both during the data-collection phase and in the subsequent scientific analysis, and she obtained spectacular results that have revolutionized the thinking on lunar structure. Robert van der Hilst, a seismologist, came to the Department from the Australian National University as an Assistant Professor in January, 1996. His primary research accomplishments involve the application of seismic tomography to imaging various features in the Earth's interior, including subduction zones, where descending lithosphere plunges back into the mantle.

HONORS AND AWARDS

The highlight of an exciting year was the announcement that EAPS Professor Mario Molina and two other atmospheric chemists received the 1995 Nobel Prize in Chemistry for their pioneering work on the depletion of strato-

spheric ozone by man-made chlorofluorocarbons. Principal Research Scientist Heidi Hammel was awarded the 1996 Harold C. Urey Prize by the American Astronomical Society, given for outstanding research by a young planetary scientist, and she was also honored by the 1996 Spirit of American Women National Award for encouraging young women to follow nontraditional career paths. Professor Thomas Herring received the Bomford Prize from the International Association of Geodesy. Professor Thomas Jordan was elected as a member of the American Academy of Arts and Sciences, and Professor Fred Frey as a Fellow of the American Geophysical Union. Professor Maria Zuber received the NASA Exceptional Scientific Achievement Medal, Professor Clark Burchfiel the Career Achievement Award from the Geological Society of America, and Professor Nafi Toksöz the Distinguished Achievement Medal from the Colorado School of Mines. Professor Edward Lorenz received the Battan Author's Award from the Bedford Institute of Oceanography, Nova Scotia. Professor Richard Lindzen was selected as the fourth Bernhard Haurwitz Memorial Lecturer for 1996, and Professor Marcia McNutt as the Phi Beta Kappa Distinguished Lecturer for 1996-7. Professor Leigh Royden was elected Associate Chair of the MIT faculty, a position she will occupy through June, 1997. The International Astronomical Union named asteroids after three members of the Department, Dr. Heidi Hammel and Professors Tim Dowling and Chuck Counselman, in honor of their contributions to planetary science.

CURRENT RESEARCH

GEOLOGY AND GEOCHEMISTRY

Professor Samuel Bowring and graduate student Dave Hawkins have pioneered a technique for U-Pb dating of monazites that involves imaging the grains using backscattered energy to identify different growth zones, followed by microsampling and precise analysis. They have achieved a spatial resolution similar to the ion microprobe (20 microns) but with an order of magnitude better precision. This has allowed them to elucidate very complex histories (up to 20 million years) of both the prograde and retrograde paths in metamorphic rocks from a single grain. Professor Tim Grove and colleagues have been investigating the processes that led to melting in the Moon's interior and the production of lunar mare basalts. Magmas that are produced deep in the Moon's interior heat and selectively melt ilmenite as they rise through the shallow crust on their ascent to the Moon's surface. This work has resolved the question of the origin of an enigmatic lunar mare basalt type discovered twenty-five years ago. Professor Fred Frey in collaboration with Dr. N. Shimizu (Woods Hole Oceanographic Institution) are identifying melt-rock reactions that occur in the Earth's upper mantle. They find that a peridotite massif now exposed in northern Japan originally formed from partial melting processes occurring 10^9 years ago in the oceanic mantle. Professor Kip Hodges's work in the Annapurna Range of central Nepal has demonstrated a close relationship between thermal, deformational, and erosional processes in the development of the Himalayan orogenic system. Professors Leigh Royden and Clark Burchfiel are mapping in China along the eastern margin of the Tibetan plateau, where they are studying the history of deformation and uplift of the plateau. Together with Principal Research Scientist Robert King, they have established a Global Positioning System (GPS) network that covers most of the eastern margin of the plateau. Results to date show that crust of the eastern plateau has been thickened and elevated by shortening in the lower crust, a mechanism as yet unrecognized in other mountain belts. Professor Kelin Whipple is currently engaged in field studies (Sierra Nevada, Himalayas, and E. Tibet) and numerical modeling of river profiles and their response to tectonic uplift. He is also constructing a new flume in the Sediment Laboratory for experimental study of debris-flow hazards. Professor John Southard is modeling the transport and deposition of sediments in rivers and in the oceans.

GEOPHYSICS

Professor Chris Marone is investigating the mechanics of earthquakes and faulting and the frictional properties of rock using a combination of laboratory experiments, numerical modeling, and analysis of seismic data. Recent work by Marone's group includes modeling of earthquake nucleation to study the effect of inertia and laboratory measurements of the rate of frictional strengthening under seismogenic conditions. Professor Brian Evans and his students and colleagues are working on understanding the effect of deformation on permeability and transport properties in rocks; they have shown that tectonic processes in the upper levels of the crust can increase the permeability and electrical conductivity of an intact rock by a factor of two or more before mechanical failure occurs, but that the most dramatic changes in transport properties occur when the deformation mechanism changes from dominantly brittle behavior to plastic flow. Professor Rob van der Hilst and colleagues at the Australian National University completed a tomographic imaging study of the complex slab structure beneath Indonesia. This study provided more evidence for slab penetration into the lower mantle and revealed that the slab had broken off beneath Sumatra. Professor Marcia McNutt recently returned from a 50-day marine geophysical expedition to the southern Austral Islands in which she collected multichannel seismic reflection and refraction data, gravity data, swath bathymetry, and tons of rocks. The new data show that the Austral Islands are composed of three distinct volcanic chains, such that the stresses produced in the plate by each older chain determined the location and

orientation of the next younger chain, casting doubt on the model that midplate volcanism requires deep-mantle plumes.

Professors Bradford Hager and Thomas Herring, Senior Research Scientist Peter Molnar, and Principal Research Scientist Robert Reilinger have used GPS measurements to determine that nearly half of the convergence between India and Eurasia occurs north of Tibet, across the Tien Shan Mountains of Central Asia; dividing the total observed shortening across the range by this rate suggests that rapid convergence resulted from forces associated with the uplift of Tibet ~10 Myr ago. Hager and colleagues have also modeled the coseismic displacements for the 1994 Northridge earthquake; they are more consistent with faults rooting in the ductile lower crust than with faults ramping up from a seismogenic detachment fault, suggesting that the seismic hazard for the Los Angeles basin has been overestimated. Working with the Mongols and Russians, Dr. Molnar has quantified slip along the rupture of the 1957 Gobi-Altay earthquake, the last event with a magnitude greater than 8 in a continental region. He has found that this rupture comprised a strike-slip event on one fault plus a thrust event on a nearby fault; this complex rupture thus serves as a prototype for the worst possible earthquake in southern California. Professor Herring has used very long baseline interferometry (VLBI) data to develop a geophysical model of the diurnal changes in the Earth's rotation due to the torques from the Sun, Moon, and planets. This model is being adopted by the International Earth Rotation Service for the analysis of astrometric, astronomical and geodetic data. Professor Daniel Rothman has used a combination of statistical analysis, physical arguments, and numerical simulation to determine the physical mechanisms of poorly understood geological processes ranging from landscape evolution to the formation of and flow through sedimentary rocks. The former studies have yielded new results on the initiation of drainage networks, while the latter have included the discovery of non-Gaussian velocity fluctuations in slow flow through complex structures.

Professor M. Nafi Toksöz, Director of the Earth Resources Laboratory, has initiated two new projects with the Idaho National Engineering Laboratory: a study of the spatial variability of earthquake ground motions, and the development of an ultra-long, multi-sensor borehole seismic array. Dr. Reilinger and Professor Toksöz are heading an international GPS project in the Eastern Mediterranean, which is providing quantitative constraints on models of continental rheology and dynamics in this zone of continental collision. They are also using GPS to map deformation along the San Andreas fault system in S. California and N. Mexico, providing tight constraints on fault slip rates for earthquake hazard studies. Professor F. Dale Morgan continued environmental geophysics work at the Oak Ridge National Laboratory, Otis Air Force Base, and the Army Proving Grounds in Yuma, Arizona. In the laboratory, he is studying the frequency dependence of seismic-electromagnetic coupling in sedimentary rocks. He has also produced a new electrochemical model for the inception and prediction of earthquakes. Principal Research Scientist Arthur Cheng and associates have developed methods of determining shear wave anisotropy using downhole logging tools for in situ stress estimation for tectonic and exploration purposes. Professor Jordan and his students have discovered a phase of slow, transient deformation that precedes, and presumably initiates, many large earthquakes on oceanic transform faults. They have also derived new models of the Earth's upper mantle that include better estimates of seismic anisotropy, and they have formulated stochastic models to explain this anisotropy in terms of small-scale heterogeneities in anisotropic, olivine-rich mantle rocks.

PLANETARY SCIENCE

Professor Maria Zuber, in collaboration with Dr. David Smith of the Goddard Space Flight Center, published a re-analysis of spacecraft occultation data resulting in an improved shape of Mars. The results provide a new, important constraint on models of Mars's early evolution. Zuber's laser experiment was successfully launched on the Near Earth Rendezvous spacecraft in February, 1996, and will arrive at the asteroid 433 Eros in 1999, when it will collect topographic measurements of the asteroid for a year. Professor Jack Wisdom has focused his dynamical studies on the evolution of the Earth-Moon system. He has found that the Earth-Moon system passes through a strong orbital resonance early in its evolution which can drastically change the configuration of the system and the subsequent evolution. Professor Richard P. Binzel has utilized the Hubble Space Telescope to produce the first geologic map of the asteroid Vesta, revealing regions of ancient lava flows and deep impact basins. His ground-based telescopic work has revealed new sources for meteorites among asteroids whose orbits cross that of Earth. Professor James Elliot and colleagues observed a second stellar occultation by Triton from several sites. Comparing Triton's atmospheric pressure derived from these data with those from their previous occultation showed little if any change over the two-year interval, which indicates that Triton's surface has an unexpectedly high thermal inertia. Dr. Heidi B. Hammel, Principal Research Scientist, has analyzed Hubble Space Telescope imaging of Neptune to determine the longevity of large storm systems in the planet's atmosphere. She has also continued studies of Jupiter's atmosphere during its recovery from the collision of Comet Shoemaker-Levy 9, again using Hubble imaging. Professor Tim Dowling combined his measurements of wave speeds in Jupiter's atmosphere from the Shoemaker-Levy 9 impact with previous theoretical work to predict that the eastward jets on Jupiter should increase in strength by 50-100% underneath the cloud tops, and his results were substantiated by the Galileo Probe Doppler wind

experiment in December, 1995. Professor Charles Counselman and his students developed a new method of determining position using radio signals from satellites that greatly improved the precision of airplane runway approaches in flight tests conducted by MIT Lincoln Laboratory.

OCEANOGRAPHY

Professor Jochem Marotzke combined historical observations with a general circulation model of the Indian Ocean and found surprisingly strong seasonal variability in the deep circulation and the poleward heat transfer. In collaboration with Professor Peter Stone, he found that Southern Hemisphere atmospheric moisture transports determine the strength of the North Atlantic thermohaline circulation, but that Northern Hemisphere moisture transports determine its stability. Professor Maureen Raymo was chief scientist of an international oceanographic expedition on the drill ship *R/V Resolution*. Leading a group of 26 scientists, she directed the recovery of nearly seven kilometers of sediment from the sea floor, which will allow marine scientists to study the record of rapid climate variability in the past. Professor Edward Boyle successfully recovered the longest piston core in the Atlantic Ocean. The 53-meter core is being studied to create a century-resolution record of marine climate variability during the past 180,000 years. Professor John Edmond continued field work in the Far East in Siberia. The Lower Lena and Yana rivers were sampled last summer. Great progress was made on the development of ^{129}I , derived from nuclear reprocessor effluent, as an oceanographic biogeochemical tracer. Professor Carl Wunsch's group has begun to produce ocean circulation estimates based upon global general circulation models, satellite altimetry and ocean acoustic tomography. These results are a prototype for an eventual system permitting depiction of the three-dimensional ocean circulation on a week-by-week basis. Professor Paola Malanotte Rizzoli and collaborators have been modeling the ocean's circulation in different regions using data assimilation to improve the models. She is also investigating the physical/biological dynamics of the Eastern Mediterranean and the Black Sea ecosystems in the context of multinational collaborative programs. Professors Glen Flierl and John Marshall are modeling the physics and biology of the Southern Ocean. Work in Professor Flierl's laboratory has focused on the dynamics of the North Equatorial current and the Gulf Stream, and on turbulence and biological patchiness. In the past year 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. His studies of oceanic convection have culminated during this last year in the planning of a large multi-national sea-going experiment to observe convection in the Labrador Sea in the winter of 1996-97.

METEOROLOGY

Professor Mario Molina and his students have developed a new laboratory technique to measure rate constants for chemical reactions under temperature and pressure conditions directly applicable to the lower stratosphere. This new approach overcomes some of the significant limitations of existing techniques, such as the need to operate at low pressures, or the occurrence of secondary reactions taking place at the walls of the flow reactor. Professor Ronald Prinn, in collaboration with colleagues in the Sloan School of Management, Center for Global Change Science, Department of Economics, and the Marine Biology Laboratory, developed and recently tested a unique Integrated Global System Model for climate policy analysis. This model addresses most of the major anthropogenic and natural processes involved in climate change. Professor Peter Stone and his colleagues have calculated the rate of heat uptake by the oceans in global warming experiments with the most advanced coupled atmosphere-ocean general circulation models. The results were highly model-dependent, and the range of values they found represent a new source of uncertainty in estimates of global warming. Professor Kerry Emanuel developed a general theory for velocity and buoyancy scales of moist convection and continued work on determining the control of atmospheric water vapor by cumulus convection. He developed a theory for hurricane eyewalls as examples of atmospheric fronts, and completed his analysis of field experimental data pertaining to tropical cyclogenesis. Professor Edmund Chang investigated the effects of tropical heating anomalies on the extra-tropical circulations. He found that poleward propagating perturbations are generated, which can be simply modeled as a delayed oscillator response of the mid-latitude jet to changes in the tropical circulations. The Galileo probe has found the slight positive static stabilities in the Jovian atmosphere that Professor Richard Lindzen and Petros Ioannou predicted were required for the tidal damping consistent with Io's orbit. Professor Lindzen has also initiated a program (in cooperation with NASA Goddard Space Flight Center) to look into the possibility of directly measuring climate sensitivity. Professor Reginald Newell's group participating in the NASA Pacific Exploratory Mission atmospheric sampling experiments in the west Pacific has discovered that tropospheric ozone and potential vorticity show a remarkable correlation for altitudes below 18 km. This work provides new insight into large-scale atmospheric transport processes, and assists in outlining regions where production and destruction of ozone by photochemical processes is important. Professor Alan Plumb's group has studied transport processes and rates in the stratosphere, through analysis of general circulation models and data obtained by satellite and by aircraft. During the past year, they provided meteorological support for the NASA-led VOTE/TOTE airborne experiment and are currently involved in the STRAT campaign.

Thomas H. Jordan

DEPARTMENT OF MATHEMATICS

DEPARTMENTAL STATISTICS

STUDENTS

During the academic year 1995-96, there were 216 undergraduates majoring in mathematics, 166 in Course XVIII, Mathematics, and 30 in Course XVIII-C, Mathematics/Computer Science. Bachelor of Science degrees, including double majors, were awarded to 76 students, 60 in Course XVIII and 16 in Course XVIII-C.

There were a total of 103 graduate students in mathematics, all in the Ph.D. program. This year 24 students received the doctoral degree and one received the master's degree.

FACULTY

There were 52 faculty members in the Mathematics Department. The following were on whole or partial leave:

- Professor Sy Friedman (spring term)
- Professor Kenneth Hoffman (year)
- Professor Michael Hopkins (spring term)
- Professor Ehud Hrushovski (year)
- Professor Robert MacPherson (year)
- Professor Willem Malkus (spring term)
- Professor James Munkres (spring term)
- Professor Gian-Carlo Rota (spring term)
- Professor Gilbert Strang (fall term)
- Associate Professor Ezra Getzler (spring term)
- Associate Professor Alexander Goncharov (spring term)
- Assistant Professor Mauricio Karchmer (spring term)

There was one Visiting Professor and two Visiting Assistant Professors in mathematics this year:

- Professor Tomasz Mrowka from the California Institute of Technology (fall term)
- Dr. Steven Lee from Oak Ridge National Laboratory (spring term)
- Dr. Kate Okikiolu from Princeton University (spring term)

FACULTY CHANGES

RETIREMENTS AND RESIGNATIONS

Professor Kenneth Hoffman retired from MIT after a long career as a mathematician and administrator. He joined the MIT faculty in 1959, was Department Head from 1971-79, and in 1989 became the Executive Director of the Mathematical Sciences Education Board.

Professor Willem Malkus retired from MIT after a distinguished career as Professor of Applied Mathematics in the area of fluid dynamics. He joined the Department's faculty in 1969.

Assistant Professors Mauricio Karchmer and Mark Matthews resigned from MIT.

NEW APPOINTMENTS

Professor Tomasz Mrowka will join the Department as Professor of Mathematics from the California Institute of Technology. He is a leading figure in gauge theory and differential geometry.

Dr. Daniel Spielman has accepted an Assistant Professorship appointment specialized in theoretical computer science.

Dr. Maurice van Putten has accepted an Assistant Professorship appointment specialized in relativity, fluid mechanics and numerical methods.

PROMOTIONS

Assistant Professors Sergey Fomin, Michel Goemans and James Propp were each promoted to Associate Professor of Applied Mathematics from Assistant Professorship appointments.

Dr. Karen Smith was promoted to Assistant Professor of Mathematics following a C.L.E. Moore Instructorship appointment. Her specialty is commutative algebra.

HONORS, PRIZES AND AWARDS

Professor Sigurdur Helgason received an Honorary Doctorate degree from the University of Uppsala, Sweden.

Professor Gian-Carlo Rota was selected as recipient of the 1996-97 James R. Killian Jr. Faculty Achievement Award. He also received the Doctor Honoris Causa from the University of Bologna, Italy.

Professor Gang Tian was selected as the inaugural holder of the Simons Professorship of Mathematics for a five year period. The Simons Professorship was established through the support of Marilyn and James H. Simons.

Professor David Vogan was elected as a member of the American Academy of Arts and Sciences.

Assistant Professor Michel Goemans received a National Science Foundation (NSF) Career Award for a four year period from the NSF Division of Computer & Computation Research. He was also awarded the Optimization Prize of the Society for Industrial & Applied Mathematics for the most outstanding paper on a topic in optimization between 1991 and 1994.

Assistant Professors Michael Brenner and Daniel Spielman were awarded Alfred P. Sloan Research Fellowships.

Graduate student Andras Vasy received an Alfred P. Sloan Doctoral Dissertation Fellowship.

The MIT Mathematics Team placed third in the Putnam Intercollegiate Mathematics competition.

Junior David Jao was awarded the Barry M. Goldwater National Scholarship in recognition of his excellent academic achievements.

Seniors Thomas Weston and Ruth Britto-Pacumio were awarded the Jon A. Bucsele Prize in Mathematics in recognition of distinguished scholastic achievement. Among those seniors awarded degrees in mathematics, ten were elected to the national honor society Phi Beta Kappa.

ADMINISTRATION

Professor Hung Cheng follows Professor Richard Stanley as Chairman of the Applied Mathematics Committee. Professor Richard Melrose replaces Professor David Vogan as Chairman of the Graduate Committee, and David Vogan follows Professor Michael Artin as Chairman of the Undergraduate Committee. Professor James Munkres continues as Chairman of the Committee of Advisors and Professor Daniel Stroock as Chairman of the Pure Mathematics Committee.

EDUCATIONAL

Among the educational initiatives of the department, here are the ones that involve the undergraduate core.

For several years, the department has offered 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. Several of these subjects are offered both in the fall and in the spring terms.

At this time, most of the freshmen coming to MIT have taken calculus in high school. About one-half of the freshman class places out of 18.01 (single-variable calculus) and takes 18.02 (multivariable calculus) in the fall term. Many of the others, though perhaps not prepared for 18.02, have had some calculus. This has put a strain on the traditional 18.01 subject. In response to this, two substantial changes are underway. First, Professor David Jerison is in the process of revising the 18.01 curriculum, designing it for students who have had little or no high

school calculus. Second, we began last fall to offer a new intermediate calculus sequence: 18.01A and 18.02A. This sequence, which has been well received, is designed for the middle group of students, those who have had some high school calculus but are not yet ready for multivariable calculus. It covers the 18.01 calculus in the first half of the fall term, and then begins with the 18.02 material.

A third innovation in the service courses was made last spring in 18.03 Differential Equations. For many years, we have run that subject with three hours of lecture and one hour of recitation each week. There is general agreement that two hours of recitation would be preferable; and as an experiment, we did have two recitations last spring. This was quite successful, but since 18.03 has a large enrollment each term it is not clear that we have the staff to do this regularly.

Our efforts to improve the quality of teaching seem to be very successful. Our practice teaching program, begun two years ago, is now standard for our graduate students. In this program, Teaching Assistants are put into a classroom situation before they are assigned a recitation of their own. The department's teaching workshops, very ably organized by Professor James Propp and Dr. Lori Breslow, are now required of all new Teaching Assistants. These initiatives supplement the mathematics department's successful videotaping program, which was organized many years ago by Professor Arthur Mattuck and by the Institute-wide teaching programs. We are fortunate that Professor Haynes Miller has agreed to supervise these programs beginning next fall.

David J. Benney

DEPARTMENT OF PHYSICS

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, 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 (CSR), Center for Materials Science and Engineering (CMSE), Plasma Fusion Center (PFC) and Harrison Spectroscopy Laboratory are members of the Physics Department, as well as the Associate Director of the Research Laboratory of Electronics (RLE). 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 and Dean of the Graduate School, respectively. In 1995-96 the total number of faculty was 81. Leonid Levitov was promoted to Associate Professor without tenure, Jackie Hewitt and Xiao-Gang Wen were promoted to Associate Professor with Tenure, John Tonry, Mehran Kardar and Edmund Bertschinger were promoted to Professor. One Assistant Professor joined our faculty: Frederic Rasio. Faculty on leaves or sabbaticals during this year included: Boris Altshuler, Robert Jaffe, Patrick Lee, Min Chen, Richard Milner, Irwin Pless. Professors Louis Osborne, John King and Michel Baranger retired from the Physics faculty. Professors Bernard Burke, Ali Javan, and George Clark took the early retirement incentive with half-time appointment for several additional years. Professor Boris Altshuler is leaving MIT for another position.

The physics faculty garnered their share of awards and honors. Department Head Ernest J. Moniz was confirmed by the U.S. Senate for the position of Associate Director for Science in the Office of Science and Technology Policy. Professor George Benedek received the 1997 Proctor Medal, sponsored by the Association for Research in Vision and Ophthalmology, for outstanding contributions to visual science and ophthalmology and also received the 1995 Vinci d'Excellence Award in Science by the LVMH Moët Hennessy-Louis Vuitton Company. Institute Professor Mildred Dresselhaus was elected president of the American Association for the Advancement of Science. Professor Lee Grodzins received a 1995 R&D 100 award for most technologically significant new products and processes for his lead detector device. Professor Emeritus Vera Kistiakowsky became a Fellow of the Association for Women in Science (AWIS) for "demonstrated exemplary commitment to the achievement of equity for women in science and technology". Professor Pawan Kumar was awarded the Vainu Bappu Gold Medal by the Astronomical Society of India for exceptional contributions in the field of astronomy and astrophysics. Professor Walter Lewin was elected to the Royal Dutch Academy of Sciences. Professor Paraskevas Sphicas was awarded the 1995 Buechner Prize for excellence in Teaching. Professor Toyochi Tanaka was awarded the 1996 Editors' Choice Award of Discover Magazine for the development of smart hydrogels. Two junior faculty, Fred Rasio and Uwe-Jens Wiese, were awarded Alfred P. Sloan Foundation Awards. Senior Research Scientist Richard J. Temkin was awarded the 1995 Kenneth J. Button Prize in Far Infrared Physics by the Institute of Physics, London, in recognition of outstanding contributions to the field of infrared and millimeter waves for his research on high-frequency gyrotrons.

EDUCATIONAL ACHIEVEMENTS AND INNOVATIONS

The Department continues to maintain a steady number of graduate, undergraduate students and number of credit units per faculty member. This year the number of undergraduate majors was 196 (including double majors), the number of minors was 6 and the number of graduate students was 256. The number of degrees awarded totaled 47 S.B., 7 S.M., 34 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. The new 8.01 format continues this year with some adjustments in format based on experience gained in the inaugural year. The emphasis of the course continues to be active student participation in the teaching/learning process through self-motivating study guides. With feedback from the first year's experience, some changes have been made to the basic format. The Department has made a concentrated effort to put its better teachers into the class instructor positions. In addition, an additional "problem solving/tutorial" one-hour session (staffed by graduate teaching assistants) has been introduced, so that the class instructors can concentrate more on introducing material and less on problem solving. Also, graded problems sets

have been introduced, as well as a weekly MIT TV problem solving session, which runs continuously 24 hours a day.

8.01L, the extended version of 8.01 is in its fourth year. The students who participated in 8.01L are enthusiastic both about its instructors and about the extended time schedule. The acceptance of the course is reflected in part in its increased enrollment, which reached 125 students in the Fall of 1995, as compared to 80 or so in previous years. Part of the academic success of the program is the intensive use of course tutors; each student must spend a half hour with a tutor each week. From studies of the distribution of Math Diagnostic scores in 8.01L as compared to 8.01, it is clear that the Department is successfully targeting students with weaker backgrounds in mathematics.

The new physics curriculum was fully implemented in Fall, 1995. As previously reported, the new curriculum adds an intermediate mechanics course in the second year and a third quantum mechanics course to allow the infusion of contemporary applications and examples into the three-term sequence. In addition, students will be required to take one of two IAP courses: advanced mechanics or advanced project laboratory.

The Advanced Project Laboratory started during the past IAP. This course was designed for physics majors who have taken at least the first three courses in the physics sequence. Students are encouraged to use computers on-line for data acquisition whenever possible. Normally, students work in pairs as a research team, proposing a project based on physics phenomena they have learned and would like to investigate. The teaching staff monitors the feasibility of the projects based on time limitations, degree of difficulty of the project, availability of equipment, and background in technical experience and laboratory work of the students. Approximately 20 students enrolled for this first official year of the project lab.

Changes in the graduate curriculum are fully implemented. Core requirements have been developed in each subunit (condensed matter, atomic, astrophysics, nuclear and particle experiment, nuclear and particle theory and plasma) that present students with a coherent set of courses in these areas.

We have encouraged the development of courses offered in conjunction with other departments at the Institute, and this is the first year for two of those efforts: 8.515J, Biological Physics, joint with Health Sciences and Technology, and 8.292J, Fluid Physics, joint with Earth, Atmospheric and Planetary Sciences. The Biological Physics course was given in Fall, 1995, with an extremely successful enrollment of about 50 students, most of whom were physics graduate students. The Fluid Physics course was offered in Spring, 1996. A course in neural nets, joint with Brain and Cognitive Sciences, is in the initial planning stages.

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 stellar 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. The X-Ray Timing Explorer satellite, containing an all-sky monitor developed at MIT, was launched in December 1995. Among the most interesting objects studied during its first months was a newly discovered transient source, thought to be a neutron star undergoing unsteady accretion from a normal companion star. Other observational programs utilize the Japanese satellite ASCA, which features a

CCD imaging X-ray detector developed at MIT and the German satellite ROSAT. Binary systems with accreting compact objects (including black holes), hot plasma in supernova remnants, clusters of galaxies containing dark matter, distant quasars, and the cosmic X-ray background are being actively studied.

The search for and exploitation of gravitational lenses are major activities of the radio astronomy group. Gravitational lenses serve as probes of the lensed object and help map the dark matter within the lensing galaxy. Several such systems are being monitored for flux variations. These yield one-step determinations of the Hubble constant which skip the many rungs on the cosmological distance "ladder." The VLA radio interferometer in New Mexico is used in many of these studies.

MIT optical astronomers carry out most of their observations at the Michigan-Dartmouth-MIT observatory in Arizona, although other telescopes, especially the Hubble Space Telescope, are also used. 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 investigated with the fluctuation-distance-indicator technique, developed at MIT, which yields relative distances accurate to ~5%. Gravitational lenses are being monitored for optical flux variations to measure time delays, in a program which complements parallel efforts at radio wavelengths. Programs such as these will benefit greatly from the Magellan project, a consortium of 5 institutions including MIT which is building two 6.5 meter diameter telescopes in Northern Chile. Completion of the first telescope is expected in late 1998.

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. Construction is well underway, and it is anticipated that the LIGO observatory will be operational by the year 2000.

The MIT Plasma Science Experiment on board Voyager 2 continues to measure the properties of the solar wind in the distant heliosphere, and will be the first spacecraft to directly measure plasma conditions in the very local interstellar medium. A plasma experiment on the WIND satellite is part of the International Solar Terrestrial Physics program designed to study the nature of solar-terrestrial interactions.

Theoretical research on the normal modes of oscillation of stars like the Sun is leading to a better understanding of the tidal interactions and evolution of close binaries. Theoretical studies continue on the formation and evolution of binary systems containing collapsed stars, especially the newly discovered class of "supersoft" X-ray sources. Hydrodynamic calculations of stellar collisions and mergers are also being carried out. Collisions explain anomalous stars seen in dense star clusters while mergers are potentially detectable sources of gravitational waves.

Numerical simulations of cosmic structure formation, including the use of large N-body simulations, and high precision calculations of microwave background fluctuations are being extensively investigated.

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). During the current year the Hermes experiment, under the co-leadership of MIT Prof. Richard Milner, has begun data taking at the HERA collider at DESY. This experiment uses novel polarized He3 gas targets in conjunction with the polarized electron beam of HERA to study the spin structure of the neutron.

At Bates, work continued on commissioning the South Hall Ring and on improving the reliability of the accelerator. Important future initiatives are: use of the new Bates Out-Of-Plane Spectrometer and Focal Plane Spectrometer; 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. This program is now in the data taking phase.

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 at BNL, collaboration in an experiment has been undertaken in the search for strange matter produced in heavy ion collisions.

In Particle Physics, the current research included:

- The probing of the Standard Model and detailed studies of the Z particle using the L3 detector at LEP and the beginning of data acquisition at the upgraded LEP2 collider, which will provide collisions above the $W+W_{\text{threshold}}$.
- Studies of the highest energy p-p collisions, using the CDF at Fermilab, and obtaining the first direct evidence for the existence of the elusive top quark and providing important new information on b-bbar production and decay. Analysis techniques developed in this experiment offer the possibility of the first measurements of CP violation in the b-bbar system;
- First look at the left-right cross-section asymmetry for Z production and detailed checks on the limits of the Standard Model from the study of heavy quark production and decay using polarized electrons and the SLD detector at SLAC;

A new proposal led by MIT scientists to study the flux of anti-matter in the cosmic radiation using a permanent magnet spectrometer on a space vehicle(space shuttle/station) has been favorably received by the scientific community and the funding agencies.

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.

Finally, a novel axion search has been mounted in a collaboration with Livermore and others under the leadership of Prof. Leslie Rosenberg, a junior faculty member. This experiment is now being commissioned and data taking should start in the near future.

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, our present knowledge of this theory is used 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. While the Standard Model of Particle Physics is consistent with all reliable experiments, most physicists are nonetheless convinced that it is only the low-energy approximation to a fundamentally simpler theory. Theorists at the CTP are working both to enhance our understanding of the Standard Model, and to explore the theoretical possibilities for physics beyond the Standard Model.

A bold approach to physics beyond the Standard Model is string theory, which aims to unite all the known interactions of nature and to explain the observed hierarchy of particles. An important contribution at MIT has been the development of a general field theory of closed strings. This theory has now been shown to be independent of the background field that is used in its construction, and progress has been made toward developing a more general formulation which is not tied to backgrounds representing classical solutions. Ideas from string theory are also being used in studies in less than four space-time dimensions to understand fundamental issues in the quantization of gravity, black hole entropy, and the paradoxical question of whether information is lost in the formation and evaporation of black holes.

Topological terms in field theories, which were introduced by this group several years ago, are now widely studied in problems both within and beyond the Standard Model, ranging from gravity to high temperature superconductivity. Recently, these terms were used to examine the high temperature behavior of quantum chromodynamics (QCD), including the response function of the quark-gluon plasma.

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 and geometric variables, and the possibility of observing new multi-quark 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. In this approach continuous space is approximated by a lattice of discrete points, so the description becomes arbitrarily accurate as the lattice spacing is decreased to zero. Recent work has used renormalization group techniques to dramatically reduce the errors caused by the size of the lattice spacing, resulting in practical QCD calculations of greatly improved accuracy. Lattice calculations have provided strong evidence that the structure of nucleons, pions and other light hadrons is dominated by topological excitations of the gluon field. Currently, moments of the structure functions characterizing the distribution of quarks in the nucleon are also being calculated. To exploit the opportunities in this field and to advance the national effort in high performance computing, a prototype for a Teraflops-scale cluster of symmetric multiprocessors is presently under construction in collaboration with an industrial partner and the Laboratory for Computer Science.

MIT has played a pioneering role in the use of high energy scattering to determine the quark and gluon structure of nucleons and nuclei. A major development this year was a QCD calculation showing that, at high momentum transfer, only half of a proton's spin is contributed by the quarks, while the remainder comes from gluons. This provides an understanding of the experimental observation that only a fraction of the proton spin arises from valence quarks, which appeared paradoxical in the context of simple quark models.

An attractive proposal for physics beyond the Standard Model is a set of relationships between integer-spin and half-integer-spin particles known as supersymmetry. Supersymmetry is implied by string theory, but could be valid even if string theory is not the correct description of nature. Supersymmetric grand unified theories provide a unified description of strong and electroweak interactions, but such theories make it difficult to explain the existence of a light doublet of Higgs bosons, as is needed in the Standard Model. MIT researchers recently proposed a mechanism that allows for a light doublet of Higgs bosons, while raising the mass of related particles by many orders of magnitude, thereby avoiding unphysical proton decay rates.

To supplement the knowledge that can be gained from accelerators on Earth, particle theorists have turned to the early universe as a testing ground for ideas about high energy interactions. MIT physicists have found that supersymmetric particle theories provide an attractive context for inflationary cosmology. Supersymmetric theories contain many fields with very small potential energies associated with them, which is exactly what inflationary models require. Viable inflationary models can be constructed in which all the requisite parameters appear naturally in terms of mass scales already present in the particle theory, without the *ad hoc* introduction of small parameters. Furthermore, these new models make testable predictions.

A subtle feature of the Standard Model is the violation of baryon number conservation, a process which is very improbable under normal circumstances but which becomes common at high temperatures (above 10^{16}) and presumably in high energy collisions. To understand such collision processes, CTP researchers have studied a modified electroweak theory in which the Higgs sector is described by a field theory admitting soliton solutions. Under suitable conditions, an incoming W-boson field is shown to destroy a soliton and thereby induce baryon nonconservation.

Electroweak nuclear 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 also been studied.

Efforts have continued to understand the nature of periodic solutions in multi-dimensional classical systems and their implications for quantum chaos. Nuclear reaction theory has been used to study parity violation and time reversal symmetry violation in low energy neutron scattering, compound nucleus enhancements in photon production by proton-nucleus scattering, and multi-step compound reactions.

As an example of the impact on other fields, ideas and techniques from lattice theory have led to significant developments in understanding quantum spin systems. Combining chiral perturbation theory with powerful cluster algorithms, CTP researchers have calculated the low energy parameters of the two dimensional Heisenberg model, which describes the precursor insulators of high temperature superconductors. They have calculated the behavior of two dimensional spin ladders, and the differences between half-integer and integer one-dimensional spin systems.

ATOMIC, CONDENSED MATTER, AND PLASMA PHYSICS

Research in this Division is aimed at understanding the new physical phenomena which manifest themselves in the bulk states of matter and at studying novel situations which can arise when a radiation field interacts with matter.

Physics made headline news this year when a group at JILA in Colorado observed Bose-Einstein condensation in an ultra-cold vapor of Rubidium atoms. That discovery used two techniques developed earlier at MIT: evaporational cooling and the dark spot trap. This fall an MIT group observed Bose-Einstein condensation in sodium vapor. The MIT experiment achieved a density exceeding 10^{14} cm^{-3} and had more than 10^5 atoms in the condensate, about two orders of magnitude more than in the JILA experiment. The density was sufficiently high that effects of the interaction between the atoms in the condensate were evident.

"Atom" interferometry has advanced to the stage where molecules can be made to produce sharp interference fringes. Using micro-fabricated gratings, a beam of sodium molecules Na_2 is split into two spatially separated beams and then recombined. Changes in the conditions in one of the two paths, such as the presence of a gas of other atoms or an electric field, causes a shift in the phase of the interference pattern.

Micro-lasers have been pushed to a new extreme with the demonstration of oscillation in the visible region with less than one atom at a time in the cavity. Correlation of the number of photons emitted per second with the mean number of atoms in the cavity reveals significant differences with predictions of the best current theoretical models.

Scientists at MIT are world leaders in understanding the physics of gels. This basic understanding has produced yet another practical application. A gel has been used in a reversible cycle to extract a specific targeted ion from a dilute solution and release it on command in another solution, which could have a high concentration of the ion. It is anticipated that this cycle can be applied to a number of industrial and environmental problems.

The aqueous protein solutions present in mammalian eyes are being studied in connection with diseases such as glaucoma and cataracts. These solutions also present model systems for studying critical phenomena in binary solutions composed of large macromolecules and water. A detailed study of the dynamic critical behavior near the phase separation point has shown significant deviation from the behavior characteristic of binary solutions composed only of small molecules.

MIT physicists, collaborating with a group from Stanford University, have used ultra-violet photoemission spectroscopy to map out the dispersion relation for the electrons in a proto-typical high temperature superconductor. The results demonstrate that conventional band theory calculations are inadequate to explain the dynamics of the electrons in these strongly correlated systems.

One of the forefront areas in mesoscopic physics concerns "artificial atoms", carefully shaped two dimensional wells in semiconductor hosts. Experimenters and theorists have combined efforts to study an "atom" with about 30 electrons. They find that Hartree-Fock theory provides a quantitative description of the spin dynamics of the electrons whereas a semiclassical electrostatic model does not. In particular, it explains a divergent spin susceptibility observed at particular values of the magnetic field.

The technique of photon correlation spectroscopy has been extended into the x-ray region of the spectrum. The dynamics of an order-disorder transition in the alloy Fe₃Al were probed using x-rays from an undulator-based synchrotron source. The experiments were able to resolve correlation times as long as 1000 seconds for the critical fluctuations, corresponding to a frequency resolution of 3×10^{21} relative to the x-ray frequency of 3×10^{18} Hz.

In the phenomenon of electronic tunneling into metals there is an anomaly near zero bias (associated with the Coulomb interaction between the electrons) which causes a suppression of the tunneling current. A general theory of tunneling has been developed which is valid even when the Coulomb suppression is strong. This allows the theory to be applied to a number of physical situations which have appeared at the forefront of condensed matter research where the Coulomb effects dominate the behavior, for example disordered metals and semiconductors near the metal-insulator transition and tunneling into two-dimensional electron gases.

The discovery of photonic band-gap materials has given rise to many new and ingenious techniques for controlling the propagation of light. MIT's pioneering work in this area has given rise to the first textbook on the subject: *Photonic Crystals*, published by Princeton University Press.

Jerome I. Friedman

CENTER FOR LEARNING AND MEMORY

The Center for Learning and Memory was established in May 1994 as an interdepartmental research center between the Department of Brain and Cognitive Sciences and Department of Biology. The Center's primary research interest is to study the mechanisms underlying learning and memory using multifaceted approaches. Susumu Tonegawa was appointed as the first Director of the Center in May 1994. Matthew A. Wilson joined as an Assistant Professor on July 1, 1994. William G. Quinn who has been a faculty member in Department of Brain and Cognitive Sciences since July 1, 1994 joined the Center on April 1, 1995.

RESEARCH BY CENTER SCIENTISTS

Susumu Tonegawa

Tonegawa's laboratory has continued to utilize the gene knockout technology and transgenic technology to study (1) molecular and cellular mechanisms underlying synaptic plasticity in the hippocampus and the cerebellum, and (2) the roles of the various types of synaptic plasticity in declarative or procedural learning and memory. In addition, Tonegawa's laboratory has developed experimental technologies that allow a regionally and/or temporally restricted gene knockout.

The molecular mechanisms underlying the long term potentiation (LTP) at one of the major hippocampal synapses, Schaffer collateral-CA1 synapses, was investigated by applying electrophysiological techniques to the hippocampal slices derived from a mouse deficient in aCaMKII gene. Tonegawa's laboratory had previously shown that LTP induction is severely impaired in these slices. Tonegawa's laboratory now found that various inhibitors of protein phosphatases "rescue" LTP in the aCaMKII mutant slices, indicating that LTP induction is subtly regulated by phosphorylation or dephosphorylation of key proteins.

Dr. Tonegawa's laboratory has also been investigating the cellular and molecular mechanisms that operate in cerebellum and underlie motor learning and motor coordination. For this purpose Dr. Tonegawa's laboratory has produced and analyzed two mutant mouse strains, one deficient in a glutamate receptor mGluR1 and the other a protein kinase PKC ζ . By analyzing these mutant mice by electrophysiology and behavioral experiments, Tonegawa's group found that a long term depression (LTD), a form of synaptic plasticity present at the parallel fiber-Purkinje cell synapses is crucially involved in motor learning. They also found that a failure in eliminating surplus climbing fibers onto Purkinje cells during the neonatal neural development leads to motor discoordination.

Finally, Dr. Tonegawa's laboratory has exploited a phage-derived DNA recombination system called the Cre-loxP system to develop tissue- or cell type-restricted gene knockout technology. Using this technology, Dr. Tonegawa's laboratory produced a mutant mouse in which the gene encoding the NMDA class of glutamate receptors is knocked out only in the pyramidal cells in the CA1 area of the hippocampus. They demonstrated that these mutant mice are deficient in LTP specifically in the CA1 area and are incapable of acquiring spatial memory. This is hitherto the cleanest evidence that supports the notion that hippocampal LTP is a required cellular mechanism for a declarative memory.

Using this and other genetically engineered mice, Tonegawa's laboratory is collaborating with Wilson's laboratory to learn more about the molecular or cellular changes that accompany at the levels of single and ensembles of synapses as the animal acquires spatial memory.

William G. Quinn

Quinn's laboratory pioneered the use of transgenes to disrupt learning and memory. Nevertheless, in the long term they believe that the forward-genetic approach offers the surest path to genuinely novel information about learning. This approach involves (a) random induction of single-gene mutations, (b) behavioral selection among these to find the ones that affect learning or memory, (c) further behavioral characterization of those mutant fly strains that look promising, and (d) molecular cloning of the altered gene, to deduce enzyme function from sequence.

Among the mutants they have isolated, *amnesiac* and *radish* are currently the most interesting. *Radish* flies show nearly normal learning ability followed by steady memory decay. *Radish* is almost extremely deficient in consolidated (anesthesia-resistant) memory (ARM) but is normal in protein-synthesis-dependent, very long term memory (VLTM). *Radish's* memory defect is in striking contrast to flies with a blocking CREB transcription

factor., which has normal ARM but lacks VLTM. If, as seems likely, results from *Drosophila* mutants can be generalized across animal phyla, then researches into long-term memory phases have been studying two entirely separate storage processes without knowing it. Work with *Drosophila* may provide the key to the molecular mechanisms underlying both these processes. Protein-synthesis-dependent VLTM appears to require the action of cyclic-AMP-activated transcription factors of the CREB family, and thus is amenable to conventional molecular analysis. The other long lasting memory process, ARM, is more mysterious.

ARM is legitimate long-term memory because it persists up to four days after spaced training in *Drosophila*. It is entirely independent of the transcriptional events that subserve VLTM. At present, the only clear path to understanding the molecular mechanism underlying ARM is by cloning the *radish* gene whose mutation specifically abolishes it. Quinn's lab has mapped the *radish* gene to an interval of 140 kilobases on the X-chromosome. They have carried out a molecular walk through the region in phages and cosmid transforming vectors, and have generated the appropriate marked *radish* host for transformation rescue experiments. Quinn's lab is currently analyzing transcription patterns in the region. His lab is, in effect, analyzing *radish's* genetic defect as other laboratories have mapped and analyzed human genetic diseases. These experiments are anticipated to take at least another year but cloning the *radish* gene, with its entree to the mechanistic nature of ARM, seems worth the long effort.

Apparently nature has elaborated even more mechanisms to prolong the effects of experience beyond the duration of simple second-messenger responses. The memory mutant *amnesiac* -- very deficient in memory measured 30-60 minutes after training and reduced in both ARM and VLTM -- is altered in a gene for an apparent pre-pro neuropeptide. The most exciting consequence of this discovery is the possibility of a mammalian homologue of the *amnesiac's* neuropeptide. After unsuccessful "short-cut" attempts to find such a homology with PCR reactions and expression vectors, Quinn's lab is cloning and sequencing the gene from related fly species in order to determine the most conserved portions of the gene to use for more enlightened homology searches. Finding an *amnesiac* homologue in mammals would have direct implications in the study of human memory processes and perhaps in human therapeutics, because neuropeptides are diffusible, extracellularly-acting compounds whose action can be altered or mimicked by drugs.

Matthew A. Wilson

Wilson's lab has successfully adapted their multiple electrode recording techniques to the mouse and have completed their initial characterization of neuronal activity in the hippocampus of the wild-type animal. This effort has been extended to several lines of genetic learning mutants which have been made available through the Tonegawa lab. This combination of genetic, neurophysiological, and behavioral approaches promises to establish a firm link between molecular mechanisms of learning and memory and the processes of higher cognition.

In an effort to extend the cognitive scope of this work, projects are now underway examining the interactions between hippocampus and prefrontal cortical areas during tasks involving the coordination of memory and behavioral decision-making. In a related project examining long-term memory consolidation, successful simultaneous recordings have been made in hippocampus and visual neocortex of the rat, revealing the nature of these interactions for the first time.

Projects engaged in the development of microstimulation paradigms for the direct manipulation of hippocampal memory formation, reactivation, and consolidation have begun.

INTRACENTER COLLABORATION

At least two collaborative projects among the three laboratories were established as a result of the discussion group meetings. The Wilson and Tonegawa laboratories began extending Dr. Wilson's multielectrode approach, developed for rats, for application to mice. This collaboration will allow the analysis of memory mutants that are either already available or will be produced in the Tonegawa laboratory by Wilson's multielectrode approach. Such experiments may be helpful in linking experience-induced changes in the activities of ensembles of neurons to the activity of specific gene products. Presently Dr. Tonegawa's graduate student, Thomas McHugh, is working in Dr. Wilson's laboratory to develop the mouse multielectrode analysis system. Recently Dr. Tonegawa's postdoctoral fellow, Pato Huerta, is also working in part in Dr. Wilson's laboratory.

A second collaboration between the Quinn and Tonegawa laboratories is in the exploratory stages. Dr. Quinn's laboratory previously demonstrated that the *Drosophila amnesiac* mutant harbors an impairment in long-term memory and has recently shown that the gene encodes a neuropeptide. Dr. Quinn's laboratory is currently cloning the mouse homologue of this gene. If successful, the Tonegawa lab will produce a mouse and analyze the mouse mutant in which the amnesia gene is knocked out.

INTERACTION WITH OTHER DEPARTMENTS AT MIT

Interactions are primarily with members of the Department of Brain and Cognitive Sciences. For instance, Tonegawa's laboratory has a collaboration with Professor Ann Graybiel's laboratory on the characterization of mutant mice deficient in dopamine receptors, and with Professor Jerry Schneider's laboratory on the mechanism of the control of nerve regeneration. In addition, Tonegawa had several scientific discussions with Professor Earl Miller on the mechanism of working memory and Professor Emilio Bizzi on motor learning and motor control. Wilson's laboratory is also collaboration with Professor Ann Graybiel's laboratory recording synaptic activity in the striatum.

FUND RAISING

Menicon Co. LTD., a Japanese manufacturer of contact lenses in Japan, gave a \$2.5-million endowment to recruit a professor to the Center for Learning and Memory. A ceremony was held on January 29, 1996, to officially announce the endowment with dignitaries from MIT and Japan participating. Menicon President Kyoichi Tanaka presented the gift to the Center for Learning and Memory and MIT to commemorate the opening of the Menicon Integrated Research Laboratory in Japan.

Susumu Tonegawa

GEORGE RUSSELL HARRISON SPECTROSCOPY LABORATORY

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. The Laboratory is directed by Professor Michael S. Feld. Professor Jeffrey I. Steinfeld and Dr. Ramachandra R. Dasari are Associate Directors. An Interdepartmental Laboratory, the Spectroscopy Laboratory encourages participation and collaboration among researchers in various disciplines of science and engineering. Professors Feld, Steinfeld, Mounji G. Bawendi, Robert W. Field, Daniel Kleppner, Keith A. Nelson, Stephen J. Lippard, Jeffrey I. Steinfeld, Toyochi Tanaka, Steven R. Tannenbaum, and Dr. Dasari are core investigators of the Laboratory.

The Laboratory operates two laser resource facilities. The MIT Laser Biomedical Research Center (LBRC), a Biotechnology Resource Center of the National Institutes of Health, develops basic scientific understanding, new techniques and technology for advanced biomedical applications of lasers; core, collaborative and outside research are conducted. The National Science Foundation-supported MIT Laser Research Facility (LRF) provides resources for core research programs in the physical sciences for thirteen MIT Chemistry and Physics faculty members. Information about the equipment and facilities of the LRF and the LBRC can be found in the Spectroscopy Laboratory Researcher's Guide.

RESEARCH HIGHLIGHTS

Professors Field and Robert J. Silbey have developed new methods for extracting information about intramolecular vibrational redistribution (IVR) from frequency-domain dispersed fluorescence spectra of acetylene. A technique called extended cross correlation enables overlapping polyads to be "unzipped". The unzipping procedure tests the goodness of generalized vibrational quantum numbers. The progressive failure of unzipping as vibrational energy and evolution time (spectral resolution) are increased may provide a general way of detecting the change in resonance structure that occurs near an isomerization barrier. Professors Field and Silbey are also examining intersystem crossing and internal conversion processes, the electronic counterparts of IVR. Experiments on acetylene with Dr. Stephen Drucker are developing new methods to populate triplet states of small polyatomic molecules and monitor the ensuing unimolecular dynamics.

Professor Field is also pursuing time domain (~1 ps) studies of intramolecular dynamics. Initial experiments on acetylene test a hypothesis concerning the profound effect of a DC electric field on the intensity, but not the apparent decay rate, of fluorescence from the S_1 state.

Professors Field and Steinfeld continue development of a free radical facility based on pulse-amplified FM laser spectroscopy. FM spectroscopy is a zero-background, linear technique capable of unprecedented sensitivity, especially in the ultraviolet region. Initial results have been obtained using a cw single mode ring dye laser, pulse amplified by a long-pulse (20 μ s) injection-seeded Nd:YAG laser.

Professor Steinfeld and Dr. Brian Gilbert have characterized explosive compounds, the objective being detection at ultratrace levels. TNT has been detected at picogram levels using near-IR surface-enhanced Raman spectroscopy, and enhancement factors up to 10^4 for mono- and trinitrotoluene Raman signals have been achieved using UV resonance-enhanced Raman spectroscopy.

Professor Bawendi is using a picosecond laser and time-correlated photon counting to study the electronic properties of semiconductor quantum dots and heterostructures containing those dots. The data on dilute samples of dots are being used to develop models of relaxation mechanisms and the fine structure in the electronic transitions. Time-resolved studies of the heterostructures (close packed arrays of dots) show that energy transfer between nearest neighbor dots is important. This last result is particularly relevant to potential device applications. Professor Bawendi has also developed a new apparatus to study the spectroscopy of individual quantum dots. Initial fluorescence results show that transition linewidths are at least 50 times narrower than expected. This result is especially relevant to quantum dot laser applications.

Professors Klavs F. Jensen and Bawendi continue their work on spectroscopic characterization of CdSe-ZnSe quantum dot composite films deposited by electrospray organometallic chemical vapor deposition.

Photoluminescence spectroscopy was employed in combination with other characterization techniques to optimize the new processing technology and assess the materials performance for optoelectronic applications.

Professor Lippard and his associates have used Raman spectroscopy to characterize iron (III) peroxo compounds as potential models for metalloenzyme systems. The $(\mu-1,2\text{-peroxo})\text{diiron (III) complex, } [\text{Fe}_2(\mu-\text{O}_2)(-\text{O}_2\text{CCH}_2\text{Ph}_2)_2\{\text{HB}(\text{pz}')_3\}_2]$, was prepared by Dr. Kimoon Kim and investigated by X-ray crystallographic and electronic, resonance Raman and Mössbauer spectroscopic methods, which revealed it to be a valuable model for the peroxo intermediate, H_{peroxo} , in the methane monooxygenase reaction cycle. A novel ferric $\eta^2\text{-}\mu^4\text{-peroxo complex, } [\text{Fe}_6\text{O}_2(\text{O}_2)_3(\text{OAc})_6]^-$, was prepared and characterized by X-ray crystallography. Raman spectroscopy was used to characterize the O-O stretching frequency at 844 cm^{-1} .

Professor Nelson has used a streak camera to record acoustic oscillations following excitation with crossed picosecond pulses. This detection method increases the acoustic frequency range accessible for optical study. Current applications include characterization of the mechanical properties of thin films, bulk polymers and other viscoelastic liquids, and biological samples whose acoustic properties are important in medical imaging.

Professor George Benedek and Drs. Jayanti Pande and Ramasamy Manoharan have studied oxidation-related structural changes in the protein, γII crystallin from the bovine ocular lens, using Raman spectroscopy. The vibrational spectra in the $2500\text{-}2700$ and $500\text{-}550\text{ cm}^{-1}$ regions of the Raman spectra of native and oxidized γII show clear evidence for the loss of cysteine thiol groups to form disulfide bridges in the protein. No other changes in secondary structure or protein functional groups are seen. Preliminary Raman spectra of a young intact, human lens *in vitro* have also been obtained.

Professor Christopher Cummins used resonance Raman equipment to study a molybdenum-mediated dinitrogen cleavage reaction. Data were collected for characterizing of $(\mu\text{-N}_2)\{\text{Mo}[\text{N}(\text{R})\text{Ar}]_3\}_2$ and $(\mu\text{-}^{15}\text{N}_2)\{\text{Mo}[\text{N}(\text{R})\text{Ar}]_3\}_2$, clarifying the degree of N-N bond activation in these complexes. The information obtained was collated with information from a plethora of techniques pertaining to the mechanism of dinitrogen cleavage.

Professor Tannenbaum and Drs. Paul L. Skipper, Dasari and V. Bhaskaran Kartha have set up an ultrasensitive high performance liquid chromatography system with laser-induced fluorescence detection to detect and quantify benzopyrene and cyclopentapyrene adducts at the attomole levels in DNA, and histone adducts of several brush biopsy and synthetic samples.

Professor Alexander Rich and Drs. Yang Wang and Dasari have continued investigations using Raman microspectroscopy to study the sequence-dependent DNA conformations in crystalline and solution states. Their aim is to further probe the detailed conformation of the DNA tetra-helix, $d(\text{CCCC})_4$. Experiments that probe the binding of proteins to Z-DNA inside intact cells utilize a YAG Laser and are being conducted in collaboration with Drs. Alan Herbert (Biology/MIT) and Stefan Wöfl (Hans-Knoll-Inst., Germany).

Professor Ali Javan continues to explore metal-oxide-superconductor junctions for optical frequency-mixing. Demonstration of direct transfer from a near-IR frequency to a near-UV frequency is under way.

Professor Kleppner has employed recurrence spectroscopy of the Rydberg states of lithium in parallel electric and magnetic fields to study quantum chaos. The system under study is a Rydberg atom in a static electric field with an additional RF electric field whose frequency is resonant with some classical orbits.

Professor Feld and Drs. Dasari and Kyungwon An have studied the single-atom microlaser, in which laser oscillation is achieved via coherent interaction between a two level atom and a single mode optical resonator. Recent progress includes realization of a traveling-wave microlaser and extensive numerical simulations based on quantum stochastic wave-function methods.

Professors Tanaka and Feld and Drs. Kartha and Dasari have studied the FT-IR and Raman spectra of N-isopropyl acrylamide (NIPA) polymer gels in the temperature range $20\text{-}50^\circ\text{C}$ across the volume phase transition. The spectra showed changes in the C-C and C-H stretching mode frequencies of the isopropyl group, indicating that the phase transition is accompanied by a reorientation of the isopropyl group.

Professor Feld and Drs. Dasari, Geurt Deinum, Irving Itzkan, Manoharan, and Lev Perelman are pursuing basic and applied applications of lasers biology and medicine. Fluorescence and near-IR Raman spectroscopy are being used for biochemical analysis of tissues and blood, and diagnosis of dysplasia, cancer, atherosclerosis and other diseases.

A novel system for acquiring real-time excitation-emission matrices with 10 nm excitation intervals and 5 nm spectral resolution is identifying optimal wavelengths for *in vivo* detection of dysplasia in many organs. Clinical studies are being pursued with researchers from the Cleveland Clinic Foundation, Brigham and Women's Hospital, Metrowest Hospital and New England Medical Center in colon, bladder, breast, and coronary and peripheral arteries. Quantitative analysis of blood analytes using Raman spectroscopy is under development. UV resonance Raman spectroscopy is being explored to characterize dysplasia. Photon migration using a newly developed time-resolved optical tomographic system is being used to image small fluorescent objects (lesions) imbedded in turbid biological tissue, and to study paths of early arriving photons. Finally, the mechanism of pulsed laser ablation of soft and hard biological tissues has been shown to be thermoelastic in origin. The experimental and theoretical work being conducted in this program is advancing new laser diagnostic technologies in the field of medicine.

Michael S. Feld

GEORGE R. WALLACE, JR. ASTROPHYSICAL OBSERVATORY

The George R. Wallace, Jr., Astrophysical Observatory is a teaching and research observatory located in Westford, Massachusetts. Its facilities consist of a 24-inch telescope, a 16-inch telescope, several 14- and 8-inch telescopes, a 5.5-inch astrograph, and a building that houses a workshop, darkroom, computer facility, and observers' quarters. Instruments used during the past year include the SNAPSHOT high-speed dual-CCD photometer, a portable high-speed CCD occultation system, several small CCD systems, conventional photometers, photographic cameras, and a high-resolution spectrograph. Work is continuing to improve the optics of the 24-inch telescope, and a low-resolution spectrograph is being studied for the smaller telescopes.

PERSONNEL

Professor James L. Elliot continued his duties as Observatory Director. Principal Research Scientist Heidi B. Hammel assisted with site management and telescope scheduling, with the help of Research Specialist Rich Meserole. Mr. Michael Person has replaced Mr. Michael Mattei as a part-time Technical Assistant for making observations, helping with observatory maintenance, and training students. Other staff (usually students) is coordinated through research programs. An undergraduate working on the spectrograph project (Asantha Cooray) is participating in the Undergraduate Research Opportunities Program (UROP); other students (Vincent Fish, Lisa Kwok, Lucy Lim, and Angela Hancock) are supported in part by NSF's Research Experiences for Undergraduates.

ACADEMIC ACTIVITIES

Last year, course 8.287J-12.410J (Observational Techniques of Optical Astronomy) drew 11 students, who used the Wallace facilities for a variety of astronomical projects. An additional 22 students in subject 12S23 (Observing the Stars and Planets) used the Observatory for laboratory work. Informal field trips were offered for courses 12.401 (Beyond the Solar System; 17 students) and 12S22 (Hands-on Astronomy; 14 students), as was an observing session for freshmen last fall. An open house held during MIT's 1996 Independent Activities Period attracted over 40 people (mostly undergraduates, though faculty and staff from other departments came). The MIT SEDS Club (Students for the Exploration and Development of Space) also hosted an undergraduate evening for observing in October 1995, which drew about 30 students.

RESEARCH PROGRAMS

Mr. McDonald, graduate student Jeff Foust, and Mr. Mattei used the 24-inch to obtain astrometric CCD data for Pluto and the star P28 (which Pluto nearly occulted in July 1995), Neptune's moon Triton and the star Tr148 (which Triton occulted in August 1995), and Saturn's moon Titan and the star GSC5254-00997 (which Titan occulted in August 1995). Graduate student Cathy Olkin, Dr. Hammel, Professor Elliot, Mr. Cooray, and colleagues successfully observed the Triton event with both NASA's Kuiper Airborne Observatory and the NASA Infrared Telescope Facility (IRTF) on Mauna Kea, Hawaii. The data, analyzed and modeled as part of Ms. Olkin's successful doctoral dissertation, revealed an unexpected lack of a temperature gradient in Triton's lower atmosphere. The Titan event was observed on the NASA IRTF; graduate student Philip Tracadas is analyzing those data.

Mr. Foust used observations of Pluto and its moon Charon made with the 24-inch to determine the mass ratio of Pluto and Charon. The number has been in contention since two conflicting reports appeared, based on data from the Hubble Space Telescope in 1993 and the University of Hawaii 2.2-m telescope in 1994. Mr. Foust's value from Wallace (0.121 ± 0.006) supports a newer estimate made with HST reported in 1996 (0.124 ± 0.008).

Dr. Steve Slivan used the 24-inch to observe rotational lightcurves of the asteroid Eriphyla. Dr. Slivan developed an extensive database of asteroid photometry using Wallace facilities as part of his successful MIT doctoral dissertation. Dr. Slivan also continued a project of imaging objects from the Messier Catalog.

Mr. McDonald and students also used CCD data from the 24-inch to continue astrometric and photometric observations of occultation candidate stars for future events involving Saturn, Uranus, Pluto, and Triton, and Mr. Foust conducted a search for stars that may be occulted by several comets. Astrometric and photometric

observations continued in support of the Hubble Space Telescope, with Dr. Amanda Bosh (Lowell Observatory) assisting in coordination of that effort.

Heidi B. Hammel

EXPERIMENTAL STUDY GROUP

For the past twenty-seven years, the Experimental Study Group has provided a unique educational alternative to the regular curriculum for first year students at MIT. Learning is based on the concept of self-motivated study through small interactive groups and seminars. Students have found this approach beneficial for a number of reasons: the opportunity to work closely with instructors and ask questions, the chance to be part of a close-knit academic community, and a flexible structure which allows students to study material at their own time and pace.

STUDENT STATISTICS

The total enrollment of students for the year included 51 freshmen, one sophomore transfer, and 17 upperclassmen who had been in ESG as freshmen. In addition, ten non-ESG undergraduates enrolled in seminars sponsored by ESG.

Forty-three percent of ESG's freshman class were female, 6 percent were underrepresented minorities, and 16 percent were international students. The percentages are based on a small number and therefore fluctuate from year to year. Over the past five years, the average percentage of women in ESG is 40, the average percentage of underrepresented minorities is 11, and the average percentage of international students is 16. The comparable figures for the MIT Class of 1999 are 42 percent women, 14 percent underrepresented minorities, and 7 percent international students.

The 44 sophomores currently registered at MIT who had been in ESG as freshmen earned a cumulative median grade point of 4.3 this spring, the same cumulative median grade point as the entire sophomore class at MIT.

ADMINISTRATION

Professor Vernon Ingram (Director of ESG) and Dr. Holly Sweet (Associate Director) administered and monitored program offerings and activities. Dr. Sweet completed her Ph.D. in Counseling Psychology at Boston College in December 1995, where she specialized in gender studies. In addition to her work in ESG, Dr. Sweet has been co-facilitating a peer training program in gender relations at MIT under the aegis of Residence and Campus Activities, and has been co-teaching an undergraduate seminar in gender roles and relationships under the auspices of the Dean for Undergraduate Education.

The ESG Advisory Committee met with Professor Ingram and Dr. Sweet during the year to supervise the academic portion of ESG. The Committee is headed by Professor Alan Davison (Department of Chemistry), and includes Dean Robert Birgeneau (School of Science), Professor Alar Toomre (Department of Mathematics), Department Head Jerome Friedman (Department of Physics), and Dean Philip Khoury (School of Humanities and Social Science). Professor Friedman replaces Professor Ernest Moniz as the physics department representative on the Committee. We thank Professor Moniz for his involvement with ESG's policy and progress during the past two years.

STAFF AND FACULTY

The physics staff included Professors Emeriti Robert Hulsizer and Robert Halfman, Dr. Peter Dourmashkin, Lecturer Craig Watkins, and Lecturer David Custer '82. The mathematics staff was headed by graduate student Thomas Colthurst and included Mr. Watkins. Professor Ingram from the Department of Biology was responsible for the teaching of introductory biology in ESG. The chemistry offerings at ESG were supervised by Dr. Patti Christie, a post-doctoral instructor in the Department of Chemistry, and Professor Davison.

ESG also offered several HASS-D and HASS classes to its students. Dr. Lee Perlman rejoined our staff after being employed for the past three years as an Assistant Professor at Swarthmore College, and taught philosophy and political philosophy. Mr. Custer taught both expository and creative writing.

Our staff were assisted by 28 undergraduate tutors (who maintained an impressive 4.6 median grade point average) and by 12 graduate tutors. Undergraduates tutoring biology, chemistry, physics, and mathematics for the first time at ESG were required to participate in a teaching seminar for credit run by staff members. Dr. Sweet interviewed all freshmen and tutors to assess the quality of teaching at ESG. Her recommendations, based on these interviews, were

reviewed at the annual ESG staff retreat. Several new methods of improving the quality of teaching have been implemented in ESG as a result, including a new tutor training manual for undergraduate and graduate tutors.

ACADEMIC INITIATIVES

ESG continued its tradition of developing new courses and seminars every year by offering three new subjects: SP298 The Art of Color, SP299 Introduction to C Programming, and SP2H1 The Philosophy of Love. All courses received very enthusiastic evaluations from students and will be repeated in the coming year.

Professor Ingram, aided by Dr. Jodeane Pringle, continued to develop the wet lab portion of introductory biology. Several undergraduates are also collaborating with him in the development of the MIT Biology Hypertext, a teaching tool on the World Wide Web. This is now widely used internationally and in the United States. It is being translated into several languages and has already earned some national plaudits.

In January, 1995, Dean Birgeneau contributed a generous grant to ESG to promote educational innovation. The following projects have been funded by this grant:

Caught in the Web: The Art and Science of Information Retrieval: an undergraduate seminar developed by Anthony Ku '97 and co-sponsored by the Edgerton Center and the MIT Libraries.

Physics demonstration videos: to be organized by Professor Emeritus Hulsizer under the co-sponsorship of the Physics Department.

Mathematics hypertexts for 18.01, 18.02, and 18.03: to be developed by Mr. Colthurst and Joy Nicholson '98.

A seminar on alternative education: to be developed by Christopher Douglas '99 under the supervision of Dr. Sweet.

Mini-seminars to be run during IAP 1997, including How to Detect and Debunk Misleading Statistics, Improving Your Math and Physics Problem Solving Skills, and Game Theory in Everyday Life: to be supervised by Dr. Dourmashkin and Mr. Watkins.

Introduction to Java: a undergraduate seminar to be taught by Mr. Colthurst.

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 pedagogical innovation.

Vernon M. Ingram
Holly B. Sweet

LABORATORY FOR NUCLEAR SCIENCE

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 1996, the Department of Energy is expected to provide LNS a total of \$29,795,000 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), 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 very successful in describing a wide variety of phenomena, and to look explicitly for physics beyond the Standard Model. LNS researchers are playing leading roles in much of this research, 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. One is of course always 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 Z^0 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 mass of the Higgs boson; and the measurement of the strong coupling constant α . L3 has recently upgraded its experiment with the installation of a precise vertex detector and implementation of greater coverage for muon detection. After a number of years of operation at the maximal Z^0 production energy, LEP is now running at higher energies to produce large numbers of the W^\pm particle, the carrier of the charged electroweak force. This next stage of the L3 experiment should test the Standard Model in an even more stringent fashion.

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. Measurements of the left-right cross section asymmetry, A_{LR} , for Z^0 boson production using polarized electrons have been completed with high statistics and small systematic uncertainties. The measurements of A_{LR} have yielded a determination of $\sin^2(\Theta_W)_{\text{eff}}$, the effective weak mixing angle, which is even more precise than the individual LEP results.

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. A recent highlight was of course the discovery of the top (t) quark, by far the most massive elementary particle ever seen. The MIT group played an important role in the development of the analysis which led to this result. As the measured mass of the t quark has become more precise, this information combined with other results has begun to provide constraints on the mass of the undiscovered Higgs boson. Future 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; and the search for possible quark sub-structure.

An experiment to search for the "axion", a particle predicted to exist as a minimal extension of the theory of strong interactions as well as a possible solution to the "dark matter" problem in cosmology, is now taking data at Livermore (California). This experiment is the first to search for the axion in a physically interesting region with sufficient sensitivity to mean a discovery is plausible.

The "strangelets" experiment at Brookhaven is now in full data production, and information on the possible existence of this exotic form of matter is expected soon.

LNS is involved in both large detector initiatives at the Large Hadron Collider (LHC) project at CERN, viz., the CMS and ATLAS detectors. 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 be major participants in the U.S. efforts at the LHC.

A new experimental project, the Alpha Magnetic Spectrometer (AMS) collaboration, has made great strides recently. AMS will look for anti-matter and dark-matter candidates above the Earth's atmosphere, first with a Space Shuttle mission in 1998 and then with a long mission on the International Space Station beginning in 2001. This remarkable collaboration, led by LNS, involves researchers from many different countries as well as coordination between DOE and NASA.

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 more than two decades. A major upgrade of its capabilities, the South Hall Ring, has recently been completed. This upgrade allows 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. The opportunity to pursue internal target experiments, especially those involving polarized beam and polarized targets, maintains a unique and important position for Bates.

In addition to the new capabilities provided by the South Hall Ring, Bates is completing the construction of several major new detectors. The Focal Plane Polarimeter is now being used very successfully for experiments which require measurement of outgoing proton polarization. The Out-of-Plane Spectrometer is nearing completion and has already been used for experiments. These new experimental capabilities, coupled with ongoing improvements in accelerator operation, will provide an unprecedented opportunity to address critical issues in medium-energy physics.

The SAMPLE experiment at Bates, designed to provide crucial information on the quark structure of the proton, is now taking data. This experiment has placed very demanding requirements on the Bates beam quality, polarization, and stability; these requirements have been fulfilled.

LNS nuclear physics researchers are also leading several important efforts at accelerator facilities other than Bates. These facilities include TJNAF (Virginia), DESY (Germany), Mainz (Germany), and PSI (Switzerland). The project at DESY is an experiment to study the spin structure of neutrons and protons, using among other targets a polarized ^3He target constructed at MIT. The first run at DESY, in 1995, was a notable success and the ^3He target performed excellently. LNS researchers are also leading the design and construction of detectors for experiments at other facilities, such as TJNAF.

LNS is 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 so-called "quark-gluon plasma". This new state of matter is predicted to exist at temperatures and densities higher than those present in normal nuclear matter, but which may be present for a brief time in collisions of heavy ions. LNS researchers are leading the current experimental efforts using heavy-ion beams at Brookhaven. The LNS group is also the leader of one of the few experiments (called PHOBOS) approved for the Relativistic Heavy Ion Collider (RHIC) under construction at Brookhaven. This experimental project is now well underway and aiming for RHIC startup in 1999. A complementary effort of the group is a search for the possible creation of a new state of the vacuum, using high-energy Pb-Pb collisions at CERN.

THEORETICAL NUCLEAR AND PARTICLE PHYSICS

Research at the Center for Theoretical Physics (CTP) 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. A few examples of recent work are mentioned below.

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 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 major thrust in the CTP 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 structures of nucleons, pions, and other light hadrons are dominated by topological excitations of the gluon field.

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 TJNAF, 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 South Hall 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.

EDUCATION

Since its founding LNS has placed education at the forefront of its goals. At present approximately 79 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 the leaders of nuclear and high-energy physics.

Robert P. Redwine

CENTER FOR CANCER RESEARCH

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 245 people work in the Center, distributed among the research laboratories of 13 faculty. In addition, four faculty members in the Whitehead Institute, one in Biology, and one in Chemistry are Affiliate Members of the CCR.

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. The current term extends to April 30, 2000. In addition to the core grant, the Center's faculty have a total of 46 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. The FY96 research volume was approximately \$12 million, which does not include \$3 million in support from the Howard Hughes Medical Institute.

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 and isolation by the Housman laboratory of genes causing acute myeloid leukemia. Two such genes were identified by sophisticated genomic analyses. Both represent fusions of other genes and their structures provide fascinating insights into the mechanisms for initiation of leukemia.

The discovery by the Ploegh laboratory of novel mechanisms by which viruses subvert the immune systems to evade immunological rejection and allow viral latency.

The discovery by the Lees laboratory of a novel level of regulation of gene transcription factors important in control of the cell cycle, which is altered in cancer cells.

The generation by the Hynes laboratory of strains of mice lacking vital cell adhesion molecules leading to failures in protection against bacterial infections; these mice provide models for human immunodeficiency diseases.

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 five 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 93 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:

Nancy Hopkins was named a Fellow of the Class of 1960 in recognition of outstanding teaching and course development.

David Housman was named Ciba-Geigy Professor of Biology.

Richard Hynes was elected to National Institute of Medicine in the fall of 1995 and to the National Academy of Sciences in the Spring of 1996.

Jacqueline Lees was named the first holder of the Irwin and Helen Sizer Career Development Professorship in Biology.

Phillip Sharp received the Lord Foundation Award for Leadership in Advancing the Application of Science and Technology, and also received honorary degrees from Bowdoin College, the University of Tel Aviv, and Albright College.

Richard O. Hynes

CENTER FOR SPACE RESEARCH

CSR conducts an active program of research in astronomy, astrophysics, 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 NASA missions: Voyager, the Japanese-US ASCA satellite, the Rossi X-ray Timing Explorer (RXTE), the WIND mission, the High-Energy-Transient Experiment (HETE), the Advanced X-ray Astrophysics Facility (AXAF), and the Shuttle-MIR program. CSR also supports MIT participation in the Laser Interferometer Gravity Wave Observatory (LIGO), the Michigan-Dartmouth-MIT (MDM) Observatory, and the Magellan Observatory. CSR supports investigators in the Space Engineering Research Center and administers a program of theoretical astrophysics and space plasma physics and of optical observations carried out using ground and space observatories. Much of the research carried out in CSR is reported by the following departments: Physics, Earth Atmospheric & Planetary Sciences, and Aeronautics & Astronautics.

HIGHLIGHTS OF THE YEAR AND RESEARCH ACHIEVEMENTS

The Bruno B. Rossi X-ray Timing Explorer (RXTE) was successfully launched from Cape Canaveral on Dec. 30, 1995. It carries two MIT-built instruments, a sophisticated Experiment Data System (EDS) and a sky-scanning All Sky Monitor (ASM), prepared at CSR under the direction of Prof. H. Bradt with Drs. A. Levine and W. Mayer. NASA named the mission in honor of the late MIT Professor Rossi who was one of the founders of the field of x-ray astronomy. By the end of June, RXTE had already observed 160 celestial X-ray sources. Results include discovery of a remarkable pulsar/burster (Prof. W. Lewin), the discovery of extremely rapid ~1000 Hz quasi-periodic oscillations from several neutron-star binary systems (Dr. E. Morgan, Prof. W. Lewin), and elucidation of the very rapid fluctuations of "micro-quasars" in our Galaxy (Prof. Bradt and Dr. R. Remillard). The MIT ASM is tracking the intensities of the brightest ~70 sources in the sky and alerts the scientists to any unusual temporal variability in such a source, or to the appearance of a new source.

CSR has been participating in the operations planning, calibration, and data analysis of ASCA, a Japanese/US X-ray astronomy satellite which was launched in 1993 and carries CSR's CCD X-ray detectors (developed in collaboration with Lincoln Laboratory). MIT personnel are participating in numerous astronomical projects, including studies of the diffuse X-ray background, supernova remnants, clusters of galaxies and distant quasars (Drs. G. Ricker & M. Bautz).

This year MIT joined the Magellan project, together with the Carnegie Institution of Washington, Harvard University, and the Universities of Arizona and Michigan. Two nearly identical 6.5 meter diameter optical telescopes are being constructed on Cerro Las Campanas in Northern Chile, with the first scheduled for completion in late 1998. CSR is administering MIT's participation (Profs. C. Canizares & P. Schechter).

MIT also continues its active participation in the Michigan-Dartmouth-MIT Observatory consortium. A major survey has been completed of very accurate galaxy distances derived using the novel surface-brightness fluctuation technique, leading to a new determination of the cosmologically important Hubble parameter (Prof. J. Tonry), and new advances have been made in the study of time delays in gravitationally lensed quasars, which also constrain the Hubble parameter (Profs. J. Hewitt & P. Schechter).

MIT's interplanetary plasma experiment on the Voyager spacecraft is now 49 Astronomical Units from the sun and heading toward the edge of the solar system. Contrary to expectations the solar wind has a great deal of structure even at these large distances. A newly discovered velocity oscillation with a period of 1-2 days must be locally generated (Prof. J. Belcher & Dr. J. Richardson).

Further analysis of the anomalous microwave scattering properties of regions on the surface of Venus, measured with the Magellan mission, have led to the surprising possibility that these may result from concentrations of the trace element tellurium within a certain altitude range on the planet (Prof. G. Pettengill & Dr. P. Ford).

The joint Caltech/MIT LIGO (Laser Interferometer Gravitational-wave Observatory) project is currently at the peak of its construction phase. Contracts have been let for major components and the building designs are out for bid. The two 4km slabs for the beam tubes have been poured at the Hanford, Washington site while the clearing and leveling has been completed at the Livingston, Louisiana site (Prof. R. Weiss & Dr. D. Shoemaker).

Theoretical investigations include: the development of a new, fast method for computing the power spectrum of microwave background anisotropies, which is a key diagnostic of cosmological models (Prof. E. Bertschinger); supercomputer simulations of the hydrodynamics of binary star coalescence (Prof. F. Rasio); studies of the evolutionary histories of millisecond pulsars in binary star systems (Profs. S. Rappaport & P. Joss); and investigations of the ages of the oldest stars in globular clusters (Prof. Joss). Closer to Earth, a theory for a global, kinetic, photoelectron-driven polar wind successfully accounts for nearly all the recently observed novel features in the "polar wind" of the Earth's Magnetosphere (Dr. T. Chang).

In the area of aerospace technology, an Advanced Dynamic Load Sensors Experiment has been installed on the MIR space station to assess the impact of human space activity on the space station (Prof. D. Newman). A new method was developed for improving the precision and reliability of positioning aircraft during runway approaches using GPS signals (Prof. Counselman) and flight simulator research in cockpit displays for GPS instrument approaches is also underway (Dr. C. Oman). The Space Microstructures Laboratory in CSR continues to develop new techniques for fabrication of precise micro- and nano-structures for space astronomy and other applications (Dr. M. Schattenburg).

UPCOMING PROGRAMS

The High Energy Transient Experiment (HETE), which will search for bright transient emissions from astronomical objects over a very broad energy interval from the UV to gamma rays, is in final preparation at CSR for launch in the fall of 1996 (Drs. G. Ricker).

AXAF is a major NASA mission of the "great observatory" series, scheduled for launch in 1998. Two of the four major instruments, the High-Energy Transmission Grating Spectrometer (Prof. Canizares) and the AXAF Charge-Coupled Device (CCD) Imaging Spectrometer (Drs. Ricker & Bautz), are entering final construction and test at CSR and will be delivered to NASA for final calibration during the coming year. CSR is also helping to establish the AXAF Science Center, which will oversee the operation of AXAF during the mission (Prof. Canizares).

An experiment for the 1998 "Neurolab" mission is now starting the active development phase. Ground based research on human spatial orientation in real and virtual environments, tactile cueing systems continues, EVA biomechanics, and a new research initiative on artificial gravity physiology and human factors has begun (Profs. L. Young & D. Newman, Dr. C. Oman).

Claude R. Canizares

CHAIR OF THE FACULTY

FACULTY POLICY COMMITTEE

This year the Faculty Policy Committee (FPC) oversaw those aspects of educational and academic policy that are specific responsibilities of the Faculty and provided faculty input toward policy development at the Institute. In addition, the FPC worked with the Administration to offer guidance on re-engineering, faculty retirement issues, and the ROTC program at MIT.

The FPC also heard from and coordinated the work of several other committees and reviewed several changes in academic policy, procedures, and programs, some of which were forwarded to the Faculty for approval.

PROGRAM IN SYSTEM DESIGN AND MANAGEMENT

In the fall, the FPC continued discussions with Professors Edward F. Crawley and Thomas L. Magnanti regarding the program in System Design and Management (SDM). Professors Crawley and Magnanti, who had visited the FPC early in the SDM Program's design process, summarized the revised program proposal, highlighting developments made since their last visit with the FPC.

Professor Magnanti explained that completion of the SDM Program leads to an S.M. in Engineering and Management and described the Program's mission, target audience, goals, areas of focus, alternative formats, thesis options, reporting and organizational structure, methods of academic quality control for distance education, admissions process, faculty incentives, and departmental commitments. He also described a pilot program currently underway and further steps required for full implementation of the program.

Program developers had made modifications to the proposed SDM Program in response to prior FPC concerns (issues associated with admissions, distance learning, faculty incentives, reporting structures and organization). FPC members complimented the program as innovative, and voted unanimously to recommend the program to the Faculty, pending written confirmation from relevant deans and department chairs indicating the commitment of appropriate faculty and other resources for the program. The program proposal was presented to the Faculty at its October meeting and was approved at the November meeting.

MASTER OF ENGINEERING PROGRAM IN NUCLEAR ENGINEERING

In December, the FPC met with Professors Jeffrey P. Freidberg, Mujid S. Kazimi, and Richard K. Lester to discuss the proposed Master of Engineering Program in Nuclear Engineering.

Professor Lester explained that the program was developed as a departmental effort to redefine the role of professional graduate education in response to anticipated changes in professional practices. The goal of the program is "to prepare students for professional careers in nuclear engineering by providing additional depth in nuclear-related disciplines beyond the B.S. level together with the breadth of perspective and skills that are necessary for engineering leadership in the field." The program will complement the existing S.M. and Ph.D. programs and should be completable within one academic year by self-supported and fellowship students. The program is intended as a first professional graduate degree program for students with a B.S. in engineering who have spent time working in industry or who enroll immediately after undergraduate studies. For most program graduates, the M.Eng. will be the most advanced graduate degree obtained; however, there will be no restrictions placed on graduates who opt to proceed to a Ph.D. degree.

The Master of Engineering degree will be offered in two fields: Nuclear Systems Engineering and Radiological Health and Industrial Radiation Engineering. Institute requirements for the M.Eng. degree include a total of 90 units, of which at least 42 must be in H-level courses. The Nuclear Engineering M.Eng. degree will require a minimum of 99 units (including a 12-unit thesis), 54 of which must be H-level. Admissions standards will be similar for both the M.Eng. and the existing S.M. programs. Students applying to either program will be required to specify either the M.Eng. or S.M. degree in their application materials. Enrollment projections assume 5 - 10 students for the first year and 15 - 20 students each year after.

After a brief discussion, the FPC voted unanimously to forward the proposal to the Faculty for approval. The proposal was presented to the Faculty at its February meeting and was approved in March. At the February Faculty Meeting, some faculty members raised the question whether -- as a matter of Institute policy -- M.Eng. degrees should be granted with departmental designation only. President Vest and Professor Bacow agreed that this issue should be referred to the CGSP and FPC. After extensive discussions, the committees determined that M.Eng. degrees should be granted with departmental designation only.

PROFESSIONAL MASTERS PROGRAM IN EARTH, ATMOSPHERIC AND PLANETARY SCIENCES

In April, Mr. Daniel R. Burns and Professor Thomas H. Jordan presented to the FPC a proposal for a professional Masters program in Earth, Atmospheric and Planetary Sciences.

Professor Jordan explained that the Ph.D. has evolved into the first professional degree in the field of geoscience. This stands in contrast to the situation of 20 years ago when students could expect to enter industry with just a bachelors degree. While the department currently offers an S.M., most students in this program have opted out of the Ph.D. program. The goals of the proposed professional Master's degree are to: 1) create a new type of first professional degree in geoscience, 2) provide national leadership in geoscience, 3) offer a master's degree of high distinction, 4) build an educational program that integrates all of the department's strengths, 5) attract excellent students, and 6) produce graduates with highly desirable skills. Parameters for the program state that it should: 1) be attractive as a one-year first professional degree in geoscience, 2) be completable as a fifth year program for students pursuing an S.B. at MIT, 3) be accessible to students with a bachelor's degree in math, science or engineering, and 4) span the breadth of geoscience. Students will be responsible for tuition.

The proposed program is consistent with other master's programs at MIT in that it will require 108 units of required coursework (84 term units, 12 IAP units, and 12 units of thesis work). Principal coursework will be completed during a nine-month period in order to allow summer fieldwork. The program includes the following components: disciplinary subjects, economic analysis, scientific writing, oral communication, analysis and inference in geoscience, and a thesis. Students will be given a systematic introduction to valuable technologies (including Athena workstations, supercomputers, massively parallel computers, geographic information systems) and numerical methods.

The group discussed incentives for faculty to advise Master's students, reasons for the thesis requirement, competitiveness of the program, and participation restrictions. After discussing various possibilities for degree titles, the Committee suggested that the School of Science consider a general name for professional Masters programs. Professor Bacow noted that the FPC typically requests a letter confirming the support of the school dean(s) who will assume administrative responsibility for the program. FPC Members agreed that the framework of the program should be forwarded to the Faculty once two items are addressed within the department: 1) how to accommodate students outside the program and 2) the degree title. Members approved the program as Master of Science in Geosystems, leaving open the option to change the degree title in the future.

The FPC also provided input for a number of changes in Institute policies and practices.

FACULTY TITLES POST-RETIREMENT

Faculty renewal was an important issue for the FPC this year. It was discussed in a number of contexts, including the Committee on Faculty-Administration survey on faculty retirement (see below), institutional incentives to provide orderly planning for faculty renewal, and the status of retired faculty members. In discussing the results of the CFA survey, FPC members concluded that the Faculty care deeply about their status post-retirement.

Traditionally, a faculty member who retires relinquishes tenure and immediately becomes Professor Emeritus. While in the past this title was viewed as an honor, some faculty now perceive that Emeritus status signals a significantly diminished role within the Institute and the larger scholarly community and may inhibit the ability to participate in scholarly activities. As many MIT Emeriti continue to maintain active teaching and research careers well into their retirement, the FPC concluded that retirement may be more attractive to some faculty if those who continue scholarly involvement at MIT are allowed to retain their titles post-retirement. Before making this recommendation to the Academic Council, the FPC sought faculty input at the November Faculty meeting. A significant number of faculty expressed their support, characterizing the suggested change as 'positive and constructive.' The Academic Council approved, and Provost Moses reported to the March Faculty Meeting a provision in MIT's *Policies and Procedures* that allows faculty members to retain the rank of professor in post-retirement appointments. His 12 March 1996 memorandum to the Faculty outlined details of the change as follows:

1. Upon retirement, a tenured faculty member relinquishes tenure. Should a faculty member be reappointed after retirement, the appointment to the academic staff shall be made at the same rank held by the faculty member prior to retirement from MIT, although without tenure. The term professor reflects our sense that it is a more fitting title to a colleague who remains active in the life of the Institute than is reflected in the emeritus designation or in the title senior lecturer.

2. Faculty members who retire and have no appointment post-retirement will still be designated as Professor Emeritus.

3. Upon retirement, an endowed chairholder relinquishes the active chair title but may use the title in connection with the emeritus status (i.e. The John and Mary Doe Professor of Chemistry - Emeritus).

ACADEMIC MISCONDUCT

In October, J. David Litster, Vice President for Research and Dean for Graduate Education, visited with the FPC to discuss proposed changes to *Policies and Procedures* regarding academic misconduct. Professor Litster explained that in order to comply with Public Health Service regulations, the following minor changes had been proposed to MIT's existing academic misconduct policies:

- Changing "academic fraud" to "academic misconduct." *Policies and Procedures* will state that academic misconduct includes 1) fabrication or falsification of data, 2) theft of ideas or plagiarism, 3) and direct interference with the integrity of others' work.

(The Public Health Service posted in the August 6, 1989 *Federal Register* the following definition, which prompted the Academic Council to discuss a definition appropriate for MIT: " 'Misconduct' or 'Misconduct in Science' means fabrication, falsification, plagiarism, or other practices that seriously deviate from those that are commonly accepted within the scientific community for proposing, conducting, or reporting research. It does not include honest error or honest difference in interpretations or judgments of data.")

- Stating more clearly MIT's procedures, indicating the two-stage process of inquiry and investigation. (An inquiry is defined as information gathering and initial fact finding designed to determine whether an allegation deserves further investigation. An investigation is a formal examination and evaluation of all relevant facts to determine if misconduct has occurred.)
- Designating the Office of the Vice President and Dean for Research as the clearinghouse for inquiries and investigations.
- Mandating that all inquiries lead to a written report.

Committee members endorsed the proposed changes, and expressed their appreciation for the fact that *Policies and Procedures* has been written to allow flexibility, good judgment, and common sense. Some also commented that there should be congruence of process between misconduct and harassment procedures.

FACULTY APPOINTMENT, PROMOTION, AND TENURE PROCEDURES AND FACULTY LEAVE POLICIES

In February, the FPC discussed proposed changes to *Policies and Procedures* pertaining to faculty appointment, promotion, and tenure procedures and faculty leave policies. These had been developed by Professor Clay in consultation with academic deans and the Academic Council.

Professor Clay explained that most of the proposed policies were developed by codifying existing procedures. Substantive changes from old policies included: clarification of institute-wide standards for faculty appointment, promotion and tenure; considerable school and departmental latitude in the management of appointment, promotion and tenure; review for successive ranks by successive levels of councils; interim evaluations of junior faculty; conformity to federal regulations with regard to child-rearing responsibilities; reduced 'notice' period for academic staff and clarification of the terms and basis of these appointments; definition of an Institute-wide standard for tenure; provision of mentoring mechanisms; and clarification of MIT's policy with regard to the confidentiality of peer assessment letters used for promotion and tenure. After a brief discussion of some details, the committee endorsed the proposed changes, which were later approved by the Academic Council.

INTERNATIONAL AFFILIATIONS POLICY

Last fall, Professor Clay reported to the FPC that policies governing MIT's international relationships had been considered in response to the growing number of opportunities for international initiative at MIT and community views that MIT should consider international institutional collaboration and international research support from alumni, foreign governments, and multi-national firms. Suggestions which had been discussed included: international exchanges of faculty and students; graduate student participation in international projects; traditional faculty research; specialized training of foreign scholars in sharply defined, product-oriented programs; specialized

training program for international executives, possibly through distance learning; and MIT-conducted research for international companies (similar to ILP arrangements with U.S. companies)

FPC members discussed the following faculty concerns:

- clamping down on international enterprise would be unhealthy;
- MIT faculty might undertake risky efforts with institutions not considered our peers;
- our standards of human rights and institutional engagement are not always comparable to those in other parts of the world with whom we collaborate; and
- MIT's educational mission might be compromised in initiatives that do not match our own education interests.

Members noted that a major task of the new Provost's Council on International Relations would be the development of an international mission statement; all agreed that the Faculty should continue to discuss the issue of international affiliations.

STANDARDS OF PROOF IN MIT DISCIPLINARY PROCEEDINGS

In December, the FPC and the Committee on Discipline (COD) met to discuss standards of proof in MIT disciplinary proceedings. Professor Bacow explained that the two principal Institute forums for student conflict resolution and discipline are the Office for Undergraduate Education and Student Affairs (OUESA) and the Committee on Discipline (COD), which primarily handles academic cases. When the OUESA began to develop written procedures for MIT's student complaint and dispute processes, it became clear that the OUESA and COD should apply the same standards of proof in disciplinary hearings.

OUESA and COD decisions had been based on a preponderance of the evidence and clear and convincing evidence, respectively. Preponderance of the evidence, applied in United States civil courts, is interpreted as "having a majority of the evidence." Clear and convincing evidence, not a widely used standard, falls between preponderance of the evidence and beyond a reasonable doubt, the standard of proof used in United States criminal courts.

Because MIT complainants have the option to take cases to the OUESA, the COD, or outside MIT to the United States legal system, MIT's legal counsel advised that the OUESA and COD should apply a uniform standard of proof to avert forum shopping between the OUESA and COD and between MIT systems and the U.S. civil courts.

After a lengthy discussion of a preferred standard of evidence for MIT disciplinary proceedings, Professor Bacow called for a vote of the FPC and COD. Fourteen supported changing the COD standard of proof to a preponderance of the evidence; three opposed. All present agreed that records should be kept of all cases, sanctioned and unsanctioned.

INCOMPLETES

In March, FPC members met with Professor Kerry Emanuel, Chair of the Committee on Academic Performance (CAP), to discuss the CAP's proposed revisions to MIT's policy on Incompletes. Although some members did not agree with all of the proposed changes, the Committee generally supported the CAP's efforts to tighten regulations on Incompletes, to allow faculty discretion in granting Incompletes, to determine the cause of increasing requests for Incompletes, and to encourage the proposition that Incompletes should entail student initiation and not place undue burden on faculty.

The CAP made minor modifications to the proposal and submitted it to the Faculty at its April meeting. The Faculty approved the proposal in May. Changes to Faculty Regulation 2.62.3 include the following:

- expired Incomplete grades ("R") will no longer remain on students' transcripts;
- instructors must submit final grades based on the work completed by the last day of the regular term during which the work was to have been completed;
- no grade of Incomplete may be assigned to any student in the semester in which he or she graduates; and
- all grades of Incomplete must be resolved prior to graduation.

FINANCIAL HOLDS

In April, Professor Emanuel met with the FPC to discuss the CAP's recommendations regarding financial holds. Professor Emanuel reported that the Registrar's office may place students on financial hold (deny registration) whose prior semester payments are delinquent. Recently, students whose financial holds have been cleared during the following term have been allowed to register retroactively.

In his 1 March 1996 memorandum to Professor Emanuel, Paul E. Gray, Chairman of the Corporation, summarized various problems that retroactive registration has created. Members agreed that current practices 1) place an

enormous burden on the Financial Aid Office (shuffling financial holds on and off), 2) provide a disincentive for those who play by the rules, 3) consume limited resources within the housing system for those who are not paying tuition or housing bills, 4) provide an opportunity for students to selectively add or drop courses before they retroactively register, and 5) allow students who are not paying class, dorm, or health fees to consume scarce Institute resources.

All present agreed that retroactive registration should no longer be allowed so as to strongly encourage students to resolve financial difficulties in a timely manner. Professor Emanuel reported that the CAP plans to develop an implementation strategy in consultation with the CUP and other appropriate committees. Issues yet to be resolved include: how far into the term (either registration or add date) should students be allowed to register, how to handle special circumstance cases, and how to prevent non-registered students from attending classes without placing this policing responsibility on the Faculty. Professor Emanuel agreed to report back to the FPC on the details of implementation.

RECOMMENDATIONS OF THE WORKING GROUP FOR UNDERGRADUATE ACADEMIC INTEGRITY

Early in the spring term, the FPC met with Deans Travis R. Merritt and Rosalind H. Williams to discuss further the recommendations of the Working Group for Undergraduate Academic Integrity. Based on the FPC's feedback last November, the Working Group developed several proposed courses of action related to record-keeping systems. Although the MIT Colloquium Committee released data showing that students frequently collaborate on problem sets and do not comply with examination procedures, only a small number of cases of academic dishonesty each year are reported to the Committee on Discipline or the Office for Undergraduate Education and Student Affairs. This makes it difficult to track the dimensions of the problem. In addition, medical and professional schools frequently call upon the Dean's Office to make representations about the integrity of specific applicants' work at MIT, which is virtually impossible without a central repository of information.

The Working Group recommended that faculty and teaching staff report all proven cases of academic dishonesty. Dean Merritt proposed mailing short, standardized forms to teaching staff at the beginning and end of term (attached to grade reports at the end of term) and making them available at departmental headquarters and the Dean's Office. Faculty would be asked to submit completed forms to the Dean's office, which would maintain individual files (with limited access) as well as compile aggregate data to be transmitted back to the departments.

After a brief discussion of some details, the Committee endorsed Professor Bacow's suggestion that Dean Merritt draft a short memorandum and reporting form, and requested that the draft be submitted to the FPC for final approval.

The FPC also discussed several issues of concern to the MIT Faculty:

FACULTY NEWSLETTER

During the spring, the FPC met on two occasions with Professor Lawrence M. Lidsky, Faculty Liaison to the MIT *Faculty Newsletter*, to discuss the future of the *Newsletter*. During the first meeting, the group discussed the *Newsletter's* history, current operations, and future possibilities. During the second meeting, Professor Lidsky proposed that the FPC endorse the following:

- the addition of an on-line component to the Faculty Newsletter, which would include a) an archival web site and b) a moderated bulletin board;
- formalization of the managing editor position, with salary commensurate with the duties and responsibilities of the position; and
- institutional support to cover the managing editor's salary and development and maintenance costs for the on-line components.

The FPC expressed unanimous support for an on-line *Faculty Newsletter* and generally endorsed formal institutional support for the managing editor position, albeit with some reservations. Expressing additional reservations about an electronic bulletin board, the Committee suggested that *Faculty Newsletter* editors explore issues associated with implementing a bulletin board function (privacy, access, feasibility, the moderator's function, etc.) and return to the FPC with more details.

ISSUES RELATED TO DISTANCE LEARNING

In December, the FPC met with Professors Richard C. Larson, Director of the Center for Advanced Educational Services, and Steven R. Lerman, Director of the Center for Educational Computing Initiatives, to discuss issues related to distance learning.

Professor Larson reported that distance learning is becoming an increasingly important consideration in modern teaching and learning methods. The Sloan School's SDM Program, the Collaborative Design Program in the School of Architecture and Planning, the Mechanical Engineering Hypermedia Lab, and the School of Humanities are currently utilizing distance learning techniques. In response to increased interest and implementation of distance learning techniques, the Committee on Education via Advanced Technology recommended "that academic computing, distance learning, and other educational uses of advanced technologies be brought under the purview of a Standing Committee of the Faculty"(report available at <http://www-evat.mit.edu/report/>).

The group discussed several issues associated with modern technology, distance learning, and the *virtual campus*:

- how to enforce copyright laws for digital media
- whether electronic cross-registration should be implemented between universities not in geographical proximity
- whether cross-registered coursework should be accepted for credit and/or toward a degree
- whether universities should implement on-campus requirements for degrees
- whether faculty should be allowed to affiliate with virtual universities
- how to construct incentive and reward structures for faculty
- how to assign ownership and copyright of videotaped coursework which is distributed off campus (faculty member, department, center, school, and/or university)

FPC members expressed the following comments:

- Student-student interaction provides tremendous educational value in current cross-registration programs. Virtual interaction might not be as positive.
- Replacing current undergraduate education models would be unwise, but the virtual classroom could provide enormous opportunity for students who cannot travel to central repositories of information because of financial restrictions, jobs, families, and other responsibilities.
- Distance learning could be used as a growth opportunity for those who we are not currently serving, rather than displacing those whom we serve well in person.
- MIT must retain its fundamental character and excellence in teaching.
- MIT should consider ways to engage the Faculty in a discussion of these issues.

The FPC also discussed several issues with a broad impact on MIT:

CFA SURVEY ON FACULTY RETIREMENT

In October, the FPC met with Professor R. John Hansman, Chair of the Committee on Faculty Administration (CFA), to discuss the CFA analysis of its survey on faculty retirement.

Professor Hansman reported that the CFA surveyed the Faculty on retirement issues in an attempt to examine *non-financial* factors which influence faculty to retire. Twenty percent of the Faculty responded, most of whom were active faculty at the full professor level. Professor Hansman then outlined the findings of the survey data (the preliminary survey data is summarized in the January/February 1996 issue of the *Faculty Newsletter*). Committee members complimented the CFA on its hard work and agreed that MIT must develop a strategy to encourage faculty to consider the concept of intellectual renewal early in their careers.

ROTC TASK FORCE UPDATE

In February, the Committee met with Members of the ROTC Task Force. Professor Stephen C. Graves, Task Force Chair, summarized the three phases of the Task Force:

- 1) gathering information (which resulted in the Task Force's 1 February 1996 Interim Report);
- 2) engaging the community in the issue and soliciting feedback and advice (through meetings with departments, living groups, and the Academic Council, and through faculty dinners, an open forum for students, a web page, and an email address); and
- 3) developing a final report and proposed Faculty resolution.

Because the Task Force's proposed resolution was scheduled to be introduced and discussed at the March Faculty meeting and voted at the April Faculty meeting, Professor Bacow asked FPC members to encourage their fellow faculty members to attend. Members noted that although the Faculty could vote to terminate ROTC, the ultimate decision would be made by the Executive Committee. Members agreed that even if a Faculty vote would not make the final decision, it would be a clear indication of the moral position of the MIT Faculty.

After a discussion of many options regarding MIT's participation in ROTC, informal votes of the FPC indicated 1) strong opposition to the current DOD policy, 2) strong support for the continuation of ROTC (with substantive constructive provisions) on campus, and 3) no support for the removal of ROTC on campus. The FPC thanked Task Force members for their hard work on this difficult issue and especially for their efforts to solicit the views of the entire community.

RE-ENGINEERING

In May, the FPC met with members of the Re-engineering Steering Committee and Ms. Janet L. Snover, Captain of the Community Involvement Team, to discuss Re-engineering issues of interest to the Faculty. The group discussed 1) how the reduction in staff (from the early retirement incentive) will be used in re-engineering efforts, 2) the status of the management reporting system, 3) the way in which faculty are involved and engaged in the re-engineering process, 4) how the academic needs of the Institute are being addressed, and 5) what non-financial measures of success will be used. Members commented that the many roll-out, training, and re-organization processes planned for FY97 will place large demands on the Institute, and suggested that continued candid discussions between the Faculty and reengineering participants may ease some of the difficulties that could arise during these transitions.

President Charles M. Vest visited the FPC to discuss a broad spectrum of issues important to the continuing development of the Institute: interdepartmental and cross-departmental initiatives, MIT's relations with the federal government in terms of the interests of science and research, Institutional leadership, faculty morale, and preparation for the academic future. During Provost Joel Moses' first visit with the FPC, he reported on the appointment of four councils (environment, technology and education, international relations, and industry relations) to address various issues facing the Institute, and summarized and discussed with the FPC "Industry/University Relations: Where Are We Going?" by Dr. Alexander MacLachlan, presented at the Industrial Performance Center's Faculty Seminar Series. During the Provost's visit with the FPC in the spring term, the group discussed interdepartmental initiatives, re-engineering, and general moods and attitudes of the Faculty.

Many thanks to all FPC members for their thoughtful participation on the Committee throughout the year, especially to the Committee's departing members: Messrs. Anand Mehta (graduate student member) and Matthew J. Turner (undergraduate student member), and Professors Linn W. Hobbs (former Associate Chair of the Faculty) Bernard J. Wuensch, and George F. Koster (faculty members).

COMMITTEE ON THE UNDERGRADUATE PROGRAM

The CUP heard updates from two of the subcommittees it appointed in 1994-95 to address aspects of the General Institute Requirements and from another subcommittee appointed to provide guidance to the UROP Program, with the following results:

ENDORSEMENT OF A PROPOSAL FOR A NEW COMMUNICATION REQUIREMENT TO REPLACE THE WRITING REQUIREMENT

In a two-part presentation by the Subcommittee on the Writing Requirement to the CUP in the fall, the CUP endorsed its proposal for a revised Writing Requirement -- with an emphasis on sustained writing experiences throughout students' undergraduate careers -- with the understanding that the proposal would be taken to academic departments for feedback. In the spring, the Committee on the Writing Requirement presented a further report based on departmental feedback, proposing a new Communication Requirement to replace the present Writing Requirement. The new requirement would require students to write, receive instructor feedback on their writing, and revise, during each undergraduate year. CUP endorsed the proposal in anticipation of its being presented to the Faculty in the Spring of 1997.

DISCUSSION OF THE 1994-95 PROPOSAL FOR A REVISED INSTITUTE LABORATORY REQUIREMENT

Dean John Vander Sande returned to the CUP to continue the discussion of the recommendation of the Subcommittee on the Institute Laboratory Requirement for a revised, two-phase Laboratory Requirement, in which

phase one, geared to freshmen and sophomores, would provide hands-on exposure to a particular field, and phase two, geared to juniors and seniors, would be project-based and pre-professional. Discussion with the CUP revealed that more work needs to be done to accomplish the currently-stated goals of the Laboratory requirement within the time constraints that both faculty and students face. A lasting solution to the lab requirement's currently unsettled state will require the resolution of a number of conflicting educational aims. Such resolution will probably not come before the Task Force on Undergraduate Life and Learning begins its deliberations.

ENDORSEMENT OF A PROPOSAL FOR A MAJOR FUND-RAISING EFFORT FOR UROP

Professor John Southard, chair of the UROP Subcommittee, and Ms. Norma McGavern, Chair of UROP, spoke to the CUP in the spring about the need for increased funding for UROP in the wake of the major changes in the Federal regulations governing student stipends, and asked for CUP endorsement of a proposal for a capital campaign which they would present to the Provost. Following several CUP discussions about the centrality of UROP to the "hands-on" aspect of MIT undergraduate education and the potential for increasing UROP participation and visibility with increased funding, CUP endorsed the proposal.

The CUP addressed several issues of concern related to the freshman year, appointing two working groups and agreeing to consider the appointment of a standing committee:

APPOINTMENT OF A FACULTY/STUDENT WORKING GROUP ON THE FRESHMAN ADVISOR SEMINAR PROGRAM

A two-part discussion in the fall, led by Dean Travis Merritt and CoC Chair Professor Suzanne Flynn dealt with issues of joint concern to the CUP and the CoC related to the Freshman Advisor Seminar program; discussion focused on the viability of continuing the program as it presently exists, particularly with respect to the sustainability of the current level of faculty participation, the unevenness in quality of the seminars, and the credit-worthiness of some seminars. Based on those meetings, CUP appointed a working group to investigate the possibility of bringing the FAS program more formally into the first-year curriculum, and to report back to CUP in the spring. The working group developed a report which it presented to the CUP in the spring, proposing several changes to the FAS program, including that Freshman Advisor Seminars become an Institute requirement for all first year students and that academic departments take over responsibility for recruiting faculty to teach them. The CUP was not able to reach consensus on these proposals and decided to revisit these issues in the Fall.

APPOINTMENT OF A FACULTY WORKING GROUP ON R/O WEEK

In another two-part discussion in the Fall, staff from the Undergraduate Education and Student Affairs office made a presentation to the CUP about Residence/Orientation Week. CUP discussion focused on the large emphasis given to the residence selection process during R/O Week, and the relatively short shrift given to academic orientation, as well as on the large amount of responsibility given to students in planning and running R/O Week. The CUP agreed that more faculty presence is needed in regard to R/O Week, and a faculty working group was appointed to serve in an advisory capacity.

CONSIDERATION OF A PROPOSAL FOR A COMMITTEE ON THE FIRST YEAR PROGRAM

In the spring, Deans Enders, Merritt and Williams of Undergraduate Education and Student Affairs described the need for a standing faculty committee, modeled on the now defunct Committee on the Science Requirement, to which deans and other administrative staff could refer for resolution of problems and questions related to the first year program, such as the Pass/No Record system, the granting of Advanced Placement credit, etc. A formal proposal to form such a committee is currently being drafted, which the CUP agreed to consider for endorsement when complete.

CUP activity during 1995-96 that involved the possible creation or revision of Faculty policy and practices included the following:

DISCUSSION OF THE PASS/NO RECORD GRADING SYSTEM

Professors Kerry Emanuel and Daniel Nyhart of CAP visited CUP in the spring to discuss the effectiveness of the Pass/No Record grading system for freshmen. The CAP's perception is that Pass/No Record grading may no longer be effective, and CUP considered whether or not the system is actually "broken." The CUP was divided about both the effectiveness of the system and the wisdom of appointing a working group to gather more information about it. It was agreed that basic information about MIT students' experiences with the first year -- such as their subject choices, prior preparation, etc. -- needed to be gathered together before any further action could be considered. The chairs of the CUP and the CAP are to consult about the information that needs to be gathered for both bodies. It was also suggested that the Task Force on Student Life and Learning might be an appropriate forum for such a discussion, and that the issue might best be referred there.

UPPERCLASS UNDERGRADUATE ADVISING

Mr. Samir Thadani '96, head of the student-run Baker Foundation, visited the CUP in the spring to present the proposed guidelines for upperclass advising developed this year by the Baker Foundation, with CUP and UESA guidance and support. CUP discussion focused on the need for more of a transition between the nurturing freshman advising system and the present culture of upperclass advising. It was proposed that the guidelines eventually be included in published Institute guidelines, as well as given more informally to faculty and departments. The CUP endorsed the guidelines in preparation for their distribution to departments.

SUBJECT LIMIT ON DEPARTMENTAL MAJORS

CoC Chair Professor Birger Wernerfelt visited CUP in the spring to discuss the limit on credit units a department can require for completion of an undergraduate major, saying there is a lack of clarity about how to enforce the credit limit -- some departments stretch the number of units they ask of their majors through artful footnotes in the catalogue, and the 15.5 subject upper bound -- intended to be an allowable exception for a few majors -- is becoming the rule for engineering majors. CoC would like guidance, when asked to consider proposals for new undergraduate majors, on how strictly they should expect departments to adhere to the real credit limit. CUP discussed the expanding knowledge base required for professional competence in many fields, and the need for better definition of what an undergraduate major should accomplish in this context, and agreed to revisit the issue in future meetings.

The CUP monitored a number of other on-going programs and new initiatives:

- It heard three times from faculty, staff and students involved with the re-engineering of Student Services about their progress, proposed changes, and possible policy implications of some of those changes;
- It heard a report in the winter about the plans for the Presidential Task Forces on Student Life and Learning;
- It heard a report from Ms. Norma McGavern and Dean Alberta Lipson in early spring on the preliminary results from the 1996 survey of sophomores about their first year experience;
- It conducted a two-part discussion of the latest proposal from MAS for a dual degree program in Media, Arts, Sciences & Technology, deciding finally not to endorse the current proposal;
- It heard a report from the co-chairs of the Provost's Council on Educational Technology, Dean William Mitchell and Professor John Belcher, about the Council's activities to date.

Finally, although discussion on the topic did not take place in a formal meeting, the CUP is monitoring the new three-year experiment using internal "intermediate" grading through its Ad Hoc Subcommittee on Intermediate Grades chaired by Professor Paul Lagace.

OTHER FACULTY COMMITTEE REPORTS

The **Committee on Academic Performance (CAP)** spent most of its time considering petitions from undergraduate students requesting exceptions from various Institute rules. A total of 540 petitions were considered this academic year (about the same number as last year). During September, January, and June the customary end-of-term meetings were held to review the performance of those with academic difficulties.

In addition to considering petitions, the CAP held several special meetings each semester to discuss various issues of concern to the Committee and to the Institute. The Committee completed its proposal to reform the Institute's policy on the grade of Incomplete and presented it to the Faculty at its April meeting. The proposal was passed by unanimous vote at the May meeting. As a result, the *Rules and Regulations of the Faculty* will be modified with the effect of strongly encouraging students to finish Incompletes during the semester after they are assigned.

The CAP, working in conjunction with the Committee on the Undergraduate Program (CUP) undertook to reform its policy on financial holds. When a student is significantly in arrears, the Financial Aid Office may forbid that student from registering. Often, a student in such a situation will continue to take courses in the hope that, should the financial hold be lifted, he or she will be allowed to register for the courses. This policy has led to the circumstance that an uncomfortably large number of students are enrolling in courses while not being registered and thus circumventing the usual checks and balances on performance. It was decided to change the policy so that no student may ever register after Add Date. The CAP will work with CUP and CUFA to implement the new policy during the 1996-97 academic year.

Finally, the CAP revisited the issue of freshman pass/no record grading. Most CAP members feel that this policy needs to be changed to discourage the tendency for freshman to take difficult courses and not do very well in them. Discussions were initiated with CUP and the FPC. This issue will be taken up again next year.

The **Committee on Corporate Relations** (CCR) began the 1995-96 academic year with continuing focus on the mission and strategic plan of the Corporate Relations Office and the Industrial Liaison Program. During the year the CCR reviewed many of the existing and new programs involving corporate relationships in the Departments, Centers and Institute. Attention was given to the increasing number of international initiatives at the Institute. The topics discussed included: the impact of large corporate programs on education, MIT's role in the technology supply chain, the effect of industrial research on junior faculty, and the relationship of the CCR to the newly formed Council on Industrial Relations. The chairmanship changed on January 1 from Professor Bernard Frieden to Professor Charles L. Cooney.

The **Committee on Curricula** (COC) met eight times during the 1995-96 academic year. The Committee approved proposals for new, cancelled, and revised subjects, and reviewed student petitions for substitutions for the General Institute Requirements, as well as approving substantive curricular changes and making several policy interpretations.

The COC approved a number of revisions to undergraduate curricula, including: major changes to Course 9's undergraduate program and degree name (to the Bachelor of Science in Brain and Cognitive Sciences) reflecting the inclusion of more neuroscience in the program; changes to Course 2 to include more material about dynamics; changes to Course 1-E to make the program more useful and attractive to pre-med students and to increase depth; and minor changes to Course 7, Course 5, and Course 6-1, 6-2, and 6-3 curricula.

In the process of approving changes to the Course 2 curriculum, the COC took the position, supported as well by the Committee on the Undergraduate Program, that the policy in the Faculty Regulations limiting departmental programs to 15^{1/2} subjects be considered an absolute upper limit, in that it must apply to every path through the program.

The COC also approved the policy that students earning an S.B. degree after receiving a Minor in the same field need to take 36 additional units for the degree.

The **Committee on Discipline** (COD) heard charges against three students this year. The charges, all for academic fraud, included taking an exam for another individual, stealing a final exam, and forging grade change forms. The Committee recommended probation for the first offender, suspension for the second, and expulsion for the third. The Committee also reviewed a number of petitions for removal of disciplinary notations from transcripts.

The COD, in conjunction with the Dean for Undergraduate Education and Student Affairs, will regularly report disciplinary actions at Faculty meetings with the hope that this will alert faculty members to the need for consistent reporting of incidents to the Committee on Discipline or to Undergraduate Education and Student Affairs, so that students may become more aware of the risks they run when engaging in academic dishonesty.

The **Harold E. Edgerton Award Selection Committee** issued a call for nominations that was distributed by direct mail to all faculty and posted in TechInfo. Follow-up letters were sent to departments heads to solicit further nominations. Fourteen nominations were received, reviewed and debated. After obtaining further information on three nominees, the Committee selected Anne E. C. McCants of the Department of Humanities as the 1996-1997 awardee. The citation presented at the April Faculty Meeting cited Professor McCants' significant contributions to early modern European social and economic history. Specifically, she studied how the Dutch faced the questions of social welfare and entitlements, and how they balanced free markets, private charity and government relief as they struggled to care for orphans in the seventeenth century. Professor McCants is an energetic, creative and effective teacher, serves on many MIT committees, and is housemaster of Green Hall.

The **Committee on Faculty-Administration** (CFA) completed the analysis of the *Faculty Survey on Issues Which Influence Retirement Decisions* early in the academic year. The results were documented in a *Faculty Newsletter* article and reported to various faculty and administrative groups within the Institute. After the Executive Committee of the Corporation announced the retirement initiative program, the CFA elected to minimize its activities with regard to retirement to avoid interfering with individual retirement decisions.

The **James R. Killian, Jr. Faculty Achievement Award Selection Committee** convened for four meetings in the process of selecting Gian Carlo Rota, Professor of Mathematics, as the recipient of the award for 1996-97. In

assessing the distinguished nominations submitted this year and those carried over from previous years, the committee kept in mind Dr. Killian's early characterization of MIT as "a university polarized around science, technology, and the Arts" and the statement of purpose at the time of establishment of the Award by the Faculty in 1971:

To recognize extraordinary professional accomplishments by full-time members of the MIT Faculty; to provide a means for the communication of these accomplishments to the Faculty, students, and other members of the MIT community and to the general public, and by so doing to honor the contributions made by Dr. Killian to the intellectual life of the Institute.

A total of eleven nominations were considered this year. Six were considered to be particularly promising, and additional information was requested for the final round of consideration. The Committee agreed unanimously on Professor Rota for the 1996-97 Award. Because of the considerable community effort that goes into preparing Killian Award nominations, the Committee will forward several of the nominations to next year's committee so as to avoid undue duplication of that effort. Next year's chairman will be a member of the present committee, providing valuable continuity in the deliberations of this happy, but inherently difficult, selection process.

In the first half of the year, the **Committee on the Library System** supported the interim administration of the library as they grappled with the continuing cuts in the library's budget mandated by the state of MIT's finances. Considerable time was spent understanding the nature of the cuts and the impact various alternatives would have on the services provided to the MIT community. This is particularly relevant for the state of periodical subscriptions, which are being cut back once again. The Committee was concerned that this not cut into the intellectual underpinnings of the Institute.

The appointment of a highly qualified new Director of the Library System, Anne Wolpert, was a hopeful sign of the Administration's determination to keep the quality of the Libraries high. The new Director listened carefully to Committee members' (faculty and students) concerns about service levels and the need to position the library effectively in this electronic age.

At the April Faculty Meeting, the **Committee on Nominations** presented the names of faculty members to serve on 14 standing committees of the Faculty as well as the name of the faculty member to serve as Chair-elect of the Faculty. At the May Faculty Meeting, the Faculty voted to approve the nomination for the Chair-elect and also the 26 faculty members to serve on the standing committees.

The **Committee on Outside Professional Activities** (COPA) assisted several faculty members and a department in resolving potential conflicts of interest arising from demands being made by a sponsor. The Committee was also available to advise faculty on interpretations of MIT's conflict of interest policies.

The main accomplishments of the **Committee on Student Affairs** (CSA) this year were (a) to sponsor an IAP offering at which students and other members of the MIT community formed small focus groups to discuss issues related to food services, (b) to issue an "Initial Report on Housing and Food Services at MIT," and (c) to help establish a small Food Service Working Group. The members of the Food Service Working Group are Larry Maguire, Phil Walsh, Andy Eisenmann, Joe Bambenek, and John Hollywood. The group will examine food services in detail, and will develop a framework for addressing five issues: cost, nutrition, time economy, social development, and citizenship development.

In other domains, the CSA had fruitful exchanges of ideas with Phillip Bernard, Staff Associate for Residence Programs; Bob Simha, Director of Planning; Lydia Snover, Senior Planning Officer for Institutional Research; Steve Immerman, Marty Schlect, Anthony Ives, and others from the Student Services Reengineering Teams; Barbara Roberts, Coordinator of Disabilities Services; and Tracy Desovich, Health Educator for Students, MIT Medical Department.

The **Committee on Undergraduate Admissions and Financial Aid** (CUAFA) focused attention on two principal items this year: 1) The changes being considered in the Offices of Admissions and Financial Aid as a consequence of the Re-engineering efforts and 2) a discussion of statements in MIT publications regarding affirmative action. Members devoted consideration of the extent to which we should become involved in the public discourse and controversy on this subject.

The **Committee on the Writing Requirement (CWR)** met nine times during the 1995-96 academic year. The majority of its time was spent in developing a proposal for a new Undergraduate Communication Requirement that would replace the current Writing Requirement.

In the fall of 1995, a subcommittee of the CUP concluded that the current Writing Requirement is ineffective in providing MIT graduates with writing and speaking skills necessary for professional success and only a sustained four-year experience could provide our students with sufficient training in communication skills. In November 1995, the CUP charged the CWR to consult with relevant decision makers, organizations, and individuals at MIT and propose a redesigned, institutionally feasible requirement that would be a more effective educational tool.

The CWR began work on the problem in December 1995 and continued its deliberations until the beginning of May 1996. The CWR met with Dean for Undergraduate Education Rosalind Williams, Dean of Science Robert Birgeneau, Dean of Engineering Robert Brown, and Dean of the School of Humanities and Social Science Philip Khoury. In addition, Committee members discussed possible guidelines for a new requirement with faculty from the departments of Electrical Engineering and Computer Science, Biology, Mathematics.

The CWR reported the result of these efforts to the CUP in May 1996. The CWR proposed to replace the current proficiency-based Writing Requirement with a newly designed experience-based Undergraduate Communication Requirement that will integrate instruction in communication skills into the entire undergraduate program and provide students each year with a substantial experience in writing and speaking. The CUP accepted and endorsed the CWR's report, and the two committees plan to carry the proposal forward to the faculty as a whole during the 1996-97 academic year.

The Committee on the Writing Requirement also considered a request from the Committee on Undergraduate Admissions and Financial Aid to allow admitted students to take the Freshman Essay Evaluation (FEE) on-line before they physically come to the Institute in August. The CWR decided that logistical and access problems made such a project difficult to administer fairly, and, consequently, decided against allowing students to take the FEE on-line from remote locations. The Committee, however, approved in principal, an experiment to allow admitted students to submit an on-line writing sample and receive feedback on their writing ability before coming to MIT to August. This exercise, however, would not replace the FEE.

* * * *

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: Kerry A. Emanuel (Academic Performance), Charles L. Cooney and Bernard J. Frieden (Corporate Relations), Suzanne Flynn and Birger Wernerfelt (Curricula), Jed Z. Buchwald (Discipline), Jeffrey H. Lang (Edgerton Award), R. John Hansman (Faculty-Administration), George Stephanopoulos (Killian Award), Michael S. Scott Morton (Library System), Graham C. Walker (Nominations), John G. Kassakian (Outside Professional Activities), Suzanne H. Corkin (Student Affairs), J. Kim Vandiver and Harold Abelson (Undergraduate Admissions and Financial Aid), Charles Stewart III (Undergraduate Program) and Kip V. Hodges (Writing Requirement). Many thanks to Leigh H. Royden and Samuel M. Allen for their service as Associate Chair and Secretary of the Faculty.

Lawrence S. Bacow
Traci Trotzer Considine

SENIOR VICE PRESIDENT, OPERATIONS

Physical improvements and changes seemed to dominate the campus landscape again this year. A record number of space changes were completed; construction of the Tang Management Center proceeded on schedule, including the installation of the pedestrian bridge over Amherst Street connecting The Tang Center to the Muckley Building (E40); and the Cogeneration Project was virtually complete at year-end with the successful testing of the gas-fired turbine. This plant will generate 20 megawatts of electricity while simultaneously producing enough steam to heat and cool MIT's buildings for most of the year.

A plan for renovating Senior House was launched during the year. The project is currently in design with preparatory construction to be completed during the summer. Full-scale renovation work will be carried out next summer.

The AXO Sorority at 478 Commonwealth Avenue and the McCormick Annex at 311-312 Memorial Drive were completed and placed in service last fall.

Throughout the year, developments and improvements to the MIT Card continued. With the advent of card access control on exterior doors throughout the residence system, thefts from residence halls were down 40 percent from last year. In addition, several parking facilities were equipped with card readers for tighter access control.

A decision with major financial implications for MIT's Endicott House was made during the course of the year. The Sloan School of Management decided to discontinue offering its Program for Senior Executives. The eight-week residential program, offered each spring and fall, has been held at MIT's Endicott House for the past 38 years. Discontinuation of this program will directly influence the operations of Endicott House but an all-out effort has been launched to replace this lost business.

During the year, The Office of Special Community Service (OSCS) became affiliated with the Campus Activities Complex. The OSCS continued to support a variety of important community programs throughout the year

Affirmative Action efforts continued throughout the year. Our on-going goal is to hire minorities and women whenever possible and to promote women in non-traditional roles. We were quite optimistic that an opportunity existed to hire a minority female candidate for the position of Director of Conference Sales at Endicott House. An offer was made and accepted by the candidate but she later rejected it when she received a more enticing offer by a major hotel chain in the area. On a more positive note, a support staff position, held by a woman in the Campus Activities Complex was upgraded to the administrative staff level, a female minority candidate was hired in a support position, and a male minority technical instructor had his position reviewed and reclassified at a higher level. We were also successful in hiring a female in a non-traditional position. A national search was conducted for a new Director of Mail Services. Several viable candidates were identified, two finalists were selected, and the female candidate was chosen for the position.

We will continue to strive toward a goal of a more diverse workforce.

Following are individual department reports.

William R. Dickson

CAMPUS ACTIVITIES COMPLEX

In keeping with the mission of the department, throughout the year, the Campus Activities Complex (CAC) provided event planning, support, and supervision for over 11,000 events with a combined attendance of approximately 200,000 people. Major Institute events supported by the department included the dedication of the Tang Center, the Media Lab's 10th Anniversary, the National Coalition of Educational Activists, the Society for Environmental Journalists, the City Year National Conference, and the 1996 Commencement and Technology Day ceremonies.

This year, significant attention was devoted to improving the quality of CAC-managed facilities. Barrier removal and access improvements were completed during the year in Walker Memorial (Building 50). These included a new exterior lift, a renovated elevator, new and renovated restrooms, and a new ramp into the gymnasium. A Program Planning document was created for proposed renovations to Kresge Auditorium, the MIT Chapel, and the surrounding landscapes. This project is designed to address accessibility and other operating issues in these designated areas. With the completion of the Tang Center for Management, CAC worked with the Sloan School to bring the Wong Auditorium into operation through coordination of scheduling and event planning functions.

The CAC sponsored and supported a number of programs during the year, including the MIT Commuter Fair, Spring Weekend, and IAP classes. The MIT Hobby Shop offered an IAP class in furniture making and held an open house for alumni of the Hobby Shop. In an effort to broaden program diversity and offerings in the complex, the department has created a student program board. It will assist the department in providing social and educational activities while also supporting community building objectives. In response to safety issues, CAC worked with Campus Police, Residence and Campus Activities, and Undergraduate Education and Student Affairs to implement metal detectors and new party regulations at large student social events.

The real estate portfolio of the Stratton Student Center maintained full occupancy throughout the year and lease options were renewed with eligible tenants. The first floor program of the Stratton Student Center continued to support the department through the Vendor Program and through service fees collected at The Source. In its second year of operation, The Source, the gift of the 1994 Senior Class, serving as an information center and ticket outlet for campus activities and events, expanded the number of organizations that utilize this facility for their ticket selling needs. To meet this increased demand, a point of sale accounting program was installed to provide instant access to sales performance and full service accounting.

The Office of Special Community Services (OSCS) continued to support a variety of important community activities. The MIT Activities Committee (MITAC) organized over 55 events for the MIT and Lincoln Laboratory communities which were attended by close to 4,000 participants. The MIT Quarter Century Club, which inducted 73 new members this year, held several events, including the Summer Picnic, the Silver Club High Tea for Ladies, and the Holiday Gathering. The United Way campaign of 1995 reached close to 90 per cent of a \$320,000 goal. A new, year-round United Way steering committee has been developed to oversee the 1996 campaign. The annual Retirement Dinner, hosted by President and Mrs. Vest and the Quarter Century Club Board, was postponed from its usual June date to September because of special arrangements needed for the more than 650 retirees to be honored this year. The Association of MIT Retirees is continuing to arrange or sponsor activities of interest to retirees. Plans are underway to produce a 1996 picture yearbook of current retirees as well as gathering historical information and impressions of MIT that will help capture and preserve the valuable institutional memory of many long-term faculty and staff members.

Phillip J. Walsh

CAMPUS POLICE

The MIT Campus Police Department continued to serve the MIT community in its mission to protect life and property, prevent and detect crime, and maintain public order and service to the community.

Throughout the year, larceny continued to be the largest category of crime on the MIT campus. Reported thefts of Institute property rose only slightly during the year, but there was a significant increase in reported thefts of personal property, both in residence halls and elsewhere on the campus. Crimes against persons, which were at a ten-year low during the last reporting period, increased to 25 during the year, an average number over the last decade.

The total number of reported incidents of larceny of Institute property this year was 126, compared to 124 last year. Computers and computer components were, once again, the most frequent type of Institute-owned property stolen. There were 706 incidents of thefts of personal property reported at sites other than residences compared with 466 the year before. Wallets, pocketbooks, and backpacks headed the list of articles stolen.

Thefts reported from within residences numbered 193 during the year compared with 67 last year. Wallets, cash, bicycles, and cameras were the major targets.

Motor vehicle thefts on campus plunged to an all-time low with only 19 vehicles reported stolen compared with 27 during the year before. This decrease is attributed to improved parking access control and security systems in campus lots and garages as well as to a drop in motor vehicle thefts in the city in general.

The Safe Ride safety shuttle service provided 160,578 personal safety escorts during the year. Campus Police also supplemented Safe Ride when early morning operations ceased by providing 781 personal safety escorts in police cruisers for members of the community.

The Rape Aggression Defense (RAD) self-defense program continued in popularity. During the year the program provided undergraduates with credit for this course and also surpassed the mark of 200 women, including students, faculty, and staff, trained since the start of the program in 1994.

The Campus Police Motorcycle Unit made its debut this year adding to the department's high visibility mobile operations. Two officers have been trained to operate the motorcycle on the day and early evening shifts.

Anne P. Glavin

ENDICOTT HOUSE

It is important to begin by noting that six Endicott House employees took advantage of the retirement incentive program. They ranged from administrative, maintenance, grounds and wait staff personnel to the Managing Director, Howard Miller. These six individuals accounted for 125 years of service to the Institute.

With the announcement of the Managing Director's retirement, a committee composed of three members of the Endicott House Board of Governors was appointed to evaluate and recommend what the future management structure ought to look like. Several options were explored and "on-site" discussions were held with two management companies. It was ultimately decided that the operation as a whole was essentially sound, but that help was needed in the sales and marketing areas to replace the lost business that resulted from the discontinuance last year of the Sloan School of Management's Program for Senior Executives. This eight-week residential program, offered each spring and fall, had been held at Endicott House for the past 38 years, represented a major portion of our conference center business. It was proposed that one of the management companies, Conference Center Consulting Group, be retained for a specified period of time to assume responsibility for the sales and marketing effort. This recommendation was contingent upon the successful negotiation of a suitable contract. The committee also recommended that a concurrent search be initiated to replace the Managing Director.

Several major capital projects were completed during the year including the replacement of the Brooks Center septic system and the expansion of the main parking lot. The living room was air conditioned as were the remaining bed rooms in the main house. Also, in an effort to continually upgrade computer capabilities and, in anticipation of the Institute's new accounting/financial system, new computers were purchased for the business operation.

From a statistical standpoint, there were 56 overnight conferences held at the facility, lasting from one night to four weeks. Of the total, MIT-related groups accounted for 17 of these residential groups, 12 were from other non-profit groups, and the remaining 27 represented corporate businesses and some educational groups not classified as non-profit. These figures compare with last year's 67 overnight conferences with MIT-related groups accounting for 33 of these groups, 13 were from other non-profit groups, and the remaining 21 represented corporate businesses. There were 3,531 room nights occupied by a total of 3,723 guests this year compared with 5,535 room-nights occupied by 5,556 guests last year. Room occupancy was 28.7 percent compared with 37.8 percent last year. There were 29,755 meals served this year compared to 25,075 last year.

Howard F. Miller

GRAPHIC ARTS AND AUDIO VISUAL SERVICES

This year, total income for all Graphic Arts services was approximately \$5 million, down 16 percent from last year. This decrease was due, in large part, to the transfer of the Graphic Arts outgoing mail operation to the new MIT Mail Services department.

Improvements within the department included completion of stage two of the ramping up of the copyright clearance service and the upgrading of the Xerox Documents on Demand System to include greatly expanded storage capacity.

Five Macintosh computers were purchased in Audio Visual to comply with the needs of the new SAP financial system. The department also purchased a portable audio mixing panel/amplifier and speaker system that increased our ability to provide high quality sound reinforcement for small to medium size audiences. A second sound system was procured which will allow for multiple music sources to be mixed and amplified. A broadcast-quality wireless microphone system was also acquired. This will allow for high quality audio feeds to sound systems and video productions, many of which emanate from MIT, to be distributed over distance learning or teleconference systems throughout the world.

Ralph Scholl, Supervisor in the Offset Printing Department, retired with over 42 years of service, the most ever by any Graphic Arts employee.

Vernon A. Raine

HOUSING AND FOOD SERVICES

MIT CARD

During the year, the MIT Card office developed an information infrastructure to improve the efficiency and technological independence of its business processes. In addition, new equipment was acquired and the quality of the service provided to customers was upgraded. Through hands-on employee training, the department was able to develop the computational and programming skills to run its operations without outside consulting assistance. In order to affirm the status of the Institute as the leader in technology and to meet the challenges of the ever-changing card industry, the office conducted research on new technologies and market trends that could improve the services provided by use of The Card.

For the first time, the MIT Card Office will be able to carry out the in-house production of cards for the entire student population beginning with the fall semester. This mass production effort requires the production of approximately 15,000 temporary and permanent cards. Additionally, the office is working with the Alumni/ae Office in an effort to create a seamless process through which all MIT alumni/ae will be able to receive an MIT Affiliate Card.

FOOD SERVICES

This year's amendment to the Food Services contract with ARAMARK was negotiated to be on a straight profit and loss basis, whereby ARAMARK must pay a commission to MIT of 23 percent of all net receipts in excess of \$9.8 million per year. Since ARAMARK experienced a loss this year, they are seeking relief from the Institute. Discussions are ongoing and should be completed shortly.

The Customer First! Program was implemented across the campus which includes an employee incentive program. An emphasis on customer services, at all levels of the Food Services organization, has been stressed through manager meetings, unit employee meetings, and at the annual employee meeting last August.

Food Services now has a home page for each food service location on campus. Information includes: hours of operation, menus, employment needs, and menu specials. A catered event can even be ordered via the web.

A very successful vegetarian program, that includes weekly vegetarian offerings posted on the Worldwide Web, was implemented this year. Baker was advertised as "the place for vegetarians to eat dinner", and the Mediterranean Trade Winds in Lobdell went completely vegetarian.

The Food Services department worked on several community service projects with the Hunger Action Group, Campus Police, and a campus sorority.

Food Services launched an initiative, through a mass mailing and advertising in conjunction with The MIT Card Office, to advise all employees to sign up for the MULTIPLAN and take advantage of the payroll deduction option.

Management worked closely with the Baker Dining Committee to design a program that meets the students' needs. It was specifically advertised to vegetarians and students athletes. At this time, however, the program still is not self-sustaining.

Three new dining concepts were introduced at the Walker dining facility: New England Traditions; Trattoria, an upscale Italian concept; and Something Fancy, a new deli program.

At Lobdell Food Court, the menu of Mediterranean Trade Winds changed to become completely vegetarian. In addition, security at the entrance was improved with the installation of glass doors.

At the Faculty Club, audio visual equipment and black-out shades were purchased and internet access was added to meet customer demand.

HOUSING

The Housing Office has carried on its process of implementing many long-term projects that benefit both the students and the MIT community. One of the main goals of the department is to be sure that the customer has a positive experience living in the dormitory system while both long-term and short-term maintenance issues are addressed. The estimated cost for this year's maintenance and repairs is \$3 million.

Some of the maintenance projects during the year included bathroom renovations in E55, W85, W1, W5, W13, W51, W61, W4, W70, and NW16; kitchen renovations in W51, W4, W13, and NW61; plumbing renovations in E55, W85, W1, W7, W13, W51, 62-64, W61, W70, and NW61; HVAC upgrades in W1, NW61, and W13; painting in all houses; and continued involvement in the Senior House construction project and Baker House restoration feasibility study.

Improvements to the Student Information System now enable the Housing Office to keep better track of individuals eligible for residential housing. This now opens up more spaces for new students needing fall term housing.

The Off-Campus Housing Service data base project is nearing completion and the equipment should be in place to test the program early this fall. Ultimately, off campus rental listings will be available via the Intra-Net (within MIT only), thereby reducing the necessity for students to visit the office when searching for off campus housing.

Interest in graduate campus housing has risen this year due to the costs of off campus housing. The end of rent control in Boston, Cambridge, and Brookline has created some dramatic rent increases that should stabilize within the year.

Lawrence E. Macguire

INSURANCE AND LEGAL AFFAIRS

The mission of the Insurance and Legal Affairs Office is to manage the Institute's exposures to risk of loss and to address any claims that arise either on the Institute's behalf or against the Institute. Counsel is provided to all departments and offices, particularly on the issue of liability. Coordination is maintained with outside counsel which provides legal assistance to MIT.

The most significant activity during the year involved the builder's risk and operational coverage for the Cogeneration facility. Seven claims are pending resolution with combined costs in excess of \$1.5 million.

The majority of the cogeneration claims relate to design issues and contractor errors. MIT is actively pursuing reimbursement for these claims through both insurance and legal channels. These losses made it difficult for MIT to obtain quotes for operational coverage until coverage was combined and marketed with MIT's blanket property coverage. MIT received very favorable quotes and secured coverage with Arkwright Mutual Insurance Company (Factory Mutual System). Overall savings for the year should exceed \$300,000.

The largest property loss this year, was a transit loss of components of a signature acquisition system. This loss was insured for \$89,000, which was fully reimbursed by MIT's insurer, less a deductible of \$5,000. The frequency of losses under the deductible increased by 34 percent from last year to \$174,576, while losses paid by MIT's insurer dropped by 11 percent to \$292,370. Of the total property losses, \$154,713 was attributed to computer thefts.

Although workers' compensation administrative expenses and excess coverage dropped by 6 percent to \$406,298, paid losses increased by 22 percent from last year to \$871,909. Premiums and losses for all other lines of coverage remained level, resulting in MIT's total insurance costs being consistent with last year at \$3.7 million.

Three significant liability claims were settled this year at a total cost of \$102,950. These claims involved charges of hazardous waste dumping, discrimination, and wrongful termination. In addition, a lawsuit brought by a former MIT student for negligence in a pole-vaulting accident resulted in a judgment in the plaintiff's favor in the amount of \$637,647. This suit is currently under appeal. This Office is involved in a continuing effort to recover from one of MIT's insurers the legal costs which were incurred in the defense of the anti-trust matter several years ago.

Legal guidance continued to be provided for MIT students and student groups over a broad range of topics, including landlord/tenant disputes, personal injury, prospective employer contracts, and questions involving city, state, and federal agencies.

Thomas R. Henneberry

OFFICE OF FACILITIES MANAGEMENT SYSTEMS

The Space Accounting Group continued to provide key information to the Comptroller's Accounting Office in support of the calculation of the Indirect Cost Rates necessary to sustain federally sponsored research. Supported by OFMS's annual field audit of over 30,000 spaces, data provided by OFMS is used in 5 of the 13 cost pools described in OMB Circular A-21 which is audited by the Office of Naval Research (ONR). The department also provided accurate and timely accounting of the Institute's nearly 10 million gross ft²., in addition to its support of utilization studies, planning references, and space allocation activities of numerous administrative and academic departments, laboratories, and centers. During the year, the group's database and related floorplans were used directly by MIT's central administration and 72 of its departments, laboratories, and centers. The group also distributes data, reports, and floorplans over the internet (<http://web.mit.edu/ofms-space/www/>) via the World Wide Web, with an average of 79 requests per day.

Once again, the Systems Development Group provided continuous systems support and enhancement of MIT's existing suite of INSITETM systems as well as support for the ongoing design and development efforts for new facilities-related systems. This action permits MIT to stay abreast of both technology and Federal requirement changes.

The Consortium Support Group provided daily support to INSITETM users in the United States, Canada, Europe, Japan, and New Zealand via innovative, customer-oriented services. This included a variety of hands-on training courses, remote system installations and support via the Internet, an INSITETM home page, an 11-hour daily Help Desk via telephone, FAX or e-mail, and video training tapes for non-classroom oriented topics.

A decision was made during the year to cease the OFMS operations next year. In its place will be a non-profit MIT spin-off corporation, OFMS, Inc. This private entity, comprised of existing OFMS staff, will allow for MIT's continued use and support of its INSITETM suite of FM systems, as well as access to all new facilities management systems developed by the spin-off corporation, in exchange for an MIT license to use the INSITETM system and name. OFMS, Inc. will also provide continuing support to the existing INSITETM Consortium.

Beginning next fall, MIT will outsource its space accounting function to OFMS, Inc. for the remainder of the fiscal year. That will include all of the space accounting activities previously provided by OFMS, including field audits, database and floorplan maintenance and distribution, building and room numbering services, and Indirect Cost Rate data for the Comptroller's Accounting Office.

Kreon L. Cyros

PHYSICAL PLANT

The main focus of this year's initiatives was the continuation of reengineering efforts designed to provide timely, measurable, quality service for our customers and to reduce our operating costs. To support that mission and provide for greater customer interaction, we developed many new communication vehicles which provide voice and data options using the World Wide Web, e-mail, and voice mail. We also began a massive training effort for both our workforce and customers to keep current with the changes underway.

REENGINEERED OPERATIONAL UNITS

Custodial Services completely transitioned into a reengineered, team-based process. Twenty-six custodial teams were rolled out providing coverage for a three-shift, 24-hour, seven-days-per-week operation. Supervisors and coaches received extensive training on the development of a self-directed work force in which teams assume overall responsibility for day-to-day cleaning. Each custodial team received individual team training and is now receiving computer training as well. A Web page was created for the MIT community along with an easy access e-mail address for each team.

The Repair and Maintenance process, redesigned last year and further defined this year, was implemented in two local zones. The redesign involved many months of hard work from over 50 members of the department. The local zones, rolled out in the East and Northwest Campuses, reflect the beginning of a new structure and new process that demonstrates how we will accomplish cross-function repair and maintenance work in the future. This structure should lead us into a new and improved way of providing a higher level of service to our customers at reduced cost.

Project work included the development of a Master Plan for the campus fire alarm system and the modification of the fire alarm systems in Building E55 and 37. Work also began on upgrading the elevator systems in Buildings E38 and 7 and management was provided for the W84 elevator modernization project for the Housing Department. The Building 12 roof was replaced

The MIT Mail Services, a newly created entity within Physical Plant, became fully operational this year. In total, 30 Distributed Mail Centers (DMC's) were established which provide pick-up service throughout the campus. In addition, a new state of the art central mail facility was created in a portion of the former Office of Laboratory Supplies space in Building WW15. Incrementally, as postage meter leases expired, outbound mail is being processed by Mail Services. It is estimated that approximately 25 percent of all the outbound campus mail is now handled by the department, with new departments coming on-line daily. Operational changes were also made enabling bar-coding and presorting of mail, thereby bypassing several handlings within the Postal Service, which moves outgoing mail much faster.

OTHER OPERATIONAL UNITS

Grounds Services is the only operational unit not yet reengineered but that effort will begin early next year. During the year, Grounds provided campus landscape plans and upgraded garden areas by planting additional low maintenance shrubs and ground cover. Of special note, however, was their excellent response to the snowiest winter on record. Under very trying conditions, they managed to keep the Institute open and operating as close to normal as possible. This record winter left us with a tremendous amount of campus landscape repair and replacement in preparation for the first time ever consolidation of Commencement and Alumni activities.

ENGINEERING, DESIGN AND CONSTRUCTION

This year, after two years of construction, the long awaited cogeneration project commenced operation. This \$50 million project included the reconfiguration of the electrical distribution system which has allowed us to go from three incoming substations to one at the Central Utility Plant. Within weeks of the start of actual operations, the Massachusetts Department of Public Utilities ordered the Institute to pay the local utility company and exit fee of \$1.3 million a year for leaving their system. This was to become the first case of assigned stranded asset cost in the country. This order was appealed and the Institute continues to fight what is being considered a landmark case. Recently a program to expand the Central Utility Plant's chilled water capacity commenced with the purchase of a 5,000 ton steam driven chiller which is scheduled to be operational next year.

The Systems Engineering Group completed the separation of the potable and non-potable water systems in Buildings E17, E18, and E25 as part of a ten-year program.

The Design and Construction group managed 102 new projects. The Tang Center, a 32,000 ft.2 classroom building was completed this year and renovation of Building 56 began with completion expected next winter. The final portion of renovation work at Senior House began with completion scheduled in time for students to return to the dormitory for fall occupancy.

Campus elevator upgrades continued this year necessitated by changes in the 1996 Elevator Regulations and the Americans with Disabilities Act (ADA).

MANAGEMENT INFORMATION SYSTEMS

The Plant's MIS team provided superb I/T guidance and assistance in a year where computer usage and development grew by leaps and bounds. Support was provided for all of the reengineering efforts as well as for deploying computers and instituting training for hourly staff, including Repair and Maintenance, Custodial, and Grounds personnel. Several programs used by employees were enhanced including the programs to track equipment lockout-tagout procedures, environmental permit tracking, and project tracking for the Design and Construction Services group. Development and maintenance of CAD facility drawings depicting campus-wide and internal building systems continued.

Victoria V. Sirianni

PLANNING OFFICE

This year the Planning Office has undertaken a wide range of Institute planning projects. Some of the accomplishments of the year are listed below.

A revision of the MIT Capital Development Program, the extensive inventory of MIT's capital projects, their estimated costs, and their location on the campus was initiated to update the underlying financial models, based on changing institutional and market economic conditions. This document provides a comprehensive picture of MIT's capital needs and their implications for land and financial resources for the next ten to 15 years.

The Planning Office provided continuing support to Resource Development in preparing the fund-raising program for the proposed Engineering Complex. The need for prospective capital financial analysis and supporting graphic materials is expected to grow as MIT considers new or alternative resource development strategies.

The groundwork for major progress in the development of a geographic information system (GIS) is nearly complete. Software technologies compatible with the existing digitized campus base have been acquired and are being evaluated with the intention of implementing such a system during the next year. These efforts include consolidation of physical surveys and title research initiatives to clarify long-standing ambiguities between Cambridge and MIT land ownership records.

In an attempt to complete the land assembly for the east campus, efforts continue to acquire the former city fire station at 350 Main Street in Kendall Square.

Progress continues in support of two major roadway improvement initiatives begun last year. The first involves the Memorial Drive/Massachusetts Avenue intersection where new signals and turning lanes will improve pedestrian safety and traffic movement. The second, reconstruction of Massachusetts Avenue from Memorial Drive to Lafayette Square, will improve both safety and aesthetics along this major transportation artery. In addition, the Massachusetts Avenue reconstruction will include support for increasing the use of bicycles as a commuting option.

Parking on the campus is always an issue of great concern. This year the Institute began to charge for parking on campus. The Planning Office provided the staff support for an ad hoc task force charged with conducting a review of policies and making recommendations for change. In addition, changes effected by reengineering on such things as purchasing and distribution of mail and materials will have a significant impact on MIT's parking resources, service circulation, and pedestrian safety. The office is providing analyses and solutions to these service problems as well as continuing to provide staff support for the Institute's Parking and Transportation Committee.

The Planning Office continued its efforts to implement an academic facilities plan for the main campus. This includes occupancy analysis and planning coordination for the renovation of Buildings 16 and 56 and the related relocation options for the current occupants of Building 20. Planning coordination for the renovation of space resources in the School of Architecture and Planning also continued. The first phases of those renovations are now complete.

The proposed relocation of the Electrical Engineering and Computer Science laboratories (Artificial Intelligence and the Laboratory for Computer Science) from Technology Square to the campus, to a proposed new engineering complex, continues with a recently-completed study of fund-raising opportunities.

Support of the Athletics department continued this year with the development of plans for improved tennis facilities, expanded rowing facilities, and improved security around the outdoor fields. The office also continued to provide support for the development of Phase III of the Central Athletic Facilities.

With new and renovated facilities making increasing demands on MIT's central utilities, Planning Office staff have been working closely with staff in Physical Plant to ensure that expanded utility capacity is available when needed and is integrated into the overall campus master plan.

Efforts continue to improve the availability and quality of student housing. Plans for the renovation of Senior House, the Institute's oldest student housing facility, were completed and construction is underway. Planning has also begun for the restoration of Baker House in anticipation of its 50th anniversary in 1999.

Progress continued on a comprehensive housing plan which would lead to the near-term development of graduate housing in the Albany and Sydney Street areas. In addition, the Planning Office staff are exploring ways of stimulating MIT and private sector partnerships designed to increase the housing inventory available to the MIT community.

As part of MIT's commitment to permit equal access to all of its facilities, implementation of the comprehensive barrier removal plan continued.

The office continued to provide planning and staff support to the Office of Government and Community Relations, the Real Estate Office, and Physical Plant's Space Administration section. In addition, the office continued to produce a variety of materials during the year in support of academic planning.

O. Robert Simha

PURCHASING

During the year, the Office of Laboratory Supplies (OLS) closed its operations and inventory was liquidated. Layoff notices were given to 29 employees within the department. Of that group, only three employees did not find employment prior to the end of their notice periods.

The entire store inventory was completely liquidated either through sales, donations, or disposal. Over \$350,000 of inventory was sold directly to MIT partners (VWR, Office Depot, and BOC Gases). In addition, a three-day sale for the MIT community was held resulting in sales of \$18,500. Finally, approximately \$65,000 worth of inventory was donated to various MIT departments and another \$1,000 of inventory was donated to the Cambridge public schools.

REENGINEERING PARTNERSHIP ARRANGEMENTS

New procurement partnership arrangements commenced this year. The selected partners are Office Depot for office and computer supplies; VWR for scientific apparatus, supplies, and chemicals; BOC for the purchase, distribution, and tracking of gas cylinders; and Sterling/Olsten for temporary help.

ELECTRONIC CATALOG SYSTEM

Department members participated in the design and pilot of the MIT Electronic Catalog (ECAT) System, a World Wide Web based ordering system, which will enable users to order small dollar items directly from the partners. Currently there are 20 pilot users ordering via ECAT to Office Depot and VWR and processing payment through American Express.

SAP

The Purchasing Department took a number of steps in preparation for the migration from the current financial system to the SAP system. This preparation included replacing Macintosh computers with DELL personal computers and training department members in the use of personal computers, Netscape, and Eudora. SAP navigation and architecture courses and network drops were also installed for every computer.

The Institute's on-line, interactive electronic requisitioning system (EREQ) is still going to be available.

ELECTRONIC REQUISITIONING SYSTEM

As mentioned above, the Electronic Requisitioning (EREQ) System is the Institute's on-line, interactive electronic requisitioning system. This free service is available to all members of the community and supports the following major functions: electronic requisitioning to Purchasing and Subcontracting, electronic speed orders, electronic requisitioning to internal providers (including partners), electronic routing, and access to Purchasing and Accounts Payable Systems' information.

Use of the EREQ system increased by 4 percent this year. Over 2,000 users logged on to the system 123,000 times, generating 286,000 transactions to view the status of their business, to create 44,110 electronic requisitions and speed orders to outside vendors, and to create 14,595 electronic requisitions to Institute internal providers.

CAMBRIDGE FIRST DAY

"Cambridge First Day" was the theme developed to remind and inform Cambridge officials, business owners, and residents of the substantial purchasing business which MIT places each year with Cambridge companies. As part of the festivities this year, the Institute hosted a celebration of the biotechnology industry in Cambridge, commemorating the Institute's fourth annual Cambridge First Day.

The Purchasing Offices employ a "Cambridge First" policy in their purchasing activities, with the goal of placing as much business as possible with Cambridge companies. Last year, MIT contributed approximately \$43,200,000 to the Cambridge economy. Direct purchases of goods and services amounted to \$33,200,000. The additional \$10,000,000 represents municipal revenue derived from MIT's payment of real estate taxes, municipal licensing fees, a voluntary payment in lieu of taxes on tax exempt property, and MIT's public improvements on municipal streets and sidewalks.

MINORITY AND WOMEN-OWNED BUSINESS PURCHASING PROGRAMS

Business placed Institute-wide under these affirmative action procurement programs resulted in the award of over \$14.5 million to minority and women-owned business concerns. Over \$5.5 million was awarded to 800 minority businesses and over \$9.1 million was awarded to 1,900 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 this effort 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 over 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.

Barry M. Rowe, the Director of Purchasing and Stores, retired after 34 years of service to the Draper Laboratory and the Institute.

Diane Shea

SAFETY OFFICE

The Safety Office continued to provide advice, counsel, and programs to the community in order to promote a safe environment and to implement safety related functions to ensure a standardized compliance with Institute policies and government legislation.

A Shipping of Hazardous Materials Program was implemented last year. The Safety Office developed the program in conjunction with the Environmental Medical Service (EMS).

In addition, a program to dispose of bottles used in academic classes continued to evolve and is now in place after three years of development with the Office of Laboratory Supplies and various other vendors.

The lockout/tagout program was changed to include procedures at the Central Utility Plant (CUP). The Safety Office, Physical Plant, and EMS are developing a more comprehensive and proactive safety program for the CUP.

Certain administrative functions in the workers' compensation area were transferred from Liberty Mutual to Sedgwick James.

The number of reports of Repetitive Stress Injuries (RSI) continued to increase throughout the year. The Safety Office alone reviews approximately ten complaints a month and the frequency appears to be rising.

The volume of chemical waste remained stable during the year and a competitive bidding process helped to keep chemical waste disposal costs in check. The use of the Central Utility Plant's new neutralization system, the third such system on campus, began this year. A fourth will follow next year when work in Building 56 is completed.

The Safety Office is in the process of reviewing the Haystack Observatory health and safety program. A safety committee has been formed and is now functioning.

Personnel at the Bates Linear Accelerator (LINAC) are making progress on implementing their Lockout/Tagout program. In addition, all Underground Storage Tanks have either been taken out of service or removed. Due to an inspection by the Department of Environmental Protection, LINAC has had its Very Small Quantity Generator status changed to a Small Quantity Generator.

PERSONNEL

Personnel changes in the Safety Office were particularly notable this year. This small department lost two of its administrative staff to retirement; John Fresina, the Director and Ray Diffley, the Associate Director. A third staff member, Don Batson, will also retire early next year.

In addition, we are proud to note that Mr. Fresina was the recipient of this year's Gordon Y. Billard Award. This award is made annually for special service of outstanding merit performed for the Institute.

W. Jerry Diaz

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 to 26 Corporation visiting committees.

CORPORATION MEETINGS

ORIENTATION PROGRAM AND ANNUAL MEETING

On October 5, 1995, an orientation program was held for new members of the Corporation. In the evening, new members and their spouses and guests were joined by the Executive and Membership Committees for a reception and dinner.

At the annual meeting on October 6, 1995, new members were introduced. The Corporation approved the action of the President in the awarding of September degrees. Memorial resolutions were presented in honor of Thomas D. Cabot and Hajime Mitarai '65. Members heard reports from the President, Treasurer, Vice President for Resource Development, and the chairs of the Auditing Committee, Membership Committee, Salary Subcommittee of the Executive Committee, and four visiting committees. Members of the Academic Council joined Corporation members and their spouses and guests for luncheon following the meeting.

DECEMBER MEETING

On December 1, 1995, George N. Butzow '51 was elected to complete the term of the late Hajime Mitarai '65. The Corporation approved a new joint program in System Design and Management in the School of Engineering and the Sloan School of Management. Edward O. Vetter '42 transferred to the status of Life Member Emeritus. Memorial resolutions were presented in honor of Life Member Jerry McAfee '40. Resolutions were also presented in honor of the conferral of the 1995 Nobel Prize in Chemistry on Mario J. Molina, Lee and Geraldine Martin Professor in Environmental Studies in the Department of Earth, Atmospheric, and Planetary Sciences and the Department of Chemistry. Professor Molina briefly described his research work in ozone depletion and its implications for the world's environment. Members heard reports from the President and the chairs of the Membership Committee and four visiting committees. Professor Molina, the Dean of Science and the Heads of the Departments of Earth, Atmospheric, and Planetary Sciences and of Chemistry, their spouses, and Lee and Geraldine Martin and their guest attended the reception and luncheon following the meeting.

MARCH MEETING

On March 1, 1996, the Corporation approved the action of the President in the awarding of February degrees. Joel Moses, Provost, was approved as a fund administrator of the Basic Research Fund in the Physical Sciences. Memorial resolutions were presented in honor of Herbert H. Dow, Jr. '52. Resolutions were also presented on the dedication of the Jack C. Tang Center for Management Education. T. A. Wilson transferred to the status of Life Member Emeritus. Reports were presented by the President and the chairs of the Investment Committee, Corporation Joint Advisory Committee on Institute-Wide Affairs, Membership Committee, Screening Committee, MIT Community Service Fund, two visiting committees, and the President of the Association of MIT Alumni and Alumnae. Members of the Academic Council joined the members of the Corporation for a reception and luncheon.

COMMENCEMENT MEETING

The quarterly meeting was held on June 7, 1995, prior to the Commencement exercises, at which the speaker was Vice President of the United States Albert Gore. The Corporation approved the awarding of June degrees, elected new members, and approved the establishment of a Master of Engineering degree in the Department of Nuclear Engineering. Resolutions were read to honor four members completing their terms of service on the Corporation. Dr. Gray announced his intention to complete his service as Chairman of the Corporation in June 1997. Members heard reports from the President and the chairs of the Membership Committee, Screening Committee, and three visiting committees. A reception and luncheon for members of the Corporation were held at the Chairman's residence following Commencement exercises.

CORPORATION MEMBERSHIP

Completed service effective June 30, 1996: Karen W. Arenson, William R. Brody, DuWayne J. Peterson Jr., and Reginald D. Tucker.

Leave of Absence: Shirley A. Jackson, Life Member, leave of absence for government service continued.

Elected to term membership effective December 1, 1995 – June 30, 2000: George N. Butzow

Elected to a five-year term effective July 1, 1996: Josephine S. Jiménez, L. Robert Johnson, Michael M. Koerner, Claudine B. Malone, Dana G. Mead, Paul Rudovsky, Theresa M. Stone, R. Robert Wickham, and Elliot K. Wolk.

Elected Life Member effective July 1, 1996: Alexander W. Dreyfoos Jr., Christian J. Matthew, Morris Tanenbaum, and William J. Weisz.

Ex officio member for one-year term effective July 1, 1996: DuWayne J. Peterson Jr., 1996-97 President of the MIT Association of Alumni and Alumnae.

Transferred to Life Member Emeritus: Joseph G. Gavin, Jr. (October 1995); Edward O. Vetter (December 1995); and T. A. Wilson (March 1996).

Deaths: Hajime Mitarai, August 31, 1995, Jerry McAfee, October 14, 1995, Herbert H. Dow, 2nd, January 26, 1996

CORPORATION COMMITTEES

ADVISORY COMMITTEE ON SHAREHOLDER RESPONSIBILITY

D. Reid Weedon, Jr., continued as Chair, with Vice President for Finance 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 19, 1996, and conducted two telephone polls. Members voted on 21 resolutions submitted to ten companies whose stocks are held by MIT in its general investments. No single issue or set of issues dominated the resolutions. The topics included smoking, the environment, nuclear power, and human rights in the United States and abroad. The number of issues before the committee continued to decline. Compared to 1995, the number of resolutions decreased by ten, and the number of companies decreased by nine.

AUDITING COMMITTEE

Meetings were held on October 5, 1995, and on February 29, 1996. Attendees at each meeting included Auditing Committee members; representatives from Coopers & Lybrand, MIT's independent public accountants; and invited members of the MIT administration.

Financial statements for fiscal year 1995 and a report on recent audit developments were discussed at the fall meeting. At the spring meeting, the MIT Audit Division reviewed its current plans and prior year accomplishments; Coopers & Lybrand presented its audit plan for fiscal year 1996; the committee discussed implications of new Financial Accounting Standards on the treatment of unrealized appreciation on funds, and reviewed plans to implement Release I of the new SAP financial system.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS

During the academic year 1995-96, CJAC held four meetings, which the Dean for Undergraduate Education attended as a guest. The committee discussed a number of issues relating to the work of the presidential Task Force on Student Life and Learning, including issues of self-esteem of students while enrolled at the Institute, views of alumni/ae on the MIT student experience, and the necessary balance between academics, residential life, and extracurricular activities. CJAC intends to focus next year on ways for the Corporation to interact more easily and more frequently with students and faculty.

DEVELOPMENT COMMITTEE

This committee is covered in the annual report of the Vice President for Finance and Treasurer.

EXECUTIVE COMMITTEE

During the past year the Executive Committee held ten meetings. Its agenda included such topics as changes in the senior administration, new directions in education and research, federal relations, industry relations, management of the endowment, the retirement incentive program, policies relating to ROTC programs on campus, and the Institute's planning, budget, and reengineering activities.

During the spring, a subcommittee was appointed to serve as the search committee for a successor to Dr. Gray, who announced his decision to complete his service as Chairman of the Corporation on June 30, 1997.

INVESTMENT COMMITTEE

The Investment Committee held three regularly scheduled meetings during fiscal year 1996. 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 four other investment management firms, of equity investments in smaller capitalization companies. The program for domestic and international alternative investments to publicly traded securities has been expanded. These alternative investments – including venture capital, private capital, real estate, event arbitrage, and distressed debt – are typically managed by several investment managers through pooled investment funds.

Membership Committee

The Membership Committee held three meetings during the academic year to discuss matters concerning membership on the Corporation, and nominations to various Corporation standing committees and committees of annual recurrence.

Screening Committee

The Corporation Screening Committee for Nomination of Recent Graduates held an open meeting for students on October 2, 1995. Two teleconferences and two committee meetings were held in January and February. The committee chose a ballot of nine nominees from a group of 71 candidates (48 of whom returned a second, more detailed nomination form requested by the committee). R. Robert Wickham '93 won the nomination and was elected to serve a five-year term on the Corporation.

Visiting Committees

During the academic year 1995-96, twelve visiting committees convened: Architecture and Media Arts and Sciences; Athletics, Physical Education, and Recreation; Earth, Atmospheric, and Planetary Sciences; Linguistics and Philosophy; Materials Science and Engineering; Mathematics; Mechanical Engineering; Nuclear Engineering; Physics; Sloan School of Management; Sponsored Research; and Urban Studies and Planning. In lieu of a full, two-day meeting, Civil and Environmental Engineering met for a half-day update only.

In 1995-96 the Institute's 26 visiting committees were comprised of 389 persons and 466 membership positions: 61 Corporation members filled 130 slots; 174 presidential nominees filled 179 slots; 156 alumni nominees filled 157 slots. (Two people each filled both a presidential nominee slot and an alumni nominee slot.) Women comprised 24 percent of the visiting committee membership, and minorities 12 percent; 60 percent of the members were affiliated with corporations, 32 percent with academia, 6 percent with government, and 2 percent with foundations.

PERSONNEL CHANGES

Susan A. Lester joined the Corporation Office in August 1995 as Associate Secretary of the Corporation, transferring from the Personnel Office where she served most recently as Assistant Manager for Wage and Salary Administration. Lois A. Graham left the Institute at the end of the year to remain at home with her child. Rachel S. Rowe joined the Corporation Office in mid-October, and Jennifer N. Carroll will leave MIT in August 1996 to attend graduate school.

Kathryn A. Willmore

VICE PRESIDENT FOR FINANCE AND TREASURER

In fiscal 1996, revenues and unrestricted gifts were \$1,266.1 million and expenses and transfers were \$1,274.6 million. This produced a deficit of \$8.5 million, and is slightly lower than the projected deficit approved by the Executive Committee in May 1995. The deficit was brought into balance by using the Research Reserve investment income, and partial decapitalization of the principal of that Reserve. This year's deficit resulted from reduced overhead recovery, lower Industrial Liaison Program fees, higher employee benefits costs, and higher than expected utilities expenses, in part due to the start-up of the cogeneration plant. The costs associated with the early retirement incentive that are being funded from existing assets including internal advances, certain unrestricted funds and funds functioning as endowment will not affect the deficit. On the positive side, unrestricted gifts received during the year were higher than budgeted, investment income and patent revenues increased, and the need for unrestricted support of undergraduate financial aid, and departmental expenditures were both lower than budgeted.

MIT had modest surpluses in the operating budget in fiscal 1984-1988, and modest deficits in fiscal 1989-1994. The deficit in fiscal 1995 was \$10.1 million and, as noted above, the deficit for fiscal 1996 is \$8.5 million. It is expected that over time reengineering will have a significant impact on the Institute's expenses and can bring financial operations into balance.

One of the highlights of the year was the upgrade of MIT's bond rating by Standard & Poor's to Triple A. They reported that this reflects MIT's "conservative management practices and very low debt," and stated further that it was "the only rating upgrade to Triple A in the education sector for almost a decade." MIT joins only 12 companies and 6 other universities with a Triple A rating.

It is important to note that MIT is a financially strong institution with its over \$2.5 billion endowment at market value, and continues to add to its financial resources. Its total invested assets exceeded \$2.9 billion at June 30, 1996. Over the past five years the market value of all general investments increased by 60 percent.

The Institute continues to control costs and has been engaged in a reengineering effort during the last three fiscal years. In financial operations this effort is focused on management reporting affecting all fiscal accounting and payroll procedures. The R3 financial accounting system developed by SAP AG in Walldorf, Germany was selected to replace the present applications. Work continues on this project, looking to implementation of Phase I in the central administration early in fiscal 1997 and Phase II in the departments, laboratories and centers by the end of fiscal 1997. Members of the administrative staff in financial operations, academic and administrative departments, centers and laboratories have been involved in all phases of this project. Their cooperation and valuable input assures the successful design and implementation of the management reporting system.

FINANCIAL OPERATIONS

There are now 11 staff members in Financial Operations dedicated full time to the Management Reporting/Financial Operations Reengineering project, 9 of whom transferred from Institute departments. More than 60 Institute staff members are involved in this effort, most of whom maintain their primary affiliations with their home departments.

The following reports of each department (Comptroller's Accounting Office, Audit Division, Office of Financial Planning and Management, and Lincoln Fiscal Office) will highlight the activities in their respective departments during the year. Effective July 1, 1996, the Purchasing Department, previously part of Financial Operations, was transferred to the supervision of the Senior Vice President.

I am grateful to the Financial Operations staff for their dedication to the effective management of MIT's resources, and for their cooperation and support during this challenging time. It is my expectation that our new management reporting systems will bring us to a higher level of efficiency with the ability to provide improved financial information while also simplifying administrative processes. It will also result in career opportunities for staff.

AFFIRMATIVE ACTION EFFORTS IN FINANCIAL OPERATIONS

The past year was a continuation of uncertainty relating to permanent staffing needs to fulfill the requirements associated with reengineering. In addition, the early retirement incentive offered to all eligible Institute employees resulted in 27 retirements. More than half of these positions are being eliminated in anticipation of implementing

the new management reporting system. A small number of new hire replacements, and staff transfers, promotions and reassignments are meeting the financial operations needs. Women represent more than 50 percent of the staff in financial operations, and underrepresented minorities comprise about 12 percent. During the year there were opportunities to promote women and minorities, including promotions from support to administrative staff positions. Financial Operations remains dedicated to increasing the diversity of its work force at every level and seeks qualified women and minority candidates for all openings.

MIT PRESS

On July 1, 1995, the MIT Press was transferred from supervision of the Associate Provost for the Arts to the Office of the Vice President for Finance and Treasurer. The Press had a good year, as described in their separate report which follows. Book sales exceeded the original sales target, with 180 new titles and 48 reprints. Foreign sales continue to represent an important segment of its business. The Press is developing a web site operation that includes its complete catalog, digital books and electronic journals. In the journals area, the Press launched 4 new print journals and 3 new electronic journals last year, remaining a leader in emerging forms of the electronic media.

The MIT Press Management Board, chaired by the Vice President for Finance and Treasurer, met twice during the year. Discussions continue toward developing a clearer business arrangement with the Institute and defining the long term role of the Press. The expansion of the Board has brought new strength and insights to all aspects of the Press's business.

Glenn P. Strehle

AUDIT DIVISION

As the entire Institute faces dramatic changes in the delivery of administrative and other support services through reengineering, audit focus and techniques are rapidly adapting to the impact of the new SAP integrated financial system, restructuring due to early retirement incentives, and major operational changes.

Internal auditing remains an integral part of MIT's overall internal control environment. To maximize effectiveness, our focus adjusts to the ever-changing risk levels of the Institute, while maintaining our fundamental role of providing reasonable assurance to management that adequate internal controls are being maintained, policies are being adhered to as intended, and assets are properly safeguarded. This is accomplished 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 external audit 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 that guide us in the discharge of our duties to ensure proper objectivity, independence and quality control of our audits.

Our compliance audits address both government compliance issues, as well as adherence to Institute internal policies and guidelines. From a financial compliance perspective, about one-third of the 150 departments, labs and centers received a visit from the Audit Division during the past year, kicking off our third Institute-wide review cycle. These "Departmental Reviews" remain one of our most visible and effective compliance audit initiatives developed to assess the level of financial accountability and basic internal controls within each operational unit. With the introduction of a refined audit program, improved financial accountability across the Institute, and a significant reduction in effort needed to develop supporting workpapers, the allocation of audit effort to these reviews has decreased markedly. These freed-up audit resources have been reallocated to a widespread collaborative effort with the Office of Environmental Medical Services, undertaken to assess the Institute's compliance with OSHA's Laboratory Standard relating to the implementation of written Chemical Hygiene Plans.

Over the past year a large segment of our reengineering-related audit effort was oriented to operational issues. An operational focus analyzes processes within administrative functions with an eye to strong internal controls, operational effectiveness and efficiency. Audit Division involvement with the introduction of reengineered processes has raised, and will continue to raise cost efficiency, effectiveness, and control related issues. Also of

concern is MIT's increased reliance on key outside service providers. As we consolidate our supplier base, the reliability of vendor operations, and their supporting information systems, become integral to maintaining smooth Institute operations.

Evaluations of financial accountability and control remain a significant commitment of audit resources each year. Consistent involvement in construction activities, Institute inventories and cash operations, in addition to a varying selection of other financial audits, help to maintain and continually strengthen MIT's overall financial control environment.

Staff highlights include one member's completion of all four parts of the Certified Public Accountant examination. 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 3 CPA, 4 CIA, and 2 CISA designations.

Charles A. Shaw

COMPTROLLER'S ACCOUNTING OFFICE

PAYROLL

Testing to receive Graduate Student Appointments electronically from the Student Information System has been completed. Five departments have been selected to initially participate in the pilot process with an expanded process to be offered to the remainder of the community pending the results of the pilot program.

Internal Revenue audits continue to proceed both from the regional Internal Revenue Service (IRS) office as well as the Coordinated Examination Program audits at the national level. The calendar years 1985 and 1986 audit is in the hands of an IRS Appeals Officer (following our meeting with the IRS in May 1996) who has indicated that he will render a decision promptly.

FINANCIAL SYSTEMS

Several personnel from this area continue to participate on the Reengineering Financial Management Team, Configuration Team, and Management Reporting Team as well as participating in training sessions. Personnel instruction in the basic SAP courses was begun and will continue into July 1996 and then instruction in job specific areas of the SAP system is scheduled to begin.

BENEFIT ACCOUNTING

The project to modify the Pension Accounting System to recognize a monthly valuation for the Variable Fund was implemented in July 1995.

Significant effort was directed to handling the processing of the Early Retirement Incentive Program. This involved the manual processing of data for the first two months of the program until the electronic transfer capability was implemented to process the July 1, 1996 retirees.

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, 13,700 newly acquired items of moveable equipment were identified and tagged. The reconciliation of the equipment biennial physical inventory is almost complete. Two hundred five final inventories were submitted as part of closing out the contracts, grants, and agreements. There were 488 financial reports prepared and submitted to various government agencies. Three hundred fifty-six items of excess government equipment with an original acquisition cost of \$2,028,891 were acquired. Six hundred forty-seven items of equipment with an acquisition value of \$485,250 were transferred between MIT departments as part of a reutilization program. Equipment, unneeded or unusable by the MIT Community, was sold for \$145,182 providing funds for replacement equipment. One hundred forty-eight items of equipment were donated to non-profit organizations.

The costs of capital space changes, major renovations, and new building construction continue to be tracked.

A Property Application (SumPROP) was delivered by the Comptroller's Accounting Office programming staff which gives Property Office users additional system functionality and SumMIT users the ability to query and report on equipment data.

Requests from various academic and administrative departments for equipment information resulted in over 500 reports being generated and distributed to the departments.

LINCOLN FISCAL OFFICE

In partnership with Group 48 (Computer & Telecommunication Systems), version 2.7.2 of the Lincoln Executive Information System (LINEIS) was completed and the Lincoln Information System (LFOINFO) was discontinued. The new Cash Till system was implemented. The new Northwest ticketing chargeback system has been installed into production. Disaster recovery planning and preparation efforts were continued. The Accounts Payable and FRAP checks were incorporated into the new Check Writing System that was introduced in the Cashier's Office. The Electronic Time (E-Time) Sheet System was modified to allow for the input of both regular and overtime percentage distribution.

Automation of the Technical Certification System which will allow for electronic approvals is well underway. OS/400 V3R1 will be installed on LFO400 early in July 1996.

Philip J. Keohan

OFFICE OF FINANCIAL PLANNING AND MANAGEMENT

To assess the impact of changes in the internal and external environment that affect MIT's financial position and to advise senior management on the influence these changes will have on MIT's current and future programs; to support the educational, research, and public service programs of the Institute by providing financial management information and recommendations necessary to make resource allocations, and to execute operating and capital programs, both current and future in nature.

The major functions of the office include: (1) the annual operating budget (preparation, monitoring, and closing); (2) the capital budget (construction, renovations, and financing of completed and future projects); (3) financial planning for ten years into the future, (4) systems design and operation to support these three basic functions; and (5) special studies.

OPERATIONS

In addition to the normal duties and reports associated with the annual operating budget, we developed 2 new formats for presenting the budget. The first new format was prepared for the Provost. The normal budget profile for each department was expanded to include comparative information from the prior year, explanation of year to year changes, and descriptions of any special programs or funding arrangements. The second new format was requested by the Executive Committee and shows the total of all activities by department.

CAPITAL BUDGET

The Institute's capital and major renovations budget is \$330 million for 22 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. The capital budget also includes \$310 million for 31 completed projects with debt outstanding, and \$935 million for 26 proposed projects.

The office was involved, along with the Deputy Treasurer's Office, in the preparation and sale of \$125 million of medium term notes. This effort included dealings with underwriters, lawyers, auditors, and MIT departments in the preparation of legal and offering documents. In addition, it included researching questions from and providing information to both Moody's and Standard and Poor's Rating Agencies. Moody's sustained MIT's Triple A rating and Standard and Poor's upgraded MIT's non-collateralized issues from AA+ to Triple A.

The Institute, in accordance with the Financial Accounting Standards Board guidelines, revised the schedules used in the Report of the Treasurer for 1995 (report prepared in Fiscal 1996). The new schedules required the development, and implementation of a plan to properly reflect the use of unrestricted funds for capital purposes in the financial statements.

The staff also developed a capitalization policy for non recoverable projects based on the requirements of the Federal Office of Management and Budget Circular A-21.

FINANCIAL SYSTEMS

Major new developments to our financial system have been suspended while reengineering of MIT's accounting and management reporting processes are under review and redesign. The choice of SAP as the new accounting and reporting system will inevitably require changes in both accounting structure and philosophy. These changes will require reworking of the office's budgeting and planning methods and processes.

The addition of new reports for use by senior management or the Executive Committee requires some development work to support the production of these reports. The *Comparison of Fiscal Operations* report was added this year which compares financial information at the end of any month with comparable data for the last two years.

SPECIAL STUDIES

Reengineering was the dominant focus of management work during the year and will result in new processes for budgeting and reporting. The results of reengineering should hold expenses to modest increases or show a decline in terms of constant dollars.

The staff participated in the Institutional Reporting Requirements Team (IRRT) and the Closing Process Team for the Management Reporting/Financial Operations reengineering project, and served on the committee for the Student Services Reengineering team. The staff was also heavily involved as resource persons as requested.

John A. Currie

MIT PRESS

The Press had a very busy and satisfying year. While the performance of the superb front list in the book division got our hopes up about exceeding sales forecast, unusually heavy returns from the chains in late spring dampened expectations. The Press did, however, meet its original sales target at \$14,090,000 and once again reported a profit from operations: \$252,000 compared to the original forecast of \$163,000. This included an adjustment of the way interest on Pool C reserves and the payment of interest on the capital debt to MIT are reported. The contribution to graduate student education by way of RA/TA this year was \$429,000, resulting in a deficit of \$177,000 carried forward on the balance sheet. This amount was lower than the forecast deficit of \$267,000.

Front list sales, at \$5,592,000 were the best in many years and it will be hard to beat in terms of the quality, depth, and reception. The Press published 180 new titles compared to 153 for last year and 48 reprints compared to 44 last year.

The MIT Press Digital Projects Lab (the renamed web group) made some impressive advances. It manages a web site which includes the Press's complete catalog, digital books such as *City of Bits*, and 6 electronic journals. It will oversee the research and development of CogNet, the proposed definitive website for the cognitive and brain sciences.

Foreign sales continue to be robust with sales to the export markets totaling 37 percent of total sales. The MIT Press bookstore continues to grow within its confined space, recording a record \$745,000 in sales in fiscal 1996 compared to \$610,000 in fiscal 1995.

The Press has reorganized the marketing operation, revising job content and promoting staff, and has also reorganized the acquisition department. The journals division continues to make significant strides, launching 4 print journals and 3 electronic journals last year.

Faculty serving on The MIT Press editorial boards in 1995–96 were Harold Abelson, Julian Beinart, Oliver Blanchard, Josh Cohen, Anita Desai, Peter Diamond, Deborah Fitzgerald, Samuel Jay Keyser, Albert Meyer, and William Mitchell. Dean Mitchell served as Chair. Frank Urbanowski, Glenn Strehle, and Anne Wolpert were ex-officio members.

On the management front, Glenn Strehle, MIT's chief financial officer, continues to play a key role as chairman of the Press management board. The MIT Press Management Board met twice during the year. Members of the board were: Joseph Esposito, Publishing Consultant; Brewster Kahle, President, Internet Archive; Steven R. Lerman, Professor in the Civil Engineering Department; William J. Mitchell, Dean, School of Architecture and Planning; Richard E. Oldenberg, Chairman, Sotheby's; Dr. Richard Rowe, President, RoweCom; Jerome S. Rubin, former Group Vice President of Times Mirror; and Jack Schulman, former Director of Cambridge University Press. William Mitchell and Frank Urbanowski served as ex-officio members of the management board.

Book sales for this fiscal year were very good, with an increase of 6.6 percent over the previous year. Bookstore sales through the large chains increased dramatically, by about 23 percent, while sales through independent bookstores were essentially flat. Unit sales increased by a modest 2.1 percent. International sales were again very strong, accounting for almost 37 percent of our total sales.

The subsidiary rights program has at its core the sale of translation rights to MIT Press books. The income generated by the licensing of foreign rights declined by 5 percent since fiscal 1995, although the number of transactions remains constant. Income in this category fell 7 percent below forecast for this fiscal year. Unlike previous years, when the Press had 1 or 2 prominent (and short) titles appropriate for translation, transactions during fiscal 1996 involved sales within a moderate range in terms of the advances offered by foreign publishers. Overall, subsidiary rights income in fiscal 1996 decreased by 3 percent since fiscal 1995. Income from the sale of electronic and audio visual rights in fiscal 1996 was over \$8,000.

Income from the reprint program, which includes permission to photocopy and to publish excerpts from Press material, increased by 9 percent. A predictable drop in income, as a result of a 1991 court decision prohibiting unauthorized photocopying, has stabilized. Income from the reprint program exceeded the forecast by 12 percent.

Income from sales to book clubs decreased by 59 percent. This market is the least predictable for the sale of subsidiary rights; purchases by book clubs depend not only on the list, but also on the increasingly narrow margins that determine the net amount that book clubs are able to pay. The Press was able to place one main selection with the Library of Science, and for the first time in several years, Readers' Subscription is carrying 2 Press titles. Income in this category fell short of forecast.

Fiscal 1996 export sales increased by 11 percent and, for the first time, totaled in excess of \$5 million. All major export territories except Canada produced percentage sales increases greater than the overall Press increase of 6.6 percent. Sales in Japan were exceptionally strong, increasing more than 25 percent over fiscal 1995.

Sales in Canada in fiscal 1996 were almost 5 percent lower than the previous year, and far below the peak of \$565,600 reached in fiscal 1993. The strength of the US dollar against the Canadian dollar, and the permanent increase in book prices resulting from the imposition in calendar 1991 of a 7 percent national tax on books, continue to depress that market.

The MIT Press exhibited books with its own staffed booth or table at more than 50 US academic conferences in fiscal 1996, and displayed books at over 75 others through combined exhibits. Sales generated from exhibits were \$200,692 in fiscal 1996. The Society for Neurosciences meeting was once again the standout meeting of the year. Book sales at the annual meetings of both the Allied Social Sciences Association and the College Art Association broke previous records. Also of note in fiscal 1996 were two small but highly successful meetings: the Towards a Science of Consciousness Conference in Tucson, and the North Eastern Linguistics Society Meeting in Cambridge.

Advertisements for MIT Press books appeared in 500 trade and scholarly journals and magazines, as well as conference programs. All of these ads were produced in-house. The amount and frequency of advertising increased over the year, and stayed under budget.

The Press's books and authors received prominent coverage in a wide array of general and scholarly media this year. Since last July, 6 MIT Press titles have been reviewed by *The New York Times Book Review*; in December, The *Book Review*'s editors chose 2 additional titles as "Notable Books of the Year 1995."

The MIT Press won 5 awards this year in the Professional and Scholarly Publishing Awards Competition of The Association of American Publishers.

City of Bits On-line has been named one of the Top 5 percent of the Web by Point Web Reviews. Point provides descriptions and ratings of the Top 5 percent of all World Wide Web sites, while searching for the best, smartest, and most entertaining sites. Their rating scale reaches from 0 to a perfect score of 50 in the categories of content, presentation, and experience. *City of Bits On-line* received a score of 43 in Content, 38 in Presentation, and 40 in Experience.

The MIT Press on-line catalog has been listed as a 4-Star Site on the Magellan Internet Directory. This is the highest rating a website can achieve in Magellan, the McKinley Group's comprehensive Internet directory.

In fiscal 1996, the Journals program had gross sales of \$4.4 million, a 12.8 percent increase over last year. The new journals added in fiscal 1996 were *Harvard International Journal of Press/Politics*, *Journal of Functional and Logic Programming*, *Review of Economics and Statistics*, *Studies in Nonlinear Dynamics and Econometrics*, *Terra Nova: Nature and Culture* and a print version of an electronic journal, *Psyche*. The division ends the year publishing 39 journals.

Frank Urbanowski

TRIBUTE TO JAMES J. CULLITON

There are people who touch our lives and there are people who touch our hearts. Few people, however, do both. James J. Culliton did throughout his life and we are all the better for having known him and having been influenced by him.

Jim was truly unique: his humanity, his caring, his knowledge, his skills as a manager and mentor, his eternal optimism, and his full and enthusiastic involvement in what we did and how we did will stay with us. More importantly, Jim will always be remembered for his humor. Whether it was thinking about walking the infinite corridor in boots, hat, and a western duster, sponsoring the rugby team, flying a plane, or using a ten year old agenda to demonstrate that issues must be continually addressed, the sparkle in his eyes and smile on his face showed us that he was having a wonderful time.

His career was multi-faceted: a United States Navy flier, an administrator in India, special assistant to the president at MIT, vice president for human resources, vice president for finance and operations, and vice president for administration, he relished each and every activity and downplayed his tremendous impact on those around him. His influence extended beyond the boundaries of the Institute as Jim was a significant influence on federal policies related to research, representing both MIT and the higher education community in interactions with the federal government.

But it was MIT and the people at MIT that benefitted the most from knowing and working with Jim. He inspired each of us to do more than what we thought was our best. His gentle guidance and unwavering support enabled us to achieve more than we expected and more than we hoped. That was the hallmark of Jim's interaction with those around him: he taught without seeming to teach, he supported our goals and our dreams, and he made each of us special.

His support of people, his love of life, and his dedication to the Institute will be remembered by all. Those of us who had the pleasure of working with him are the richer for it and the Institute is the richer for his association with it. These words perfectly describe Jim and his life:

“I shall pass through this world but once. Any good that I can do, or any kindness that I can show another human being, let me do it now and not defer it. I shall not pass this way again.”

To the end, Jim's interest in those around him and his involvement in Institute activities were surpassed only by his determination and his humor. That is what we will remember him for and that which will encourage each of us to carry on.

We miss you, Jim, and carry you in our hearts.

Julie T. Norris

VICE PRESIDENT FOR ADMINISTRATION

This report is the second report for the offices reporting to the Vice President for Administration following the reorganization of Institute support services in the summer of 1994. The offices include the office of the Vice President, Admissions, the Department of Athletics, Physical Education and Recreation, the Bursar's Office, Career Services and Preprofessional Advising, the MIT Medical Department, the Registrar's Office, the Office of Sponsored Programs, and the Student Financial Aid Office. During this past year, Student Information Services was officially recognized as a department separate from the Registrar's Office. Additionally, the Vice President for Administration has Institute responsibility for coordination of MIT's legal affairs.

Our mission is to manage effectively these offices in a time of Institute financial constraint and to develop a management team that is fully aware of the goals and objectives of Institute leadership, is positioned to provide input on how to achieve these goals, and is cooperatively involved with others in the area to communicate these goals effectively to our own community members and to our customers. Units in this division continue to perform effectively the specific jobs required of each department. In addition, certain units in the area have been extensively involved in a major reengineering of student services, in coordination with other Institute reengineering efforts.

The reports of each department that follow this section highlight the major activity that occurred during the year. While they describe many of the activities, they cannot adequately express the amount of care and effort of staff to ensure that each area is effectively managed or to indicate the additional activities which department heads undertook during the illness of the vice president. Illustrative of the richness of the reports are the following examples of activities undertaken in 1995/1996:

- Completed the Sponsored Programs Management System and began work on the development of the electronic proposal system
- Provided interview space for 600 employers this past year (up almost 50% from the year before) and coordinated the efforts of more than 1650 students seeking employment opportunities
- Moved surgical and medical activities to the Massachusetts General Hospital
- Reviewed over 8000 applications for admission, highest in MIT's history
- Participated for the first time in a new federal loan program, Direct Lending

Major priorities for the Vice President for Administration area developed by staff for implementation in 1996/1997 are listed below:

- Facilitate and support current Reengineering efforts, particularly student services reengineering.
- Continue to seek, with others at MIT, the wisest and most effective balance in the student aid program using the competing vectors of fairness, cost, and diversity in the student body.
- Continue to improve effectiveness in counseling and support of students in all student-related areas.
- Assure MIT interests are served in interactions with sponsors, government agencies, congressional committees and other organizations.
- Continue the implementation of more reliable, accurate, and timely financial, academic and other data and the electronic processing and transmission of information through computerized efforts.
- Continue to implement the MIT Medical Department Strategic Plan and to examining how MIT should provide health care to its students and employees and provide options for the future, including the range of health care benefits MIT now offers and the value to MIT of internally providing health care services.

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- Continue to promote the outstanding achievements of our students in all sports while operating a fiscally sound athletic program. Maintain the momentum for the new 50 meter swimming pool and support facilities. Continue efforts to identify and utilize funds to prevent the deterioration of existing athletic facilities.
 - Continue to help students and alumni frustrated by the poor job opportunities in many sectors, including Ph.D.s who face few openings in academia and industry.
 - Develop automation and computerization within the Office of Sponsored Programs, including the development of an electronic proposal system to complement the recently completed sponsored program information system which will allow the creation, review and submission of proposal electronically to some (federal) sponsors.
 - Continue priority in affirmative action hires, performance evaluation and job development. Continue to assure that replacement, new hires, and promotions adhere to the long-term objectives of succession planning, affirmative action, and development of a dynamic staff.

Julie T. Norris

ADMISSIONS OFFICE

Applications for admission to the freshman class exceeded 8000 for the first time in MIT's history. An element of uncertainty was added to the process by changes in procedure at three of our four major competitors. Princeton and Yale changed from Early Action programs to Early Decision, and Stanford started an Early Decision program. Students who are admitted Early Decision to a school are obligated to attend. We predicted an increase in yield in view of the fact that some students who might have applied and been admitted to MIT but who then would have chosen to enroll at one of those three schools would have been admitted Early Decision to one of those schools and hence been precluded from applying to us at all. Indeed, the percentage of admitted applicants choosing to enroll at MIT increased from 53% to 56%. The increase in applications and the increase in yield resulted in a decrease in the percentage of students admitted from 26.5% to 24% making this the most selective year in MIT's history.

Our special efforts to enroll women and minority students continued to meet with success. For the second year in a row, women will make up over 40% of the class, 42.2% to be exact. African, Mexican and Native Americans along with Puerto Ricans will make up 17.7%, the second highest representation of these groups.

There appeared to be another increase in the level of concern expressed by applicants and their parents over financial aid. Some institutions use what is called "econometric modeling" of financial aid packages, and give extremely generous awards to those students their research suggests are least likely to enroll. These are often the very bright students we admit. Consequently, our awards do not look competitive or fair. This obviously has not affected our yield; we are increasingly successful at enrolling the students we admit. But it may be affecting good will.

Faculty participation in the selection process recovered somewhat from last year's all-time low. The number of faculty members reading admissions applications increased from 10 to 13, and those reading more than thirty cases increased from two to eight. We continued to have good lines of communication with individual members of the faculty who helped us to identify students with exceptional accomplishments in specific areas. The drop in the number of application folders read by admissions staff members was due to the fact that two staff members were assigned close to full time to reengineering. The gap was made up for by increased use of paid outside readers. We were very fortunate in having the services of Diane Proctor, the former Dean of the Faculty at Hotchkiss School, who spent a sabbatical year with us.

<u>Number of Reads</u>	<u>91-92</u>	<u>92-93</u>	<u>93-94</u>	<u>94-95</u>	<u>95-96</u>
Admissions Staff	9100	8500	9500	9800	8325
Faculty	890	620	400	200	330
Administrative Staff	2400	2200	1500	2200	1030
Athletics Staff	425	590	550	625	655
Paid Readers	0	0	0	0	1800

Our very successful publications program grew to include a new piece directed at parents of applicants. It also refers them to special sections of our WEB site. With respect to the World Wide Web, we worked on having a version of our application on the WEB and hope to have that project completed for use in September of this year.

In this second year of our new policy on international students in undergraduate admissions, we were not successful in limiting the percentage of aid going to international students to ten percent or less. While the number of students did not increase, they were more needy. We will have to reconsider our approach for next year.

Members of our staff were very active in MIT's reengineering efforts. Vincent James served on the Student Services Redesign Team, and Marilee Jones served on the Assessment Team. Vincent is now captain of the Co-curricular Team, and Marilee may be captain of a Graduate Admissions Team. Their absence has put a great strain on the remaining staff members. I don't believe that we have been as responsive as we have been in the past or that we have made as much progress as we usually do on our own improvements, but we still had a very successful year.

When we were not chosen as an area to be reengineered in the near future, we turned our attention to areas which needed improvement. The most pressing has been graduate admissions. We have made significant improvements in the past two years, but the need for an entirely new system has become more apparent. At the same time, MITSIS became operational, and it became clear that we need to modify our system to be more compatible with it. Finally, this is the time to move toward an electronic application. To meet these needs, we started an Admissions Discovery Effort which will lead to a redesign of the technology environment for the admissions process.

Michael C. Behnke

Admissions Office

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EDUCATIONAL COUNCIL

The Educational Council included 1725 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 370 women and 55 minorities (34 Blacks, 8 Puerto Ricans, 11 Mexican-Americans, and 2 Native Americans). The Educational Counselors conducted 7444 admissions interviews, and held countless conversations with prospective MIT students and with local school personnel. Of all MIT applicants who were eligible for an interview, 92 percent (93 percent within the United States) were interviewed by a local Educational Counselor.

New this year was our reduced presence in local college fairs. Less than twenty college fairs were attended by Educational Counselors (down from 180 last year). The Admissions Office has used a successful direct contact approach to qualified high school students as a way to develop an applicant pool.

Project Contact is a program which puts current undergraduates in touch with applicants, Educational Counselors, and school personnel. This past year 500 students, representing 200 different geographic areas (including 27 foreign countries), participated in this program run by the Educational Council Office. Effective next year, this program will run from the Admissions Office.

MIT Open House Meetings were held throughout the United States in the fall. Local Educational Council members assisted members of the admissions staff in arranging for 109 central meetings in 92 cities. Attendance at central meetings was up sharply at many locations due to a change in the layout of the invitation and the use of a direct mail service who handled our invitation production and mailing.

Meetings for newly admitted students were held in 40 cities throughout the United States by Educational Council groups. Thirty-six of these meetings were held during MIT's spring break. Kathy Breland organized panels of current students to speak at each meeting. Dianne Goldin from Resource Development assisted in arranging the meeting at the MIT Faculty Club. Ms. Goldin's involvement was the second successful joint effort by our offices.

Another program supported by the Educational Council office was the AMITA High School Visiting Program. Marti Ward runs this program, and coordinated the efforts of 70 volunteers, all women professionals (from AMITA, SWE, AWIS, or other women's professional organizations) to make 31 visits to 28 high schools throughout the greater Boston 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. Next year, this program will be running out of the Admissions Office.

The MIT admissions videotape continues to be extremely popular. Requests have come from 126 high schools (up from 74 last year), 5 colleges, 13 Educational Counselors, 43 prospective students, 20 MIT offices, and four current MIT students. Twenty-four copies have been sold.

The MIT Alumni Award program is in its sixth year. The award, given to high school juniors for outstanding achievements, especially in areas of math and science, was sponsored by three alumni (two 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*.

Two Personnel changes should be noted: Marti Ward was promoted to Assistant to the Director for Administration in the Admissions office, and Brian Ellis was promoted to Administrative Assistant for the Educational Council. Marti has served in the Educational Office for 17 years. Her promotion is well deserved. Brian formerly served as Senior Staff Assistant in the Admissions office. All the best to Marti and Brian in their new positions!

Vincent W. James

ADMISSIONS TRENDS 1987 - 96

	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>
<u>Entrants from Secondary Schools</u>										
Preliminary applications	16,237	17,408	17,832	17,941	20,169	17,423	19,136	26,588	37,179	32,836
Final applications	7,372	7,437	6,698	6,426	6,481	6,652	6,410	7,139	7,958	8,022
Admissions offered	1,826	1,833	2,018	2,051	2,012	2,219	2,141	2,165	2,113	1,947
Actual registration to date	1,001	992	1,045	1,084	1,049	1,157	1,093	1,107	1,145	1,094
Registrations as percent of admissions	54.8%	54.1%	51.2%	52.9%	52.1%	52.1%	50.9%	51.3%	54.2%	56.2%
Number of secondary schools represented	848	844	867	867	852	896	835	813	876	853
Percent of students from 9 northeastern states	39.8%	36.4%	32.5%	36.9%	37.1%	36%	36%	36%	35%	33%
<u>College Transfers</u>										
Total applications	870	905	688	838	839	792	1,006	791	800	5,659*
Applications completed	304	349	328	399	389	339	323	273	211	220
Admissions offered	106	141	103	118	91	77	51	49	25	46
Actual registrations	80	94	79	98	77	54	34	30	20	33**
Registration as percent of admissions	69%	69%	77%	83%	84%	70%	67%	61%	80%	73%
<u>Graduate Students</u>										
Total applications	8,443	8,863	8,655	9,445	10,002	10,714	10,450	11,590	12,038	12,148
Admissions offered	2,243	2,101	2,549	2,378	2,338	2,359	2,341	2,342	2,493	2,455
Actual registrations	1,019	1,104	1,437	1,169	1,179	1,211	1,145	1,186	1,257	1,353
Registration as percent of admissions	45%	53%	56%	49%	50%	51%	49%	51%	50%	55%

*Because preliminary applications are no longer required for all applicants, with the exception of international students, a count for "Total Applications" can no longer be kept. "Total Applications" referred to the number of preliminaries received. A count of the number of inquiries, instead is reported.
 **expected to register; actual number is not available.

ATHLETICS DEPARTMENT

The Department of Athletics, Physical Education, and Recreation has concluded another year of commitment to continuous improvement of opportunities and services provided to the MIT community despite seven senior colleagues' early retirement at the end of Fiscal Year 1996. Additionally, the Visiting Committee reviewed the department on May 1-2, 1996.

The department's mission is as follows: To provide an adaptive, high-quality, student-oriented athletics, physical education, and recreation (intramural) program that emphasizes participation, competition, confidence, and leadership while enhancing the athletics and health fitness environment for the entire MIT community.

During Fiscal Year 1996, the department faced many challenges. It was asked to reduce the scope and cost of the proposed Central Athletics Facility (CAF), improve the Pierce Boathouse's facilities for women, and proceed with renovation of other existing facilities. Personnel matters required adherence to Equal Opportunity/ Affirmative Action guidelines and consideration of professional development and support. The trend towards part-time coaches decreased the number of instructors available to Physical Education, impacting course offerings. Reduced sports and support program operating budgets also complicated efforts to provide high-quality competitive experiences. Additionally, the greater number of female students at MIT demanded compliance with gender equity and appropriate handling of requests for varsity status. Therefore, the intercollegiate scheduling/budget relationship was strengthened to manage a cost-effective, competitive program given inflation and conference requirements. The department extensively reviewed support needs and devise strategies to accommodate reoccurring costs from advances in computer technology. Balancing increased graduate interest and constant environmental constraints was an important task for the Intramurals program. The MIT Athletics Card Sales program was not exempt from challenges as interest in physical fitness continued to grow. Finally, strict budget constraints had to be given consideration in meeting each challenge.

The department also achieved the following accomplishments. With assistance from the Planning Office, a revised CAF plan was developed to aid in fundraising. New locker room space was completed at the Pierce Boathouse, enlarging the area available to female rowers and increasing weight room size. Recently approval was granted for renovation of the west tennis courts during the summer of 1996. Additionally, computerization continued in the department. Most notable were the new Physical Education lottery on Athena and the Athletics home page on the World Wide Web with development of individual team pages that piqued much interest. Despite financial constraints, the department maintained the number of intercollegiate sports available to student-athletes, increased or sustained each sport's competitive level, and encouraged coaches' professional development. After serious searches in which women and minority candidates were encouraged to apply and received careful consideration, new coaches and staff were hired. These hires (five women and nine minority individuals) added valuable experiences and diversity to the department. A position combining the women's tennis coaching responsibilities with management of the Tennis Bubble was created, enhancing program offerings and providing more accessible and attentive management without increased salary costs. An orientation program was established for new hires. Increased monitoring of facilities produced a greater awareness of safety and security, improved signage and security (cipher locks in strategic locations and a reduced number of access doors) and hours that more accurately reflected general usage, especially at the Alumni Pool and the Health Fitness Center. The duPont Equipment Desk was redesigned to promote general efficiency and the ability to locate and dispense equipment to coaches and athletes. A secondary service area was also established in the Johnson Athletics Center. The investigation into field space available at University Park and elsewhere continued; this proved to be a long-term project. Additionally, the department worked with Housing and Food Services to provide food service after 7 PM. This year Baker dorm offered full service until 8 PM. This appeared to meet student-athletes' needs, and the Baker nutritionist was sensitive to their special requirements. Furthermore, the department successfully staged several special events, most notably the first ever co-educational Intercollegiate Fencing Association Championship. Two crew shells (Anne McKinnon '75 and Charles O. Jackson) were dedicated this year.

PHYSICAL EDUCATION

Registrations for 1995-96 were 7930, 262 fewer than last year. Undergraduates taking classes for credit numbered 4600 while 3300 (undergraduates, graduates, staff, spouses, alumni) registered as non-credit students. Sixty-five

courses were offered with the highest registration coming from aerobics (1579), skating (909), and weight training (585). Thirty-seven credit courses and 4 non-credit courses were offered during IAP, accounting for 1661 registrations. Ten courses are being offered during the summer.

This past August a new registration system (PELOTT) was launched. PELOTT is an Athena-based selection system developed in cooperation with programmers from the Administrative Systems Development group. The lottery has proven successful. Of the 6447 people registered in the five lotteries this year, 82% received their first choice.

For the third consecutive year, the staff was responsible for the MOYA project. The staff trained 120 student-leaders and then supervised them on August 24 with great success.

CLUB PROGRAM

The department's club program continued to be popular with 36 offerings and approximately 700 participants.

INTERCOLLEGIATE ATHLETICS

The overall record for women was 97 won, 86 lost, 0 tied (.530); for men, it was 206 won, 168 lost, 3 tied (.550). The combined record is 303 won, 254 lost, 3 tied (.544).

ACADEMIC ACHIEVEMENT AWARDS

Rhodes Scholar Winner Toby Ayer '96 (crew) led a talented group of 12 student-athletes receiving 12 national scholar-athlete awards. Additionally, the men's cross country team earned a team award for excellence in athletics from the Division III Cross Country Coaches Association. Jeff Morrow '96 received a postgraduate scholarship from the National Association of Collegiate Directors of Athletics for his work with MIT's Marching Band.

NOTABLE MEN'S TEAM HIGHLIGHTS

- The cross country team captured the Constitution Athletic Conference Championship and was ranked as highly as fifth in the country during the season..
- José DeLeon '97 became the leading rusher in MIT football history with one season remaining in his career.
- Soccer had the most wins in its 63 year history (10-7-1) and won the Union College Tournament to begin the season.
- Matt Lau '96 was named All-East in water polo.
- Gymnasts Rob Cooper '97 and Jason Miller '99 were named Eastern College Athletic Conference (ECAC) Gymnasts of the Week and helped lead the team to its highest point total ever.
- The hockey team had its best season ever with a 14-3-2 record.
- John Novak '96 and Ben Leong '97 were named Pistol All-Americans.
- Swimmer Zak Lee '99 set new Institute records in the 500 free and 100 individual medley.
- Joel Morales '99 was named to the All-New England Team as he led the baseball team to a 20-11 record and the team's third berth in the ECAC Division III New England Tournament in the last seven years. The 20 wins is the team's highest regular season win total ever.
- Lacrosse defeated Tufts for the first time since 1982.
- John Wallberg '96 placed second in the NCAA Division III hammer throw.

NOTABLE WOMEN'S TEAM HIGHLIGHTS

- The ladies sport pistol squad won the national championship, and three women also captured the air pistol national championship. Myong-Sin Yi '98 was the individual champion in air pistol.
- Cross country's Eve Phillips '99 became the second continuous MIT runner to win the New England Women's 8 (NEW 8) Runner of the Year and Rookie of the Year awards in the same season.
- Field hockey played its way to a 12-1 record and a berth in the ECAC tournament. The team defeated WPI for the first time ever.
- Tennis had a program best seventh place finish (of 25 teams) at the New England Championships.
- Alli Christenson '98 earned All-America honors in the all-around at the National Collegiate Gymnastics Association championships.
- Swimmer Jennifer Gruzza '98 set an Institute record in the 200 backstroke. The 400 medley and 800 freestyle relays also set school records.

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- Crew took the NEW 8 championship for the fourth consecutive year and also captured the Smith Cup for overall superiority in the regatta for the fourth year in a row.
 - Anne Torres '96 became the all-time leading scorer in MIT women's lacrosse history.

STAFF HIGHLIGHTS

- Associate Professor *Candace Royer*, Senior Woman Administrator and Assistant to the Department Head for Sports Administration, received the Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching.
- Assistant Professor *Pasquale "Pat" Melaragno* was National Rifle Association Coach of the Year.
- On his recent retirement, Assistant Professor/Sailing Master *Harold "Hatch" Brown* received an honorary lifetime membership in the MITAA Alumni/ae Association. Additionally, the Sailing Pavilion's lobby was named in his honor.
- Three coaches received Coach of the Year honors: Associate Professor *Halston Taylor* (CAC Cross Country), Mr. *Joe Sousa* (NEW 8 Cross Country), and, for the fourth year in a row, Assistant Professor *Mayrene Earle* (NEW 8 Crew).

PERSONNEL CHANGES

The department was fortunate that Larry Anderson joined the staff this year as Assistant Professor of Physical Education and Head Coach of Men's Basketball. Other new coaches were Head Coach of Women's Volleyball and Softball, Cherry Bennett; Head Coach of Men's Volleyball, Tom Klemas; and Head Coach of Wrestling, Jim Carls. There were three very positive additions to the athletics training staff this year: Assistant Trainers Robert Eberly, Kimberly Goulding, and M. Cristina Monterroso. Arthur Russell joined the administrative staff as Administrative Coordinator of Equipment Rooms, bringing with him a wealth of experience.

Seven senior colleagues chose to accept MIT's early retirement incentives. They were as follows: Professor Emeritus/Golf Coach *Jack Barry* who first came to MIT in 1959 and retired for the first time in 1987; Associate Professor *E. Jane Betts* who was hired in 1976; Associate Professor/Baseball Coach *Francis C. O'Brien* who came on board in 1969; Assistant Professor/Sailing Master/ Head Coach of Women's Sailing *Harold "Hatch" Brown* who began as instructor/coach in 1967; Associate Professor/Lightweight Crew Coach *Peter Holland* who joined the department in 1969; Assistant Professor/Range Master/Pistol Coach *Pasquale "Pat" Melaragno* who became a department member in 1977; Associate Professor/Men's and Women's Ski Coach/Assistant to the Department Head for Facilities and Operations *David Michael* whose career at MIT began in 1963; and Equipment Staff Administrator *Pasquale "Pat" Ferrara* who had served the department and MIT community since 1974. These retirees will be very much missed by the department and Institute community.

In addition to the early retirements, other personnel changes occurred. Sandra Tenorio recently joined the Day Camp and Intramurals support staff in place of Inge Kilduff. Brian Callahan left the Alumni Pool Service Staff this year to become a lifeguard. Joe Clark left the utility staff to work for the new West Campus Zone in Physical Plant.

SPORTS MEDICINE

The area of sports medicine changed dramatically during 1995-96 with the influx of new personnel. Their energy and expertise greatly enhanced this important support service. The Coordinator of the Training Room, Kathy Davis, was afforded the opportunity to complete coursework toward her Ph.D. while managing her responsibilities at MIT. Renovation of the training room brought about an improvement in overall service, morale, and energy.

Richard A. Hill

BURSAR'S OFFICE

Reengineering of Student Services was the primary focus of the Bursar's Office during the year. The reengineering process will result in the creation of a Student Services Center in the main building and a reorganization and possible relocation of this office and other MIT offices responsible for student services.

ALUMNI SERVICES

This was the first year of MIT's participation in Direct Lending, a federal loan program. Although entering this new program was stressful, the elimination of red tape for students made our efforts worthwhile.

In FY96, student loans receivable totaled \$60,487,446 at fiscal year end. These notes were funded by \$16,047,951 of MIT loan funds established by friends and alumni of the Institute; \$27,114,121 of federal funds in support of the Perkins Loan Program; and \$15,325,374 borrowed from the Student Loan Marketing Association; and \$2,000,000 borrowed from local banks.

DEFAULT RATES

MIT's cohort default rate on Perkins/National Direct Student Loans was 1.1 percent in 1994 and 1 percent in 1995. MIT's default rate on Stafford/ Guaranteed Student Loans was 2.6 percent in 1994 and 2 percent in 1995. We are very proud of our performance over time in this area.

FINANCIAL SYSTEMS

Much time was devoted to system work and business procedures to handle our first year in the Direct Lending program. Technical requirements of upcoming Reengineering initiatives mandated the purchase of new desktop computer systems for the entire office.

STUDENT SERVICES

This was the first full year on MITSIS, the student information system. We are pleased with many of its features. For example, MITSIS has made it possible for us to expand our electronic communications with students. We are now able to send e-mail to specific populations.

We have begun to revise our statement and as a result, we have been able to eliminate some paperwork. The elimination of the Student Payment Information Card has increased staff efficiency and saved many hours of work for our staff.

Student tuition, fees and other charges totaling \$255,463,387 were billed, an increase of 6% from last year. Servicing approximately 10,000 student accounts required 254,722 transactions to the student accounts receivable system. Income from late payment fees was \$137,344; income from finance charges was \$151,665.

There were 192 active Parent Loan Plan accounts. A total of \$1,489,860 was disbursed during the year and \$1,405,422 in principal was collected. The PLP receivable at the end of the fiscal year was \$1,980,990.

STAFF NOTES

Carolyn Bunker and Sandra Chauncey served as performance evaluation trainers for the V.P. Administration staff. Mary Barry, Barbara Johnson, Lynn Flury, and Lan Wang served as Ambassadors at Commencement exercises in June. Lynn Flury was a member of the Student Services Reengineering Redesign Team. Carolyn Bunker is a member of the Financial and Academic Services Transition Leadership Team. Sandra Chauncey and Carlene Chisom-Freeman are team leaders for Student Services Reengineering.

The following changes in staff occurred in FY96:

Annette Brown left her position as Senior Office Assistant in May 1996.

Cheryl Baranaukas was appointed Senior Office Assistant in May 1996. She came to us from the Purchasing Office at MIT.

Carolyn Bunker was promoted from Associate Bursar/Financial Systems to Bursar on July 1, 1995.

Huey Chang was appointed Analyst /Programmer III on November 1995. She came to us from Yale University. She left her position in May 1996 when she was promoted to Senior Analyst/Programmer on the MITSIS staff.

Sandra Chauncey was promoted from Assistant Bursar/Loan Collection to Associate Bursar/Student Services on July 1, 1995.

Shawn Dunn will be appointed Analyst/Programmer III July 1, 1996. He comes to us from the Student Financial Aid Office at MIT.

Jim Galvin retired from his position as Assistant to the Bursar/Student Services in May 1996.

Sarah Hernandez was promoted from Senior Office Assistant to Assistant to the Bursar/Loan Collection in November 1995.

Barbara Johnson was promoted from Assistant Bursar/Information Systems to Associate Bursar/Financial Systems in September 1995.

Erin McCoy was appointed Senior Office Assistant in January 1996. She graduated from MIT in June 1995.

Kevin Paulding left his position of Office Assistant in May 1996 when he was promoted to a technical position in the Office of Sponsored Programs.

Lan Wang was appointed Financial Officer in March 1996. She came to us from Rogal, Inc.

Eleanor Wolcott was promoted from Assistant to the Bursar to Assistant Bursar/Alumni Services on September 1, 1995.

Carolyn Bunker

CAREER SERVICES AND PREPROFESSIONAL ADVISING

The year saw a bull market for MIT talent. Unlike the bull market on Wall Street, which showed signs of faltering in the spring, employers continued to solicit resumes up to graduation. Upwards of 600 employers (including divisions of companies making their own recruiting arrangements) used the facilities of the office to interview candidates. This compares with 442 in 1994-95 and 393 in 1993-94. It is doubtful that the office has ever seen more traffic in its seventy-year history.

That the office has never been busier can be said with assurance of the quarter-century since 1969 when the present director, who retires this year, assumed his responsibilities. Buoying the market was a voracious demand from employers for graduates with software skills. It came from every corner of the economy - from the computer industry, from software firms and firms engaged in information systems consulting, and from firms of all sorts in manufacturing and the service sector using computers in their business. We do not have exact numbers yet, but we estimate that as many as 5 out of 6 employers interviewing on campus listed "computer science" as a desired discipline. Many were also looking for students with other skills, but many only wanted students with a computer science background. Among these, many wanted a high level of proficiency (as indicated, for example by a degree in 6-3); others were willing to take students from any department who had learned something about programming along the way. Five years ago students in electrical engineering were sought by as many employers as students with software skills. Last year software skills were requested by four employers for every three requesting electrical engineering. This year the ratio is likely to have tilted still further.

Over a quarter of all the firms recruiting this year were entirely devoted to software, as developers of software or as information systems consultants. This is up from a fifth (19.4 percent) three years ago, 6.9 percent in 1982-83, and a scant 1.5 percent in 1969-70 (not including a few software firms on Department of Defense contracts). The software industry has opened a sphere of activity for graduates which was barely imagined in 1969 and which challenges classification. Does it belong with manufacturing or with the service sector? For that matter, where does the writing of software fit among the technical disciplines? Does the term "computer science" make it a science, or does it fit more naturally with engineering? However one settles these issues, the industry appeals to students. It is young, it offers lots of opportunity for individual inventiveness, and it welcomes entrepreneurs. Many of the firms coming this year advertised the fact that they were started by MIT graduates and they wanted more bright sparks from the Institute to join them.

Changing mix of employers recruiting at the Careers Office

	1969-70	1982-83	1995-96
Oil, chemicals, materials, food	26.4%	13.2%	4.2%
Pharmaceuticals, medical research	0.8%	2.0%	1.1%
Biomedical devices, hospital products	0.8%	0.6%	2.2%
Computers & components, communications	6.2%	14.0%	15.9%
Other civilian electronics	5.0%	12.6%	7.7%
Mechanical & electro-mechanical products	13.6%	6.6%	8.3%
Design, construction, engineering services	3.9%	6.6%	5.0%
Utilities (power & light)	1.2%	1.4%	0.4%
DOD & DOE contractors, federally-funded labs	20.5%	19.8%	6.1%
Government agencies, armed services	10.1%	5.7%	1.3%
Software firms	1.5%	4.3%	18.5%
Information systems consulting	-	2.6%	8.3%
Management consulting, economics consulting, etc.	1.5%	4.0%	6.6%
Financial institutions	1.9%	3.7%	10.0%
Insurance	1.9%	0.9%	1.1%
Miscellaneous	4.7%	2.0%	3.3%
	100.0%	100.0%	100.0%

While the market was especially strong for students with software skills it was also strong for students with other interests. There was a welcome jump in recruiting, for example, by firms building mechanical and electro-mechanical equipment. Recruiting by builders of computing and communications equipment was also up significantly. We hosted more manufacturers of biomedical devices. We also saw more financial houses looking for students from any major with good analytical and interpersonal skills. The number of oil and chemical firms coming on campus held steady with the year before. So did the number of DoD and DoE contractors and the number of management and economics consulting firms, which, in a rising market, reduced their respective percentage showings on the recruiting roster.

Back in 1969-70 only four management consulting firms thought to recruit through our office. On the other hand we greeted 68 firms in the category "oil, chemicals, materials, food", - three times the number we hosted this year. Interestingly, there were only 95 graduates in chemical engineering that year (at all degree levels) for them to talk to. Clearly MIT students had not heeded the legendary career advice given to Dustin Hoffman three years before in *The Graduate*, "I want to say one word to you - just one word - plastics".

The industrial world then was dominated by big companies. So was campus recruiting. John Kenneth Galbraith offered the opinion in 1967 in his best-seller *The New Industrial State* that only large companies could raise the capital modern technology needed or assemble a large enough technical staff. To believe anything else was "drive". He went on: "The small firm cannot be restored by breaking the power of the large ones. It would require, rather, the rejection of technology". One of the most auspicious developments in the past quarter-century has been the success of small companies, often led by MIT graduates, in proving him wrong.

This year 1,687 students had employment interviews in our facilities, among them 900 undergraduates (including students not yet graduating interviewing for summer jobs), 514 master's degree candidates, 255 doctoral candidates, and 18 postdocs. There seemed to be more opportunities for PhDs in industry this year than in the past but times are still hard for them. More than 300 PhD students went to hear McKinsey talk about its interest in hiring PhDs as management consultants; 200 went to a similar presentation by Boston Consulting Group. As in past years a steady stream of PhD students came to the office to discuss their career options, including the opportunities for them in consulting and finance. They are among our most attentive and appreciative clients.

The strong market had a positive effect on salary offers. For example, the median offer to bachelors in computer science (Course 6-3 to be precise) rose 7.5 percent, to \$43,000. The median offer to masters was up 4.0 percent, to \$52,000. In electrical engineering the median offer to bachelors rose 7.7 percent to \$42,000, the median offer to masters 4.2 percent to \$50,000. In mechanical engineering offers to bachelors were up 4.3 percent to \$41,700, but to masters up only 2.3 percent to \$48,060. A typical base salary offer to a bachelor joining an investment bank or a management consulting firm was \$40,000, up 8.1 percent from last year. Salary offers to PhDs in engineering were widely spread, ranging from the mid-fifties to the mid-eighties, but with \$70,000 roughly the median.

MEDICAL SCHOOL

The office was as busy assisting medical school candidates as it was welcoming recruiters. We do not have final figures on how many MIT candidates completed the application process, still less how many were accepted, but 254 enlisted the help of the office in filing their applications. There is no question that the Institute has never fielded more candidates. The number is up from a total of 201 MIT candidates in 1995 and 187 in 1994. The 254 this year included 153 undergraduates, 29 graduate students, and 72 alumni. There has been a corresponding surge in the number of applicants across the nation, with the total number rising from 26,915 as recently as 1989 to 49,591 in 1995. Meanwhile the number of first-year places in medical schools has barely changed. As a consequence, the national acceptance rate dropped from 59 percent in 1989 to 35 percent last year. We are proud that 59 percent of MIT's candidates last year were accepted (62 of the 103 undergraduates, 4 of the 6 graduate students, and 52 of the 92 alumni). The odds on getting in will have been longer again this year, but we have no doubt that our candidates will continue to have done well.

The director looks back on the past quarter-century with pleasure. It is hard to think of another job which would give the same opportunity to watch the changing interplay of technology and business, from Silicon Valley to Wall Street, and to meet so many of the actors, from students (as bright as any in the world) itching to get a piece of the action to leading players who have already made a difference. It has been a stimulating and rewarding experience,

made all the more so by a wonderful team of colleagues. Elizabeth Reed, a long-standing member of the team, has been appointed Interim Director to serve during the reengineering of student services.

Robert K. Weatherall

MEDICAL DEPARTMENT

Turmoil and change in the health care industry continue locally and nationally. The Medical Department has not been isolated from these events. Most notably, the illness and eventual incapacity of Mr. James J. Culliton, Vice President for Administration and our reporting VP, cast a heavy cloud over our activities. His efforts, through most of the year, helped guide us through significant changes in our internal and external relationships, and his constant attention to the spirit and the detail of personnel, financial and professional relationships will be remembered with great appreciation, admiration and affection. Mr. Culliton died on June 3, 1996.

The Blue Ribbon Panel completed its review of the Medical Department in April and we now await its report, which we re hopeful will be both supportive and productive. The strategic plan, completed during the prior year, has lead us in new directions, most notably, moving our surgical and medical activities to the Massachusetts General Hospital (MGH) in January, 1996 while continuing pediatric referrals to Children s Hospital, and Obstetrics and Gynecology at Brigham and Women s (B&W). We are currently developing contractual agreements with Partners (MGH, B&W and Dana Farber Cancer Center) that will result in significant savings in hospital costs. We are exploring the potential for use of peripheral satellite facilities associated with the larger Partners network. This initiative includes a marketing survey and evaluation of financial benefits and risks. Negotiations with Blue Cross have also resulted in significant savings in ambulatory medicine and technological costs.

These changes should help our financial position as well as provide our students and health plan members with outstanding tertiary medical care and the convenience of a facility literally across the Charles River. Our physician group has begun taking on the responsibility for care of hospitalized patients, providing essential continuity as well as efficiency. A bi-product of involvement in the robust MGH medical center is the opportunity for broadening continuing education through working with a variety of specialists, subspecialists, fellows and residents.

Finally, this introduction should not close without commenting on the impact of the early retirement incentive taken by seventeen individuals, representing 374 years of service to this department at MIT. Many of the individuals leaving are in key positions and we face the challenge and the task of restructuring, reallocating and recruiting. This is an opportunity, but it also represents a loss of valuable colleagues and the need for a significant effort to regroup and renew in ways salutary to our mission and to MIT s needs. We continue to seek the very best individuals to serve our community and its diversity as a highest priority. Joining the Department in July 1996 are an Hispanic American male and an Asian woman physician. In our current recruitment, we are very aware of the need to identify women and individuals of color and diverse ethnic backgrounds. We all learn from each other and contribute to the health and well-being of the MIT community.

MEDICAL CARE ACTIVITIES

Dental Service: Cynthia Stevens, D.D.S, Chief

Efforts have been made to come in with a favorable financial statement and this is the first year where budget revenues met expectations. Efforts are now under way to further work at decreasing expenses. There have been some staff changes during the past year resulting in more available general dentist time. A dental payment plan is going to be implemented this year which should help the efficiency and reliability of revenue collections. Services have been expanded to include aesthetic enhancement through bleaching of enamel. The Department has undertaken some improvements in the physical structure of the dental area through the help of Physical Plant personnel. Next year we plan another look at a student dental plan. Also a consulting group, recommended by the Medical Management Board, will review our current practices in hopes of enhancing our effectiveness in caring for students and other members of the MIT community.

Medical Service: William A. Ruth, M.D., Chief

This has been a year of transition and change and throughout this the internists continue to deliver high quality, personalized services to members of the MIT student and general community. There have been two resignations. Dr. Michael Myers left in the summer of 1995 and Dr. J. Christian Kryder cut back to part time and then retired from MIT in the autumn of 1995 to focus on a career in medical administration. We are currently in the process of evaluating a number of candidates to fill these positions.

Accomplishments have included computerization of all the medical offices. GroupWise E-mail has enhanced communication between individuals and among the entire staff. CD ROMs for Scientific American Medicine, Harrison's Text of Medicine, and the Electronic Library of Medicine have all been added to the system and have enhanced the ability of the staff to access articles and also to provide materials for patients with specific questions or problems.

The biggest transition has been the move from Mt. Auburn Hospital to the Massachusetts General Hospital which occurred in January, 1996. Members of the medical group are beginning to admit their patients to the MGH as primary physicians, or with the help of subspecialists provide continuing care with early referral back to the MIT Inpatient Unit or discharge home, whichever is feasible. A senior care program has begun to be explored and we are currently awaiting the resolution of some internal problems with Blue Cross/Blue Shield to complete the decision and planning of this program. A patient care survey has been completed and our patients continue to value the easy access to physicians. The role of the internists, the full-time commitment as well as assuming a variety of new responsibilities, has been a continuing effort. Quality improvement programs continue, including routine cancer prevention or early detection studies with mammography and Pap smears, as well as a focus on diabetic eye care evaluation and decision making in after hours services.

Off Hours Service: Leigh M. Finn, M.D., Coordinator

Emergency and urgent care for patients in the MIT community is provided on a 24-hour basis by the Off Hours Service, staffed by a roster of department internists, nurse practitioners, and moonlighting internists and pediatricians from the leading hospitals in the Greater Boston area. The patient volume has stabilized, but to reduce patient waits, a same-day appointment system was introduced and staffing has focused on traditional peak patient hours. This has resulted in fewer long waits and a much smoother flow of patients which has enhanced patient satisfaction as well as provider efficiency. As part of our effort to improve the standard of care, we continue to assess our needs, do focused review of medical problems that are seen in the Off Hours Service, update our equipment and medications, and educate our staff in emergency procedures including advanced cardiac life support.

Inpatient Medical Service: Elaine Shiang, M.D., Chief

The Inpatient Unit continues to play a vital role in the care and management of MIT patients. There were 707 admissions this past year which include student, affiliate, health plan, Medicare and fee-for-service admissions. In addition, the Clinical Research Center had 452 inpatient days, a 300% increase from the previous year. The recent renewal of Health and Human Services 4-year grant promises to continue the CRC admissions at a steady rate or possibly an increase. Areas of research include metabolic, nutritional and sleep studies. The new relationship with Partners Health Care and the Massachusetts General Hospital is progressing well. Continuing efforts are being made to ensure that all aspects of patient care between MIT and Partners hospitals is of the highest quality. Patients who require acute hospitalization will be transferred back to our full-service hospital at the earliest possible time, through improved communication and MIT physician input.

Obstetrics and Gynecology Service: Lori A. Wroble, M.D., Chief

The major staffing changes this past year included the loss of Dr. Carey York to become full-time at the Massachusetts General Hospital and the hiring of Dr. James Marquardt as a full-time provider in July 1996. Dr. Marquardt, a B&W staff member, has been familiar with our obstetrical activities at the Brigham. The statistics for 1995-1996 included 8,400 visits and 170 deliveries. There was a 12.9% Caesarian section rate and there were 52 GYN surgeries of which 30 were major. Karen Halvorson, R.N.C., has continued her role as coordinator and co-chair of the highly successful and appreciated Infertility Consult Committee, which is made up of a group of individuals expert in advising patients with infertility problems. Our OB/GYN physicians have applied for clinical privileges at the MGH. This will allow us to do occasional GYN consults on MIT Health Plan patients who are on the medical or surgical services at the MGH. We have worked to improve our services to patients, to find areas to cut costs, and have had ongoing meetings with the Chief of the Obstetrics Service at the Brigham and Women's to accomplish those ends.

Pediatric Service: Mark Goldstein, M.D., Chief

A pediatric resident rotation with the Massachusetts General Hospital was initiated. Monthly clinical sessions for pediatricians and a nurse practitioner have been instituted and the efficiencies in the administration of the Pediatric Service to improve patient and staff communications have been enacted successfully. A new pediatrician, Dr. Ellen

Bass, trained at Georgetown Medical School and Yale New Haven Hospital began practicing last summer and has added to the responsiveness of the service. Efforts to communicate with non-English speaking parents and patients were strengthened with written materials in their native languages and the use of a Japanese-English computer. Efforts at communication with the diverse international students will continue to be explored.

Psychiatric Service: Peter Reich, M.D., Chief

Frequency of hospitalization in outside facilities and the MIT Inpatient Unit remained similar to last year. Inpatient days in outside hospitals actually decreased secondary to shorter hospitalizations. Psychiatric ambulatory visits once again reached a record level, slightly higher than the level of utilization the prior year. We have continued to have trainees from the Harvard Longwood Psychiatry residency training program and this continues to be successful for the trainees while enhancing their contributions to the clinical psychiatric services. This year marked the retirement of four long-time members of the mental health program, Jacqueline Buck and Myra Rodrigues, L.I.C.S.W.s, Charlotte Schwartz, Ph.D. and Peter Jenney, M.D. In addition, Dr. Elizabeth Childs accepted a position as Chief of Psychiatry at Carney Hospital and leaves the Department after providing excellent consultative care in child psychiatry.

Community service was again a major part of the work of the Psychiatry Service in health education, in weight reduction, cancer awareness, wives groups, committee on academic performance, consultation to Institute administrators, and serving as advisors to the MIT student night-line program.

Social Work Service: Ronald C. Fleming, L.I.C.S.W., Chief

The Social Work Service remains principally a direct provider of community mental health and medical social work services. An estimated 700 people were assisted this year. For students and especially for members of the MIT Health Plan and MIT employees, the Social Work Service continues to provide direct on-site clinical services including Lincoln Laboratory. Through the use of groups, creative and flexible response to community needs is met. Groups are an efficient way of providing assistance and in general have been enormously well received including in areas such as cancer and alcohol abuse. There are a variety of self-help organizations that use the social service department as a clearing house, including Alcoholics Anonymous, Overeaters Anonymous, Co-Dependents Anonymous, etc.

In addition to the clinical services, community social work is a vital part of what we provide. Minority student concerns are addressed in the minority student concerns group and in the summer science programs. The staff participated in a special program for African American administrators, a meeting that brought together veteran staff with newcomers. Elder care issues are a growing concern in this community and specialized educational seminars as well as group activities have been successfully developed. Social work staff members participated in several forms of community education and consultation, the most significant being to the administrative offices group and the family resource center. The Institute Personal Assistance Program (IPAP) celebrated its 17th year and provided on-site employee assistance to the community.

Members of the Social Work Service also contribute to numerous activities within the Medical Department. It should be mentioned that the loss to the Service of Myra Rodrigues and Jackie Buck to the early retirement program leaves an enormous void, for these two individuals have served the Institute for a total of 56 years. Both have been especially sensitive to the needs of families, student families, foreign students, and their families, minority students and staff, as well as other members of the community. Their loss will be deeply felt by many within the Department and throughout the MIT community.

Surgical Services: Stephen J. Healey, M.D., Chief

The volume of patient visits has remained stable. Minor surgeries numbered 250 procedures. In addition, approximately 150 major surgical procedures were performed at Mt. Auburn Hospital during the year. Transition to a primarily MGH related general surgical activity is now under way and with the early retirement of Dr. Stephen Healey, Dr. Larry Geoghegan from MIT and several individuals from the MGH General Surgical Services will be providing surgical care.

Nursing Service: Janet V. Beyer, RNC, Chief

The Nursing Service provides nurse practitioner services in the internal medicine clusters at the Medical Department, the after hours service and Lincoln Labs, as well as in subspecialty areas such as dermatology and psychiatry. The Inpatient Unit continues to extend exceptional care to our patients. The Lincoln Laboratory clinic is staffed primarily by Monique Canton and a total of almost 3,000 patients were seen this year. Community service continues to be an important function of the Nursing Service, including graduation and alumni week activities, freshmen orientation, screening physicals, various vaccination clinics, and also activities during IAP and Health Plan open enrollment. Nurse practitioners now have prescription writing privileges. All providers have a co-signing MD and a log book of all prescriptions written and these are reviewed at frequent intervals. Involvement in their own continuing education has been a significant part of the Nursing Service's activities. This is the last year that Janet Beyer will serve as Director of Nurses and it is with regrets and with great appreciation that this report is provided for the annual report.

OTHER DEPARTMENT ACTIVITIES

Clinical Research Center (CRC): William H. Dietz, M.D., Ph.D., Associate Director

The CRC grant from the NIH was renewed with a priority score allowing an additional four years of funding. At the end of the next funding cycle the MIT CRC will have been supported for its clinical research programs for a total of 37 years. Studies done at the CRC continue to focus on human nutrition and metabolism, neuroscience and brain function. Major advances in the last year include the demonstration that stroke patients appear to recover function more rapidly after the administration of CDP choline and this research had its origins in basic clinical research performed at the CRC. The CRC continues to relate clinically to the Medical Department. Representatives from the CRC serve on all of the major committees of the Medical Department including the Medical Executive Committee.

Environmental Medical Service (EMS): Robert J. McCunney, M.D., M.Ph, Director

The EMS continues to thrive. The Director assumes responsibility in clinical oversight of medical surveillance programs for a variety of MIT personnel including those exposed to asbestos, berillium, lead, and other hazards in the course of their work. Within the past year, a medical surveillance program for animal handlers has been established to assist the Department of Comparative Medicine in meeting a regulatory audit for the summer of 1996. Clinical evaluations are performed for a variety of regulatory requirements including those related to respirator use, tower climbing, confined space activities and for evaluation of a variety of symptoms that may be related to work. In addition, educational and research services and activities are provided through the office of the Director of EMS. For example, an EMS co-sponsored meeting with MediChem, part of the international commission on occupational health, entitled *The Chemical Industry as a Global Citizen: Balancing Risks and Benefits* was held on campus for over 200 people representing 40 countries. A physician's guide to emergency response to be published later this year in the *Journal Occupational Medicine* involved research studies that were undertaken at MIT. Another research study involved biological monitoring methods associated with inadvertent ingestion of radioactive P32.

In addition to the Office of the Director, the Biosafety, Industrial Hygiene, and Radiation Protection Offices all were involved in major service and research activities on campus. These activities included studies of generic blood borne pathogen exposure control, the expansion of the Whitehead Institute with documentation of waste management planning and training, assistance to the American Biosafety Association for their meeting in Boston, and the extension of the QA and QC program to include animal care in the Department of Comparative Medicine. A systematic program to respond to and correct indoor air quality complaints in a timely manner was undertaken, and the group participated in several of the academic courses providing health and safety education to engineering and science students. In the area of radiation protection, all three radiation protection office divisions, campus, Bates Lab, and reactor continue to maintain all established training personnel monitoring radiation survey, radioactive waste management, record keeping, authorization review, radiation committee support in emergency response programs throughout the past year. Major achievements have included waste disposal management, radioactive material ingestion dosimetry evaluation and security of radioactive materials stored on campus.

Health Education Service (HES): Jessica Goldhirsch, M.P.H., Director

Health Education has enjoyed a productive year of growth and expansion with the coming of a new Director as well as physical renovations of the resource center and library, allowing for expanded topics and up-to-date information as well as easier access for the community. New fall and spring health promotion classes, with a focus on stress reduction and complimentary therapies, were provided and met with enthusiasm. Under the leadership of Sally

Ciampa and the guidance of Dr. Margaret Ross, Health Education coordinated the Medical Department's successful representation at IAP with over 72 lectures serving more than 1,600 people. Under the direction of Tracy Desovitch, the student liaison and education program MEDLINKS added a second 20-hour training in January bringing the total of new student members to 62. Highlights of the year included the KISS (Keeping Intimacy Safe and Sensual) Health Fair, a World AIDS Day observance, and numerous well received workshops by the peer education drama troupe, UpFront, and the prefinals health expo. With guidance from the nutrition service, a student intern worked with the MEDLINKS group. Working with MEDLINKS group, CHEW (Choosing How to Eat Well) to forge a new relationship with MIT Food Services, resulted in a new specially designed menu during finals week. The work of the MEDLINKS program included the expansion and refinement of the mentors program, resulting in 18 medical staff members becoming involved in visits to student living groups to learn more about student life and to provide health education. Under the leadership of the new director, Jessica Goldhirsch, and with the continued guidance of the Health Education Advisory Group, new marketing plans are under way that direct people to health education, to new literature displays and new publications. Relationships with the Family Resource Center, the Dean's Office, Environmental Medical Services, the Women's League and retirement community have been strengthened.

Lincoln Laboratory Medical Service: Bruce J. Biller, M.D., Coordinator

Staffing of the clinic has continued to be provided by a nurse clinician, a secretary and by Dr. Biller. Patients are seen daily by the nurse practitioner and a single afternoon a week by the M.D. Quarterly monitoring of routine and emergent care is reported to the Quality Improvement Committee of the Medical Department and patients requiring medication or prescriptions are reviewed each week. Consultation for the nurse clinician has also been provided for those patients seen who need diagnostic evaluations. Pharmacy prescription service using the Lincoln shuttle is provided at great convenience to patients; and specimens can be delivered to the MIT Laboratory.

Student Health Service (SHS): Mark A. Goldstein, M.D., Chief

The first ever pre-matriculation survey to determine use of alcohol during the last year of high school was completed with the freshman class entering in September 1995. Compared to the national average of 30% of high school students having binge drinking episodes in the prior month, 7.5% of the MIT students reported similar activities. Preliminary results of another study indicated that students entering MIT at age 16 did not utilize the Medical Department any differently from students entering at age 18. An article on the importance of hepatitis B immunization for adolescents was supported by an educational grant to Dr. Goldstein. Its co-author was a former MIT student, now at Yale Medical School. It appears that increasing numbers of physicians are immunizing all adolescents against hepatitis B and after publication of the above article, the Massachusetts Department of Public Health began to sponsor administration of the vaccine in Grade 7.

Input from student members of the Student Medical Advisory Council helped to redesign brochures about the Medical Department and based in part on suggestions from students, hours were extended on Tuesday evening to 8:00 PM for members of the MIT community which includes students often busy in daily class activities.

The Definitive Guide to Medical School Admission written by Dr. Goldstein and his spouse and based on his 18 years of pre-medical advising was published and made available to students in the MIT community.

The Pharmacy benefit for the MIT student insurance plan was initiated and for a \$6 co-payment, students under the plan receive up to a month's supply of prescription medication from the Pharmacy. For Dr. Goldstein's continued activities in student health, he has been appointed to the Massachusetts Medical Society School Health committee.

Clinical Operations and Administration: William M. Kettle, M.D., Associate Medical Director

An affiliation with the Partners Health Care Network was a major administrative undertaking for the MIT Medical Department. Driven by the need to ensure excellent care at reasonable costs, a thorough search of the best courses of medical care for services outside the Medical Department was undertaken. Discussion with local area hospitals and health care delivery systems included a careful look not simply for excellence, but also for ease of use by our patients and physicians. By focusing the care of our patients at a smaller number of institutions and by including the use of our inpatient unit in the planning and negotiations, an agreement was made that should save a significant amount of money.

The affiliation required moving our principal place of hospitalization for medical and surgical patients from the Mt. Auburn Hospital, an institution that had served us well for a number of years, to the Massachusetts General Hospital. This change also led to the involvement of our physicians in the acute care management of our hospitalized patients. This will allow closer control of resource use, maintain a high degree of continuity of care and facilitate the use of our inpatient unit as a subacute facility. The affiliation went into effect on January 1, 1996 and has been implemented smoothly. Overlapping arrangements have allowed a graceful transition for both patients and staff.

The early retirement program has resulted in a significant reduction in some key patient care positions. While some positions will absolutely need to be refilled, we are actively seeking ways to meet the needs of our community without simply rehiring all those who have retired. The retirement of 17 individuals, 14 of whom had direct clinical responsibilities, presents a significant challenge and an opportunity to rethink how patient care can remain excellent and still be delivered in a convenient cost-effective manner.

In addition, efforts are under way to assess our information system needs both current and for the future. It is vital that we have the data necessary for the decisions that face us daily in the rapidly changing health care environment.

The Medical Department staff continues to play an active role in the activities of the campus. Pre-med advising, teaching of medical students and medical engineering students in the HST program continue to be important tasks undertaken by the Medical Department. Providing speakers for IAP and mentors for the MEDLINKs program continue to be important functions served by the Medical Department.

MIT Health Plans: Mary P. Smith, Director

The MIT Health Plans, as in years past, continue to have more than 50% of the MIT employee base as subscribers in the Traditional and Flexible plans even as the overall employee numbers decrease at the Institute. While it is important to maintain that 50% base, it also becomes necessary to find ways in which to increase the plans enrollment and ensure the long-term viability of the plans.

The Health Plans managers have been meeting with representatives of Blue Cross & Blue Shield to explore more favorable payment rates for hospital and physician services. Plans are under way to implement HMO Blue payment rates for all services rendered outside of the Medical Department. This process involves physician credentialing, developing care management protocols with Blue Cross & Blue Shield and other operational details. It is hoped that these favorable rates will be in place by September 1, 1996.

Continued cost pressures, demand for additional benefits and competitive premium rates among all plans offered by MIT will challenge the Health Plans during the next open enrollment period.

Administrative Operations and Management: Annette Jacobs, Executive Director

Administrative activities in the Department have focused on supporting the clinicians during our change of hospital affiliation and providing the Blue Ribbon Panel and the Institute with financial and statistical data regarding the Department's activities.

The change in hospital affiliation from Mt. Auburn to Partners (MGH and B&W) involved major financial negotiations which will allow us to substantially decrease our costs for acute care hospitalization without reducing or changing the way we provide service. We have coordinated with MGH staff and many support service areas including medical secretarial, Medical Records, Pharmacy, Lab, and X-ray to assure smooth and seamless patient care and identify and resolve problems instantly.

In support of the Blue Ribbon Panel, we have continued to refine our methodology for defining lines of business with profit and loss statements for each. These profit and loss statements will become part of our annual financial reporting. We continue to develop reports at a more detailed level by service, by physician, and by activity to allow us to monitor costs and reduce them appropriately.

With the help of outside consultants, we are engaged in market research related to our strategic plan. We will be surveying organizations begun by MIT alumni and faculty in the greater Boston area to ascertain interest in offering

our health plans to their employees. In the fall, we will be conducting a telephone survey of employees (both Health Plan and non Health Plan members) to determine the feasibility of and best locale for possible satellites.

Lobby renovations, which have been in planning during the year, will begin just after Commencement in June. We expect the new lobby to provide a more welcoming, warmer, and safer environment on our first floor.

PERSONNEL CHANGES

Appointments

Ellen Bass, M.D.	Pediatrician
Danielle Bodley	Assistant Radiation Protection Officer
Anne Boppe, R.N.	Inpatient Nurse
Michele Brody, Ph.D.	Psychologist
Leslie Byrne	Administrative Assistant
Mariah Daly, R.N.	Inpatient Nurse
Todd Date	Assistant Radiation Protection Officer
Joanne Fellin, R.N.	Inpatient Nurse
Jessica Goldhirsch	Director, Health Education Service
John Lightfoot	Director, Management Information Systems
Kathleen Maloney, R.N.	Manager, Quality Improvement, Utilization Review, Risk Management
Claudia Mickelson	Biosafety Officer
Martha Von Dette, R.N.	Inpatient Nurse

Terminations

Marcia Austin	Assistant Radiation Protection Officer
Barbara Frank	Administrative Assistant
Susan Katlove, M.D.	Psychiatrist
John Kryder, M.D.	Physician
Kathleen Maloney, R.N.	Manager, Quality Improvement, Utilization Review, Risk Management
Michael Myers, M.D.	Physician
Lisa Newfield	Manager of Special Projects
Nancy Sidhu, Ph.D.	Clinical Psychologist
Ronald Tracy, D.M.D.	Dentist
Andrea Wilson, M.D.	Fellow, Psychiatry
Bruce Wood, D.P.	Podiatrist

Changes

Kin Lye	Consultant (Promotion)
Mary Smith	Director, Finance and Health Plans (Promotion)

Retirements

Janet Beyer, R.N.C.	Director of Nurses
Barbara Bidstrup, R.N.	Inpatient Nurse
Jacqueline Buck, L.I.C.S.W.	Social Worker
Robert Burgess	Radiation Technician
Michael Erard, O.P.A.-C.	Orthopedic Assistant
Charles Hatem, M.D.	Physician
Stephen Healey, M.D.	Surgeon in Chief
Peter Jenney, M.D.	Psychiatrist
Helen Katz	Administrative Assistant
James Manson, M.D.	Orthopedic Surgeon
Barbara Merrifield, C.N.M.	Nurse Midwife
Elaine Miller	Dental Service Coordinator
Myra Rodrigues, L.I.C.S.W.	Social Worker
Beverly Scarlett	Admin. Secretary
Charlotte Schwartz, Ph.D.	Clinical Sociologist

Arthur St. Andre, R.N.C.

Nurse Practitioner

Marcia West, R.N., C.P.N.P.

Nurse Practitioner

Our basic commitment continues to be the provision of quality medical care to the MIT community. To do this while maintaining a low barrier and keeping costs down has become a difficult task but remains a worthy objective. Health care includes prevention, education and early intervention by dedicated individuals with values that resonate with those of this community. We are making progress to modernize our information systems, to work through a strategic plan that has many operational as well as innovative components, and to reduce our costs without any compromise of quality and availability. Through the hard work of many dedicated individuals we anticipate continuing progress on many fronts while we deal with the every-day issues confronting our multi-faceted department. Our preparations for the visit by surveyors of the Joint Commission on Accreditation of Health Care Organizations in October 1996 give us great confidence that we are making progress.

Arnold N. Weinberg, MD

OFFICE OF THE REGISTRAR

REGISTRATION

In 1995-96 student enrollment was 9,960, compared with 9,774 in 1994-95. There were 4,495 undergraduates (4,472 the previous year) and 5,465 graduate students (5,302 the previous year). The international student population was 2,138, representing eight percent of the undergraduate and 33 percent of the graduate populations. These students were citizens of 104 countries. (Students with permanent residence status are included with US citizens.)

In 1995-96, there were 3,013 women students (1,705 undergraduate and 1,308 graduate) at the Institute, compared with 2,813 (1,604 undergraduate and 1,209 graduate) in 1994-95. In September 1995, 471 first-year women entered MIT, representing 42 percent of the freshman class of 1,122 students.

In 1995-96, there were, as self-reported by students, 2,630 minority students (1,980 undergraduate and 650 graduate) at the Institute, compared with 2,496 (1,944 undergraduate and 552 graduate) in 1994-95. Minority students included 363 African Americans (non-Hispanic), 37 Native Americans, 505 Hispanic Americans, and 1,725 Asian Americans. The first-year class entering in September 1995 included 493 minority students, representing 44 percent of the class.

DEGREES AWARDED

Degrees awarded by the Institute in 1995-96 included 1,223 bachelor's degrees, 1,350 master's degrees, 28 engineer's degrees, and 554 doctoral degrees -- a total of 3,155 (compared with 2,839 in 1994-95).

MAJOR ACCOMPLISHMENTS FOR THE YEAR

The following highlights some particular accomplishments in addition to the normal services provided by the Office in the areas of registration; maintenance of academic/address/biographical records; certification of MIT attendance; transcripts; tuition administration; cross-registration; subject, classroom, and exam scheduling; classroom maintenance and renovations; Academic Calendar; degree audit; Commencement and diploma preparations; Catalogue subject/curricular management; interpretation of policy; maintenance/operation of the Student Information System; privacy of information; and statistical reporting:

Designed, implemented, maintained, and publicized an interactive, integrated subject listings/schedule on the World Wide Web which allows students to query on a number of subject characteristics and times, then create a schedule preview which displays conflicts; modified system based on feedback from students, faculty, and staff; developed schedule for updating system; worked with departments, HASS Office, UROP Office, subject instructors, and others to link to their Web pages; worked with UAA to include descriptions and schedule information for undergraduate seminars on subject listings/schedule.

Collaborated with Communications Office and Information Systems to create a Web version of the Summer Session Catalogue that lists only "real" subjects being offered, supplied from Registrar's Office PC Catalogue database; worked with departments to determine list of "real" subjects offered in the Summer Term; designed Web version so that specific audiences are targeted and directed to the appropriate information; linked to related Web pages; simplified and minimized the number of printed copies.

Worked with the Committee on Race Relations to provide electronic copy of subject listings for Race Relations Guide.

Created a Registrar's Office home page on the Web that lists areas and phone numbers and includes links to other related pages, including Summer Session Catalogue, Commencement, Schedules Office home page, and Academic Calendar; responded to questions sent to Registrar's Office web address associated with home page.

Redesigned Application for Advanced Degree and Transcript Request Form, worked with Registrar's Office staff to make forms easier to use.

Worked with COC and CUP to uphold the policy in the Faculty Regulations that limits departmental programs to 15 1/2 subjects as an absolute upper limit, in that it must apply to every path through the program.

Continued to provide HASS Office, IAP Office, Committee on Race Relations, and departments with electronic passes of subject information for their various publications.

Developed and implemented an e-mail notification system on MITSIS to enable administrative offices to easily communicate with students.

Enhanced the Registrar's Office module on Athena OLSIS by improving the biographic and academic information available to students.

Assisted the work of the CAP by doing research on the history of Incomplete grades which supported their recommendation to change the policy regarding incompletes.

Coordinated with Academic Computing to implement secure electronic mailing to students at the request of Vice President Gore's Office.

Collaborated with RCA to implement a new procedure for the electronic transfer of incoming freshman housing data.

Collaborated extensively with Physical Plant, Dean for Undergraduate Education, and Planning Office regarding maintenance of classrooms; provided design input for the new classrooms in Building 56 and Building E51 renovation Phase II; in response to faculty desires, planned and implemented Athena workstation and projection capabilities in 10-250. Collaborated with Audio-Visual and Academic Computing to install equipment suitable for classroom operation, such as video demos, computer notes etc.; responded to several requests for classroom utilization data.

Pioneered a web site for scheduling information including detailed descriptions of the classrooms integrated with a campus and floor map, policies and procedures for reserving classroom space, listing of rooms not scheduled by the Schedules Office, listing of support services in Audio-Visual and Physical Plant with links to each service. Notified students via the Web of rescheduled final examinations allowing them to know earlier and more efficiently.

Collaborated with the Sloan School to automatically pre-register incoming students for a series of core subjects, automated notification of students on their Reg Form regarding status in Lottery classes based upon Sloan's results.

Worked with ISO to register Visiting Students for the first time.

PERSONNEL

Vicky Diadiuk left the office after nearly five years as Associate Registrar for Curriculum Services joining the Microsystems Technology Laboratories. Dorothy Ann Gordon and Varian F. Woolfork retired after more than twenty-five years each of dedicated service to the Registrar's Office; they made significant contributions in many areas of the office. David S. Wiley retired this May. It was through David's vision that the Student Information System came to be. He was the guiding force and chief architect behind MITSIS, and a warm and loving friend to many at MIT. We wish David and his family much happiness on their farm in Virginia.

FUTURE PLANS

The Registrar's Office staff will be heavily involved in all areas of Student Services Reengineering. Two-thirds of the staff are serving on teams in the areas of Best Practice Research, Academic Services, On-Line Student Access, Student Services Center, and Human Resources. Design of an electronic certification system has been completed and implementation is expected this Fall which will optimize service for students.

Elizabeth C. Bradley
Mary R. Callahan
Constance C. Scribner

TABLE I: NUMBER OF STUDENTS BY COURSE AND YEAR, 1995-96

COURSE NAME	Year					Total Under-grads	Master/Eng.	Doctoral			Total Grads	Grand Total No.	
	2	3	4	5	6			Reg.	Non-Res.	Spec'l			
SCHOOL OF ARCHITECTURE AND PLANNING													
Architecture, IV	20	20	17	2	2	59	160	24	15	2	201	260	IV
Architecture, IV-B	-	-	4	1	5	5	-	-	-	-	-	5	IV-B
Urban Studies and Planning, XI	2	3	6	3	14	14	151	42	21	17	231	245	XI
Program in Media Arts and Sciences, MAS	-	-	-	-	-	-	49	44	1	1	95	95	MAS
Total	22	23	27	6	6	78	360	110	37	20	527	605	Total
SCHOOL OF ENGINEERING													
Aeronautics and Astronautics, XVI	26	30	26	3	85	114	67	1	1	3	185	270	XVI
Aeronautics and Astronautics, XVI-B (Cooperative)	-	1	1	-	2	-	-	-	-	-	-	2	XVI-B
Aeronautics and Astronautics, XVI-C (Internship)	-	1	7	-	8	-	-	-	-	-	-	8	XVI-C
Chemical Engineering, X	119	100	96	4	319	56	169	-	-	-	225	544	X
Chemical Engineering, X-C	1	1	3	-	5	-	-	-	-	-	-	5	X-C
Civil and Environmental Engineering, I	-	-	-	-	188	92	5	5	5	5	290	290	I
Civil and Environmental Engineering, I-C	15	12	17	1	45	-	-	-	-	-	-	45	I-C
Civil and Environmental Engineering, I-E	20	23	25	1	69	-	-	-	-	-	-	69	I-E
Civil and Environmental Engineering, I-W (Woods Hole)	-	-	-	-	-	1	3	1	1	-	5	5	I-W
Electrical Engineering and Computer Science, VI	-	-	-	-	179	371	4	18	4	18	572	572	VI
Program 1-Electrical Science and Engineering	66	59	83	22	230	-	-	-	-	-	-	230	VI-1
Program 2-Electrical Engineering and Computer Science	154	66	44	12	276	-	-	-	-	-	-	276	VI-2
Program 3-Computer Science and Engineering	97	88	94	12	291	-	-	-	-	-	-	291	VI-3
Electrical Engineering and Computer Science, VI-P (M. Eng.)	-	-	-	-	-	171	-	-	-	-	171	171	VI-P
Electrical Eng and Computer Science, VI-PA (M. Eng., Internship)	-	-	-	-	-	51	-	-	-	-	51	51	VI-PA
Electrical Engineering and Computer Science, VI-A (Internship)	-	-	-	-	-	6	-	-	-	-	6	6	VI-A
Program 1-Electrical Science and Engineering	-	28	35	1	64	-	-	-	-	-	-	64	VI-1A
Program 2-Electrical Engineering and Computer Science	-	23	10	-	33	-	-	-	-	-	-	33	VI-2A
Program 3-Computer Science and Engineering	-	22	25	1	48	-	-	-	-	-	-	48	VI-3A
Electrical Engineering and Computer Science, VI-W (Woods Hole)	-	-	-	-	-	-	5	-	5	-	5	5	VI-W
Materials Science and Engineering, III	33	7	10	4	54	74	97	4	4	14	176	230	III
Materials Science and Engineering, III-A	1	-	-	-	1	-	-	-	-	-	-	1	III-A
Materials Science and Engineering, III-B (Internship)	2	30	28	1	61	-	-	-	-	-	-	61	III-B
Mechanical Engineering, II	133	101	130	10	374	230	175	6	6	5	416	790	II
Mechanical Engineering, II-A	3	5	7	-	15	-	-	-	-	-	-	15	II-A
Mechanical Engineering, II-B (Internship)	-	14	11	1	26	-	-	-	-	-	-	26	II-B
Mechanical Engineering, II-W (Woods Hole)	-	-	-	-	-	-	1	-	-	-	1	1	II-W

Nuclear Engineering, XXII	5	4	7	-	16	64	53	1	1	119	135	XXII
Nuclear Engineering, XXII-A (Internship)	1	-	1	-	2	-	-	-	-	-	2	XXII-A
Ocean Engineering, XIII	5	3	3	1	12	53	39	-	1	93	105	XIII
Ocean Engineering, XIII-W (Woods Hole)	-	-	-	-	-	8	13	-	-	21	21	XIII-W
Naval Construction and Engineering, XIII-A	-	-	-	-	-	24	-	-	-	24	24	XIII-A
Ocean Systems Management, XIII-B	-	-	-	-	-	8	-	-	-	8	8	XIII-B
Center for Advanced Engineering Study, EN	-	-	-	-	-	-	-	-	41	41	41	EN
Total	681	618	663	74	2,036	1,227	1,085	22	75	2,409	4,445	Total

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

Economics, XIV	29	36	31	9	105	-	116	24	6	146	251	XIV
Anthropology/Archaeology, XXI-A	-	1	2	1	4	-	-	-	-	-	4	XXI-A
Foreign Languages and Literatures, XXI-F	-	-	-	1	1	-	-	-	-	-	1	XXI-F
History, XXI-H	-	1	3	1	5	-	-	-	-	-	5	XXI-H
Literature, XXI-L	2	1	2	3	8	-	-	-	-	-	8	XXI-L
Music and Theater Arts, XXI-M	-	3	6	1	10	-	-	-	-	-	10	XXI-M
Writing and Humanistic Studies, XXI-W	2	-	4	4	10	-	-	-	-	-	10	XXI-W
Humanities, XXI	-	-	-	1	1	-	-	-	-	-	1	XXI
Linguistics and Philosophy, XXIV	1	2	1	1	5	1	52	6	-	59	64	XXIV
Political Science, XVII	2	5	7	5	19	12	67	39	3	121	140	XVII
Program in Science, Technology, and Society, STS	-	-	1	-	1	-	19	4	-	23	24	STS
Total	36	49	57	27	169	13	254	73	9	349	518	Total

SLOAN SCHOOL OF MANAGEMENT

Management, XV	37	57	29	8	131	634	84	6	14	738	869	XV
Management Fellows, XV-A	-	-	-	-	-	55	-	-	10	65	65	XV-A
Operations Research, OR	-	-	-	-	-	14	34	-	-	48	48	OR
Total	37	57	29	8	131	703	118	6	24	851	982	Total

SCHOOL OF SCIENCE

Program in Biological Sciences, XX	-	-	-	-	-	-	1	-	-	1	1	XX
Biology, VII	118	133	124	8	383	-	207	2	3	212	595	VII
Biology, VII-A	2	4	8	1	15	-	-	-	-	-	15	VII-A
Biology, VII-W (Woods Hole)	-	-	-	-	-	1	33	-	-	34	34	VII-W
Brain and Cognitive Sciences, IX	12	24	26	1	63	-	45	1	1	47	110	IX
Chemistry, V	40	41	37	2	120	1	234	-	1	236	356	V
Earth, Atmospheric, and Planetary Sciences, XII	9	11	5	-	25	7	84	1	1	93	118	XII
Earth, Atmospheric, and Planetary Sciences, XII-W (Woods Hole)	-	-	-	-	-	2	77	-	-	79	79	XII-W
Mathematics, XVIII	30	34	42	2	108	-	92	8	1	101	209	XVIII
Mathematics with Computer Science, XVIII-C	14	12	15	3	44	-	-	-	-	-	44	XVIII-C

Physics, VIII	45	43	42	10	140	2	248	5	1	256	396	VIII
Physics, VIII-A	9	4	2	-	15	-	-	-	-	-	15	VIII-A
Total	279	306	301	27	913	13	1,021	17	8	1,059	1,972	Total
WHITAKER COLLEGE of Health Sciences and Technology												
Division of Toxicology, TOX	-	-	-	-	-	14	22	-	-	36	36	TOX
Harvard-MIT Division of Health Sciences and Technology, HST	-	-	-	-	-	-	234*	-	-	234	234	HST
Total	-	-	-	-	-	14	256	-	-	270	270	Total
Undesignated Sophomores	32	-	-	-	32	-	-	-	-	-	32	UND
First Year	1,122	-	-	-	1,122	-	-	-	-	-	1,122	First Year
Special -- No Course	-	14	-	-	14	-	-	-	-	-	14	Special-NC
Grand Total	1,122	1,087	1,077	142	4,495	2,330	2,844	155	136	5,465	9,960	Grand Total

Not included in above totals:

Foreign Study: 2 students in the second year, 6 students in the third year, 4 students in the fourth year. Domestic Study: 1 student in the second year, 1 student in the third year, 1 student in the fourth year.	-	-	-	-	-	-	-	-	-	1	1	NIR
Non-Institute Brandies, NIR	17	15	23	41	96	-	-	-	-	226	322	NIH
Non-Institute Harvard, NIH	14	9	5	3	31	-	-	-	-	-	31	NIT
Non-Institute Tufts, NIT	-	17	25	19	62	-	-	-	-	6	62	NIW
Non-Institute Wellesley, NIW	-	-	2	-	2	-	-	-	-	8	8	NIV
Non-Institute Research Visitor, NIV	-	-	3	-	3	-	-	-	-	4	7	NIE
Non-Institute Exchange, NIE	31	41	58	63	194	1	237	431	431	431	431	Total

*Number includes 151 students working on Harvard degrees only.

TABLE II: NUMBER OF DEGREES AWARDED IN SEPTEMBER 1995, FEBRUARY 1996, AND JUNE 1996

	MARCH, M.C.P.												TOTAL					
	S.B.			S.M.			ENGINEER			Ph.D.			Sc.D.			TOTAL		
	Sep	Feb	Jun	Sep	Feb	Jun	Sep	Feb	Jun	Sep	Feb	Jun	Sep	Feb	Jun	Sep	Feb	Jun
SCHOOL OF ARCHITECTURE																		
Architecture	-	-	-	-	-	-	1	23	6	-	-	-	-	-	-	-	-	-
Undesignated	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Architecture Studies	-	-	-	-	2	18	-	-	-	-	-	-	-	-	-	-	-	-
Art and Design	-	2	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Building Technology	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Media Arts and Sciences	-	-	-	-	17	3	6	-	-	-	-	-	-	-	-	-	-	-
Planning	2	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Real Estate Development	-	-	-	-	22	3	4	-	-	-	-	-	-	-	-	-	-	-
Urban Studies and Planning	-	-	-	-	1	1	1	4	7	52	-	-	-	-	-	-	-	-
Total	2	4	26	40	10	31	5	30	58	-	-	-	1	6	8	-	-	-
SCHOOL OF ENGINEERING																		
Aeronautics and Astronautics	2	1	35	16	10	22	-	-	1	-	-	1	5	4	-	-	-	-
Chemical Engineering	-	3	94	2	1	3	-	-	-	-	-	-	7	8	9	-	-	-
Undesignated	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chemical Engineering Practice	-	-	-	12	6	18	-	-	-	-	-	-	-	-	-	-	-	-
Civil Engineering	-	2	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Civil and Environmental Engineering	-	-	-	14	14	37	-	-	21	-	-	1	3	7	7	-	-	-
Undesignated	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Computer Science and Engineering	4	13	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical Science and Engineering	7	11	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical Engineering and Computer Science	-	8	60	20	20	59	13	36	126	3	-	6	17	25	26	1	1	3
Environmental Engineering Science	-	1	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Materials Science and Engineering	-	8	33	2	6	20	-	-	-	-	-	-	6	10	11	1	2	3
Undesignated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mechanical Engineering	4	14	114	15	19	56	-	-	-	1	-	-	9	14	23	-	1	-
Undesignated	1	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	-	-	1	6	-	-	-	-	-	-	-	-	-	-	-	-
Naval Engineering	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-

Nuclear Engineering	1	1	9	2	10	15	-	-	-	1	3	8	5	6	-	1	3	11	18	36	
Ocean Engineering	1	-	4	6	3	4	-	1	6	1	-	4	3	4	-	-	-	12	7	18	
Ocean Systems Management	-	-	-	1	2	5	-	-	-	-	-	-	-	-	-	-	-	1	2	5	
Technology and Policy	-	-	-	9	6	32	-	-	-	-	-	-	-	-	-	-	-	9	6	32	
Transportation	-	-	-	5	1	9	-	-	-	-	-	-	-	-	-	-	-	5	1	9	
Total	22	62	616	104	99	286	13	37	154	5	2	18	55	77	90	2	9	12	201	286	1,176
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																					
Economics	1	9	43	1	1	4	-	-	-	-	-	9	2	18	-	-	-	11	12	65	
Foreign Languages and Literatures	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
History	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	
Humanities	-	2	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	8	
Humanities and Engineering	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	
Humanities and Science	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	
Linguistics	-	-	-	-	-	1	-	-	-	-	-	6	1	-	-	-	-	6	1	1	
Literature	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	
Music	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	
Philosophy	-	-	3	-	1	-	-	-	-	-	-	1	-	2	-	-	-	1	1	5	
Political Science	-	-	10	2	2	2	-	-	-	-	-	2	6	7	-	-	-	4	8	19	
Science, Technology and Society	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	
Writing	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
Total	1	15	87	3	4	7	-	-	-	-	-	18	9	28	-	-	-	22	28	122	
SLOAN SCHOOL OF MANAGEMENT																					
Management	-	-	-	-	1	111	-	23	204	-	-	3	3	13	-	-	-	3	27	328	
Management Science	-	5	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	39	
Management of Technology	-	-	-	-	1	41	-	-	-	-	-	-	-	-	-	-	-	-	1	41	
Operations Research	-	-	-	2	1	8	-	-	-	-	-	3	-	7	-	-	-	5	1	15	
Total	-	5	39	2	3	160	-	23	204	-	-	6	3	20	-	-	-	8	34	423	
SCHOOL OF SCIENCE																					
Biology	2	15	116	-	-	2	-	-	-	-	-	11	19	13	-	-	-	13	34	131	
Undesignated	-	3	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	15	
Brain and Cognitive Science	-	-	-	1	-	1	-	-	-	-	-	10	2	2	-	-	-	11	2	3	
Chemistry	-	3	32	3	2	5	-	-	-	-	-	7	13	23	-	-	1	10	18	61	
Cognitive Science	-	3	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	24	

TABLE III: NUMBER OF WOMEN STUDENTS BY COURSE AND YEAR, 1995-96

COURSE NAME	Year										Total	Under-grads	Master/Eng.	Doctoral			Total	Grand Total No.
	2	3	4	5	Reg.	Non-Res.	Spec'l	Grads	Total	Course								
	11	12	13	14										15	16	17		
SCHOOL OF ARCHITECTURE AND PLANNING																		
Architecture, IV	11	11	6	2	30	53	12	8	1	74	104	IV						
Architecture, IV-B	-	-	1	1	2	-	-	-	-	-	2	IV-B						
Urban Studies and Planning, XI	1	2	3	-	6	60	22	11	9	102	108	XI						
Program in Media Arts and Sciences, MAS	-	-	-	-	-	11	8	-	-	19	19	MAS						
Total	12	13	10	3	38	124	42	19	10	195	233	Total						
SCHOOL OF ENGINEERING																		
Aeronautics and Astronautics, XVI	7	8	10	-	25	19	5	-	-	24	49	XVI						
Aeronautics and Astronautics, XVI-B (Cooperative)	-	-	1	-	1	-	-	-	-	-	1	XVI-B						
Aeronautics and Astronautics, XVI-C (Internship)	-	-	2	-	2	-	-	-	-	-	2	XVI-C						
Chemical Engineering, X	67	48	50	2	167	15	39	-	-	54	221	X						
Chemical Engineering, X-C	-	1	-	-	1	-	-	-	-	-	1	X-C						
Civil and Environmental Engineering, I	-	-	-	-	-	43	24	2	1	70	70	I						
Civil and Environmental Engineering, I-C	8	6	8	1	23	-	-	-	-	-	23	I-C						
Civil and Environmental Engineering, I-E	15	13	17	-	45	-	-	-	-	-	45	I-E						
Civil and Environmental Engineering, I-W (Woods Hole)	-	-	-	-	-	1	-	1	-	2	2	I-W						
Electrical Engineering and Computer Science, VI	-	-	-	-	-	27	66	-	3	96	96	VI						
Program 1-Electrical Science and Engineering	22	6	15	5	48	-	-	-	-	-	48	VI-1						
Program 2-Electrical Engineering and Computer Science	37	14	4	4	59	-	-	-	-	-	59	VI-2						
Program 3-Computer Science and Engineering	18	16	17	3	54	-	-	-	-	-	54	VI-3						
Electrical Engineering and Computer Science, VI-P (M. Eng.)	-	-	-	-	-	26	-	-	-	26	26	VI-P						
Electrical Eng and Computer Science, VI-PA (M. Eng., Internship)	-	-	-	-	-	12	-	-	-	12	12	VI-PA						
Program 1-Electrical Science and Engineering	-	8	6	1	15	-	-	-	-	-	15	VI-1A						
Program 2-Electrical Engineering and Computer Science	-	5	4	-	9	-	-	-	-	-	9	VI-2A						
Program 3-Computer Science and Engineering	-	3	6	-	9	-	-	-	-	-	9	VI-3A						
Electrical Engineering and Computer Science, VI-W (Woods Hole)	-	-	-	-	-	-	1	-	-	1	1	VI-W						
Materials Science and Engineering, III	20	1	2	-	23	18	20	2	-	40	63	III						
Materials Science and Engineering, III-A	1	-	-	-	1	-	-	-	-	-	1	III-A						
Materials Science and Engineering, III-B (Internship)	1	14	16	1	32	-	-	-	-	-	32	III-B						
Mechanical Engineering, II	37	29	32	-	98	28	10	-	1	39	137	II						
Mechanical Engineering, II-A	2	-	1	-	3	-	-	-	-	-	3	II-A						
Mechanical Engineering, II-B (Internship)	-	4	3	-	7	-	-	-	-	-	7	II-B						
Nuclear Engineering, XXII	1	2	1	-	4	6	8	-	-	14	18	XXII						
Nuclear Engineering, XXII-A (Internship)	1	-	1	-	2	-	-	-	-	-	2	XXII-A						

Ocean Engineering, XIII	2	-	2	1	5	9	5	5	-	14	19	XIII
Ocean Engineering, XIII-W (Woods Hole)	-	-	-	-	3	-	3	-	-	3	3	XIII-W
Naval Construction and Engineering, XIII-A	-	-	-	-	-	1	-	-	-	1	1	XIII-A
Center for Advanced Engineering Study, EN	-	-	-	-	-	-	-	-	3	3	3	EN
Total	239	178	198	18	633	205	181	8	399	1,032	Total	

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

Economics, XIV	10	13	13	5	41	-	33	8	-	41	82	XIV
Anthropology/Archaeology, XXI-A	-	-	1	1	2	-	-	-	-	-	2	XXI-A
Foreign Languages and Literatures, XXI-F	-	-	-	1	1	-	-	-	-	-	1	XXI-F
History, XXI-H	-	-	2	-	2	-	-	-	-	-	2	XXI-H
Literature, XXI-L	2	1	1	2	6	-	-	-	-	-	6	XXI-L
Music and Theater Arts, XXI-M	-	1	2	1	4	-	-	-	-	-	4	XXI-M
Writing and Humanistic Studies, XXI-W	2	-	2	-	4	-	-	-	-	-	4	XXI-W
Humanities, XXI	-	-	-	1	1	-	-	-	-	-	1	XXI
Linguistics and Philosophy, XXIV	-	1	-	-	1	-	20	-	-	20	21	XXIV
Political Science, XVII	1	1	4	1	7	7	20	14	1	42	49	XVII
Program in Science, Technology, and Society, STS	-	-	1	-	1	-	8	2	-	10	11	STS
Total	15	17	26	12	70	7	81	24	1	113	183	Total

SLOAN SCHOOL OF MANAGEMENT

Management, XV	20	23	14	2	59	152	18	3	6	179	238	XV
Management Fellows, XV-A	-	-	-	-	-	6	-	-	1	7	7	XV-A
Operations Research, OR	-	-	-	-	-	4	9	-	-	13	13	OR
Total	20	23	14	2	59	162	27	3	7	199	258	Total

SCHOOL OF SCIENCE

Biology, VII	67	82	63	2	214	-	82	1	1	84	298	VII
Biology, VII-A	2	1	3	-	6	-	-	-	-	-	6	VII-A
Biology, VII-W (Woods Hole)	-	-	-	-	-	-	22	-	-	22	22	VII-W
Brain and Cognitive Sciences, IX	6	12	16	-	34	-	20	-	-	20	54	IX
Chemistry, V	22	22	19	1	64	-	80	-	-	80	144	V
Earth, Atmospheric, and Planetary Sciences, XII	7	9	2	-	18	3	29	1	1	34	52	XII
Earth, Atmospheric, and Planetary Sciences, XII-W (Woods Hole)	-	-	-	-	-	-	29	-	-	29	29	XII-W
Mathematics, XVIII	11	9	20	-	40	-	20	1	-	21	61	XVIII
Mathematics with Computer Science, XVIII-C	5	1	2	1	9	-	-	-	-	-	9	XVIII-C
Physics, VIII	12	8	8	3	31	-	25	1	-	26	57	VIII
Physics, VIII-A	1	-	-	-	1	-	-	-	-	-	1	VIII-A
Total	133	144	133	7	417	3	307	4	2	316	733	Total

WHITAKER COLLEGE of Health Sciences and Technology

Division of Toxicology, TOX

Harvard-MIT Division of Health Sciences and Technology, HST

Total	9	77	9	66	11	20	86	20	TOX
11	-	-	11	-	-	-	-	-	UND
471	-	-	471	-	-	-	-	-	First Year
-	6	-	6	-	-	-	-	-	Special NC
Grand Total	430	381	42	1,705	510	715	55	28	1,308
									3,013
									Grand Total

FACULTY AND ACADEMIC STAFF COUNT AS OF OCTOBER, 1996

DEPARTMENT	Professors in Administration	Professor	Associate Professor with Tenure	Associate Professor without Tenure	Assistant Professor	Subtotal - Tenure Track Faculty	Adjunct Professor	Senior Research Associate	Senior Research Scientist	Senior Research Engineer	Professor (non-tenure)	Senior Lecturer	Lecturer	Instructor	Technical Instructor	Postdoctoral Associate	Postdoctoral Fellow	Research Fellow	Research Affiliate	Visiting Professor	Visiting Associate Professor	Visiting Assistant Professor	Visiting Lecturer	Visiting Scholar	Visiting Engineer	Visiting Scientist	Coach/Trainer	Other Academic Staff*	GRAND TOTAL	Instructor-G	Teaching Assistant	Research Assistant							
VP - RESEARCH, DEAN GRADUATE SCHOOL																																							
CENTER FOR ENVIRONMENTAL HEALTH SCIENCES																																							
CENTER FOR MATERIALS SCIENCE & ENGINEERING																																							
CLINICAL RESEARCH CENTER																																							
DIVISION OF COMPARATIVE MEDICINE																																							
DIVISION OF TOXICOLOGY																																							
ENERGY LABORATORY																																							
FRANCIS BITTER NATIONAL MAGNET LAB																																							
HAYSTACK OBSERVATORY																																							
HRVD-MIT DIVISION OF HEALTH SCIENCE & TECH																																							
NUCLEAR REACTOR LABORATORY																																							
OPERATIONS RESEARCH CENTER																																							
PLASMA FUSION CENTER																																							
RESEARCH LABORATORY OF ELECTRONICS																																							
SEA GRANT COLLEGE PROGRAM																																							
WHITAKER COLLEGE OF HEALTH SCIENCES & TECH																																							
SUBTOTAL	1	4	1	1	3	10			8	3	1	3	1	50	52	4	##	1	1	11	13	##	48	455	15	109	8	70	5	20	2	19	2	1	1	1	1		
VP - RESOURCE DEVELOPMENT																																							
SUBTOTAL																																							
DEAN-UNDERGRADUATE EDUCATION																																							
AIR FORCE AEROSPACE STUDIES																																							
ATHLETIC DEPARTMENT																																							
CAMPUS ACTIVITIES COMPLEX																																							
MILITARY SCIENCE																																							
NAVAL SCIENCE																																							
SUBTOTAL																																							
ADMINISTRATION																																							
GRAND TOT	74	##	81	86	##	11	4	33	4	##	80	##	40	74	##	41	##	42	25	11	9	##	49	##	19	##	3363	7	##	##	##	##	##	##	##	##	##	##	

*Other Academic Staff includes: Institute Professors Emeriti, Honorary Lecturers, Affiliated Artists, Postdoctoral Trainees, Visiting Senior Lecturers, Visiting Instructors

OFFICE OF SPONSORED PROGRAMS

For fiscal year 1996, the total volume of sponsored research performed on campus was \$367,283 (all numbers rounded to nearest thousand). This represents an increase of 2.4% percent over fiscal 1995 volume of \$361,689. The breakdown by sponsor is shown in the table below.

SIGNIFICANT DEVELOPMENTS

Activities in the Office of Sponsored Programs during 1995-1996 were impacted in two distinct arenas: externally by ongoing policy issues related to federal funding of research and internally by a major new emphasis on computerization and automation within the office. Each of these is described below:

FEDERAL INITIATIVES

Indirect Cost Issues

In February, 1995 another set of proposed revisions to OMB Circular A-21, the Federal cost principles applicable to universities, were issued. Adopted in May, 1996 these revisions will further constrain the ability of institutions to fully recover the costs of performing research for the federal government.

One of the significant changes adopted in May is the requirement to "fix" the indirect cost rate for the life of an award or competing segment thereof. This poses not only additional strain on resources to accommodate multiple indirect cost rates but also will require significant communication with both Institute researchers and federal agencies to implement this change fairly and equitably.

As discussed last year, a troublesome issue still exists related to departmental administration expenses. Despite the fact that the Office of Management and Budget issued a formal interpretation of the section of A-21 which had restricted direct charging administrative and clerical expenses to federal research awards, some federal agencies have restricted or eliminated secretarial and administrative support from federal awards. This issue is continuing to be addressed by OSP and by Washington-based organizations such as the Council on Governmental Relations.

Research Assistant Compensation

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 regulation, which appear in OMB Circular A-21, provide a transition period which will result in MIT's treating tuition as a direct charge for these appointments beginning in FY 99. The problem is compounded now for NIH awards because that agency is now restricting graduate student compensation (defined as salary plus employee benefits plus tuition charges) to a "reasonable" level and, furthermore, will limit funding from NIH for these costs to \$23,000.

Conflict of Interest

Over the past year, MIT has developed policy and procedures to implement the disclosure and review requirements of the National Science Foundation and the Public Health Service with regard to possible investigator conflict of interest on research projects. NSF and NIH implemented their policies October 1, 1995. Annual updates of disclosures for currently funded awards and pending proposals are now required from all principal investigators.

The Lobbying Disclosure Act of 1995

This Act was signed into law in December 1995 and, as a result, MIT (along with many other institutions of higher education) registered as required by the act. Certain named individuals who spend significant time in an advocacy role at the federal level are now required to report their activities and associated costs biannually. Others (including deans, directors, and faculty) are required to report internally similar activities for consolidated reporting.

INTERNAL INITIATIVES

Streamlining of research administration processes

Significant effort has been devoted toward streamlining some internal processes related to the management of research awards at the Institute which have provided relief to schools, labs, and departments, as well as to central administrative offices. We have provided additional flexibilities to principal investigators in the use of federal

research grant funds by relaxing many of the internal approvals previously required and have streamlined the Research Proposal Summary form, to reduce the items on the form and make the remaining items more useful. In addition, MIT has been accepted into Phase III of the Federal Demonstration Partnership, which will provide even greater flexibilities to researchers and will provide avenues to utilize electronic initiatives underway by the federal government.

Automation and computerization

The major internal effort of the office this year has been the implementation of an OSP database to capture award and proposal information in a computerized database. This will permit more effective and efficient management of awards by OSP staff, will permit Institute personnel to access the database, and will provide the capability to produce standard and custom reports quickly and independently. The database is fully loaded and OSP is currently deploying the system to interested departments, laboratories, and centers.

Last year, MIT committed to participating in two federal initiatives to develop and submit the administrative portion of selected research proposals to NSF, ONR, NIH, DOE, AFOSR, ARO, and ARMAA electronically. Initial development has proceeded and proof of concept proposals were submitted this past year. MIT also completed a discovery project which has led to approval for full development of an electronic proposal creation, processing, and submission process. This project is expected to be completed by January 1998 and will result in any researcher at MIT using the technology already available in the researcher's office or laboratory being able to electronically create and submit proposals to federal agencies.

IN MEMORIAM

We note with sadness the death of one of our contract administrators, Ms. Marie Cedrone, who died of cancer in June, 1996.

CAMPUS RESEARCH VOLUME BY SPONSOR - 1988-1996 (in thousands of dollars)

<u>FEDERAL</u>		<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>
DHHS	\$	49,070	52,565	57,915	59,025	60,177	64,882	60,192	61,066	58,211
DOE	\$	55,629	54,045	61,098	60,625	57,355	57,325	63,180	67,114	69,588
DOD	\$	46,836	47,921	51,158	49,104	48,539	66,769	61,601	55,866	59,997
NSF	\$	39,177	38,962	38,093	37,953	36,574	38,008	39,574	38,564	35,837
NASA	\$	12,509	15,256	18,469	22,755	25,889	32,324	37,449	41,291	39,190
Other	\$	7,283	6,713	7,430	8,647	9,773	8,899	8,722	9,641	8,721
Subtotal	\$	210,504	215,462	234,163	238,109	238,307	268,206	270,718	273,542	271,544
 <u>NON-FEDERAL</u>										
Industry	\$	35,315	41,937	46,223	48,360	53,578	62,068	59,117	56,120	67,164
Nonprofit	\$	19,779	23,602	25,220	23,751	24,920	25,593	23,666	26,430	25,926
Other	\$	3,796	4,727	5,053	5,599	5,461	5,487	6,173	5,597	5,649
Subtotal	\$	58,890	70,266	76,496	77,710	83,959	93,148	88,956	88,147	98,739
TOTAL	\$	269,394	285,728	310,660	315,819	322,267	361,354	359,674	361,689	370,283

Julie Norris

OFFICE OF STUDENT FINANCIAL AID

The mission of the Student Financial Aid Office is to develop and maintain fair and equitable financial aid policies and practices which assure equal access by all students qualified for admission to MIT. Activities that advance this mission include counseling students and parents in all financial aid matters, managing grant and loan funds from outside agencies, stewarding undergraduate scholarship endowment funds, managing on- and off-campus student employment opportunities, and advising senior management and faculty on all matters pertaining to financial aid policies.

HIGHLIGHTS OF THE YEAR

The Financial Aid Office became heavily involved in the reengineering efforts for student services begun this year. A number of specific recommendations for improving the services provided by financial aid were made by a redesign team, and specific implementation plans were begun for improving the quality and efficiency of student financial services.

In 1995-96 MIT joined the federal Direct Loan Program and made its first student loans under the program in July 1995. The program was designed to eliminate the complications associated with the bank-based Family Education Loan Program. Students found the new program to be very helpful in providing the proceeds of their student loans simply and efficiently.

Communications with students and parents were enhanced by the creation of World Wide Web pages for both the Financial Aid and Student Employment Offices. The financial aid page provides information on MIT's policies, sources of outside loan and scholarship information, and answers to questions regarding application procedures. The Student Employment page provides students with the listings of job opportunities both on- and off-campus.

The year brought intense political fighting in Washington over the federal budget, and student aid allocation were under intense scrutiny. The Direct Loan Program was subject to partisan attacks with many Republicans vowing to eliminate the program in the face of strong support from the Democratic side. Proposals to cap the number of participating schools were narrowly defeated as were proposals to eliminate or greatly reduce the federal commitments to other student aid programs. In the end, modest cuts were made in some federal scholarship programs, but most of the funding of student loans was left intact.

SCHOLARSHIPS AND GRANTS

(Awarded to undergraduates with need)

Source	1993-94	1994-95	1995-96
Pell Grants	1,261	1,276	1,183
SEO Grants	1,980	1,903	1,970
ROTC Scholarships	499	770	601
Scholarship Endowment	9,724	10,854	12,021
Current Gifts	1,064	873	773
Direct Grants	2,810	3,071	3,311
Unrestricted Funds	15,523	16,165	14,965
Total Grants Awarded	32,861	34,912	34,824

The average need of the undergraduate's eligible for financial aid increased to \$20,078 in 1995-96. This is an increase of x% over last year. The economic picture continues to be bright for most parents and this improving economic situation is reflected in the moderating requirement for need-based financial aid.
(detail of use of funds will follow)

LOANS

(Received by needy and non-needy students)

Source	1993-94	1994-95	1995-96
A. Awarded to Undergraduates			
Technology Loan Fund	1,324	1,863	1,911
Perkins/Nation Direct Loans	3,043	3,753	4,406
Stafford Loans to Needy Students	7,555	8,091	8,631
Stafford Loans Beyond Need	186	459	475
Supplimental Loans to Students	580	130	188
Sub-Total	12,688	14,296	15,611

B. Awarded to Graduate Students

Technology Loan Fund	2,120	2,739	4,471
Stafford Student Loans			
by Commercial Lenders	3,572	4,970	5,651
Stafford Student Loans			
by MIT	236	0	0
Stafford Loans Beyond Need	13	2,768	3,553
Perkins/National Direct Loans	11	47	172
Plus Loans & Federal			
Supplimental Loans for Students	1,843	12	51
Sub-Total	7,795	10,536	13,898

In 1996 student loans to undergraduates increased by 8.4% and loans to graduate students increased by 24%. This is the second year in which the loan volume to graduate students increased by more than 20%. This year MIT began participation in the The Stafford Direct Loan Program which represent the largest source of loan funds to undergraduates.

STUDENT EMPLOYMENT

The off campus job market was clearly favorable for our students seeking employment. Together with our on campus jobs, there were more than enough offerings to satisfy all. High-end, skilled jobs were on the rise, and there was a decline in clerical positions; employers are seeking more technical and engineering skills.

2,880 undergraduate students worked on campus earning \$5,671,771 in 1995-96.

The MIT Student Minimum Wage was increased to \$7.25 as of June 1, 1996. This is the first increase since June of 1991. The MIT Self-help level has increase 34% during this time frame.

The College Work- Study Program allocation remained about the same as last year. One third of the CWS grant subsidized work done by undergraduates and two thirds subsidized graduate student teaching assistantships.

The Higher Education Act of 1965, as amended, and the regulations of November 30, 1994, require that each institution participating in the Federal College Work Study Program (FWS) must spend at least 5 percent of its FWS allocation to compensate students employed in community service activities. This past year was the second year of this program, and the participation has doubled. Now more than one hundred students are using their skills to enhance the lives of others.

The SEO designed a state of the art World Wide Web site. Jobs are posted to the WEB daily, students can also sign up for the 'On Call' lists on-line. Now students can browse through the job listings at their leisure, selecting topics of interest. The SEO site was featured at the National Student Employment convention as a model for others who were designing sites.

PERSONNEL

Elizabeth Barnes was promoted to Assistant to the Director after serving as administrative assistant for eight years. Daniel Langdale resigned as Associate Director and took a position as Associate Dean in the Graduate Education Office at MIT.

FUTURE PLANS

The coming year will bring substantial changes to the Student Financial Aid Office. Reengineering task will include not only changes in internal processes but also the reorganization of some of the functions of the Bursar, Registrar, and Financial Aid Offices. In addition significant part of today's financial aid services will be provided in a new student services center that has been recommended by the reengineering design team. These changes will be implemented at the same time that the office will be providing financial aid services to prospective freshman, upperclass, and graduate students.

Stanley Hudson

STUDENT INFORMATION SYSTEM

The Student Information System Department (SIS) exists to serve the students, administrators and faculty of MIT. It provides 24 hours a day, seven day a week support for both the On-Line Student Information System (OLSIS) and the administrative system (MITSIS). The Department is user driven in its approach to all aspects of SIS support and the goal is to meet or exceed the User's needs within the schedule required.

HIGHLIGHTS OF THE YEAR

This year was the first full year with MITSIS under new management. The SIS Team, which began the year reporting to the Office of the Registrar, became a department reporting directly to the Vice President for Administration. This change in reporting recognizes the continued broadening of the scope of the SIS.

The Student Services Reengineering (SSReE) effort took center stage. The SIS Team provided technical consultation to the redesign effort early in the year. The subsequent implementation effort, known as the Financial and Academic Services Transition (FAST), was formed and served as a project structure in which new SIS development for redesigned business processes is being accomplished.

Early in the FAST implementation, the emphasis was on building the procedural and technical foundation on which the redesigned processes would be supported. The FAST IT Mobilization project targeted the following tasks (among others) to create this structure: 1) profiling of the current system, 2) investigation of system development methodology and 3) initiation of future system architecture.

Several FAST-related tasks were undertaken. Some of these, such as the Graduate Student Awards processing (started by the Graduate Student Office), Automated Pre-Registration (initiated by the Office of the Registrar) and Student Access Enhancements (in support of the Bursar and Student Financial Aid offices) were begun prior to the SSReE effort. These tasks, embraced by the FAST team, continue to make progress toward successful implementation in the near future.

PERSONNEL

This year met with some personnel opportunities. Specific personnel changes were: 1) JoAnne Stevenson, a Senior Analyst Programmer was recognized as the SIS Assistant Manager and continues to be a valuable partner to the SIS Director, 2) Andrea Bernard was promoted to Network Application Programmer Analyst, recognizing her key role in expanding the SIS computing infrastructure, 3) Chris Gerstner, Senior Analyst Programmer in charge of the Financial Aid functionality resigned and 4) Huey Chan joined the staff as Senior Analyst Programmer, providing leadership support to the Financial Aid Office. In addition to the changes to the permanent staff, short term needs were met by the utilization of expert consultants. This combination of MIT personnel and outside assistance created a highly skilled and responsive development team which continued to provide a high level of system maintenance and development support.

FUTURE PLANS

As part of the Student Services Reengineering effort, the SIS department will undergo organizational changes to more effectively support its user base. This internal reassessment of the SIS department will take place in conjunction with the FAST effort. Working with the reorganized home offices (Bursar, Registrar, SFAO) and the new Student Services Center, a broadened user group to provide direction of need and priorities of new SIS support will be defined. In addition, partnership with MIT's IS organization will continue to be fostered.

Specific projects to be undertaken will be defined by/with the User departments. However, the goals for the coming year are to:

- Provide more people with access to more useable data, using a flexible, open system (client server and other technologies); eliminate hard copy where possible.
- Focus on customer service/needs, user education/training, pleasant/friendly user-interface screens; develop MITSIS Home Page on WWW.

Specific approaches to accomplishing the above goals include:

-
- Broaden *student access* (on Athena/WWW) to view a wider range of academic and financial information, and to conduct business conveniently
 - Broaden access for *individual Faculty* (via MIT Network) by providing Faculty access to a variety of information, with substantial Faculty control over what they want and when they get it
 - Upgrade access to MITSIS for *departmental offices/faculty* through implementing MITSIS on the MIT network (consistent with adequate privacy/security provisions), using client-server technology to facilitate faculty and departmental use.

Robert A. Rippondi

VICE PRESIDENT FOR HUMAN RESOURCES AND EQUAL OPPORTUNITY OFFICER

PERSONNEL

Members of the staff have continued to be involved in reengineering team efforts, either as team members or as advisors to departments and teams as change in work processes continues. These are exciting, challenging and sometimes painful times, as we improve work processes with fewer people engaged in the work.

Members of the Benefits Office staff deserve special mention for the outstanding work they accomplished on the special retirement incentive. It was a massive effort, handled in a finite amount of time, and they can be very proud of their accomplishment.

In the area of affirmative action and equal opportunity, accurate statistical data has allowed us to more easily monitor activity in the employment area. We need to find better ways to encourage promising minority group members to consider MIT when developing their careers, and we need to present MIT as an attractive place to work. Shelly LaVallee has been instrumental in gathering statistical data in preparation for distribution of the 1995 - 96 Affirmative Action Plan.

A number of staffing changes took place. Notable among those was the retirement of Kerry B. Wilson. Kerry took advantage of the retirement incentive after working here for 34 years. Kerry embodied all the finest qualities one wishes to find in a colleague. We wish him well in retirement and we miss him. Members of the staff who transferred from our office included Ramona Allen to the Biology Department, Kathleen Avison to the Benefits group at the Lincoln Laboratory, Susan Lester to the Office of the Secretary of the Corporation, and Cynthia Vallino to a full time engagement in the reengineering process.

Barbara Roberts joined us to fill the position of Coordinator of Disabilities Services. Cynthia Kam replaced Susan Lester in the Compensation Office. Roslyn Allen was hired as a Benefits counselor and there were two new Personnel Officers hired, Kenia Franco and Deborah Tyrrell. Stephanie Neal-Johnson came on board as Assistant to the Vice President replacing Cynthia Vallino.

Seongae Han, a member of the Benefits Office staff was promoted to Retirement Program Administrator.

Paul Glac and Susan Cina left to pursue positions that provided greater job interest.

As of June 1, 1996, of the total of 34 administrative staff in the Personnel Office, 10(29%) are minorities and 27(79%) are women. (In 1995, of the total of 33 Administrative Staff in the Personnel Office, 6(18%) were minorities and 24(73%) were women.)

As of June 1, 1996, of the total of 20 support staff in the Personnel Office, 4(20%) are minorities and 15(75%) are women. (In 1995, of the total of 20 support staff in the Personnel Office, 5(25%) were minorities and 16(80%) were women.)

Joan F. Rice

COMPENSATION OFFICE

The mission of the Compensation Office is to establish and implement fair, equitable and competitive compensation programs for the Institute's faculty, research, administrative, and support staff, in accordance with the Institute's reward philosophy and strategy.

SALARY SURVEYS

This year, the Compensation Office participated in 40 external salary surveys conducted by universities, associations, and consulting groups from across the country. As in previous years, the Office conducted two major surveys with approximately 30 participants each. The survey results continue to provide us a solid basis in determining our market positions, and in developing our review allocation proposals to the Executive Committee.

SALARY REVIEWS

Nine salary reviews covering approximately 7,300 Campus employees were conducted this year. As part of our continuous effort to increase the efficiency and effectiveness of the annual salary review processes, we developed electronic review sheets for the faculty review which were used by the Dean's Offices; and for the research, administrative, and support staff reviews, electronic sheets were provided to the Personnel Officers. All of the electronic review sheets provide meaningful summary statistics which enable management to assess the financial impact of review recommendations. The feedback from users have been most favorable.

CLASSIFICATION

Given the reengineering efforts and reorganizations that have been taking place at the Institute, a total of 92 administrative positions were classified or re-classified this fiscal year. The total number of active classified positions that currently exist in the Institute's Administrative Staff Classification System is 1,016. The process to request classifications of new or existing positions can now be done electronically, which not only reduces the amount of paper flow, but more significantly, reduces the duplicate efforts and time needed to record job descriptions. In addition, we have developed an electronic Job Description Index, which provides quick and easy access to the library of over 1,000 job descriptions which currently exist in our electronic system.

Cynthia Kam

BENEFITS OFFICE COMMUNICATION

The new hire orientation program was revised using MS PowerPoint software. The content of the program was also revised resulting in a more efficient presentation of information and reducing the length of the presentation by almost 50%. Use of this software allows for simple and inexpensive editorial changes. The visual presentation has eliminated the need to have slides or overheads produced. Plans are underway to make the program available on the Benefits Home Page of the World Wide Web. This approach will allow employees hired at remote locations and those unable to attend a presentation to obtain important benefit and personnel policy information. The Benefits Home page combined with an e-mail address was used extensively during the Special Retirement Incentive Program. This form of communication allowed individuals to access information about the program and gave us a tool to provide rapid response to questions from employees.

OPEN ENROLLMENT

In a continuing campaign to encourage participation in the Supplemental Retirement Plan [401(k)], the Benefits Office provided an opportunity to employees who were not maximizing their plan contributions to increase the level of their contribution by telephone. Like last year, the telephone system also allowed employees who were not contributing to enroll in the plan. As a result, there were 79 additional savers and 57 participants increased their rate of savings. These efforts resulted in the Plan's passage of IRS discrimination tests and prevented the need to suspend contributions for highly compensated employees. This was the first time since 1993, when the test became more restrictive, that corrective action was not needed to bring the plan into compliance with federal regulations.

EDUCATIONAL ASSISTANCE PLAN

The Children's Scholarship program made 1173 payments to colleges and universities for tuition payments for the children of MIT employees. The total expenditure was approximately \$3,600,000. In addition, approximately 1200 employees enrolled and successfully completed 2,600 courses through the Tuition Assistance Program.

MIT RETIREMENT PLAN

This year the Benefits Office developed and instituted the first phase of a comprehensive retirement planning and investment education program. During this first phase, the Benefits Office instituted an additional tax-deferred retirement savings program, introduced additional high-quality, low-cost investment options for the TDA program, and offered or sponsored a number of seminars on such important topics as investment fundamentals, investment asset allocation, estate planning and health insurance in retirement. Approximately 400 faculty and staff members attended these seminars.

The Benefits Office also administered the Special Retirement Incentive Program. We identified 1,384 faculty and employees who met the eligibility criteria of being 55 or older with 10 years of service. Of those eligible, 642 accepted the offer and will have retired from the Institute by September 30, 1996. The incentive to retire was an additional monthly annuity equal to 10% of base pay and a bridge payment of \$500 a month for those between ages 55 and 62. The incentive plan was funded through the MIT Retirement Plan. An additional incentive, not funded through the Retirement Plan, was made available for tenured faculty members. Tenured faculty who were at least age 60 by July 1, 1996, and who agreed to leave MIT, were eligible to receive a transition payment of 1.5 times annual salary. Tenured faculty who were at least age 65 by July 1, 1996, and were rehired by their departments for up to 49% time for up to 5 years, were eligible to receive a transition payment of 1.0 times annual salary. The magnitude of this program was enormous, in that within a 6-month period, more than four times the normal annual number of retirees were counseled and guided through the retirement process. In order to accommodate this increased volume, the Benefits Office set up a special unit in Building 16. We took various steps to reengineer our operations by automating processes, simplifying other processes, increasing communications with other MIT departments involved in the retirement process and using the capabilities of outside organizations to enhance our own capacity. Use of the telephone for enrollment and as a means of receiving additional information helped us get timely information to the individuals affected. Many of the changes made to the processes and systems will enhance our ability going forward to produce accurate and timely information to our customers. In the future, much of the data previously passed in paper forms will be transferred electronically, directly into the pension payroll.

I would like to thank the staff of the Benefits Office for their dedication, professionalism, and good humor in getting through an enormously challenging year.

Marianne Howard

FACULTY AND STAFF INFORMATION SERVICES

Faculty and Staff Information Services (FASIS) 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 continues to process approximately 14,000 appointments and changes. In addition, the office continues its role in the processing of salary reviews, in the servicing of data requests received from within the Personnel Office and the MIT Community, in responding to external employment verification requests, and in the production of the staff telephone directory.

In this fiscal year there were three major upgrades to the personnel systems. The first major upgrade involved the upgrading of the personnel file servers and the Novell local area network. It was necessary to upgrade Novell in order to technically support the personnel-benefits staff who provided administrative support for those individuals who were eligible for the special retirement incentive. This personnel-benefits staff resided in building 16 and required access to the personnel office local area network. The second major upgrade was to the Restrac employment management system. This upgrade involved the installation of Restrac Hire 3.0 and PC Oracle. Restrac Hire is designed around an open, client/server architecture that supports industry standards. These include the use of Microsoft Windows on desktops and popular SQL relational databases on the server. Our choice of relational database was Oracle. The third major upgrade was the Cyborg Human Resource System. This system was upgraded from version 8.2 to the latest release called Solutions/ST. This new product is a significant enhancement that has introduced a brand new GUI interface that takes full advantage of the Windows standards for ease-of-use and consistent presentation design.

This fiscal year data and process enhancements included the monthly loading of Lincoln Laboratory benefits data for the purpose of benefits reporting, and the completion of the conversion of the MIT-ID number which included assisting the payroll office with its conversion. In addition numerous data files and listings were generated to support the data needs of the personnel-benefits office. Computer programs were developed to generate the data needed for the special retirement incentive, the electronic transfer to an outside vendor for administration of COBRA program and to Blue Cross/Blue Shield, the Benefits Accounting Office coverage changes and layoff letters.

Reengineering continued to dominate the time and effort of some of the staff during the first half of the fiscal year. While only a few are involved in reengineering, the demands of that work impact all of the staff. And, because there is a strong sense of commitment and dedication, every effort is made by all of the staff to focus in on all of the details and to carry out the many responsibilities which require accuracy, and completion in a timely manner. For this effort I wish to thank the FASIS staff.

The Appointment Process System(TAPS) which also included the Query Facility (TQF)was the major reengineering effort that required the assistance of the FASIS Staff. During this fiscal year Cynthia DeSimone tested the TAPS application which included acceptance testing, conducted a number of TAPS workshops, assisted with the installation of TAPS for a pilot project and trained TAPS pilot team members on the use of the application. Virginia Hillen, the Personnel Senior Analyst Programmer, worked very closely with Information Systems in the design of TQF and to provide data to the warehouse for the TQF application. In addition she coordinated the installation of TQF on the pilot team's desktop, conducted TQF workshops, provided training and support on the use of TQF, and assisted in the acceptance testing of TAP.

It is with sadness that I report that Paul Glac our Systems Coordinator left MIT for another job opportunity. Paul was primarily responsible for the internal and external data requests. In addition, Paul assisted with networking and troubleshooting of computer problems. His job required him to listen very carefully and patiently to his customers. He excelled in those talents. He will be missed!

Claire Paulding

EMPLOYEE RELATIONS

Employee Relations consist of three areas within the Personnel Office: Personnel Services, Labor Relations and Employment.

PERSONNEL SERVICES

The primary mission of the Personnel Services section 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. A new Personnel Officer, Kenia Franco, was hired to bring the number of Personnel Officers up to the regular complement of seven and Jacqueline Gillis transferred into Personnel Services from FASIS as Administrative Assistant.

During the year we have worked closely with several of the reengineering teams advising them on the human resources implications of the planned redesigns. As a result of increased demand for human resources support for the reengineering teams we got budget approval to add two more Personnel Officers. With the addition of these two positions we have been able to assign Personnel Officers to be full members on some of the reengineering teams.

Several Personnel Officers were actively involved in counseling employees affected by curtailment of staff at the Francis Bitter Magnet and Plasma Fusion Center Laboratories as well as the transfer of the Parking and Safe Ride Program to an independent contractor and have assisted these employees in understanding their benefit choices and job opportunities. The Personnel Officers have also been actively involved in the Institute's increased emphasis on performance evaluations and teamed with department representatives to provide training to supervisors and employees on how to successfully conduct and benefit from performance reviews. This was an extensive effort and several hundred employees received training on giving and receiving effective performance reviews during the past year.

We also represented the Institute before the Massachusetts Commission Against Discrimination on several occasions. Of the nine complaints filed, the Commission found no probable cause in any of the cases.

LABOR RELATIONS

The Office of Labor Relations is responsible for negotiating and administering the collective bargaining agreements covering approximately 1,400 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 the course of the last year the following agreements were concluded: On November 28, 1995 the Institute signed a new agreement, expiring June 30, 1997, with Local 254 of the Service Employees International Union, (SEIU) for the Campus bargaining unit; on November 28, 1995, the Institute signed a new agreement, expiring June 30, 1997, with Local 254 SEIU for the Lincoln Laboratory bargaining unit; on December 8, 1995, the Institute signed a new agreement, expiring June 30, 1997, with the Research, Development and Technical Employees Union (RDTEU); on February 5, 1996, the Institute signed a new agreement, expiring June 30, 1997, with the MIT Campus Police Association (MITCPA). The wage increase in all the agreements was consistent with MIT budgetary guidelines.

The agreement with the Security Officers Independent Union (SOIU), who represent the Security Guards at Lincoln Laboratory, expires on June 30, 1996.

In addition to the above, during the last year MIT also reached agreements with SEIU (Campus bargaining unit) over aspects of the implementation of reengineering efforts in mail, custodial, and building maintenance services.

The number of grievances fell in comparison with the prior year. Arbitration awards were received in three cases: one award was in favor of the union, the other two awards were "split" decisions. Two cases have had at least one day of hearing and are on-going. Five cases were settled prior to arbitration. Eight grievances have been filed to arbitration and have yet to be heard.

During the year, the Office of Labor Relations also handled a number of cases brought before the National Labor Relations Board. Two cases were resolved in favor of MIT; one other case is pending.

In addition, this Office continued to provide advice and council to departments, centers and laboratories contemplating business design changes that impact collective bargaining issues, and continued to work closely in support of various re-engineering efforts.

EMPLOYMENT

The Employment Group provides support in the processing of job listings, applicant materials, employment advertising and unemployment claims for campus employees. The group is also responsible for reception area activities for the Personnel Office.

During the past year, approximately 11,275 applications for positions were received and processed in the Personnel Office, 612 persons were hired for positions listed in the Personnel Office, of which 185 were MIT internal applicants who were seeking employment alternatives for promotional opportunities or other circumstances. Nancy Collins, Personnel Recruiter, reviewed 1070 applications for support staff positions, interviewed 340 candidates and assisted in filling 190 positions.

In May the Employment Group started promoting the option of consolidated advertising in the Boston Sunday Globe for job opportunities at MIT. Consolidated advertisements save money compared to individual advertisements and receive better placement and therefore enhance visibility. So far the response has been rewarding with the departments willing to participate and the number of applicants for position openings have increased.

Some 270 unemployment claims were processed this year for former campus employees. We have worked closely with representatives of the Massachusetts Department of Employment and Training to provide timely information to MIT employees who are terminated and may be eligible for benefits, including individuals in departments impacted by funding reductions or staff restructuring related to reengineering efforts. We also selected Jon-Jay Associates as our new agent to represent us in unemployment compensation matters.

Robert J. Lewis

Vice President for Human Resources and Equal Opportunity Officer

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TRAINING AND DEVELOPMENT PROGRAMS

The Training & Development Programs office in Personnel supported three major efforts at MIT throughout the last year.

The first major effort was its agenda of courses offered to all MIT employees as well as specific courses tailored for departments, laboratories, and centers. Approximately 1200 people attended these programs. Most courses offered in the fall had high demand, thus these classes were repeated in the spring and summer for people on waiting lists. Topics included teamwork, meeting leadership, handling conflict, writing effectively (business, technical and scientific), and preparing research proposals.

The second major effort was leading the performance appraisal training effort in support of the Human Resource Principles. Fifty-five course leaders selected from among Campus employees were trained to lead two courses: one about giving performance appraisals and one about receiving them. The Training & Development Programs office helped create course materials and teach the course leaders, as well as support the course leaders in a variety of ways throughout the roll-out.

The third major effort was leading the Training & Development Planning Team for reengineering. One important result was the creation of the new Human Resource Practices Design team. This office is also actively participating on that team.

Margaret Ann Gray

FAMILY RESOURCE CENTER

The Family Resource Center offers faculty, staff and students a broad range of services to assist with child care and schooling, normal parenting concerns, family relocation, and balancing work and family. Our work requires comprehensive knowledge of area programs and resources, and ongoing collaboration with many MIT offices and departments. In addition, the Center makes available information and materials on institutional, local and national initiatives related to work/family and family policy.

Services offered by the Center this year included approximately 950 office consultations plus 35 informational "briefings", 35 workshops, and 5 discussion groups; approximately 950 members of the MIT community attended workshops and groups.

Family Resource Center services were enhanced this year through the upgrade of our computer network and the addition of a computer terminal for client use, allowing clients to access directly a number of databases and internet resources. Major new initiatives to publicize services within the MIT community included the development of an email network, <"families@mit">, a new Family Resource Center brochure, and, by means of a collaborative project with other departments, a new flyer for incoming families that identifies the Center as one of several "first stops" for relocation assistance.

In November, the Family Resource Center hosted the first annual conference of the College and University Work/Family Association, an organization the Center helped found in order to provide opportunities for information exchange and professional development among work/family specialists at institutions of higher learning.

Nancy Hay, the Center's Senior Office Assistant, was replaced in July by Carolyn Hart.

Kathy Simons, Rae Simpson

DISABILITIES SERVICES OFFICE

The Disabilities Services Office (DSO) is responsible for the development of effective disability services and programs for the Institute. These services include physical and communication access, academic accommodations, and identification and implementation of reasonable accommodations for employees and students. The DSO also

facilitates committees that address the development of concrete plans, goals, and strategies to foster and promote equal access to services, opportunities and benefits at MIT.

The Coordinator for Disabilities Services conducts forums/meetings with students, administrators, faculty members and staff on disability issues, and also serves as liaison to governmental and professional agencies, and associations relative to disability issues.

ACADEMIC ACCESS

In the past year, the DSO has dedicated most of its time to providing academic access for students with disabilities at MIT. This required the translation of all course materials supplied by instructors into an accessible format for students with disabilities such as vision impairment, hearing impairment, and Repetitive Strain Injury (RSI), and in a timely manner.

The accessible formats for students with vision impairment included electronic files to be enlarged, brailled, and/or used in conjunction with other computer equipment, reading course materials onto taped recordings, and creating tactile images of graphs and/or charts; interpreters were procured for students with hearing impairments; notetakers for students with learning disabilities; and typists and/or notetakers were procured for students with disabilities such as RSI.

The DSO also worked closely with the members of the Adaptive Technology for Information and Computing Laboratory (ATIC) in determining an efficient system by which to utilize its services and procure 24-hour access for all of the DSO's student employees.

The DSO's main purpose is to create a system by which student employees can provide MIT students with disabilities, equal academic access, while working as independently of the DSO as possible, to allow the DSO time for researching current ADA legislation, educating and training the MIT Community about ADA, and identifying and assessing reasonable accommodations for employees.

REASONABLE ACCOMMODATIONS FOR EMPLOYEES

A total of 21 employees, including 3 Lincoln Laboratory employees, identified themselves as individuals with disabilities and requested services from the DSO. Fifteen of these individuals required the determination of the need for a reasonable accommodation. This required meeting with the self-identified employee, the employee's supervisor, Personnel Officer, and any other relevant parties involved, to assess the essential functions of the job, and to identify the appropriateness of the accommodation requested.

EDUCATION AND TRAINING

In addition to the above, I also performed several ADA presentations to the following departments/members of the MIT community: MIT Medical Department; MIT Medical Department physicians; Bursar's Office; Admissions Office; Undergraduate Education and Student Affairs - the Office of Counseling and Support Services; Resource Development; Social Work Services; Psychiatry; Campus Activities; Presidential Staff; Office of the Senior Vice President; and MIT's Personnel Office;

Barbara Roberts

VICE PRESIDENT FOR INFORMATION SYSTEMS

Information Systems (IS) strives to enable members of the MIT community to use information technology more productively in all their work. IS focuses on providing specialized services to the specific constituencies of academic and administrative computing, as well as a broad array of general services including telephones and network connections to the rest of the Institute.

In March 1995, senior officers announced the launch of I/T Transformation, the transition of the Institute's I/T staff into a new framework designed to meet the challenge of delivering "great systems fast," as well as supporting dramatic increases in network-based applications and users expected to arise from reengineering initiatives. The Information Technology Leadership Team, led by the Vice President for Information Systems, has worked over the past year to implement I/T Transformation and to ensure successful results on all of its three dimensions – work, skills, and customers.

Over the year, Information Systems staff left behind the six departments that previously defined IS and moved fully into the new team-oriented, process-driven framework. The five work processes – I/T Discovery, I/T Delivery, I/T Integration, I/T Service, and I/T Support – and the two practices – Academic Computing and Office Computing (which were recently joined by a third practice – Voice, Data, and Image Networking), as well as the I/T Competency Groups – replace the old IS departments of Academic Computing Services, Administrative Systems Development, Computing Support Services, Distributed Computing and Network Services, Operations and Systems, and Telecommunications Systems. As in the past, IS staff continues to work with others throughout the Institute in ongoing activities and new initiatives, and they remain deeply involved in efforts to reengineer the Institute's administrative processes. By the end of the fiscal year, IS staff had achieved an impressive range of accomplishments, some of which are highlighted in the reports which follow. This section presents an IS overview.

Use of MIT's information technology resources continues to grow as the I/T infrastructure is improved and expanded. Annually the MIT community comes to IS with some 100,000 requests for help and service changes, ranging widely from upgrading telephone service to installing a new office computing environment to assisting faculty in using computing in their teaching. As in past years, new and more platforms and services, including more third-party software, were introduced into the Athena environment. IS staff worked to provide full telephone and network connectivity to all on-campus student residences. In fiscal 1996, a new voice mail system was installed; site licenses for Oracle and SAP R/3 were negotiated and their software made available; a new I/T core curriculum for members of the MIT community was developed and implemented to support the rollout of reengineering applications; and the campus I/T infrastructure was more completely defined and communicated.

At the end of the last fiscal year, a new team was named to lead the I/T framework. Over the course of the year, there were some changes to that team:

- Leaders of I/T practices advocate both on behalf of customers to IS and on behalf of IS to customers. Late in fiscal 1995, Diane Devlin was named the Director, Office Computing Practice. In May 1996, M. S. Vijay Kumar succeeded Gregory A. Jackson in the position of Director, Academic Computing Practice. At the end of fiscal 1996, a third practice area was added to focus on MIT's electronic communications infrastructure. The Voice, Data, and Image Networking Practice, with Dennis Baron as its Director, will ensure that the necessary I/T systems and services are available to support academic, research, and administrative efforts at MIT. This will include working with IS process owners and outside vendors to make sure current systems are accessible and have adequate capacity. In addition, this practice will identify the need for new communications technology and facilitate its availability to meet future needs.
- At the end of fiscal 1995, named I/T process leaders were Greg Anderson as the Director, I/T Discovery; Susan Minai-Azary as the Director, I/T Integration; and Roger A. Roach as the Director, I/T Service. Late in the year, William F. Hogue succeeded Cecilia R. d'Oliveira as the Director, I/T Support, and IS's year-long search for the Director, I/T Delivery ended with the appointment of Robert V. Ferrara.
- I/T Competency Group leaders concentrate on the skills dimension of Information Systems, working to provide a staff well-qualified to meet future work requirements. In fiscal 1996, Erin Rae Hoffer succeeded Timothy J. McGovern to join Shirley M. Picardi as a Director, I/T Competency Groups.

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- At the end of June 1996, Marilyn A. McMillan completed 18 years of service to information technology at MIT, and accepted the position of Director of Application Assembly and Integration in Information Technology Systems and Services at Stanford University. Thomas Mullins will assume Marilyn's planning responsibilities, which fit well with his own responsibilities as Director for Administration and Finance.

The I/T leadership team and the IS staff are committed to continuing to learn our way into working in the new framework, and to ensuring that the new framework works for us, for our customers, and for the Institute.

James D. Bruce

ACADEMIC COMPUTING PRACTICE

The Academic Computing Practice seeks to promote and enable MIT education through the effective use of computers and other information technologies. Collaborating with I/T Process teams and in partnership with academic departments, the Academic Computing Practice provides widely distributed client-server computing designed to facilitate undergraduate education, primarily through the Athena Computing environment, which is used by thousands of users each day and over 10,000 different people on peak days. Academic Computing provides advocacy, training, documentation, and consulting services to support academic work.

During fiscal year 1996, the Academic Computing Practice focused its resources on activities aimed at strengthening the infrastructure for educational computing:

- It continued to encourage new instructional uses of Athena. In the past year, MIT's suite of educational software was enlarged to include molecular modeling software for Chemistry, Chemical Engineering, and Materials Science, as well as rendering and graphics software for Architecture and Electrical Engineering and Computer Science (EECS).
- Academic Computing also assisted faculty interested in using the World Wide Web in novel ways to enhance instruction, helping them digitally animate natural phenomena for use in Physics classes, and helping them create and publish digital images for educational use in the departments of Architecture, Foreign Languages and Literatures, and the Health Sciences and Technology (HST) Program. MAE (Macintosh emulation) was provided on Sun workstations in various Athena clusters to support the needs of faculty using Macintosh software in classes.
- In partnership with I/T Support teams, the Academic Computing Practice introduced a "moveable workstation" service, through which faculty members may obtain a Silicon Graphics workstation with projection capabilities for use in any classroom equipped with a network drop.
- Working with the Athena Computing Environment Software Release Delivery team, the Academic Computing Practice continued its annual renewal of Athena equipment, purchasing workstations and peripherals to replace aging equipment, and purchasing additional functionality for older machines to address the emerging computational needs of MIT subjects. A new Athena cluster was added in the Rotch Library in fiscal 1996, and the 4-035 cluster was equipped with twenty SGI Indy machines as a specialized facility for classes.
- Academic Computing enhanced its constituent relationships by participating in a number of joint projects with groups such as the Public Service librarians from the MIT Libraries, the Educational Technology Council, and the Development Office.
- To improve communication on campus, the Academic Computing Practice introduced WebMeet, a Web-based conferencing and electronic mail archiving system. To extend the spirit of that communication outside MIT, the Academic Computing Practice continued to host a variety of visitors from organizations worldwide who express interest in Athena and MIT's educational computing environment.

Dr. Vijay Kumar succeeded Dr. Gregory Jackson as Director, Academic Computing Practice.

M. S. Vijay Kumar

OFFICE COMPUTING PRACTICE

The Office Computing Practice works to ensure that office computing customers derive maximum value from MIT's information technology resources. Collaborating with I/T Process teams and in partnership with administrative offices and departments, the Office Computing Practice works to build constructive relationships with office customers. This work relies on a solid understanding of office computing needs, opportunities, and priorities is essential to discovering and implementing the best applications of information technology to simplify and improve administrative work.

- Complementing its primary purpose of advocating on behalf of customers with IS, and on behalf of IS with customers, the Office Computing Practice devoted a substantial amount of time in fiscal 1996 to meeting directly with administrative customers to identify opportunities for I/T improvements. Many of these conversations involved clarification of IS's new process-centered, team-oriented organization.
- Also during fiscal 1996, the Office Computing Practice worked to build relationships with individuals and teams within IS who specifically impact office customers. This effort led to the formation of the Practice/Discovery (PD) Team, which is chartered to focus on customer needs and to support Discovery Process teams and the Office Computing and Academic Computing Practice leaders. Also established this year was the Office Computing Management Group (OCMG), a forum for IS and other administrative I/T staff to meet, share ideas and information, discuss issues of mutual concern, and plan together for the future.
- To a large extent, MIT's reengineering initiative has meant a reexamination of MIT's business practices. This, combined with the shifting work demands necessitated by the need to align MIT with changing market opportunities, has created a rapidly changing environment for the Institute's administrative processes. The Office Computing Practice conducted strategic planning meetings in major administrative areas this past year to prepare for the delivery of reengineered business applications, with a primary focus on SAP R/3. Collaborating with IS teams and customers, the Office Computing Practice coordinated reengineering-related planning for MIT's central administrative groups and the new MIT Learning Center, including the deployment of over 300 new computers. These computers were delivered with administrative software and networking installations as needed.
- Throughout the year, the Office Computing Practice championed the MIT Electronic Catalog (ECAT) project. Built in partnership with VWR Scientific, Office Depot, and American Express, and using private-key authentication technology (Kerberos) to provide security over the network, the Electronic Catalog is a custom Internet and World Wide Web sourcing, pricing, approval, ordering, and payment system. ECAT is currently in its pilot phase, and will rollout over the remainder of calendar 1996.

Diane M. Devlin

I/T DISCOVERY

As the first of the five work processes identified in the new I/T process-centered organization, the I/T Discovery Process seeks to define the I/T requirements of the MIT community. Discovery creates a dynamic and bold environment in which business customers and technologists can work together to define systems which create value. Beginning primarily as a business process, where "business" encompasses the full range of academic, office, and research activities at MIT, Discovery projects design and frame technology solutions that can be delivered to the community efficiently and effectively.

Working in focused project teams, Discovery efforts pursue and structure ideas that promise dramatic change and improvement to current work. Discovery efforts seek innovative solutions to problems, and work to add value to and remove unnecessary work from work. The goal of the Discovery Process is to challenge the status quo, and to influence and guide "best practice" approaches to I/T work. Although it locates efforts within the context of the Institute's strategic mission and near-term goals, Discovery also remains aware and cognizant of the rapidly changing business and technology landscape at MIT and beyond.

In its first year, the Discovery Process has been extraordinarily productive and has realized several organizational and project milestones. These accomplishments are testimony to the talented staff involved in the projects and to their willingness to engage new approaches to our work. Highlights of the year include:

- The Electronic Proposal Submission System Discovery team – a cross-organizational team composed of customers from labs, centers, and departments, OSP, local I/T specialists, and IS staff – completed Discovery and prototype projects to realize the business requirement of submitting research proposals electronically to federal agencies. This project has moved to the Delivery Process for full development and implementation.
- Conducted primarily by Telecommunications Service staff, the Voice-Mail Discovery project resulted in the smooth implementation of a new voice-mail system for MIT in January.
- The Writing Requirement Discovery team recommended a new technology design to support the administration of MIT's Writing Requirement. This project has also moved to its Delivery phase.
- The Alumni Networked Services Discovery team designed an overall strategy to deliver electronic, networked services to MIT alumni. In its Delivery phase, the project focuses on the building of an electronic mail forwarding-for-life facility as its initial service.
- The Admissions Discovery project is underway to determine a new conceptual design for MIT Admissions.
- The ISDN/Tether Discovery team determined that changing technology, the cost of ISDN services to the home, and promising new alternatives suggest that MIT not develop its own products to provide network access via ISDN connections.
- As part of IS's effort to maintain existing services, the Discovery process ensured the successful operation of "Back to School" activities, such as HASS-D lottery, PE Lottery, Math Diagnostics, Freshman Essay Evaluation, and Freshman Housing Lottery.

In addition, there is an ongoing effort to understand, establish, improve, and frame the Discovery Process within the new I/T organization.

Greg Anderson

I/T DELIVERY

As the second of the five work processes, the I/T Delivery Process exists so that MIT and its schools, departments, laboratories, and centers can realize business value as rapidly as possible from the implementation of new information technology products and services.

- Working with I/T Integration teams to continue the work of the reengineering program's Information Technology Readiness Team, Delivery Process teams focused on devising workable and supportable strategies for the initial offerings of a number of reengineering-related projects, including among others the Appointment Process (TAP) applications TAPS and TQF; MIT's new financial system of record SAP R/3; the Electronic Catalog; the Office of Sponsored Programs awards system; and the Physical Plant system.
- The Athena Computing Environment Software Release Delivery team updated Athena to newer versions of system software from Sun and SGI, as well as more current versions of several third-party software packages, including a Institute-wide filesystem software, AFS from Transarc. The Athena Delivery team also began to phase-out older models of IBM RS/6000 and Digital DECStation hardware from Athena's public cluster infrastructure. In the coming year, the team expects to qualify at least one new hardware/software platform for Athena Cluster use.
- Currently, Delivery Process teams are working to implement the Electronic Proposal Submission System "discovered" in fiscal 1996 by the I/T Discovery Process. Also in Delivery phase are the new technology designs to support the administration of the Writing Requirement and the building and implementation of the Alumni "E-mail-Forwarding-For-Life" project. On-going work towards Release One of SAP continues, and work on Release Two will commence shortly.

The nationwide search to fill the position of the I/T Delivery Process leader ended in July 1996 with the appointment of Robert V. Ferrara as Director, I/T Delivery.

Michael D. Barker, William D. Cattet, Paul B. Hill, and Daniela A. Aivazian

I/T INTEGRATION

The mission of I/T Integration is to implement an information technology infrastructure that has high levels of reliability, availability, and serviceability; provides excellent price/performance; meets current MIT needs and can quickly adapt to meet future needs; and enables effective performance of the other I/T processes. During the past year, teams working in the Integration Process made progress in the following areas:

- The Integration Team worked to educate developers and purchasers of software about the current information technology infrastructure. To encourage its effective use, the Integration Team developed and presented a four-day course, "A Developer's Introduction to Secure Client-Server Computing." Building on this effort were a participatory series of lunch seminars and discussions for system designers. Other educational services of the Integration teams included adding to information for developers on the World Wide Web, and purchasing bulk training units for selected tools so that all MIT developers could share in reduced training rates.
- Integration work teams also provide consulting services to designers and developers. Data Administrators have helped with data modeling for new systems and reverse engineering to develop models for current systems. By reviewing designs for new systems and possible commercially-packaged software for teams working in other processes, and by checking high level process and data models, Integration teams work to ensure that different teams are developing systems that are either independent or well-integrated, and adhere to MIT's current standards and practices.
- Early work with Discovery teams helps Integration teams understand and prepare for coming infrastructure needs. Collaborating with developers from across MIT, Integration teams have extended the MIT data model and added shared data to the MIT Warehouse. Fiscal year 1996 also saw the inauguration of an Integration Laboratory for developers to use to test the integration of their business applications into the MIT application set. Also in fiscal 1996, the Security Officer and other interested parties at MIT formed the Institute Physical Security Coordination Team.
- Integration teams worked both to update current I/T infrastructure components and to build new ones. A key accomplishment of the past year was the building and implementation of a People ID Server and Database, a single coordinated service for assigning a unique MIT ID available to people and systems. The building of the database was accomplished with the help of the Service teams; thus its implementation rests with the Service Process. The MIT Data Model and sharable data in the MIT Data Warehouse were extended. By designing, developing, and coordinating the external development of Kerberos Version 5, Integration teams continued MIT's leadership in network security. On a related note, a "Pretty Good Privacy" (PGP) Key Server, which provides a directory service for public keys, was added to the MIT infrastructure. Integration teams designed a secure and authenticated web server to be built unless the market provides a comparable solution within the next six months. Integration teams designed and prototyped an MIT-wide access system to provide a consistent, high level interface for defining who is authorized or responsible to perform various operations in business applications. Integration teams also developed tools to move bulk data securely between systems. Throughout the year, they continued to test new releases of selected tools for developers and to provide example interfaces between different tools.
- One goal of the Integration process is to propagate strategic MIT technology to vendors of commercial products and to other users outside MIT. By exerting influence in strategic areas like network security in open-network environments, MIT has the opportunity to buy rather than build our preferred infrastructure in the future. Intending to encourage a standard for network security, the Integration Process provided Kerberos Version 5 to the public domain, and urged its use in industry.

Susan Minai-Azary

I/T SERVICE

The I/T Service Process works to keep MIT's information technology infrastructure running in a reliable and efficient manner. This infrastructure includes the datacenter in W91, MITnet, telephone and related services, the Athena computing environment, database services, and desktop maintenance (PC repair) services.

A number of significant milestones were reached in each of these areas during the past year:

- Efforts to improve the reliability and performance of the W91 datacenter continued throughout fiscal 1996. Accomplishments include migration of data stored on the datacenter's oldest disk devices to newer, more reliable devices, and an incremental upgrade of the VM/ESA operating system on the IBM mainframe. To support secure transfers of data to and from the IBM mainframe, the "Pretty Good Privacy" (PGP) encryption program was ported to the VM mainframe operating system. To support the new SAP financial system and other administrative systems, new administrative servers were installed in W91. Throughout the year, I/T Service staff continued to work with BBN Planet to enhance their facilities on campus to support intra/inter New England Internet traffic.
- Working collaboratively with I/T Support, I/T Service extended MITnet to MIT's Professional Learning Center (W89). Network Operations and Network Software Services teams upgraded routing connectivity to NEARnet, and completed planning for a major upgrade of the MITnet backbone. Towards this effort, the electronic mail servers were upgraded to Sparc 20 systems. I/T Service staff also worked to improve the performance and reliability of *web.mit.edu*, the campus' primary World Wide Web server, and worked on applications to support the SAP and ECAT reengineering efforts.
- The 5ESS Operations Service team upgraded the MIT 5ESS generic software to 5E9, and replaced the voice mail system with an Aria 350 system to increase both its capacity and robustness. MITnet was extended to two graduate residential units, Eastgate and Westgate, and the data network and 5ESS telephone services were provided to newly constructed or acquired buildings, like Tang Management Center and W89, as well as the new addition of the Whitehead Institute. In May 1996, Service teams installed an Automated Call Distribution (ACD) system to be used initially by the new I/T Support Help Desk to provide better control of call flow and statistical data on the helplines. Other telephone-related accomplishments include the installation of new PBX's for Endicott House, MIT Process, and WW15 (Mail Services), and the upgrade and extension of radio systems for Campus Police and Physical Plant.
- Efforts to upgrade the hardware and software used to provide Athena services to the MIT community continued throughout fiscal 1996. To improve reliability, many of the older servers were upgraded to a new server platform; uninterruptable power supplies (UPS) were installed; and fixes were applied to the Athena file system. To accommodate the growing need for more disk space, the default disk quota for Athena accounts was raised to 12.5 Megabytes this year. To achieve significant gains in efficiency, cluster services restructured their deployment process for Athena workstations.
- The Database Services team consistently provided database support and maintenance of many administrative applications to the wider MIT community, while continuing to be heavily involved in the implementation of new reengineering systems like SAP.
- With the addition of a new software updating service for HP scientific workstations, Desktop Maintenance Services now services Apple and IBM microcomputers, HP printers, and DEC, Sun, SGI, and HP workstations.

Roger A. Roach

I/T SUPPORT

Fiscal year 1996 was highlighted by the continued evolution and refinement of services related to the core mission of the I/T Support Team: the effective and efficient delivery of timely, high-quality support to the Institute's information technology users. Support was provided by a variety of standing teams: I/T Help Desk; Training and Publications; Desktop Products; Adaptive Technology Support; Departmental Computing Support; Campuswide Information Systems Support (CWIS); Athena Help/Residential Computing Consulting; Academic Computing Support; Telephone Operators; 5ESS Support; and Support Team Headquarters.

To better identify and refine support services, Support team members concentrate on listening carefully to customers and balancing customer feedback with Institute goals and resource availability. While focused on different aspects of users' needs, the highly qualified staff on these teams share a common commitment to the I/T Support mission. During 1995-96:

- I/T Support staff participated intensively on numerous MIT reengineering projects and teams. In particular, Support teams provided extensive support for SAP development, deployment, training, and documentation. One notable accomplishment was the completion of the information technology infrastructure for the W89 training facility on a very short timeline.
- One of the key functions of the Support Process is to provide Macintosh, DOS/Windows, and Athena technical support, as well as consulting and user-account services, to the MIT community. In fiscal 1996, the Help Desk was reengineered, which involved the installation of new hardware, the realignment and consolidation of Help Desk staff, the integration of new tracking tools, and the initiation of planning for self-help and local expert components of support.
- In a partnership with the Academic Computing Practice, I/T Support inaugurated a "movable Athena workstation" service for classroom use.
- In collaboration with the I/T Service Process, I/T Support introduced Eudora to the MIT community. This new electronic mail product will eventually replace TechMail.

Dr. William F. Hogue succeeded Cecilia R. d'Oliveira as Director, I/T Support in May 1996.

William F. Hogue

I/T COMPETENCY GROUPS

I/T Competency Groups organize Information Systems staff by their technical expertise and/or common focus. A "job competency" may be defined as an underlying characteristic of an employee – a motive, trait, self-concept, knowledge, or skill – that results in effective or superior performance on a job. Competency Group Leaders work to ensure that appropriately skilled human resources are available to staff MIT's I/T processes and projects.

In late summer 1995, four I/T Competency Groups were established, and staff were encouraged to enroll. About 70% of IS staff enrolled, as well as several staff in the I/T areas outside of IS. The four groups are:

Applications (investigate, design, and build products and services)

Assistance (help customers, document, and communicate)

Systems (keep operational aspects of work running)

I/T Management (help all the rest of staff get the business work done)

The I/T Competency Group leadership focused on three primary activities throughout the year:

- To address the increasing need for skilled project managers not only within Information Systems but within MIT as a whole, IS engaged the firm of Duncan Nevison to provide project management training and consulting services to MIT. Duncan Nevison developed and customized an eight-day training program based upon project manager competencies. Within the framework of this program, project managers were able to speak openly about the challenges they face in the MIT-IS environment. Using competency assessments, individualized feedback, and training plans, the Duncan Nevison consultants taught the tools needed to cope with these challenges, including scope statements, work breakdown structures, three-point estimation, team-building, scheduling, critical paths, progress measurements, accountability, and risk management.
- In May 1996, the I/T Competency Group leadership launched a project to help define and plan for the development of the I/T competencies. Working with the consulting firm of Hay McBer (part of The Hay Group), they defined the following objectives:

Define “roles” in IS’s process-oriented, team-centered environment, with the ultimate goal of replacing older and sometimes outdated “job descriptions.”

Identify the competencies required to successfully perform work in this environment.

Help individuals determine what competencies are important to them today and in the future, as well as prepare personal development plans.

Redefine the four I/T Competency Groups.

Develop a training agenda for I/T professional development to address broad needs over the next few years.

Introduce a consistent approach to competency assessment in I/T recruiting and hiring; learn how to interview for I/T competencies and train staff in these skills.

Begin the process of redesigning the IS performance appraisal system.

- Throughout the year, Competency Group leadership sought to learn more about competency-based organizations. In addition to attending conferences, they met or talked with outside organizations which have implemented “competencies,” including Canadian Tire, the Church of Jesus Christ of Latter Day Saints, Eli Lilly, London Life, and OSRAM/Sylvania.

In the future, the I/T Competency Group leadership will work to tie skills inventory results into MIT’s strategic I/T needs, while identifying “gaps” for future training, hiring, and outsourcing. Guided by MIT’s Human Resource Principles, they will work closely with the MIT Human Resources and the newly chartered Human Resources Practices Design (HRPD) reengineering team. Throughout the coming year, the Competency Group leaders will strive to maintain their awareness of similar developments in corporations and other institutions, and will work to make Information Systems a “best practices” example.

Erin Rae Hoffer succeeded Timothy J. McGovern as Director, I/T Competency Groups. Katherine K. Allen recently joined the I/T Competency Group leadership as Senior Project Manager, Human Resources.

Erin R. Hoffer
Shirley M. Picardi

VICE PRESIDENT FOR RESOURCE DEVELOPMENT

Building on the fundraising momentum from the previous year, private support to MIT during FY96 rose to its highest level in the history of the Institute. An extraordinary sense of legacy among key donors and alumni — as demonstrated by the strength of bequests and life income funds — a strong stock market and collaboration between Resource Development and the senior officers, deans, department heads, faculty, Alumni/ae Association and others were critical elements of this success.

As Resource Development considers how best to build on the success of the past year, it is important to acknowledge the Institute's history and traditional fundraising strengths and to look to opportunities that will lay the foundation for even stronger support in the decades ahead. In an era where MIT will increasingly rely on philanthropic support to sustain and enhance its preeminence in science and technology, we must continue to form new partnerships with individual donors, corporations and foundations world wide to achieve our goals. The achievements and results of this past year provide an important guide to the years ahead.

Over the past year, staffing remained relatively stable. During the year there were 14 promotions (5 men and 9 women, including 2 minorities). In addition, 9 open staff positions were filled including 5 women (1 African-American woman). Resource Development maintained a strong commitment to the hiring and promotion goals set out in our Affirmative Action report by working closely with Personnel and others to identify new resources from which to draw applicants. In addition, in collaboration with the Council for the Advancement and Support of Education (CASE), a research-based minority internship was created and filled.

PRIVATE SUPPORT

Private support for Fiscal Year 1996 totaled \$130.9 million, up 22% over last year, including the following: \$123.6 million in gifts, grants, and bequests, and \$7.3 million in support through membership in the Industrial Liaison Program. The total compares with \$108.9 million in 1995, \$94.5 million in 1994, \$96.8 million in 1993, and \$97.4 million in 1992. Gifts-in-kind for the past year (principally gifts of equipment) were valued at \$8.8 million.

Sources of gifts for Fiscal Year 1996 were: alumni, \$47.1 million; non-alumni friends, \$16.4 million; corporations, corporate foundations, and trade associations, \$29.3 million; foundations and charitable trusts, \$29.5 million; and others, \$1.3 million.

Donors designated expendable and endowed funds as follows: unrestricted, \$27.6 million; departments, \$36.9 million; faculty salaries, \$20.6 million; graduate student aid, \$6.3 million; undergraduate student aid, \$16.8 million; building construction funds, \$7 million; and other funds \$8.4 million.

Barbara G. Stowe

OFFICE OF INDIVIDUAL GIVING

The Office of Individual Giving, directed by George Ramonat, is comprised of the major gifts field staff, the development officer for the arts, and the planned giving associate director. While maintaining a steady pace of field activity, the office began to organize to address an accelerated fundraising program to meet MIT's future needs. Staffing changes were made to strengthen our focus on the major markets for individual giving in New York Metro, New England, and the West Coast and Pacific Rim, as well as balancing out responsibilities among the staff for the other regions.

Three members of the field staff left to pursue other opportunities and Betsy Millard moved to part-time status to continue to manage the Emma Rogers Society. Christine Rinaldi was hired to manage the New York Metro region and Alexander (Sandy) Washburn joined her as a senior major gifts officer. Stephanie Harriston-Diggs added management of the Mid-Atlantic South region to her existing New York Metro responsibilities. Direction of the West Coast and Pacific Rim region was assumed by David Woodruff, who came from the Office of Corporate Relations. Maryglenn Vincens, from the Alumni Association and Alex Chisholm, from Development Research and Systems, joined him as major gifts officers for this region. John Landry, former associate director for New England, took on the planned giving responsibilities and added the Great Plains region to his prospect management responsibilities.

Following the Campaign Feasibility Study, George Ramonat headed a council to assess MIT's ability to increase volunteer participation in the gift-getting process, one of five such councils established to better gauge MIT's fundraising opportunities.

CORPORATION DEVELOPMENT COMMITTEE

During the year the Corporation Development Committee (CDC) redefined its mission with the help of the steering committee, renamed the CDC Advisory Group, to clarify their role as Institute volunteers.

At the annual meeting in November 1995 President Vest and Provost Moses engaged the attending members in a highly energized dialogue focusing on current Institute challenges and the opportunities for financial support now and into the future. Jack Crowley, director of MIT's Washington, DC office, emphasized the importance of President Vest's efforts to confront the federal support issues MIT faces in Washington.

The Advisory Group met in April 1996 to discuss the findings of the Campaign Feasibility report and MIT's need for increased volunteer support in its fundraising efforts.

H.E. Ramonat

OFFICE OF PRINCIPAL GIFTS

Under the direction of Lucy Miller, this office managed the cultivation, solicitation and stewardship of the most generous donors to the Institute.

As a result of working closely with President Vest, Chairman Gray, Provost Moses, the Deans, senior administration and faculty, and colleagues throughout MIT, key initiatives were realized this year with the support of MIT's alumni/ae and friends. The strength of funding for junior and full professorships was extraordinary for a non-campaign year and demonstrated enormous commitment to the intellectual capital of the Institute. In addition, the dedication of the Stella Room and Elliot K. Wolk Gallery, and the Jack C. Tang Center for Management Education reflected a growing understanding among our most generous donors of the ongoing importance of renewing the physical plant of MIT.

Finally, given the central importance of principal giving to any expanded fundraising effort, Lucy Miller guided the inquiry of the Principal Gifts Council as they framed the opportunities and challenges of deepening and strengthening MIT's relationships with its most significant supporters.

Lucy V. Miller

OFFICE OF COMMUNICATIONS AND DONOR RELATIONS

This office, headed by Elizabeth Harding, continued to provide editorial support for fundraising, plan fundraising events, and coordinate major gift stewardship at MIT.

The editorial group worked with individual, corporate, and foundation front-line staff to write and edit newsletters, proposals, special letters, and brochures. *Spectrum*, a 16-page tabloid newsletter, is a principal project of the office and has a circulation of 32,000, including donors to MIT, faculty and staff at the Institute. Other ongoing publications included a series of eight full-page advertisements in *Technology Review* which profiled alumni/ae who established life income funds, and brochures including: *MIT Facts*, *Ways of Giving*, *Undergraduate Scholarships: Making a Difference*, and *Science at MIT*. In addition, the staff worked closely with the Office of Principal Gifts and the Office of the Corporation to produce the materials for the dedication of the Jack C. Tang Center for Management.

Within the Office of Communications and Donor Relations (COMDOR), the *Office of Events* helped organize 48 Resource Development events including spring and fall Campus Visits, two 2 1/2 day programs for donors and prospective donors. Other highlights include: a California Leadership Dinner, the dedication of the Elliot K. Wolk Gallery, and the opening of the MIT Sloan School of Management Trading Room. The staff with the Office of the President and several faculty produced a Senior Congressional Staff Seminar in the spring of 1996.

COMDOR continued to refine and expand a systematic stewardship program. This year reports provided information about student recipients and fund performance to 150 scholarship donors and 6 donors to the Undergraduate Research Opportunity Program. The stewardship staff worked in concert with the Office of Events on small stewardship events to bring together the donors and the student beneficiaries of the gifts.

Elizabeth T. Harding

OFFICE OF DEVELOPMENT RESEARCH AND SYSTEMS

Under the direction of Shelley Brown, this office provided critical research, information, analysis and systems support to help facilitate a stronger understanding of the Institute's base of private support.

The staff continued a series of impact studies to understand the effect of MIT's alumni/ae, faculty and staff on specific regions and on particular industries. Regional profiles focused on the Silicon Valley, Southern California, Connecticut, Florida, Missouri, Ohio and other states with a strong Congressional presence. In addition to last year's impact study on the biotech industry, industrial profiles focused on financial services and venture capital firms. A report analyzing the impact of MIT-research and MIT-founded companies on the software industry is in progress.

In one of five inquiries to follow on the work of the Campaign Feasibility Study and assess the possibilities of an expanded fundraising program, Shelley Brown chaired the effort to better understand the composition and potential of the individual prospect pool. To support the efforts of all the inquiries, the staff provided extensive data and analysis of the giving potential of the different prospect segments.

Working with the Treasurer's Office and the CAO, this office helped program several necessary revisions to bring the Institute in conformity with new standards issued by the Financial Accounting Standards Board. In addition, to provide greater clarity about the Institute's philanthropic support, the staff also revised the Private Support Summary.

In collaboration with the Bank of Boston, the staff continued work on the New Founders Project and expects the Bank to issue a report in Fall 1996 on the economic and social impact of companies founded by MIT alumni.

In partnership with the Alumni/ae Association and the Treasurer's Office, the office continues to spearhead the conversion to a new alumni/ae development client-server system, currently targeted for completion by the close of FY97.

The above initiatives were carried out in addition to the office's primary responsibilities which include: research support for fundraising activities of the senior officers, fundraising support for the Office of Individual Giving, the school development officers, the recording secretary, and the Alumni/ae Association; the National Screening Program, and ongoing technology and programming support for Resource Development.

This past year two staff members left to pursue other opportunities at the Institute. Else Slepecky was hired as a Research Analyst and Alex Midler was hired to the position of Analyst Programmer II. Lillian Paratore was promoted to the administrative staff position of Administrative Manager, and Marc Gunderson was promoted to the position of Systems Specialist. In addition, through the efforts of John Solmonese, the office worked with CASE to create a research-based minority internship.

Shelley Brown

OFFICE OF FOUNDATION RELATIONS AND SCHOOL DEVELOPMENT SERVICES

Under the direction of John S. Wilson, gifts from private foundations for this fiscal year totaled more than \$30 million, down 11% from FY95, and continued to provide significant support for MIT's educational and research programs. Major grants or pledges were received in support of the Daniel K. Ludwig Professorship, the MIT International Science and Technology Initiative (MISTI), the Museum Art Loan Project, and the Youth Focused Community Fellows Program. Anne Marie Michel was promoted to Associate Director of Foundation Relations.

The Office of School Development Services (OSDS) continued to provide support to the five schools and the Office of Academic Development for their fundraising initiatives. The primary areas of support include: prospect research and identification, stewardship, proposal writing, qualification calls, donor events, and systems design. Kevin Holland was promoted from Development Research and Systems to Senior Research Analyst in OSDS.

Highlights of OSDS support included: A 50% increase in membership of \$1000+ donors to the Dean's Council of the School of Architecture and Planning and the coordination of an open house for SAP headquarters in the fall. The Sloan team helped to plan and execute the successful Tang Center dedication and continued to assist in fundraising activities for the Zenon Zannetos Professorship Fund. The team for the School of Science welcomed John Christel as Senior Research Analyst and supported the successful campus visit in the spring, creating \$900,000 in new gifts and pledges to the school. The team for the School of Humanities and Social Science, newly headed by Pamela Lomax, met with every department head to discuss prospects and conduct screenings.

Members of the School of Engineering team focused on recruiting and training volunteers for the Bisplinghoff Chair, which now has \$200,000, and Mary Hanifin and Greta Morgan worked closely with the School Development Officer and the Dean to create a Dean's book of potential prospects. They are currently creating similar books for each of the department heads.

In the fall, support was provided to the Provost's Office and MISTI to host Madame Deng Nan of China and representatives from 15 corporations as a follow-up to discussions held the previous summer at the International Conference of Sustainable Development and Environment. Support was also provided to the Provost for the Chlorine conference in June, sponsored by the Alliance for Global Sustainability.

The office completed a full series of academic department profiles and funding opportunities for each school. In addition, primers to summarize key academic initiatives by school were completed on 13 projects, including the Minority Introduction to Engineering and Science (MITES) and the MIT Washington Summer Internship Program. These materials served as resources across the Institute and provided in-depth information to development staff about academic initiatives and programs. Information about academic initiatives was also communicated through the monthly FYI series sponsored by OSDS. Featured presenters included, Joel Moses, Ed Barrett, Steve Lippard, Dave Marks, Paul Asquith, Tom Eager, and Bish Sanyal.

John S. Wilson, Jr.

CORPORATE RELATIONS INCLUDING INDUSTRIAL LIAISON PROGRAM

Under the direction of Thomas R. Moebus, corporate cash gifts to MIT this fiscal year totaled \$29.3 million, down 16% from FY95. During this time Corporate Relations worked to expand and strengthen corporate partnership development; to maximize revenues to support Institute-wide and School-based faculty initiatives, international regional opportunities, and sponsored research; to rebuild the membership of the Industrial Liaison Program (ILP) and improve ILP product and service quality. This was accomplished while streamlining ILP Member Relations, creating a New Business Development Team and consolidating Communications, Information Services, Personnel and Finance into an Operations Unit.

The *Corporate Development* group continued to support Institute and faculty initiatives including, the Alliance for Global Sustainability, the Competitive Product Development Center, and Leaders for Manufacturing. They worked to expand significant international activities in Argentina, Spain, and Taiwan while pursuing new opportunities in areas such as Thailand. A project developed jointly with the Technology Development Program established a new \$4.5 million annual program of research, education and institution building in Thailand. A world wide web site was established to provide better access to information for industry, MIT faculty and staff.

With its new sales staff, the *Industrial Liaison Program* garnered eleven new memberships in the United States, nine in Europe, five in the Asia-Pacific region and one in South America. New members represent a range of industries including chemicals, manufacturing, electronics, scientific instruments, energy, and the service sector. As evidenced by mergers, particularly in the defense industry, and decreasing memberships, especially in Europe, the current business climate continues to present a challenge to maintaining the ILP membership base. Overall, the total membership and fee base remained constant and final ILP revenues for FY96 were \$7.3 million.

Corporate Relations sponsored several events. The "Technology and the Corporation" conference series in 1995-96 which covered topics ranging from *Investing in China*, *Telemedicine*, and *Compression Technologies* to

Reengineering, Environmental Strategies for Industry, and Electronic Commerce. Two additional events of note include the *Research Director's Conference* in April and the *MIT-ILP European Members Workshop*, held in May in Paris. Over 1,500 representatives from 700 companies attended ILP events during the year, with an additional 200 "remote" attendees participating through video-conferencing. A record number of non-members (close to 500) attended on a paid basis through a collaboration with a conference promotion agency, the Center for Management Research.

During the last year, five members left Corporate Relations to pursue other opportunities, two accepted early-retirement and one member took an educational leave-of-absence. Two Industrial Liaison Officers, Anddie Chan and Robert Malster, realigned their efforts within Corporate Development and Ms. Chan was promoted to Senior Liaison Officer. Nat Mayes, of the Sloan School of Management, joined Corporate Development one-quarter time. Carlos Arcos '81 joined Corporate Development to assist with initiatives in Latin America. Priscilla Whoolery and Michael Healy were hired as Research Analysts. William Culbert was promoted to Principal Liaison Officer. Carl Accardo was promoted to Manager of Corporate Relations Asia Pacific Operations. Bruce Anderson and Imee Jackson were hired to market and solicit memberships to the ILP. Jackie Womble and Margaret Duke were promoted to Information Specialists. Margaret Gonzalez was hired as Manager of Corporate Relations for Communications. Susan Shansky was promoted to Director of Operations and Lisa Bartolet was promoted to Assistant Director of Operations.

Thomas R. Moebus

ASSOCIATION OF ALUMNI AND ALUMNAE OF MIT

This year was one of remarkable accomplishment and significant change at the Association of Alumni and Alumnae. A record Alumni/ae Fund reached \$24.8 million dollars and over 30,500 donors while maintaining a median gift of \$100. It was also a year of new beginnings. Reunions and Technology Day were combined with Commencement, providing a real continuity for MIT's newest alumni, the Class of 1996. *Technology Review* (TR) hired its first full-time publisher, R. Bruce Journey, to strengthen the magazine's finances. Further, the Association launched a new venture into alumni on-line services at the recommendation of an alumni committee ably chaired by L. Robert Johnson '63. This new venture responded to needs uncovered by research in support of the Long Range Strategy Committee (LRSC). The first "product" to be offered in 1996-1997 will be an e-mail forwarding service for alumni. The Association's Regional Programs and Graduate Alumni/ae Program (GAP) were significantly restructured into a new Geographic Programs department to offer added value to MIT clubs, departments, graduate alumni, and the Alumni/ae Travel Program.

Association president Karen W. Arenson '70 led the Association with distinction as the Board oversaw the continued implementation of the 1994 LRSC. Association president Arenson has taken a new assignment reporting on higher education for her employer, *The New York Times*, which asked her to sever her MIT connections to prevent a perceived conflict of interest. Alumni/ae Fund chair Gregory K. Arenson '70, Audit and Budget Committee chair Bennett M. Zarren '61, Enterprise Forum Board chair Wendyl A. Reis '56, and TR Search Committee chair Robert M. Metcalfe '68 all worked exceptionally hard in a year of heavy innovation and implementation. MIT President Charles M. Vest HM and his wife Rebecca M. Vest continued to give of their time and hospitality meeting and greeting alumni on campus during Alumni/ae Week, Parents Weekend, and Senior Dinners, as well as at MIT clubs around the world. The balance of an exceptional staff and innovative, involved volunteers continues to be the Association's strongest asset. Thanks to their efforts, the Association continues to thrive.

A continued emphasis on developing relations with alumni overseas led Association executive vice president and CEO William J. Hecht '61 to travel to the MIT Clubs of Switzerland and Germany in November. Mr. Hecht visited Tokyo, Japan, in January to mourn the passing of Dr. Hajime Mitarai '65, president of the MIT Association of Japan, with the senior officers of the Association of Japan, members of Dr. Mitarai's family, and Dr. Vest. In May Mr. Hecht returned to Japan and also traveled to alumni groups in Hong Kong, Taiwan, and the Philippines, where he made the first visit of an Association officer to the Technology Club of the Philippines. Founded in 1910, this is the oldest MIT Club in Asia.

ALUMNI/AE ACTIVITIES

Completion of the staff restructuring begun in FY '95 was a major achievement of this year. A new unit, Geographic Programs, was established by combining regional activities with GAP, the Institute Career Assistance Network (ICAN), and the Alumni/ae Travel Programs. Geographic Programs is headed by a new director, Rosemarie Resnik. A summary of the Geographic Programs is included elsewhere in this report.

ALUMNI/AE FUND

Led by Mr. Arenson, the FY '96 Alumni/ae Fund set new records for total dollars, broad based participation and gift upgrading in support of MIT. The Fund received \$24.8 million in gifts from 30,509 alumni, of which 51% were donations of \$100 or greater.

The \$24.8 million in gifts exceeded the FY '96 goal of \$23 million, which was also the prior record, by \$1.8 million, a gain of 8%. The donor total of 30,509 alumni achieved the FY '96 goal and was the first time that the number of contributors reached 30,000. With 51% of the donors at the \$100 or greater level, the Fund achieved a median gift of \$100.

Other highlights of the year included support from non-alumni parents. A total of 697 parent donors, which exceeded last year's number by 16%, contributed \$555,000 in gifts credited to the Alumni/ae Fund, which exceeded last year's total by 80%.

Each year, separate goals are established for both undergraduate and graduate alumni participation in the Fund. Undergraduate alumni participation increased to 44%, with over 19,700 contributors; of that total, a record 10,500 individuals, 53%, contributed \$100 or more. Graduate alumni set a new record for contributors with over 10,800 donors -- the sixth consecutive year of increased participation.

The Alumni/ae Fund results cited above represented the successful volunteer efforts of several thousand alumni, students and parents, who worked to increase financial support of MIT. Important as well are the several thousand additional volunteer alumni who provide leadership of the Association's national boards and committees, regional clubs, undergraduate classes, special constituencies, and more. The outstanding results of the Alumni/ae Fund demonstrate the abiding strong affection that MIT graduates have for their alma mater.

CLASS PROGRAMS

Class Programs encompass reunions and mini-reunions, reunion gifts, activities with the senior class, and ongoing activities with all classes. These programs continue to be vibrant with over 300 volunteers involved in planning reunions and raising reunion gifts, and an additional cadre of volunteers working as class agents, class secretaries, and telethon volunteers.

There were four overall areas of focus in FY '96: sustaining the upward growth in undergraduate donors, creating strong reunion gifts, launching the first combined reunion and Commencement weekend, and building stronger connections with students and new graduates.

As noted above, the undergraduate donor goals were achieved. Reunion gifts from the fifth through 70th reunion classes were remarkable, with total gifts and pledges of nearly \$37 million. The Class of 1946, one of the smallest 50th reunion classes with only 386 active members, raised \$4.35 million from 67% of the class. The other two major reunion classes, which, like the 50th include five years of alumni giving and pledges payable over the next five years, are the 25th and 40th reunions. The 40th reunion class raised over \$5.4 million from 65% of the class, including \$274,000 for the newly established Class of 1956 Scholarship Fund. The Class of 1971 raised nearly \$1.4 million from 70% of the class and fully funded a new Class of 1971 Scholarship Fund.

Other reunion classes set new standards. The Class of 1951 raised a record 45th reunion gift of \$1.5 million from a record 54% of the class. The Class of 1961 set a new dollar record for a 35th reunion gift of \$1.9M with 51% of the class participating. The Class of 1966, which set a record participation rate at its 25th reunion, has set a new standard for the 30th reunion, with 54% of the class participating. While not record breaking, other classes had strong results: \$378,000 from 46% of the Class of 1976; \$69,000 from 44% of the Class of 1981; \$55,000 from 39% of the Class of 1986; and \$18,000 from 26% of the Class of 1991.

The post-55th reunion classes, which include gifts received in the five years leading up to reunion, were also impressive. The Class of 1936 established a new gift record for the 60th reunion with \$13.5 million from 81% of the class. The Class of 1931 raised \$2.2M from 74% of the class, and the Class of 1926, in its 70th reunion year, raised \$5.1M from nearly 100% of the class over the five-year crediting period.

Engaging student volunteers before they graduate is a top priority for ensuring the future of MIT. In an effort to educate students about the services offered to alumni and the many ways they can stay connected to MIT after graduation, the Association sponsored a full day Alumni/ae Activities Expo. The Student Alumni/ae Council (SAC) activities included an Externship Program held during IAP that gave students the opportunity to "shadow" an alumnus/a who is in a career of interest to the student, and the Annual Career Connections Forum focusing on non-traditional career options for engineering majors. Senior Dinners at the Presidents House, graciously hosted by Dr. and Mrs. Vest, were attended by nearly half of the senior class. Forty-one alumni volunteers attended the dinners to welcome the Class of 1996 to the ranks of MIT alumni.

Tech Week and Reunions

In an attempt to build a stronger sense of community, as well as streamline the two major spring events at MIT, Tech Week and Reunions was combined for the first time with Commencement. This increased the percentage of alumni marching in Commencement from the 25th and 50th reunion classes, and allowed greater opportunities for the alumni and students to interact. A total of over 2,600 alumni and guests participated in Tech Week activities.

The Technology Day Committee, chaired by Mr. Ronald Fergle AR '86 and faculty advisor Mr. John T. Preston HM, designed a program to explore emerging technologies in the areas of communications, biology, and materials. The morning program featured Mr. Bran Ferren '74, of Disney Imagineering, Mr. Preston, and MIT Professors David Baltimore LI '61 and Michael L. Dertouzos EE '64, followed by a lively question and answer session moderated by Dr. Vest. Afternoon sessions included three panel discussions: the social implications of new technologies, moderated by Dean Rosalind H. Williams; the environmental implications, moderated by Professor Gregory McRae; and the entrepreneurial implications, moderated by Professor Eric A. von Hippel ME '68.

For many, Tech Night at the Pops is the kickoff event for reunion activities. This year's concert was a sell-out, as graduating seniors and their parents joined alumni and guests for a concert featuring MIT soloist Pamela Woods along with Pops favorites. The day of Commencement, on- and off-campus tours complemented reunion activities planned by the reunion classes. A revitalized Technology Day reception, which included faculty as hosts, attracted record numbers of faculty and alumni. The fifth annual Tech Challenge Games, designed by alumni volunteers, were quite competitive with the classes of 1976 and 1986 tying for first place. Children of alumni participated in Camp Tech, a four day program designed for kids of returning alumni.

ALUMNI/AE LEADERSHIP CONFERENCE

Several hundred alumni volunteers and their guests attended the September 16 ALC, the theme of which was "Technology and Leadership: Leading the Future." Association president Arenson set the context and introduced the speakers for the morning program. Provost Joel Moses MA '67 spoke about "Leadership in Engineering Education;" Dean Glen L. Urban, MIT Sloan School of Management, described "Management in the 21st Century: The Leadership Challenge;" and Dr. Vest gave his reflections on institutional and individual leadership.

After the awards luncheon, a panel of alumni considered these questions: "What makes a leader? Does MIT make them?" Panelists were Mr. DuWayne J. Peterson '55, president-select of the Association; MIT Senior Lecturer Paul F. Levy '72, former director, Massachusetts Water Resources Authority; Ronald S. Newbower '65, senior vice president for Research and Technology, Massachusetts General Hospital; Douglas B. Berman EE '86, senior health analyst, Permanente Medical Group, Inc.; Ms. Carrie R. Muh '96, president, MIT Undergraduate Association; and Mr. Caryl B. Brown GM '95, former Graduate Student Council president.

GEOGRAPHIC PROGRAMS

As noted above, the Geographic Programs group was formed in 1996 to develop a comprehensive program which integrates all the activities and services where alumni/ae live. The programs which include both alumni relations and annual fund activities are: Clubs and Regional, ICAN, Alumni/ae Travel Program, Alumni/ae Continuing Education, Departmental Relations, and GAP. The staff have conducted an assessment of the program, mailed a survey to alumni regarding club and program interests, developed a strategic plan, and traveled to major cities to visit volunteers and to involve them in the planning process.

In FY '96, 92 active worldwide clubs provided programs, faculty speakers, and activities for alumni. Dr. Vest was a featured speaker at U.S. club events in Atlanta, Dallas, San Diego, Southern California, and Washington, DC, and overseas at MIT gatherings in Japan and Singapore. The MIT Club of Boston celebrated its 50th anniversary in May with over 300 attendees at the Museum of Fine Arts. One hundred twenty-two alumni participated in ten Alumni/ae Fund telethons across the U.S. Over 2,000 alumni were contacted in these telethons, of whom some 1,700 pledged gifts to MIT, a pledge rate of 85%.

Support from alumni whose first degree is at the graduate level increased for the sixth consecutive year as reported above. Key to the success was the collaboration with academic department heads on course mailings and departmental telethons.

International and middle donor pilot programs continue to be priorities in the GAP plan. For the second year in a row, a special version of Dr. Vest's annual fund appeal was sent to international alumni. Special middle donor initiatives focused on upgrading graduate alumni gifts at the level of \$250 and above, and included several successful pilot programs.

Department-based professional association events, hosted by MIT faculty members, have again proven to be very successful in bringing department alumni together at several key locations around the country. Sixteen alumni receptions were held in FY '96, attended by a total of over 650 alumni and guests.

Collaborations continued with the Graduate Student Council and the International Students Office to improve quality of life for these special constituencies and provide a connection to the Association. Deserving of special note was the two-day Women in Chemistry Symposium, organized by a group of current graduate students in the Department of Chemistry.

Recruitment efforts for ICAN, initiated in 1995, proved most successful. This program matches volunteer alumni mentors already in an occupational field with other alumni and students seeking employment. Due to alumni population density issues, recruitment has focused on seven major metropolitan areas. To date, more than 1,300 alumni mentors have been recruited, while some 500 individuals have pursued a match with a mentor.

The Alumni/ae Travel Program continues to attract a wide variety of travelers, sending them to destinations both domestic and international. In 1996, 32 programs were offered. Of special note were the trips to Alaska and China, where travelers met with local alumni in Anchorage and Beijing respectively. Guest lecturers during the year included MIT Professors James G. Bellingham '84, Donald R.F. Harleman CE '50, and Robert V. Whitman CE '49.

SPECIAL PROGRAMS

In addition to its more traditional class, geographic and annual fund activities, the Association supported a variety of special programs. The Association of MIT Alumnae (AMITA), the Black Alumni/ae of MIT (BAMIT) and the Chinese Alumni/ae of MIT (CAMIT) conducted programs for these special groups of alumni including regular newsletters, group directories and Alumni/ae Fund gifts for special projects initiated by each group. Association staff supported alumni activities in cooperation with student residences, the department of athletics and student campus activities. Family Weekend held on September 29-30 continued to draw families to campus from around the world.

ALUMNI/AE INFORMATION SERVICES

During the past year, the AIS group expanded its reorganization efforts through the creation of additional work teams dedicated to enhanced customer service for alumni, students, parents, friends, and staff.

Continued progress was made toward the implementation of the Association's new client/server computer system with technical staff acquiring the training and skills necessary to support this system. The technical staff, through ongoing communication with functional users, was able to complete data conversion between the current ADDS system and the new Advance Client/Server system.

Scheduled to "go live" in 1997, this system will result in a reduction in mainframe costs and provide the Association with a flexible system which will allow us to meet our customer's expanding information needs in the coming years.

Additionally, the creation of a new Events Management System was undertaken in-house and should be operative within the year.

TECHNOLOGY REVIEW

After a yearlong search headed by Dr. Metcalfe, Mr. Journey was chosen as the magazine's first full-time publisher and CEO. Most recently the head of *Fortune*'s New England ad sales office, Mr. Journey intends to focus on boosting TR's advertising revenues as well as examining every aspect of its business operation with an eye toward producing steady growth. He will be building on the success of circulation and marketing director Martha Connors in attracting significant new income through a "careers" section in which high-tech companies post their positions available. The magazine also saw a five percent increase in its circulation base this year.

Soon after Mr. Journey arrived, the TR staff was shocked by the death of longtime associate publisher Peter D. Gellatly. Mr. Gellatly had been a major stabilizing force in his 18 years at TR and an enthusiastic proponent of attracting a full-time publisher. His wisdom and guidance will be sorely missed.

Although it maintains a national readership and focus and thus does not aim specifically to promote MIT, TR nevertheless drew significantly on the resources of its home base this year to produce three cover-story interviews, with Sherry Turkle, Tim Berners-Lee, and Professor Lester C. Thurow HM. The editors also saw marked success in attracting prominent writers to the TR stable, including best-selling MIT author Professor Alan Lightman, Boston University writer-in-residence and literary journalist Mark Kramer, physician and prolific author Perri Klass, and award-winning science writer John Horgan. An article on the problems with electric vehicles by five MIT researchers headed by Professor Richard R. DeNeufville '60 sparked significant attention as states debated whether to promote the alternative vehicles. And 17 diverse essays in the ambitious August/September special issue commemorating 50 years of the atomic age drew numerous accolades.

MIT ENTERPRISE FORUM

The MIT Enterprise Forum had an active program year with a number of new initiatives launched. First, the Forum conducted a phone survey of CEOs who previously presented at Forum business plan case presentations. The survey was designed both to solicit feedback from past presenters concerning their experience as a presenter and to evaluate the progress their companies had made since presenting.

The results of the survey showed that an overwhelming majority (81%) of presenters were generally satisfied or highly satisfied with their experience as a Forum presenter. Many commented on the fact that the Forum was an excellent practice ground for presenting their companies to investors. Also, preparing the detailed business plan required by the Forum forced them to think more clearly about their company and its business strategy. The Forum plans to conduct follow-up surveys with presenters on an ongoing basis as it is an excellent way for the Forum to evaluate and improve its programs continuously and to stay in close contact with its entrepreneurial constituency.

The Forum also focused considerable effort this year on moving itself into the electronic age. The push to use technology more effectively was aimed at fostering increased intra-Chapter communication and collaboration as well as experimentation with new ways to deliver new programs to more entrepreneurs. To improve chapter communications e-mail boxes and linked World Wide Web pages were established and the first Chapter Chairs on-line chat session was held.

To increase collaboration among the regional Forums on innovative programs, the Forum successfully launched the first in a planned series of satellite teleworkshops featuring technology leaders discussing topics of importance to the entrepreneurial community. The first international teleconference was held in May and featured Tim Berners-Lee, the creator of the WorldWideWeb, discussing trends in the new cyber-workplace. The event, *Virtually Live with Tim Berners-Lee*, was interactive with seven Forum chapter sites participating throughout North America.

PERSONNEL

The Association had a busy year in staffing, building on a major reorganization in FY '96 while generating a record-breaking Alumni/ae Fund and developing a number of new initiatives. In addition, the Institute's offer of a special incentive for early retirement led to the departure of some valuable long-time staff members: Nancie M. Barber, program manager for special constituencies, after 12 years; Virginia Gimilaro, senior data entry operator, after 17 years; Patricia A. Kane, financial officer, after 30 years, 25 of them spent with the Association; and Theresa Speaks, senior data entry operator, after 26 years at MIT. Sadly, as has been mentioned above, the Association lost Mr. Gellatly to lung cancer on May 18.

Several other departures deserve some mention: Ann P. Brazier, who directed the Alumni/ae Travel Program for almost 20 years, both in its previous home at the Quarter Century Club and with the Association, left MIT in June; she plans to venture into the for-profit world. Eliza G. Dame, director of reunions and events since 1986, departed in July for the position of director of alumni relations at Emerson College. Kristin Montemagno left her post as assistant director of the Fund in June upon the birth of her second child. William W. Redway, Jr. director of GAP (now a component of Geographic Programs, as has been mentioned), also left MIT in June for St. Mark's School as their director of development. And Maryglenn Vincens departed the Association in May, for a position in the Office of Resource Development as a major gifts officer.

It was a building and rebuilding year for the Class and Geographic Programs staffs, with a total of eight new hires, among them Ms. Resnik. The appointment of Mr. Journey as full-time publisher and CEO sets in motion an exciting new agenda for the magazine. The Enterprise Forum burgeoned in several new areas, and now prepares to build on this momentum as it seeks a replacement for outgoing executive director Kathleen F. Hagan, who will leave in July, 1996, for a leadership role at Babson College.

A new title and salary structure was put in place within the Alumni/ae Fund. Using the titles of alumni affairs officer (level I, II, or III), non-line-management titles were created to offer new or different opportunities for hiring and promotion.

All told, there were 20 departures from the Association, 17 new hires made, and in keeping with a general impetus to grow from within the organization, eleven promotions at a variety of staffing levels. We look forward to more growth, challenge, and consequent staffing opportunities in FY '97.

AWARDS

Honorary Memberships were presented at the Technology Day luncheon on June 16, 1995. All other awards were presented at the awards luncheon of the ALC on September 16.

Bronze Beaver: Mr. Denis A. Bovin '69, Mr. James O. McDonough '43, Mr. Edwin G. Roos '44

Harold E. Lobdell '17 Distinguished Service Award: Mr. Melvin Castleman '32, Mr. Domingo R. Giorsetti NU '77, Dr. Joan Martin Roth CP '81, Mr. Michael Sarfatti '76, Dr. Martin O. Schloh CM '90, Ms. Elizabeth Seifel '78

George B. Morgan '20 Award: Sid F. Atlas '43, Mr. Thomas H. O'Connor, Jr. '60, Mr. Erlend H. Graf '61

Henry B. Kane '24 Award: Mr. Gregory K. Arenson '70, Mr. Leo P. Harten '77, Mr. and Mrs. Richard Koch P '94, Ms. Paula Jean Olsiewski CM '79

Presidential Citation Award: 1994 Technology Day Committee (The Arts at MIT), Alumni/ae Challenge Games Committee (1994), Class of 1944, Council for the Arts at MIT, MIT Club of Southeastern Massachusetts

Honorary Membership: Miss Mary L. Morrissey, Professor Philip Morrison, Provost Mark S. Wrighton

William J. Hecht

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