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ABSTRACT

To help strengthen education in medicine, biology, and related sciences, the Howard Hughes Medical Institute (HHMI) launched a grants program in those areas on 1987. The grants support graduate, undergraduate, precollege and public science education, and fundamental biomedical research abroad. This document provides summaries of all projects receiving grants in 1993 and is also, in effect, a 1993 annual report for each programmatic area supported by HHMI. (ZWH)

Howard Hughes Medical Institute

Grants for Science Education

1994

Office of Grants and Special Programs

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Howard Hughes Medical Institute Programs

The Howard Hughes Medical Institute was founded in 1953 by aviator-industrialist Howard R. Hughes. Its charter, in part, reads: *The primary purpose and objective of the Howard Hughes Medical Institute shall be the promotion of human knowledge within the field of the basic sciences (principally the field of medical research and medical education) and the effective application thereof for the benefit of mankind.*

Biomedical Research Program

The Howard Hughes Medical Institute is a nonprofit medical research organization dedicated to basic biomedical research and education. Its principal objectives are the advancement of fundamental knowledge in biomedical science and the application of new scientific knowledge to the alleviation of disease and the promotion of health. Through its program of direct conduct of medical research in conjunction with hospitals, the Institute employs over 220 independent investigators who conduct research at Institute laboratories in more than 50 leading academic medical centers, hospitals, and universities throughout the United States. The number of investigators is expected to grow to about 270 within two years.

The Institute conducts research in five broad areas: cell biology and regulation genetics, immunology, neuroscience, and structural biology.

In support of these research efforts, the Institute is involved in the training of pre- and postdoctoral scientists in the laboratories of Hughes investigators; has provided substantial support to the genome mapping program which involves international collection, dissemination, and coordination of data; provides research training to medical students through the Research Scholars Program (conducted jointly with the National Institutes of Health); and organizes scientific conferences, workshops, and program reviews.

Grants and Special Programs

In the fall of 1987, as a complement to its research program, the Institute launched a grants program to help strengthen education in the biological and related sciences. The program is administered through the Office of Grants and Special Programs and has as its primary objectives the enhancement of science education at the graduate, undergraduate, and precollege levels; the education of the public about science; and the promotion of fundamental biomedical research abroad. In addition, this office is establishing a comprehensive assessment program. The grants extend across a wide range of institutions involved in formal and informal science education, including colleges, universities, research centers, medical schools, elementary and secondary schools, and science museums.

Since launching the grants program, the Institute has developed an array of initiatives designed to help ensure the future quality and vitality of the scientific enterprise. Today, the Institute supports graduate students, medical students, and physicians through a grants program for graduate education in the biological sciences; undergraduate institutions through an undergraduate science education program; and science museums through a precollege and public science education program.

Contents

Precollege and Public Science Education

International Program

Program Assessment

1993 Awardees

Graduate Science Education

Undergraduate Science Education

Precollege and Public Science Education

Figures

Preface

The grants program of the Howard Hughes Medical Institute focuses on science education at all levels and, in so doing, complements the Institute's core programs in the direct conduct of biomedical research. The Institute's biomedical research activities currently involve over 225 investigators at more than 50 leading academic centers, hospitals, and research institutions throughout the United States. The number of investigators is expected to grow to about 270 at more than 60 sites within the next year. This research encompasses the fields of cell biology, genetics, immunology, neuroscience, and structural biology.

Since its launching seven years ago, the grants initiative has grown to include support for graduate, undergraduate, and precollege education; for programs to educate the public about science; and for biomedical research in selected countries abroad. This array of activities is designed to help ensure the future quality and vitality of the nation's scientific enterprise.

Changing the Way Science Is Conducted

The world of science is changing fundamentally. The rise of science as a profession in 19th century academia was accompanied by the development of departments, each based on a single scientific discipline. Today that older structure is giving way to new arrangements related to the revolutionary changes in science itself.

The dynamics and complexity of modern scientific research can be illustrated by the discovery and understanding of oncogenes and the role of specific genes in the development of cancer. This area of research was stimulated by the discovery of Drs. Michael Bishop and Harold Varmus, at the University of California–San Francisco, that genes in tumor viruses responsible for cancers in animals can be found in normal cells. These insights have had important and far-ranging implications. The realization that oncogenes appear to have been conserved for billions of years has affected our understanding of evolutionary biology. And the similarity between the protein products of oncogenes and growth-factor receptors has helped link oncogenes to developmental biology. Indeed, the oncogenes present a new representation of cancer, and this modified view may eventually alter how clinicians treat cancer patients.

Expanding International Research Opportunities

In recognition of the international nature and scope of modern biomedical research, and the presence of outstanding scientists outside the United States who contribute to the advancement of knowledge relevant to the Institute's biomedical research program, the Institute in 1990 created the International Program.

In the first two rounds of competition, a total of $24.3 million was awarded in 49 five-year grants for

scientists in Australia, Canada, Mexico, New Zealand, and the United Kingdom. For the third round of international competition, biomedical scientists in 10 countries of the former Soviet Union and Eastern Europe, including Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovak Republic, and Ukraine, were invited to apply for grants. It is anticipated that these awards for research at the scientist's own institution or to support international research collaborations will total about $3 million each year for five years.

We are extremely pleased with the development of this program and with the opportunities it affords for Institute investigators and international scholars to meet at the Institute. International exchanges of ideas and data are already in progress.

Providing Needed Research Resources

The Institute's support of valuable research resources underscores our commitment to ensure the continuation of important biomedical advances. A $1.2 million grant to the Jackson Laboratory in Maine will help expand their capacity to provide unique genetically altered (transgenic) mice at low cost for biomedical research worldwide. Through genetic engineering, new strains of mice are being created to mimic such human disorders as arthritis, cancer, and cystic fibrosis.

The Institute is a major producer and user of genetically engineered mice. Of the 35 new strains acquired by the Jackson Laboratory in 1993, 15 were developed in our laboratories. More than 50 Institute investigators use transgenic mice in their research.

Educating the Next Generation of Scientists

The Institute supports graduate students and physicians in obtaining research training in basic biological processes and disease mechanisms at leading research laboratories. Fellows from the first years of the fellowship programs are now emerging as independent young scientists. The physician postdoctoral fellowship program made its first awards in the fall of 1990, and several of these enthusiastic young scientists are being recruited into faculty positions at research-oriented medical schools. Christopher Walsh used his postdoctoral research fellowship to study how cells are dispersed in proliferative layers of developing cerebral cortex. Dr. Walsh is now Assistant Professor of Neurology at Harvard Medical School. Sharon Plon used her award to investigate the regulation of the beta-like globin gene cluster, an important blood constituent. Dr. Plon has a faculty position in the Pediatric Oncology Department at Baylor College of Medicine.

Students who received predoctoral fellowships in the biological sciences are now successfully com-

peting for postdoctoral fellowships to train in some of the leading research laboratories in the country. Hao Wu, for example, received her Ph.D. degree from Purdue University after completing her dissertation on the structure of canine parvovirus. Dr. Wu was one of 26 scientists recently awarded an Aaron Diamond Foundation Postdoctoral Research Fellowship and will conduct research on AIDS at Columbia University with Dr. Wayne Hendrickson, an HHMI investigator.

Brendan Cormack completed his Ph.D. studies on a yeast DNA-binding protein involved in regulating the transcription of genetic information. He is now a Helen Hay Whitney Foundation postdoctoral fellow with Dr. Stanley Falkow at Stanford University. Ilaria Rebay received her Ph.D. from Yale University upon completion of her dissertation on a protein essential to early development in *Drosophila*. Dr. Rebay was awarded a Life Sciences Research Foundation Fellowship for postdoctoral studies with Dr. Gerald Rubin, an Institute investigator at the University of California–Berkeley.

Altering the Academic Structure of Science

Changes in the academic organization of science are beginning to reflect the nature of laboratory research. Science departments such as microbiology or physiology are being reorganized at a number of academic institutions into broad new departments emphasizing, for example, cellular and molecular biology. Because of the rapidity of scientific advances on the one hand and financial constraints on the other, science departments at colleges and universities are finding that they must boldly change what they teach and how they teach it. The growing interdisciplinary nature of science in general, and the expanding overlap of biology and chemistry in particular, mean that science departments must collaborate in developing curricula and integrating courses—activities that tear down the traditional walls between scientific disciplines.

As part of its grants activities, the Institute sponsors an annual meeting of undergraduate program directors from grantee colleges and universities. A major theme of the 1993 meeting was institutional strategies for enhancing undergraduate science education. In particular, participants offered a variety of approaches to integrating biology and chemistry through Institute-funded programs. Stronger ties can be forged between the biology and chemistry departments through joint faculty appointments and research seminars, interdepartmental student exchanges, and team teaching of science courses. In other cases, majors in cellular and molecular biology can be developed and courses revised to integrate biology-based problems into chemistry courses, and vice versa.

Important questions arise as science departments develop strate-

gies for long-term change in the way science is taught. For example, how can science faculty who are committed to laboratory research be persuaded to get involved in the reform of science education? What will induce them to teach undergraduates, welcome them into their laboratories, or give extra help to students who need it? Can science faculty be drawn into outreach programs that strengthen science education at elementary and secondary schools?

Institute support in many cases has helped increase faculty involvement at all levels of science education. Faculties at many institutions are already committed to the Institute-funded programs that are focused on attracting and retaining women and minority students underrepresented in the sciences.

Transferring Science to the Classroom

Through the Undergraduate Biological Sciences Education Program, precollege activities are being developed and summer courses offered to upgrade the training of science teachers in subjects such as molecular genetics, which was not available until recently as an academic discipline. Teachers can be offered laboratory research experiences and opportunities for sabbaticals in order to take courses in various scientific fields. Scientists from colleges and universities can help develop science instruction kits and, during the summer, train teachers from middle schools, high schools, and two- and four-year colleges to train other teachers to use the new materials.

As noted by undergraduate program directors experienced in outreach programs, teachers in the kindergarten–12th grade school system are an integral part of the science reform effort. They can spark a burning interest in science among young students or coldly douse their natural desire to explore. Outreach efforts to kindergarten–12th grade can be complex undertakings, and colleges and universities seeking to develop linkages to precollege science teachers must become involved in planning the outreach activities.

Capturing the Wonder Years

For many children the vast halls of a science museum become a cherished memory in their adult years. Distinguished scientists have credited visits to museums as a central influence in their decision to pursue a science career. Dr. Frank Press, a geophysicist and former president of the National Academy of Sciences, said he would never have become a scientist had it not been for the Brooklyn Museum. Dr. Robert Lefkowitz, Professor of Medicine and Institute Investigator at Duke University Medical Center, wrote, "When I was a child growing up in New York, I spent many happy weekend afternoons wandering around the American Museum of Natural History. Those experi-

ences very much helped to shape my decision to become a scientist."

The Institute in 1992 and 1993 awarded a total of $10.65 million to 51 natural history museums, science museums, children's museums, aquaria, botanical gardens, and zoos to support innovative education programs to interest youngsters in science.

A key question for science museum professionals is how can museums structure programs and exhibits to capitalize on children's natural curiosity and capture their interest? Geologist Robert Hazen of the Carnegie Institution of Washington and co-author of the book *Science Matters* was the keynote speaker at an Institute-sponsored meeting for program directors of science museums that have received grants from the Institute. Dr. Hazen noted that the biggest challenge for science education today is to stir the interest of the 99 percent of students who will not choose a career in science.

The program directors stressed that science education programs, to be successful, must show how science relates to everyday life. For children or adults, this can mean studying local wildlife or using household materials to demonstrate scientific phenomena. The lively exchange of ideas and information at the meeting should lead to effective strategies for nurturing children's interests. If so, both the children and the museums will flourish as we enter the 21st century.

The grants programs supported by the Institute extend across a wide range of institutions involved in formal and informal science education, including colleges, universities, research centers, medical schools, elementary and secondary schools, and science museums. Just as the world of science is rapidly changing, so is our understanding of how students learn and the role of teachers in the process. The Institute is pleased to be supporting programs in science education that will help develop the next generation of biomedical investigators and a public with a broadened understanding of science and technology.

Purnell W. Choppin
President
Howard Hughes Medical Institute

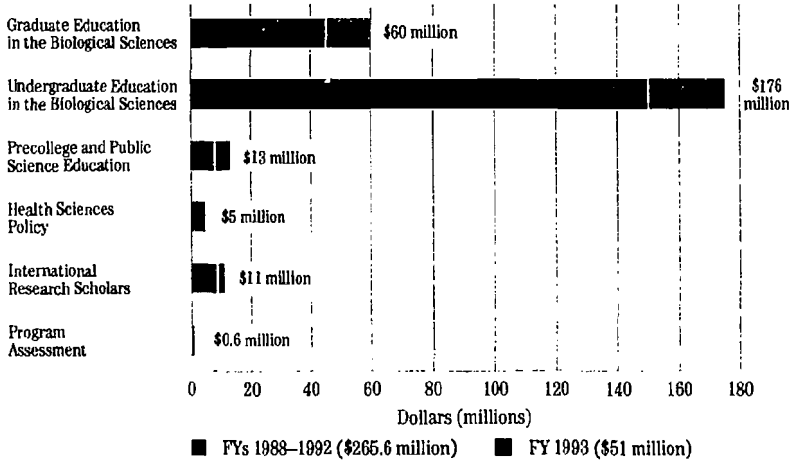
Introduction

Colleges and universities that embark on reforming science education face three principal challenges, said Samuel Ward, Professor and Head of Molecular and Cellular Biology at the University of Arizona. First, the goals of teaching must be changed. Second, educators must learn how to go about altering the ways science is taught. And third, colleges and universities must increase the institutional rewards and status assigned to teaching, which is too often undervalued relative to research. Dr. Ward's comments sounded the theme of his keynote address at the October 1993 meeting of program directors for the Institute's undergraduate science education grants (see *1993 Undergraduate Program Directors Meeting: Institutional Strategies for Enhancing Undergraduate Science Education*). Similar challenges face other educational institutions that serve the spectrum of students from kindergarten through graduate school.

The grants programs of the Howard Hughes Medical Institute pursue two related goals. One is to help train the next generation of biomedical scientists to sustain the momentum of today's extraordinary biomedical discoveries. The other is to develop a scientifically informed American public that will participate in societal decisions about science education, scientific research and development, and applications of new technologies. The Institute also seeks to ensure greater participation in science by those who have not traditionally been well represented, particularly women and

Figure 1

Howard Hughes Medical Institute Grants Program Expenditures, 1988–1993 ($316.6 million)



members of underrepresented minorities.

To complement its research program, the Institute launched a major grants program in 1987 to help strengthen science education and encourage talented young people to pursue research and teaching careers. This endeavor, administered through the Office of Grants and Special Programs, has ... its primary objectives the enhancement of science education at all levels, the education of the public about science, and the promotion of fundamental biomedical research abroad. The program extends across a wide range of institutions involved in biological science education both formal and informal. The Institute supports predoctoral students, medical students, and physicians through fellowships for graduate education; colleges and universities through an extensive undergraduate program; and science museums, aquaria, botanical gardens, zoos, and biomedical research institutions through precollege educational activities (see *The Annual Report of the Howard Hughes Medical Institute, 1992*).

The international program was created in 1990 as part of the Institute's grants activities. It reflects the international nature and scope of today's biomedical research and the presence of outstanding scientists outside the United States who are advancing knowledge relevant to the Institute's biomedical research program.

HHMI's grants program is the nation's largest privately funded initiative to enhance the performance of U.S. students in science, awarding about $50 million annually. To disseminate information on grant-supported activities and to encourage grantees and others to discuss their experiences, the Institute hosts five annual conferences. These bring together medical student fellows, predoctoral and physician postdoctoral fellows, undergraduate and precollege program directors, and students in the Washington, D.C., metropolitan area who receive support through the Institute's local grants activities.

The present report highlights grant-supported activities for 1993 and policies and special initiatives for the 1994 competitions. The grants office budget for 1994 awards is approximately $52.5 million. This comprises $18 million for graduate education in the biological sciences, $28.5 million for undergraduate biological sciences education, and $6 million for the precollege initiative for biomedical research institutions, the local precollege science education activities, the international program, and program assessment.

Program Highlights for 1994

- Fellowships will be awarded to about 80 promising young scientists to support five years of predoctoral graduate training.
- Fellowships will be awarded to 25–30 physicians who will conduct research for three years under the guidance of mentors at

universities, research institutes, and hospitals.

- Fellowships will be awarded to about 60 medical students for one year's training in research at a U.S. academic or nonprofit institution of their choice, and to 20 additional medical students for completion of their medical studies after finishing the research year.
- Grants for undergraduate science education, totaling about $72 million for four years, will be awarded after review of invited proposals from 140 research and doctorate-granting universities, public and private. These grants will support student research (including opportunities for women and underrepresented minorities), equipment acquisitions and laboratory renovations, and precollege and outreach programs.
- Grants for five years totaling up to $5 million will be awarded to medical schools, academic health centers, and independent research institutions to provide hands-on science education for students and teachers at the precollege level.
- About 100 research grants totaling $3 million annually for five years will be awarded to scientists in 10 countries of the former Soviet Union and Eastern Europe for research at their own institutions or for collaboration with scientists in Western countries.

Educating the Next Generation of Biomedical Scientists

Undergraduate Science Education

Since 1988 the Institute's Undergraduate Biological Sciences Education Program has awarded $204 million to strengthen life sciences education at 197 public and private colleges and universities. These include 15 historically black institutions, 10 other colleges and universities enrolling substantial numbers of undergraduate minority students, 7 women's colleges, and 3 universities in Puerto Rico. The process of selecting the colleges and universities to compete in each round of the undergraduate program has been based on extensive records of recent scientific productivity obtained from national databases.

The program has supported research opportunities for more than 11,500 undergraduates. Of these, 56 percent are women and 27 percent are students from underrepresented minority groups. The Institute has also supported the development of approximately 2,500 courses covering 30 fields of biology and other disciplines and has generously funded laboratory enhancement.

Since 1988, Institute funds have enabled 55 colleges and universities to appoint 169 faculty members in a range of scientific disciplines. This is providing departments with opportunities to develop new courses in important areas of modern science and to update and expand

Changing the attitude of instructors from a "weed-out" mentality to one of encouraging students was considered by many participants to be as important as new curricula and teaching methods.

1993 Undergraduate Program Directors Meeting

existing curricula. The appointments include 82 women and 21 members of minority groups. The Institute's program is helping to foster reform of undergraduate science education at colleges and universities across the country.

Changing the Goals of Teaching

Several themes emerged at the 1993 meeting of the directors of undergraduate science education programs. Changing the attitude of instructors from a "weed-out" mentality to one of encouraging students was considered by many participants to be as important as new curricula and teaching methods. At Washington University, Institute funds support efforts in the biology department to augment student support services with mentoring and problem-solving tutorials.

Several Institute-funded programs aim directly at nurturing science students, especially underrepresented minority students and women. Fisk University, with a predominantly African American population, has developed a science learning center organized to help students with mathematics, science, and study skills and to instill academic self-confidence. At the meeting, Fisk participants noted that learning styles seem to vary according to culture and gender and should be taken into account in the classroom and laboratory.

At the University of California–Berkeley, Dr. Corey Goodman, Professor of Genetics and Neurobiology and an Institute investigator, observed that the grant-supported program offers opportunities for tutorials, career discussions, time-management workshops, and other activities, fostering a nurturing academic environment. In addition, the program provides student tutors who work with study groups in mathematics, biology, chemistry, and physics.

Does such nurturing lead to a drop in academic standards? Not necessarily, said Dr. Joseph Ackerman, Professor and Chairman of Washington University's Department of Chemistry. Most students, he believes, can make the leap from high school to college-level academic performance if they have some help getting started. At many institutions, however, more instructors are needed to provide the additional attention. Eventually, he said, students must make the transition to independent college-level science if they are to proceed into majors, graduate study, and careers in research.

Changing How Science Is Taught

In her recent book *Revitalizing Undergraduate Science*, Sheila Tobias advocated structural change at the departmental level of colleges and universities as a crucial step in reforming science education. Her concepts broadly molded the agenda for the 1993 program directors meeting. Discussions of curriculum reform brought out two issues that departments must resolve. The first was how to determine the content of interdisciplinary courses. What is

included and what is left out? Organic chemistry courses, for example, might include stereochemistry demonstrations in biological laboratory experiments.

The second issue, referred to as the "freshman-year problem," concerns the uneven preparation of incoming students for college-level mathematics and science, particularly chemistry. In the Notre Dame panel discussion, participants described a variety of scheduling approaches to allow students to catch up on requisite chemistry skills before entering biology courses. The Institute-funded program at California State University–Los Angeles is addressing this problem with courses to improve student proficiency in mathematics and other critical fields before and during the freshman year.

At the meeting the program directors paid a great deal of attention to the role of computer technology in science education. This and other technologies hold great promise for strengthening science teaching for majors and future scientists as well as students who pursue studies in other areas.

Graduate Science Education

The graduate education initiative of the Institute grants program is intended to promote excellence in scientific training, to complement other sources of available support, and to aid in meeting national needs. Since 1988 the Institute has provided $42 million in fellowship support to more than 800 students and physician-scientists who have shown strong promise of becoming tomorrow's leading biomedical researchers. Additional support for graduate education has been provided through research resources grants to scientific and educational organizations, such as the Cold Spring Harbor Laboratory.

Altogether 400 predoctoral fellowships in the biological sciences have been supported to date. Women have received 40 percent of these awards, and underrepresented minorities 11 percent. Of the 280 research training fellowships for medical students, women have received 36 percent and underrepresented minorities 7 percent. Of the 85 postdoctoral research fellowships for physicians, women have received 19 percent and underrepresented minorities 3 percent. As the Institute's outreach and education initiatives mature, the participation of even greater proportions of women and underrepresented minorities is expected for the graduate fellowship programs.

An extensive tracking system for participants in the Medical Student Research Training Fellows program and those in the Howard Hughes Medical Institute–National Institutes of Health Research Scholars program is already well developed through a five-year grant to the Association of American Medical Colleges (see *Grants for Science Education, 1991–1992*). A parallel effort to track the progress of the Institute's predoctoral and postdoctoral fellows will be initiated during 1993–1994.

We need to re-create the teacher-scientist partnership along the lines that existed in the post-Sputnik years in the form of summer institutes, but now in the schools themselves.

Dr. Timothy Goldsmith
Yale University

Through outreach programs, colleges and universities can be instrumental in enhancing science teaching at the precollege level.

1993 Undergraduate Program Directors Meeting

Enhancing Science Literacy

Increasing the Value of Science Teaching

Timothy Goldsmith of Yale University, keynote speaker at the 1992 meeting of undergraduate program directors, noted that "a central purpose of biological education should be to convey science as a powerful way of understanding the world" (see *Enriching the Undergraduate Laboratory Experience, 1992*). Dr. Goldsmith called on scientists to become more involved with science education at the kindergarten–12th grade level. "We need to re-create the teacher-scientist partnership along the lines that existed in the post-Sputnik years in the form of summer institutes, but now in the schools themselves," he wrote recently in the *American Journal of Human Genetics*.

Many institutions supported through the Institute's Undergraduate Biological Sciences Education Program use substantial amounts of their grants to assist in the development of science programs for students and teachers at elementary, middle, and high schools. Fifty-nine percent of the approximately 25,000 students who have benefited from these outreach efforts are from underrepresented minority groups and 54 percent are female. Of the 8,200 teachers who have benefited, 19 percent are from underrepresented minority groups and 56 percent are women.

Through outreach programs, colleges and universities can be instrumental in enhancing science teaching at the precollege level, often providing equipment and supplies that are not available to many kindergarten–12th grade science teachers. With Institute support, Washington State University has set up a program to loan electrophoresis apparatus, spectrophotometers, video cameras, and other science teaching aids to schools that cannot afford to purchase them. Oklahoma State University supplies science footlocker kits to local teachers.

At Oklahoma State the Institute-funded program is designed specifically to help rural Native Americans progress through the educational system and complete a degree in the biological sciences. The Institute's grant has been especially crucial in getting faculty involved in a program for reaching rural Native Americans during a time of cutbacks across the campus, said Alan Harker, Professor of Microbiology and Molecular Genetics and plenary presenter at the 1993 program directors meeting. According to his colleague Myra Alexander, Manager of Outreach and Counseling, the program has made progress in dealing with cultural disparities of the communities it serves by working with tribal leaders.

Precollege Science Education

The Institute in 1992 and 1993 awarded a total of $10.65 million to 51 natural history museums, science museums, children's muse-

ums, aquaria, botanical gardens, and zoos to support innovative education programs designed to interest youth in science. Under the science museums initiative, the Institute focuses on three major areas: museum-related activities for children and youth, pre-service preparation and in-service training for teachers, and family- and community-oriented science education activities (see *Science Museums: Creating Partnerships in Science Education, 1993*).

In the program's first year, over 37,000 students, 3,300 teachers, and 4,300 adult and family members participated in Institute-funded program activities ranging from classroom use of science kits to year-long research experiences. Of the student participants, 28 percent were minority and 50 percent were female. Over half of the students involved were very young (pre-kindergarten to third grade), confirming the Institute's commitment to provide early opportunities for exploration of science.

Dr. Robert Hazen of the Carnegie Institution of Washington, the keynote speaker at the 1993 meeting of the museum program directors, stated: "one of the biggest challenges for science education today is to stir the interest of the 99 percent of students who will not choose a career in science." He recommends that science education begin in elementary school and capitalize on the natural curiosity of children. Science museums are particularly suited to kindle their interest, he says. As Dr. Frank Oppenheimer, a pioneer in this field, once noted, "Nobody flunks museums!"

One of the biggest challenges for science education today is to stir the interest of the 99 percent of students who will not choose a career in science.

Dr. Robert Hazen
Carnegie Institution of Washington

Alliances for Science

The meeting of museum program directors held in September 1993 focused on how museums create partnerships in science education with schools, families, youth organizations, and community groups. Museums meet a special need at the state and local levels in regard to educating average citizens about science, because of their emphasis on interactive exhibits and their connections with young people and their families.

Strong local alliances have played a critical role in the initial successes described by the directors of the museum programs. In many cases, these partnerships involve a broad network of participants, including schools, teachers, families, corporations, universities, and other institutions. Local community organizations, ranging from the Girl Scouts and 4-H clubs to senior citizens associations, are also helping in the effort to bring science to youngsters. Indeed, organizations that start out as constituencies to be served by the programs often become partners in the museum efforts.

With a major focus on elementary school children, this initiative complements the precollege outreach activities funded through the Institute's undergraduate science education program, which is addressed primarily to secondary school students and teachers.

We're supporting teachers, we're befriending teachers, and we're sharing with them our enthusiasm for hands-on science education.

Roree Iris-Williams
Franklin Institute Science Museum

Besides producing scientists, we must also create citizens who understand the role of science in a democracy and its contributions to society's economic well-being.

Dr. David Goodstein
California Institute of Technology

Reaching Teachers

Of the various alliances that have formed under the Institute's precollege program, the most common are those between museums and teachers. Virtually all of the programs funded during this first year of the Institute's museum initiative involve teacher training. Some instruct teachers on specific topics so that they can prepare their students for participation in science activities. Others aim to improve science education more generally through teacher development.

Teacher "empowerment" is the term used by Peter Dow of the Buffalo Museum of Science. Dr. Dow said at the 1993 meeting of program directors that his museum is seeking to be more of a teaching resource. In 1989 an elementary school was built onto the museum, which now provides courses to selected teachers who in turn develop programs for their own schools.

The Franklin Institute Science Museum has already reached thousands of middle-school teachers in the Philadelphia area. Its multifaceted biology education initiative, operated in conjunction with a similar program funded by the National Science Foundation, offers workshops, previews of exhibits, and even an overnight retreat. Program director Roree Iris-Williams views the Franklin Institute's efforts as more than training teachers: "We're supporting teachers, we're befriending teachers, and we're sharing with them our enthusiasm for hands-on science education," she told her colleagues during the museum directors meeting.

The Woodrow Wilson National Fellowship Foundation will use its HHMI award to continue a summer biology institute at Princeton University. This initiative gives exceptional high school teachers the opportunity to explore ideas for improving biology education. In addition, some of the successful graduates of the program will travel the country, sharing ideas from their sessions with less experienced peers. This teacher-to-teacher training will occur at 28 sites, many in remote areas where teachers lack information on new approaches to teaching biology.

Conclusion

Meeting the Challenge of Science Education

Perhaps the paramount challenge of the future lies in expanding science education beyond the scientific professionals to nonscience majors in colleges and universities and to the population in general. Dr. David Goodstein, Vice Provost at the California Institute of Technology, recently commented in *Engineering & Science* on the role of science education in the United States. Besides producing scientists, he said, we must also create citizens who understand the role of science in a democracy and its contributions to society's economic well-being. Moreover, a scientifically literate citizenry is necessary to form

the broad political consensus that supports basic scientific research as a common good.

At the meeting of undergraduate program directors, Dr. Pamela Bjorkman, an Institute investigator and Assistant Professor of Biology at the California Institute of Technology, noted that the greatest value of science education for nonscience majors, like that of a liberal arts education, may lie in helping students learn how to think critically and analyze logically. Others view such education as a "seeding" effort to extend science literacy to the general population. Dr. Norman Hackerman, President Emeritus of Rice University, recently cited another benefit: "This same group might well be the best source of teachers of science below the college level." At the same meeting Dr. Sarah Elgin, Professor of Biology and program director at Washington University, stressed the importance of high school biology for educating the general public. "That first year biology class is really the only place we can talk to the majority of Americans," she said. "When it comes to science education, for a lot of folks that's it."

If You Build It, They Will Come

The education programs being developed with support from the Undergraduate Biological Sciences Education Program are attracting and educating students with general academic interest as well as those focusing on a Ph.D degree. The lesson is clear, said Dr. Frank Vellaccio, Dean of the College of the Holy Cross: "Build it, and they will come."

Providing students with opportunities for hands-on research experiences is especially important. Dr. Elizabeth Jones, Professor of Biological Sciences at Carnegie Mellon University, noted in a recent statement before the National Research Council Committee for Biomedical and Behavioral Research Personnel, "The fact remains that a very large fraction of students who participate in undergraduate research programs end up in biomedical research careers. They are able to make the commitment knowing *in advance* that they enjoy doing research and are good at it."

In order to interest students in science, museums are also focusing on imaginative new ways to present exhibits and programs. These efforts can have a significant impact on how students feel about science. For example, Stephen Jay Gould, Professor of Geology and of Zoology at Harvard University, recalled being taken by his father to the American Museum of Natural History "to see the tyrannosaurus when I was five." Dr. Gould dedicated his book, *Ever Since Darwin: Reflections in Natural History*, to his father in appreciation.

A wide range of science-rich institutions are devoting more attention to developing strategies for enhancing science education. In a recent article entitled "Careers '93: A Survival Guide," Dr. James Watson, President of Cold Spring Harbor Laboratory, offered four rules of

The greatest value of science education for nonscience majors, like that of a liberal arts education, may lie in helping students learn how to think critically and analyze logically.

Dr. Pamela Bjorkman
Howard Hughes Medical Investigator
California Institute of Technology

That first year biology class is really the only place we can talk to the majority of Americans. When it comes to science education, for a lot of folks that's it.

Dr. Sarah Elgin
Washington University

The lesson is clear...Build it, and they will come.

Dr. Frank Vellaccio
College of the Holy Cross

Believe in yourself...learn from your experiences...and let yourself dream.

Dr. Paul Grobstein
Bryn Mawr College

thumb that might be applied to building effective science education programs: learn from winners, take risks, have a fallback strategy, and have fun. The innovative science education programs being offered with support from the Institute are attracting students to the world of science and enhancing the quality of their education and training.

The faculty and staff at these institutions are opening the doors to young people, with new attention to women and minorities, to offer them the extraordinary opportunities in science and the unlimited potential, especially in biology and medicine, to benefit humanity. Paul Grobstein, Professor and Chair of the Department of Biology at Bryn Mawr College, advises students, "Believe in yourself...learn from your experiences...and let yourself dream." Dr. Grobstein is one of the many scientists and teachers throughout the nation who are helping the next generation join the scientific revolution. The Institute is pleased to be a partner in this effort.

Joseph G. Perpich, M.D., J.D.
Vice President for Grants and
Special Programs

Graduate Science Education

The grants program for graduate education in the biological sciences complements the Institute's program of biomedical research. Support is provided for the education of young scientists who show strong promise of becoming tomorrow's leading investigators.

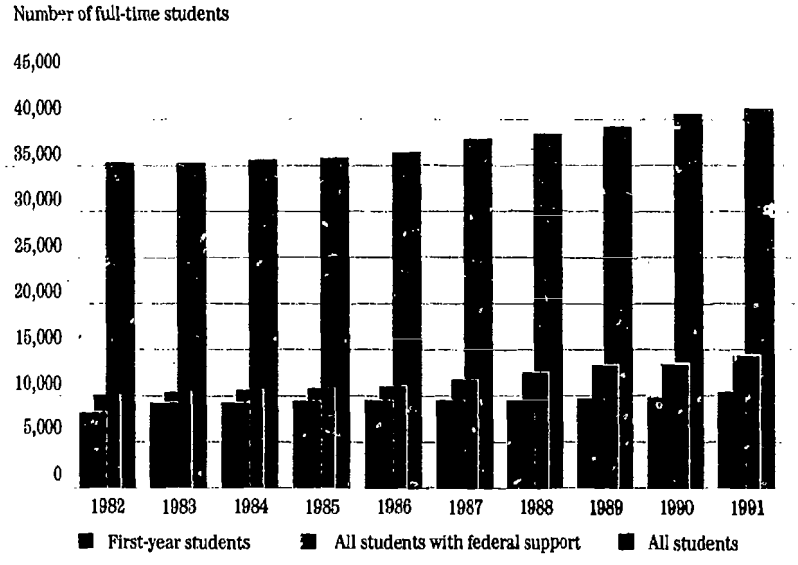
Through its graduate fellowships, the Institute seeks to foster excellence in research and to address unmet national needs. Although projections of the future supply of biomedical scientists vary from study to study, there is agreement that the numbers of graduate students from underrepresented minority groups and of medically trained investigators engaged in fundamental research are relatively low and should be increased.

The number of full-time graduate students in the biological sciences at doctorate granting institutions has continued to rise slowly over the past 10 years (from 35,000 to more than 40,000) (Figure 2). The number who are U.S. citizens has remained at about 30,000, despite declining numbers of baccalaureate degrees in biology.

Ph.D. degrees awarded in the biological sciences remained at just under 4,000 until the late 1980s, when they began to increase (Figure 3). On average, the 4,794 who received Ph.D.'s in biology in 1992 were registered in graduate school for 6.7 years, an increase of 0.7 of a year over the previous 10 years. Women are well represented in the pool of new biology doctorates (39

Figure 2

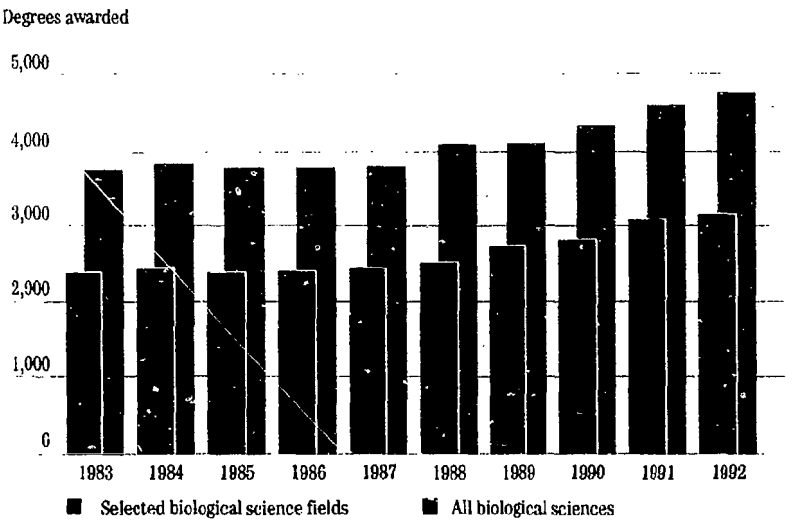
Biological Sciences Graduate Students at Doctorate-Granting Institutions, 1982–1991



Source: National Science Foundation, 1993

Figure 3

Ph.D. Degrees Awarded in the Biological Sciences, 1983–1992



Note: Selected fields include those related to the five areas of the Institute's scientific program: cell biology and regulation, genetics, immunology, neuroscience, and structural biology.

Source: National Research Council, Summary Report, Doctorate Recipients from United States Universities, annual.

percent), whereas some minority groups remain substantially underrepresented (1.3 percent black, 1.5 percent Hispanic, and less than 1 percent Native American).

Universities and the federal government continue to be the major sources of financial support (50 percent and 28 percent, respectively). The National Institutes of Health alone, in 1992, supported 6,700 predoctoral students through its training program awards to individuals and institutions; additional predoctoral support is provided through research grants.

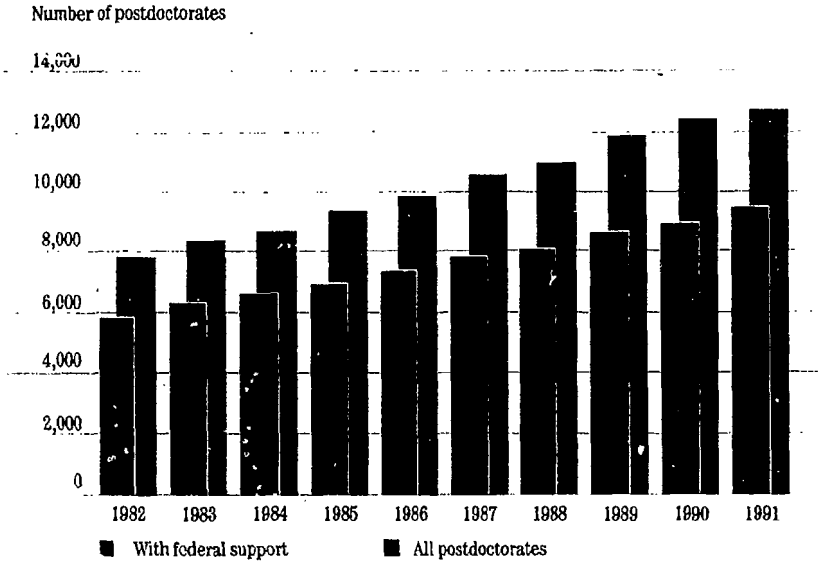
Postdoctoral training is a vital apprenticeship for biomedical investigators. In the past decade, the increase in postdoctorates has paralleled the increase in graduate students. The federal government is the source of support for three-quarters of these scientists (Figure 4). In 1992, 73 percent of new Ph.D.'s in the biological sciences had plans for postdoctoral training, and about 20 percent of new physicians planned to seek a research fellowship at some time in the future.

Overview

The graduate education initiative of the Institute grants program is intended to promote excellence, to complement other sources of available support, and to meet special

Figure 4

Biological Sciences Postdoctorates, 1982–1991



Source: National Science Foundation, 1992.

needs. Highlights of the program include the establishment of Predoctoral Fellowships in Biological Sciences in 1988 (see *Grants Program Policies and Awards, 1988–1989*). After six rounds of awards, predoctoral fellowships now provide over $8 million annually to more than 300 students. Each may receive up to five years of support for graduate study in selected biological sciences. Since the inception of the program, a total of $26 million has been awarded for almost 400 fellows who have been enrolled in outstanding graduate programs. Reflecting the maturation of the program, 43 fellows have successfully defended their Ph.D. thesis and have gone on to pursue postdoctoral training at leading laboratories. A few have attained faculty status.

In June 1993 the Institute convened its first meeting of predoctoral and physician postdoctoral fellows. About 50 predoctoral fellows, in the last year or two of their fellowship, presented their research in oral and poster presentations (see *1993 Meeting of Predoctoral and Physician Postdoctoral Fellows, Program and Abstracts*). Such meetings will be held annually.

The first Research Training Fellowships for Medical Students were awarded in 1989 (see *Grants for Science Education, 1989–1990*). These fellowships provide support for one year of full-time research on basic biological processes and disease mechanisms. In 1990 the program was expanded so that a small number of fellows could continue their research for a second year or

receive support for up to two years as they completed their medical studies. The Institute now provides over $2 million annually for these new and continuing fellows. A total of $8 million has supported more than 350 medical students.

At the first Scientific Meeting of Fellows, in May 1990, the 1989 medical student fellows reported on their research. Each year since then the students have presented the results of their fellowship research (see the 1991, 1992, and 1993 editions of the Institute publication *Scientific Meeting of Fellows, Research Training Fellowships for Medical Students, Program and Abstracts*).

The Institute launched a third program of fellowship awards in 1990, the Postdoctoral Research Fellowships for Physicians. These are intended to help increase the supply of well-trained physician-scientists by providing three years of support for training in biomedical research to physicians who have completed at least two years of postgraduate clinical training (see *Grants for Science Education, 1990–1991*). About $6 million is provided annually for these fellowships. Since the inception of the program, a total of almost $8 million has been awarded for about 100 men and women as they work at the leading edge of their research field under the guidance of superb mentors.

The Research Resources program has been another avenue for support of graduate education. The first grants under this initiative, in 1987 and 1988, went to Cold Spring Harbor, Jackson, and Marine Biological Laboratories. These three grants and a second one to Cold Spring Harbor Laboratory, totaling altogether $14 million, were awarded in part to support these institutions' unique series of short courses for biomedical scientists.

Predoctoral Fellowships in Biological Sciences

The goal of the Institute's program of predoctoral fellowships in biological sciences is to promote excellence in biomedical research by helping exceptional students obtain high-quality graduate education. Fellows must pursue a full-time graduate program leading to the Ph.D. or Sc.D. degree.

Predoctoral fellowships are awarded to students at or near the beginning of their graduate study toward a Ph.D. or Sc.D. in any of 16 eligible fields in the biological sciences. In general, these areas of fundamental research parallel those of the Institute's scientific program.

College seniors, college graduates with limited or no postbaccalaureate graduate study in the biological sciences, or first-year graduate students may apply for the predoctoral fellowship. Individuals who hold or are pursuing a medical or dental degree (M.D., D.O., D.V.M., or D.D.S.) may also apply if they meet eligibility criteria.

The predoctoral fellowship program is open to applicants from any country. Fellows who are U.S. citizens or nationals may study in the United States or abroad. Fellows

who are foreign citizens or nationals may study only at U.S. institutions.

The National Research Council of the National Academy of Sciences conducts the predoctoral fellowship competition on behalf of the Institute. For the 1993 competition, panels of distinguished biomedical scientists evaluated nearly 1,500 applications. They were particularly attentive to the applicant's plan of study and research, reference letters, and previous research experience, in addition to such quantitative indicators as Graduate Record Examination scores and undergraduate grade point average. Based on the panels' evaluations, awards were made to applicants who had demonstrated superior scholarship and showed the greatest promise for achievement in biomedical research (Figure 5).

The Institute selected 39 men and 31 women as fellows. Among these are two from India and one each from Australia, China, Israel, Japan, Malaysia, Peru, and the Philippines. Included in the 1993 group are eight outstanding students from minority groups underrepresented in the sciences, bringing to 36 the current number of predoctoral fellows who are black, Hispanic, Native American, or Native Pacific Islander (Figure 5). The fellows selected for this year studied at 48 undergraduate institutions, including 4 abroad (Figure 6). They intend to pursue their graduate studies at 30 U.S. and foreign institutions.

As the Institute invests in graduate education, it seeks to encourage

Figure 5

Predoctoral Fellowships in Biological Sciences, Program and Award Highlights

Fellowship Terms

- 66 awards annually
- Up to five years of support
- $26,700 annually
  - $14,000 stipend
  - $12,700 cost-of-education allowance

Eligibility

- Less than one year of graduate study completed
- Full-time study toward a Ph.D. or Sc.D. degree
- Selected biological sciences
  - biochemistry
  - biophysics
  - biostatistics
  - cell biology and regulation
  - developmental biology
  - epidemiology
  - genetics
  - immunology
  - mathematical biology
  - microbiology
  - molecular biology
  - neuroscience
  - pharmacology
  - physiology
  - structural biology
  - virology

1993 Awards

- Total number: 70
  - 31 women and 39 men
  - 61 U.S. citizens and 9 foreign citizens
  - 39 college seniors (at the time of application) and 31 graduate students, including 4 medical students and 1 physician
  - 8 minorities underrepresented in the sciences
- Fellowship institutions: 30

All Current Predoctoral Fellows

- Total number: 310
  - 128 women and 182 men
  - 270 U.S. citizens and 40 foreign citizens
  - 156 college seniors (at the time of application) and 154 graduate students, including 24 medical students, 3 physicians, and 3 veterinarians
  - 36 minorities underrepresented in the sciences
- Fellowship institutions: 55
- Distribution by field
  - 52 biochemistry and structural biology
  - 10 biostatistics, epidemiology, and mathematical biology
  - 46 cell biology and immunology
  - 106 genetics, microbiology, molecular biology, and virology
  - 96 neuroscience, biophysics, developmental biology, pharmacology, and physiology

Figure 6

Predoctoral Fellowships in Biological Sciences, Educational Origins of 1993 Awardees

Undergraduate Institutions

Beijing University (People's Republic of China)
Brown University, 3
California Institute of Technology, 2
Calvin College
Carnegie Mellon University
College of William and Mary
Cornell University
Duke University, 2
Evergreen State College
Harvard University, 7
Indiana University at Bloomington
Johns Hopkins University
Kenyon College
Kyoto University (Japan)
La Salle University
Macalester College, 2
Michigan State University
North Dakota State University Main Campus
Northern Arizona University
Princeton University, 2
Purdue University
Reed College, 3
Rice University, 3
Rutgers the State University of New Jersey New Brunswick Campus, 2
Spelman College
Stanford University, 2
Texas A&M University
University of California–Berkeley
University of California–Los Angeles, 2
University of California–Santa Cruz, 2
University of Chicago
University of Illinois at Urbana-Champaign, 2
University of Michigan–Ann Arbor
University of Montana
University of New Mexico Main Campus
University of Pennsylvania
University of Peru–Cayetano Heredia (Peru)
University of Pittsburgh Main Campus
University of Queensland (Australia)
University of Tennessee, Knoxville
University of Texas at Austin
University of Utah
University of Virginia
Washington University
Wellesley College
Wesleyan University
Yale University, 3

High Schools

Arizona
Flagstaff, Flagstaff
Arkansas
Hall, Little Rock
California
Colton, Colton
Crystal Springs Uplands, Hillsborough
Jefferson, Dale City
Polytechnic, Pasadena
Skyline, Oakland
Terra Linda, San Rafael
Florida
Pine View School for the Gifted, Sarasota
Georgia
Henry Grady, Atlanta
Illinois
Glenbard East, Lombard
Illinois Mathematics and Science Academy, Aurora
Rich Central, Olympia Fields
Indiana
Valparaiso, Valparaiso
Louisiana
Benjamin Franklin, New Orleans
Maryland
T.J. Wootton, Rockville
Massachusetts
Concord-Carlisle, Concord
Newton North, Newtonville
Windsor School, Boston
Michigan
Green Hills, Ann Arbor
Haslett, Haslett
Michigan Christian, Muskegon
Missouri
David H. Hickman, Columbia
Mehlville, St. Louis
Park Hill, Kansas City
Parkway South, Manchester
Nevada
McQueen, Reno
New Jersey
Bridgewater-Raritan, Bridgewater
Columbia, Maplewood
Freehold Township, Freehold
Newark, Newark
North Hunterdon, Annandale
Wayne Hills, Wayne
West Windsor-Plainsboro, Princeton Junction
New Mexico
Los Alamos, Los Alamos
New York
Alternative Community, Ithaca
Anglo-American International, New York City
Hillcrest, New York City
Ithaca, Ithaca
Lakeland, Shrub Oak
Ohio
Dublin, Dublin
St. Ignatius, Cleveland
Worthington, Worthington
Pennsylvania
Cumberland Valley, Mechanicsburg
Dover Area, Dover
Lansdale Catholic, Lansdale
Philadelphia High School for Girls, Philadelphia
Pottsgrove, Pottstown
Tennessee
Clinton, Clinton
Oak Ridge, Oak Ridge
Texas
Bryan, Bryan
Plano, Plano
Utah
Skyline, Salt Lake City
Virginia
Fairfax, Fairfax
Washington
Olympia, Olympia
Wisconsin
Madison West, Madison
Sparta, Sparta
University School of Milwaukee, Milwaukee
Wausau East, Wausau
Outside the United States
Australia, Keebra Park State, Southport
Ecuador, C. Alemán Humboldt, Guayaquil
India, DAV Higher Secondary, Madras
India, Springdales, Delhi
Jamaica, Wolmer's Boys School, Kingston
Japan, Hiroshima University Senior High, Hiroshima
People's Republic of China, Accessory Middle School of Northeast, Changchun
Peru, Colegio Alfonso Ugarte, Lima
Philippines, International School, Manila
U.S. Virgin Islands, Ivanna Eudora Kean, St. Thomas

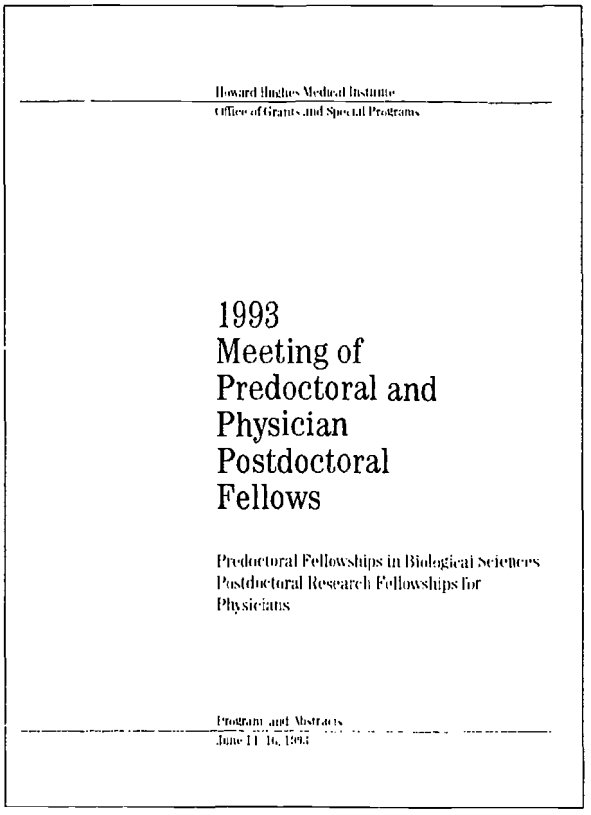
diversity among students working full-time toward a doctorate in the biological sciences. If current program trends continue in future competitions, 10 to 15 percent of the fellows will be from minority groups underrepresented in the sciences and 40 to 45 percent of the fellows will be women.

The predoctoral fellows selected in the 1988–1992 competitions continue to demonstrate exceptional ability as biomedical researchers. They have notified the Institute of 88 peer-reviewed journal articles and 87 abstracts published during the past year, based on fellowship research, and of 48 oral and 103 poster presentations at international, national, and regional scientific meetings. By June 1993, 43 fellows had informed the Institute that they had completed their graduate studies and defended their thesis.

About 50 predoctoral fellows near the end of their fellowship term were convened at a June 1993 scientific meeting of predoctoral and physician postdoctoral fellows (Figure 7). In the presentations on

Figure 7

1993 Meeting of Predoctoral and Physician Postdoctoral Fellows

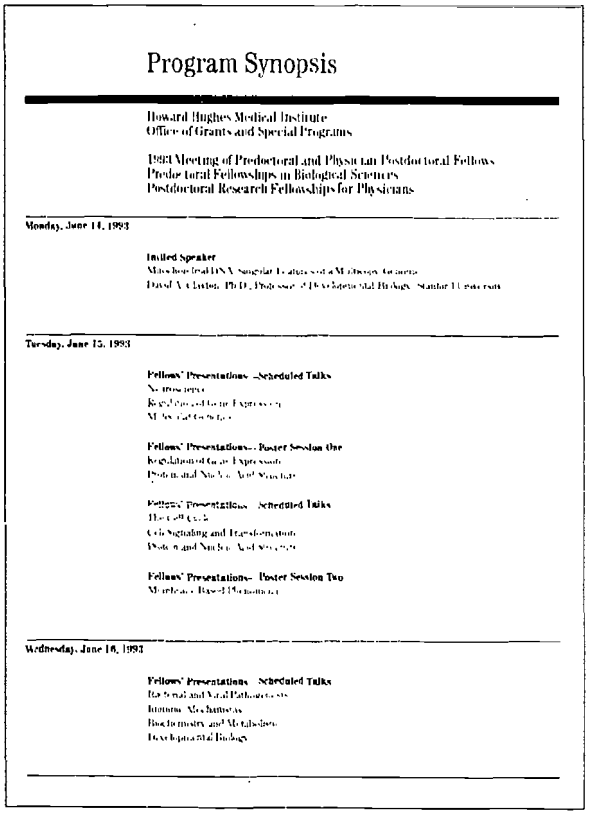


Howard Hughes Medical Institute
Office of Grants and Special Programs

1993
Meeting of
Predoctoral and
Physician
Postdoctoral
Fellows

Predoctoral Fellowships in Biological Sciences
Postdoctoral Research Fellowships for Physicians

Program and Abstracts
June 11–16, 1993



Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Meeting of Predoctoral and Physician Postdoctoral Fellows
Predoctoral Fellowships in Biological Sciences
Postdoctoral Research Fellowships for Physicians

Monday, June 14, 1993

Invited Speaker

Tuesday, June 15, 1993

Fellows' Presentations—Scheduled Talks

Fellows' Presentations—Poster Session One

Fellows' Presentations—Scheduled Talks

Fellows' Presentations—Poster Session Two

Wednesday, June 16, 1993

Fellows' Presentations—Scheduled Talks

Figure 8

Predoctoral Fellowships in Biological Sciences, All Current Fellowship Institutions

Albert Einstein College of Medicine
Baylor College of Medicine
Boston University
Brandeis University
Brown University
California Institute of Technology
Carnegie Mellon University
Case Western Reserve University
Columbia University
Cornell University
Duke University
Emory University
Harvard University
Johns Hopkins University
Massachusetts Institute of Technology
McGill University (Canada)
Northwestern University
Princeton University
Rockefeller University
Rush University
Rutgers the State University of New Jersey New Brunswick Campus
Scripps Research Institute
Stanford University
State University of New York at Buffalo
Tufts University School of Medicine
Tulane University
University of Arizona
University of California–Berkeley
University of California–Los Angeles
University of California–San Diego
University of California–San Francisco
University of Cambridge (United Kingdom)
University of Chicago
University of Colorado at Boulder
University of Colorado Health Sciences Center
University of Connecticut
University of Florida
University of Houston
University of Illinois at Urbana-Champaign
University of Michigan–Ann Arbor
University of Minnesota–Twin Cities
University of New Mexico Main Campus
University of North Carolina at Chapel Hill
University of Oregon
University of Oxford (United Kingdom)
University of Pennsylvania
University of Pittsburgh Main Campus
University of Texas Medical Branch at Galveston
University of Texas Southwestern Medical Center at Dallas
University of Utah
University of Virginia
University of Washington
University of Wisconsin–Madison
Washington University
Yale University

their research, the fellows gave further evidence of their skill and productivity and showed enthusiasm for their chosen careers as scientists. (See the Institute publication *1993 Meeting of Predoctoral and Physician Postdoctoral Fellows, Program and Abstracts.*)

The Institute will continue to award about 66 new predoctoral fellowships annually. At present 310 predoctoral fellows are receiving support at 55 academic institutions, at an annual cost of over $8 million (Figure 8).

Predoctoral Fellowships in Biological Sciences, 1993 Fellows

Name	Fellowship Institution	Department
Biochemistry and Structural Biology		
Suzanne Admiraal	Stanford University	Biochemistry
Eldon Baird	California Institute of Technology	Chemistry
Alexis Borisy	Harvard University	Chemistry
Annette Dexter	University of Illinois at Urbana-Champaign	Biochemistry
James Jontes	Scripps Research Institute	Office of Graduate Studies
Shuo Liu	University of California–Los Angeles	Chemistry and Biochemistry
Michael Potter	University of Houston	Chemistry
Chad Rienstra	Yale University	Chemistry
Laura Rusche	Johns Hopkins University	Biochemistry, Cellular and Molecular Biology
Peter Savage	Stanford University	Combined Admissions Mode
Biostatistics, Epidemiology, and Mathematical Biology		
Cari Bergstrom	Stanford University	Biological Sciences
Stephen Lane	University of California–Berkeley	Integrative Biology
Eli Meir	University of Washington	Zoology
Amy Sayle	University of North Carolina at Chapel Hill	Epidemiology
Joseph Wiemels	University of California–Berkeley	Biomedical and Environmental Health Sciences
Cell Biology and Immunology		
Sheryll Barker	University of New Mexico Main Campus	Biomedical Sciences
Scott Bowling	Duke University	Cell and Molecular Biology
Daniel Buchholz	University of California–Berkeley	Molecular and Cell Biology
Javier Chinen	Baylor College of Medicine	Microbiology and Immunology
Diana Harris	Harvard University	Biological Sciences
Amy Kistler	University of California–San Francisco	Biochemistry and Biophysics
Sarah Mutka	University of California–San Francisco	Biochemistry and Biophysics
Genetics, Microbiology, Molecular Biology, and Virology		
Joanne Adamkewicz	University of California–Berkeley	Molecular and Cell Biology
Shane Albright	University of California–Berkeley	Molecular and Cell Biology
Adriana Briscoe	Harvard University	Organismic and Evolutionary Biology
Reynaldo Carabeo	University of Wisconsin–Madison	Oncology
Hil Carmi	University of California–Berkeley	Molecular and Cell Biology
David Cortez	Duke University	Cell and Molecular Biology
Ewa Davison	Massachusetts Institute of Technology	Biology
Leena Gandhi	University of California–Berkeley	Molecular and Cell Biology
Keow Goh	Massachusetts Institute of Technology	Biology
Marc Ibanez	University of California–Berkeley	Molecular and Cell Biology
Seiko Ishida	University of California–San Francisco	Biochemistry and Biophysics
Laura Kozlevcar	University of California– San Diego	Biomedical Sciences
Cosette LeCiel	University of Washington	Genetics
Brian Lewis	Johns Hopkins University	Human Genetics
Whitney Neufeld-Kaiser	University of Washington	Genetics
Sophie Peterson	University of California–Berkeley	Molecular and Cell Biology
Kimberly Phillips	Cornell University	Genetics and Development
Frances Pu	University of California–Berkeley	Molecular and Cell Biology
Anne Quennan	Princeton University	Molecular Biology
Brent Rupnow	Stanford University	Cancer Biology
Trina Sarafi	Washington University	Biological and Biomedical Sciences
Mark Siegal	Harvard University	Organismic and Evolutionary Biology
Michael Sohaskey	Stanford University	Combined Admissions Mode
Thomas Wang	University of California–San Francisco	Biochemistry and Biophysics
Kevin White	Stanford University	Developmental Biology
Andrew Zahalsky	Brown University	Biology and Medicine
Neuroscience, Biophysics, Developmental Biology, Pharmacology, and Physiology		
Michael Bianchetta	Harvard University	Neurobiology
Heather Corbett	University of California–Berkeley	Molecular and Cell Biology
Saumya Das	Harvard University	Neurobiology
Reid Feldman	California Institute of Technology	Biology
Balasubramanian Girish	University of California–Berkeley	Molecular and Cell Biology
Lisa Goodrich	Stanford University	Neurosciences
Melina Hale	University of Chicago	Organismal Biology and Anatomy
Jonathan Heller	University of California–Berkeley	Biophysics
Alan Jasanoff *	Harvard University	Biophysics
Christopher Kousky	State University of New York at Buffalo	Biochemical Pharmacology
Daniel Lyons	Stanford University	Combined Admissions Mode
Valerie Pierce	University of Chicago	Organismal Biology and Anatomy
Jennelle Richardson	University of Minnesota–Twin Cities	Pharmacology
Kimberly Scearce	Columbia University	Neurobiology and Behavior
Paul Schaeffer	University of Arizona	Ecology and Evolutionary Biology
Marion Sewer	Emory University	Physiological and Pharmacological Sciences
Michael Silver	University of California–San Francisco	Neuroscience
Joshua Tenenbaum	Massachusetts Institute of Technology	Brain and Cognitive Sciences
Monica Torres	University of Washington	Pharmacology and Neurobiology
Matthew Tresch	Massachusetts Institute of Technology	Brain and Cognitive Sciences
Nathaniel Urban	University of Pittsburgh Main Campus	Behavioral Neuroscience
David Wheeler	Stanford University	Neurosciences

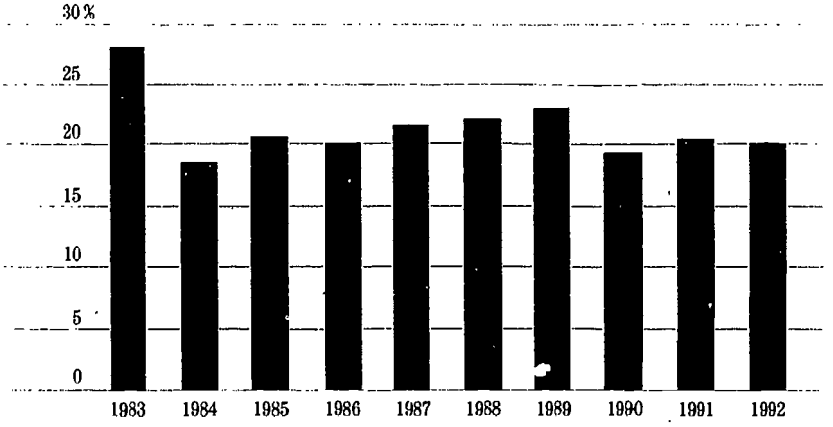
**Award deferred from 1992*

Figure 9

M.D. Plans at Graduation, 1983–1992

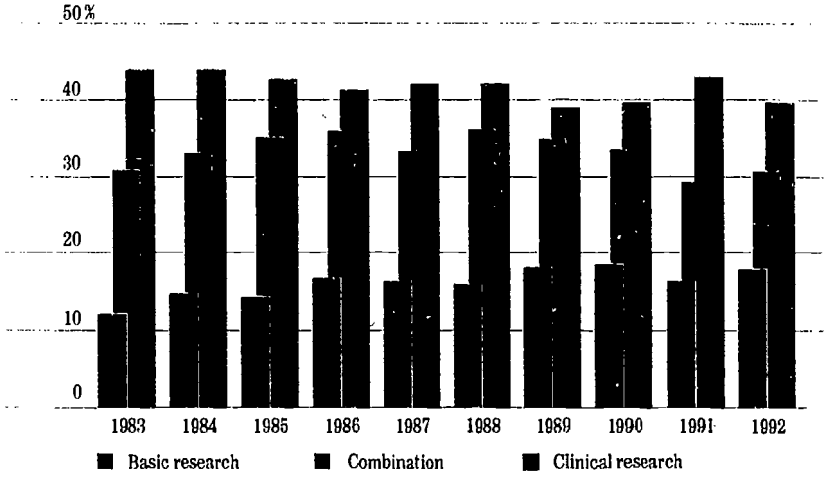
Intention to Seek a Research Fellowship

Percentage of graduating physicians



Research Interests

Percentage of planned fellowships



Note: The questionnaire allowed for an "undecided" response for the first time in 1984, which may account for the abrupt drop between 1983 and 1984 of intended research fellowships (top graph).

Source: AAMC Graduation Questionnaire, *annual.*

Research Training Fellowships for Medical Students

The Institute's Research Training Fellowships for Medical Students have as their primary objective an increase in the proportion of physicians who are significantly involved in research. The fellowships provide support for an intensive year of laboratory investigation for medical students who have begun to consider research as part of their career.

The pool of potential physician-scientists is drawn from current medical school students with a keen interest in research. The Association of American Medical Colleges annually surveys all students receiving an M.D. degree in a given year. According to the latest AAMC graduation questionnaires, about half the M.D. recipients had participated in research projects in medical school and a third were coauthors of a published paper. Further, one-fifth of the graduating medical students intend to seek a research fellowship. Among those, the percentage planning to focus on basic science, either alone or combined with clinical research, remains fairly steady (Figure 9).

The AAMC also reports that about 14 percent of M.D. graduates foresee a significant involvement in research. However, only slightly more than 1 percent want a full-time academic career with a focus on basic science. These trends highlight the continuing importance of providing training opportunities in

Figure 10

Research Training Fellowships for Medical Students, Program and Award Highlights

Initial Award Terms

- Up to 60 awards annually
- One year of support
- $23,200 fellowship for 1993
  - $14,000 stipend
  - $4,500 research allowance
  - $4,700 institutional allowance
- Continued awards possible for a second year of research
- Continued awards possible for up to two years while completing medical school

Continued Awards Terms

- Second Year of Research ($23,200 for one year)
  - $14,000 stipend
  - $4,500 research allowance
  - $4,700 institutional allowance
- Return to Medical Studies ($26,700 annually for up to two years)
  - $14,000 annual stipend
  - $12,700 educational allowance

Eligibility for Initial Awards

- Currently enrolled in a U.S. medical school
- Fundamental research (basic biological processes and disease mechanisms)
- Full-time research
- Fellowship year at any academic or non-profit research institution in the United States, except NIH in Bethesda, Maryland
- Not enrolled in an M.D./Ph.D. or Ph.D. program

1993 Initial Awards

- Total number: 57
  - 21 women and 36 men
  - 3 minorities underrepresented in the sciences
  - Medical school level completed
    - Year 1: 2 fellows
    - Year 2: 32 fellows
    - Year 3: 21 fellows
    - Year 4: 2 fellows
- Fellowship institutions: 27
- Distribution by field
  - 2 biochemistry and structural biology
  - 21 cell biology and immunology
  - 17 genetics and molecular biology
  - 17 neuroscience and physiology

Continued Awards—Return to Medical Studies or Second Year of Research

- Total number: 42*
  - 20 women and 22 men
  - 8 minorities underrepresented in the sciences
  - Medical school level completed
    - Year 2: 5 fellows
    - Year 3: 11 fellows
    - Year 4: 26 fellows

**These figures include 13 medical student fellows and 12 HHMI-NIH Research Scholars selected in 1993 for continued awards for return to medical studies, and 1 medical student fellow selected for a second year of research. In addition, the figures include 16 of the continuing fellows selected in 1992 who are in the second year of such support.*

Figure 11

Research Training Fellowships for Medical Students, Educational Origins of 1993 Initial Awardees

Undergraduate Institutions

Bryn Mawr College
City University of New York Brooklyn College
College of William and Mary
Cornell University, 5
Duke University, 5
Eastern Mennonite College and Seminary
Georgetown University
Harvard University, 2
Haverford College
Johns Hopkins University, 2
Knox College
Louisiana State University and A&M College
Luther College
Northwestern University, 2
Oberlin College
Pomona College
Princeton University
Purdue University Main Campus
Rutgers the State University of New Jersey New Brunswick Campus
Siena College
Stanford University, 4
Swarthmore College
University of California–Irvine
University of California–Los Angeles
University of Illinois at Chicago
University of Michigan–Ann Arbor
University of Missouri–Columbia
University of North Carolina at Chapel Hill, 4
University of Oregon
University of Southern California
University of Texas at Austin
University of Utah
University of Washington
Wake Forest University
Wayne State University
Wellesley College
Williams College
Yale University, 3

High Schools

California
Alhambra, Alhambra
Leland, San Jose
Los Alamitos, Los Alamitos
San Gabriel, San Gabriel
Santa Monica, Santa Monica

Connecticut
Wilton, Wilton

Florida
Trinity Preparatory, Winter Park

Illinois
J.B. Conant, Hoffman Estates
Lawrenceville, Lawrenceville
Niles North, Skokie

Indiana
Lake Central, St. John
St. Joseph's, South Bend

Louisiana
Baton Rouge Magnet, Baton Rouge

Maryland
Old Mill, Millersville
Walt Whitman, Bethesda

Massachusetts
Lenox Memorial, Lenox
Rivers School, Weston
Weston, Weston

Michigan
Delasalle Collegiate, Warren
Grosse Pointe South, Grosse Pointe
Lahser, Bloomfield Hills

Minnesota
John Marshall, Rochester

Missouri
Horton Watkins, St. Louis
Lindberg, St. Louis
Rock Bridge, Columbia

New Hampshire
Phillips Exeter Academy, Exeter

New Jersey
North Brunswick, North Brunswick
East Brunswick, East Brunswick
Hunterdon Central, Flemington

New York
Dalton School, New York City, 2
Ramapo, Spring Valley
Regis, New York City
Schalmont, Rotterdam
Williamsville East, Williamsville

North Carolina
Ashe Central, Jefferson
Asheville School, Asheville
North Carolina School of Science, Durham
Paisley, Winston-Salem
Southeast Guilford, Greensboro

Ohio
Beachwood, Beachwood
Columbus School for Girls, Columbus
Rocky River, Rocky River
Solon, Solon

Oregon
Churchill, Eugene

Pennsylvania
Churchill, Pittsburgh
Lancaster Mennonite, Lancaster

Texas
Georgetown, Georgetown
Kinkaid School, Houston
Klein, Spring

Utah
Olympus, Salt Lake City

Virginia
Fairfax, Fairfax

Washington
St. George's, Spokane

Washington, D.C.
Woodrow Wilson, Washington, D.C.

West Virginia
Mount View, Welch

Outside the United States
Canada, La Canada, La Canada
Ghana, Mawuli Secondary School, Ho

fundamental research and nurturing student interest.

For the last seven years, the Research Scholars Program, sponsored jointly by HHMI and NIH, has brought selected medical students to the NIH intramural laboratories for a year of fundamental research experience. To increase the number of students who may benefit from a similar experience, the Research Training Fellowships for Medical Students were initiated. Fellows may affiliate with a laboratory at any academic or nonprofit research institution in the United States (except NIH in Bethesda, Maryland), thus complementing the HHMI-NIH program.

Initial Year of Research

Research Training Fellowships for Medical Students are awarded to applicants who show the greatest promise of achievement in biomedical research and who have demonstrated superior scholarship in their undergraduate and medical school work (Figure 10). Applicants must be enrolled in a medical school in the United States. A panel of biomedical scientists convened by the Institute evaluates each application, placing special emphasis on the letters of reference, the research plan, and the mentor's plans for training the student.

The 1993 competition resulted in awards to 57 new fellows, including 36 men and 21 women, for one year of full-time laboratory research (Figure 10). These fellows are enrolled in medical school at 27 institutions and are graduates of 38 colleges and universities (Figure 11). Eleven of the fellows will be in a laboratory not affiliated with their medical school. The fellowship institutions, including those for continued fellows, number 34 (Figure 12).

By the end of June of the fellowship year, 27 papers by 20 of the fellows selected in the 1992 competition had been accepted for publication in peer-reviewed journals, and 16 abstracts had been published.

Figure 12

Research Training Fellowships for Medical Students, All Current Fellowship Institutions

Albert Einstein College of Medicine
Brown University
Case Western Reserve University
Columbia University
Cornell University Medical Center
Duke University
Harvard University
Johns Hopkins University
Mayo Medical School
Mount Sinai School of Medicine
Northwestern University
Ohio State University Main Campus
Oregon Health Sciences University
Pennsylvania State University
Rockefeller University
Rush University
Stanford University
State University of New York at Buffalo
Tufts University
University of California–San Francisco
University of Illinois at Chicago
University of Maryland at Baltimore
University of Massachusetts at Worcester
University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School
University of Michigan–Ann Arbor
University of Minnesota–Twin Cities
University of North Carolina at Chapel Hill
University of Pennsylvania
University of Pittsburgh Main Campus
University of Southern California
University of Utah
University of Washington
Washington University
Yale University

Forty-two of the fellows participated in 74 regional, national, and international scientific meetings. The medical student fellows were also convened in Bethesda at the May 1993 Scientific Meeting of Fellows (Figure 13), where they provided further evidence of a productive year and enthusiasm for continued involvement in fundamental science. (See the Institute publication *1993 Scientific Meeting of Fellows, Research Training Fellowships for Medical Students, Program and Abstracts*).

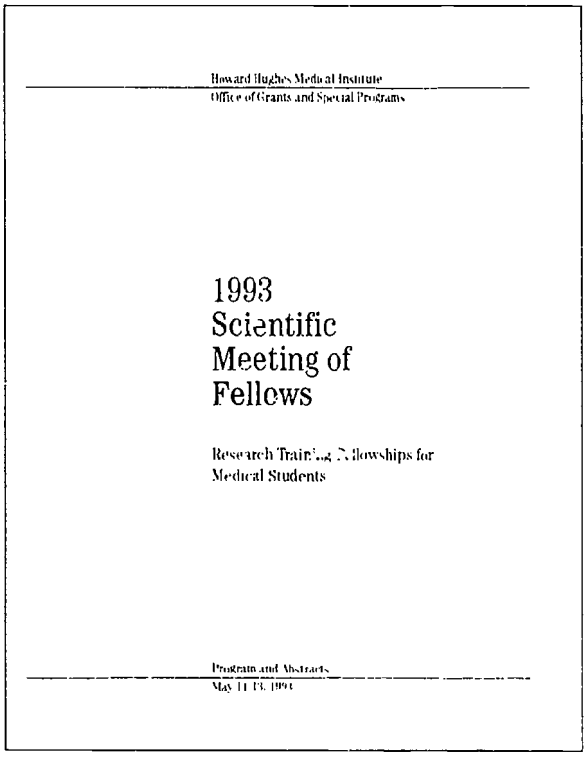
Continued Support

Fellows may apply for support for a second year of research. They may also compete for continued fellowship support for up to two years while they complete their study toward the M.D. degree. Medical students at NIH under the auspices of the HHMI-NIH Research Scholars Program are also eligible to apply for continued support toward the completion of medical studies (Figure 14).

Candidates for continued fellowship support in 1993 were evaluated

Figure 13

1993 Meeting of Medical Student Fellows

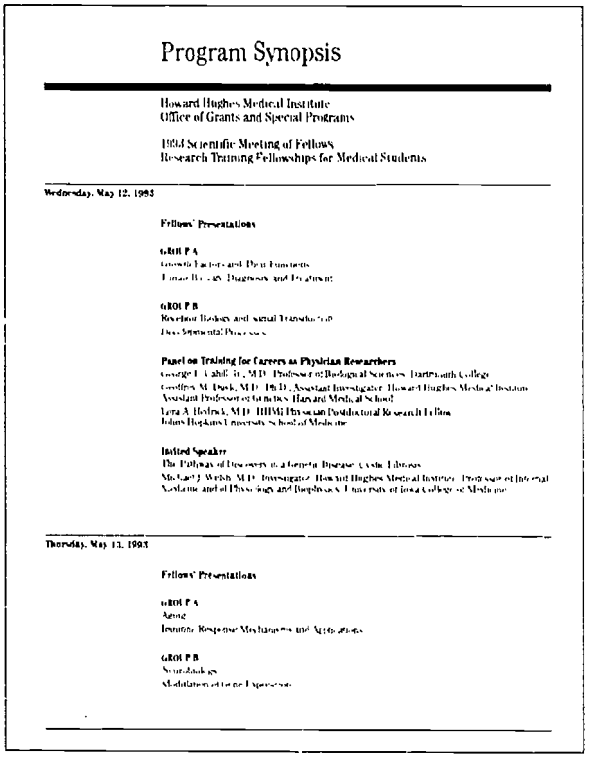


Howard Hughes Medical Institute
Office of Grants and Special Programs

1993
Scientific
Meeting of
Fellows

Research Training Fellowships for
Medical Students

Program and Abstracts
May 11-13, 1993



Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Scientific Meeting of Fellows
Research Training Fellowships for Medical Students

Wednesday, May 12, 1993

Fellows' Presentations

Thursday, May 13, 1993

Fellows' Presentations

Figure 14

Research Opportunities for Medical Students

The Howard Hughes Medical Institute has two programs that provide opportunities for medical students in the United States to spend a year doing intensive research. For each program, the students are selected on the basis of a national competition. **Students may apply to only one of these programs in a given year.** A comparison of the two programs follows.

	HHMI-NIH Research Scholars Program (Cloister Program)	HHMI Research Training Fellowships for Medical Students Program
Time	Appointment is for nine months to one year, with an opportunity for some scholars to extend for an additional year of research.	The fellowship term is one year, with an opportunity for a small number of fellows to extend for an additional year of research.
Place	Research is conducted at NIH in Bethesda, Maryland. The Cloister, a residential facility for scholars, is available on the NIH campus. Travel to and from Bethesda is provided.	Research is conducted at an academic or nonprofit research institution in the United States chosen by the fellow. Research may not be at NIH in Bethesda, Maryland.
Salary/Stipend	The annual salary for scholars is $16,800. Research scholars are employees of HHMI, with fringe benefits.	The annual stipend for fellows is $14,000. Fellows are not HHMI employees and receive no fringe benefits. However, a portion of the $4,700 allowance to the fellowship institution may be used for health insurance for the fellow.
Research Topic	The research project is selected upon arrival at NIH, after a round of laboratory visits.	The research project must be described in the fellowship application.
Research Costs	There is no special research allowance. Costs are covered by the scholar's laboratory.	A $4,500 research allowance on behalf of the fellow is provided to the fellowship institution, in addition to the $4.700 institutional allowance.
Citizenship	Scholars must be citizens or permanent residents of the United States.	There are no citizenship requirements. However, applicants must be attending medical school in the United States.
Medical School Support	Students from each program may compete for a small number of awards for up to two additional years of fellowship support while completing medical school. The support will be a $14,000 annual stipend and a $12,700 annual allowance toward tuition and other education-related expenses.	
For Information and Applications:	HHMI-NIH Research Scholars Program Howard Hughes Medical Institute 1 Cloister Court, Department G Bethesda, MD 20814-1460 (301) 951-6770 or (800) 424-9924	Research Training Fellowships for Medical Students/GSE94 Howard Hughes Medical Institute Office of Grants and Special Programs 4000 Jones Bridge Road Chevy Chase, MD 20815-6789 (301) 215-8889

Research Training Fellowships for Medical Students, 1993 Fellows

Initial Awards—First Year of Research

Fellow	Research Mentor	Fellowship Institution	Department
Biochemistry and Structural Biology			
Brian E. Daikh	Dennis R. Koop, Ph.D.	Oregon Health Sciences University	Pharmacology
Site-directed mutagenesis of cytochrome P-450 2C2			
Vickie Fowler Ingledue	Saul M. Schanberg, M.D., Ph.D.	Duke University	Pharmacology
Cellular mechanisms mediating the inhibition of ornithine decarboxylase expression during maternal tactile deprivation in the neonate			
Cell Biology and Immunology			
Dieter Bruno	Jeffrey L. Platt, M.D.	Duke University	Cardiac and Thoracic Surgery
Xenoreactive natural antibodies: a B-cell repertoire analysis			
Douglas G. Brust	Warner Greene, M.D., Ph.D.	University of California–San Francisco	Virology and Immunology
Identification of cellular factors that interact with HIV rev		(Columbia University College of Physicians and Surgeons)*	
Charlene Chiang	Joseph A. Hill, M.D., and Deborah J. Anderson, Ph.D.	Harvard University	Obstetrics
Expression of TNF-α, γ-IFN, CSF-1, and IL-1β in endometriosis and adenomyosis			
Robert L. Ferris	Robert Siliciano, M.D., Ph.D.	Johns Hopkins University	Medicine
Human CD8+ cytolytic T cell response to a novel avian pox virus-env gene AIDS vaccine			
Sarah M. Fortune	Seth Lederman, M.D.	Columbia University	Medicine
Molecular dissection of T-B lymphocyte interactions			
Bruce Frederick Israel	Jeffrey A. Frelinger, Ph.D.	University of North Carolina at Chapel Hill	Microbiology and Immunology
The role of CD4+ CTL in β-2 microglobulin-deficient mice			
Lloyd H. Ketchum	Roy L. Silverstein, M.D.	Cornell University Medical Center	Hematology and Oncology
Structure-function analysis of CD36, a vascular cell adhesion receptor			
Mustafa Kezar Khokha	Philip M. Iannaccone, M.D., D.Phil.	Northwestern University	Pathology
Iterating cell division programs and fractal mosaic pattern in organ development			
Stella K. Kim	Thaddeus Dryja, M.D.	Harvard University	Ophthalmology
Development of a novel ELISA to quantitatively measure RB protein: evaluation of its usefulness as a tool in the diagnosis of hereditary retinoblastoma			
Richard Yu-Tsang Lin	N. Scott Adzick, M.D.	University of California–San Francisco	Surgery
Fetal wound healing		(Harvard Medical School)*	
Michael J. Louie	Lloyd Mayer, M.D.	Mount Sinai School of Medicine	Medicine
Monocytic function during chronic HIV-1 infection			
Mitra Mofid	Joseph P. Vacanti, M.D., and Douglas W. Wilmore, M.D.	Harvard University	Surgery
Tissue engineering and neocartilage: an analysis			
Andrea C. Monroe	Joanne Kurtzberg, M.D.	Duke University	Pathology
Pathogenesis of interleukin-2 modulation of expression of human stem cell leukemia in SCID mice			
Nicklas B.E. Oldenburg	John A. Glowski, Ph.D.	University of North Carolina at Chapel Hill	Physiology and Biochemistry
Mechanisms of resistance to glucocorticoid-regulated apoptosis			
Amy D. Opperman	David L. Epstein, M.D.	Duke University	Ophthalmology
How ethacrynic acid changes the shape of endothelial cells and increases the outflow facility in the glaucomatous eye			
Marc Sabatine	Hugh Auchincloss, Jr., M.D.	Harvard University	Surgery
Mechanisms of rejection of skin grafts from mice lacking MHC antigens			
Athanasia Syrengelas	Ronald Levy, M.D.	Stanford University	Medicine
Cell-mediated immunity in idiotype vaccination			
Annemarie Thompson	Salvatore V. Pizzo, M.D., Ph.D.	Duke University	Pathology
Rheumatoid arthritis and fibrinolysis			
Cole Taggart Thomson	Stanley G. Nathenson, M.D., and James C. Sacchettini, Ph.D.	Albert Einstein College of Medicine	Immunology and Biochemistry
Structural studies of class I MHCs and T cell receptors			
Jennifer Tseng	Robert N. Taylor, M.D., Ph.D.	University of California–San Francisco	Obstetrics and Gynecology
Estrogen regulation of a novel cytokine in endometriosis			
Han-Ising Irene Wu	Andrew Arnold, M.D.	Harvard University	Endocrine Unit and Oncology
Chromosome breakpoint analysis to identify a parathyroid oncogene		(Yale University School of Medicine)*	
Genetics and Molecular Biology			
Steven B. Bleyl	Mark Leppert, Ph.D., and Kenneth Ward, M.D.	University of Utah	Genetics and Obstetrics
Familial total anomalous pulmonary venous return: linkage analysis and gene mapping			
David J. Harnick	Andrew Marks, M.D.	Mount Sinai School of Medicine	Molecular Biology
Molecular characterization of a human T cell calcium channel			
Carolyn Yung Ho	Gary Gilliland, M.D., Ph.D.	Harvard University	Medicine
Genetic linkage analysis of a familial platelet disorder with propensity to develop acute myelogenous leukemia			
Eric Christian Johannsen	Elliott Kieff, M.D., Ph.D.	Harvard University	Microbiology
Structural and functional analysis of a key transforming gene of Epstein-Barr virus			
Angela Margaret Keen	Albert J. Banes, Ph.D.	University of North Carolina at Chapel Hill	Surgery
The effect of cyclic load on expression of matrix protein in osteoblasts			
Erin Elizabeth Kershaw	Rudolph L. Leibel, M.D.	Rockefeller University	Human Behavior
Molecular genetic basis for type II diabetes susceptibility in obese rodents		(Cornell University Medical College)*	
Rhett P. Ketterling	Steve S. Sommer, M.D., Ph.D.	Mayo Medical School	Biochemistry
The dopamine D3 receptor (D3DR) as a candidate gene for schizophrenia			
Kevin Korenblat	Alison M. Goate, D. Phil.	Washington University	Psychiatry
Positional cloning of candidate genes on chromosome 14 linked to Alzheimer's disease			
Kin-Man Lai	W. French Anderson, M.D.	University of Southern California	Biochemistry
Site-specific mutation of the envelope protein gp70		(University of California, Irvine, College of Medicine)*	
Robert Skyler McCurley	Brent Weston, M.D.	University of North Carolina at Chapel Hill	Pediatrics
Determination of the physical maps of α-(1,3)-fucosyltransferase loci			
Kristen Melnyk	Joseph S. Handler, M.D.	Johns Hopkins University	Medicine
Role of mRNA stability in myo-inositol and betaine transporter expression			

Fellow	Research Mentor	Fellowship Institution	Department
Chi Y. Nguyen	Thomas S. Kupper, M.D.	Harvard University	Medicine
The role of VLA-2 integrin in cell-mediated collagen gel contraction			
Kevin E. Potts	Samuel E. George, M.D.	Duke University	Medicine and Pharmacology
Intracellular calcium signal transduction and vascular smooth muscle migration			
Jeffrey R. Raval	Thomas E. Carey, Ph.D.	University of Michigan–Ann Arbor	Otolaryngology
Loss of heterozygosity for DCC in squamous cancer			
Franco Maria Recchia	Jack D. Keene, Ph.D., and Barton F. Haynes, M.D.	Duke University	Microbiology and Medicine
Molecular action of T cell-specific RNA-binding proteins intrinsic to early T cell development			
Anne R. Robinson	M. Sue O'Dorisio, M.D., Ph.D.	Ohio State University Main Campus	Pediatrics
Neuroblastoma: a defect in neural crest differentiation			
Soonhok Grace Woo	Hamilton O. Smith, M.D.	Johns Hopkins University (University of Maryland School of Medicine)*	Molecular Biology
DNA regulatory sites for competence induction in *Haemophilus influenzae*			

Neuroscience and Physiology

Rose Baghdady	Colin G. Nichols, Ph.D.	Washington University	Cell Biology and Physiology
Regulation of the ATP sensitive K^+ channel in hypertrophied myocardium—implications for arrhythmogenesis			
Daniel Garth Barbee	Eric Shooter, Ph.D., and Philip Barker, Ph.D.	Stanford University (Duke University School of Medicine)*	Neurobiology
Palmitoylation of p75 NGF receptor: biochemical characterization and functional consequences			
Phillip C. Berryhill	Harvey S. Levin, Ph.D.	University of Maryland at Baltimore (University of Texas Medical School at Galveston)*	Neurosurgery
Prefrontal effects of closed head injury in children: an MRI analysis			
Amos O. Dare	Matthew During, M.D.	Yale University	Neurosurgery and Medicine
Adenosine and nitric oxide as potential mediators of the changes in blood flow associated with seizures in the rat			
Michelle Lynn Garnett	William Semple, Ph.D., and Peter Goyer, M.D.	Case Western Reserve University	Psychiatry
Structural and functional brain imaging in schizophrenia			
Tom J. Guttuso	Susan Udin, Ph.D.	State University of New York at Buffalo	Physiology
Can pineal ablation extend the critical period for plasticity in *Xenopus* tectum?			
Steven C. Lane	Rose-Mary Boustany, M.D.	Duke University	Pediatrics
The role of subunit-9 of ATP synthase in Batten's disease			
Junhee Lee	Bruce R. Ransom, M.D., Ph.D.	Yale University	Neurology and Psychiatry
Extracellular pH and epileptiform activity in rat hippocampal slices			
Lucille Lee	Cheryl Dreyfus, Ph.D.	University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School	Neuroscience
The effect of neurotrophic factors on oligodendrocyte differentiation and function			
Jeffrey Leonard	M. Sean Grady, M.D., and Lesnick E. Westrum, M.D., Ph.D.	University of Washington	Neurological Surgery and Surgery
The effects of fluid-percussion on axonal transport in the septal hippocampal pathway			
Griffith E. Liang	Thomas A. Woolsey, M.D.	Washington University	Neurosurgery
Stimulus-evoked changes in local cerebral blood flow			
T. Christian H. Mix	Fredric S. Fay, Ph.D.	University of Massachusetts at Worcester	Physiology and Pharmacology
Cellular and molecular mechanisms of feedback control of Ca^{2+} removal in smooth muscle			
Jason M. Schwalb	Larry I. Benowitz, Ph.D.	Harvard University (Yale University School of Medicine)*	Neurosurgery
Tyrosine kinase assay as a means of purifying a neurotrophic factor from the goldfish optic nerve			
David Keith Selig	Robert C. Malenka, M.D., Ph.D.	University of California–San Francisco (Johns Hopkins University School of Medicine)*	Psychiatry and Physiology
The role of G proteins in the induction of long-term potentiation			
David Griffith Soergel	Solomon H. Snyder, M.D.	Johns Hopkins University (Cornell University Medical College)*	Neuroscience
Characterization of the promoter/enhancer region of neuronal nitric oxide synthase			
Brian L. Stauffer	Russell L. Moore, Ph.D., and Joseph Y. Cheung, M.D., Ph.D.	Pennsylvania State University	Medicine
Cardiac myocyte Ca^{2+} regulation in hypertension			
Howard L. West	Bradley T. Hyman, M.D., Ph.D.	Harvard University	Neurology
Characterization of nitric oxide synthase-containing neurons: distribution and functional variability across brain regions in the rat			

** medical school affiliation other than the fellowship institution is indicated in parentheses.*

Continued Awards—Second Year of Research

Peter Alan Barton	Jeffrey S. Warren, M.D.	University of Michigan–Ann Arbor	Pathology
Complement component C5 modulates the systemic tumor necrosis factor response in murine endotoxic shock			

Continued Awards—Return to Medical Studies

Susan A. Bardwell	Rush University
Anne-Marie B. Brillantes	Mount Sinai School of Medicine
Jeffrey Critchfield	University of California–San Francisco
Tejal K. Gandhi	Harvard University
Yolanda I. Garces	University of Illinois at Chicago
Jeffrey A. Guy	Harvard University
Andrew C. Hecht	Harvard University
Fred Hsieh	Brown University
Malcolm John	Harvard University
Daniel Kraft	Stanford University
Victoria A. Mancuso	University of California–San Francisco
Kreton Mavromatis	University of Michigan–Ann Arbor
Barbra Jill McFarland	Duke University
Margaret E. McLaughlin	University of Pennsylvania
Ryland E. Melford III	Washington University
George B. Payne	Duke University
Melanie Ann Ryan	Harvard University
Bernadette Y. Smith	Ohio State University Main Campus
Stacy L. Smith	Harvard University
Stephanie B. Teal	University of California–San Francisco
Amy Beth Warren	University of Michigan–Ann Arbor
Jennifer Reikes Willert	University of California–San Francisco
Lester Keoki Williams	University of Michigan–Ann Arbor
Julie A. Wissink	Stanford University
Barbara Zelbert	Stanford University

on the basis of their demonstrated ability during the research year, their promise for future achievement in biomedical research, and their career intentions, including any plans for additional research training after completion of medical school. One fellow was awarded support for a second year of research, and 25 fellows and research scholars were selected for up to two years of fellowship support while completing medical school. These new awards bring to 41 the number of continued fellows currently supported in their studies toward medical degrees.

Assessment

As part of the coordinated series of grants program assessment activities, the Institute is continuing the long-term tracking of the education and careers of the medical student fellows and research scholars. Of special interest will be the students' continued involvement in research and pursuit of further training, either toward the Ph.D. degree or in postdoctoral positions. By the end of the initial fellowship year, at least two of the 1992 fellows reported plans to pursue a Ph.D. degree in addition to the M.D. degree, as a result of the fellowship experience. Others intend to pursue postdoctoral research training after completing medical school and postgraduate clinical training.

The Institute is interested not only in the career paths of its fellows, but also in the size, composition, and activities of the national pool of physician-scientists. Pursuit of both these interests is described in the Program Assessment section of this report.

Postdoctoral Research Fellowships for Physicians

The pace of fundamental discoveries emerging from biomedical research has been remarkable in recent years, yielding significant new understanding of basic biological processes and disease mechanisms. To reap the full benefit of this knowledge, now and in the future, it is vital that physicians remain involved in fundamental research (Figure 15).

The HHMI program of Postdoctoral Research Fellowships for Physicians is designed to help increase the supply of well-trained physician-scientists. The awards, first made in 1990, are intended for physician-scientists who are seeking additional research training with a view to becoming independent investigators.

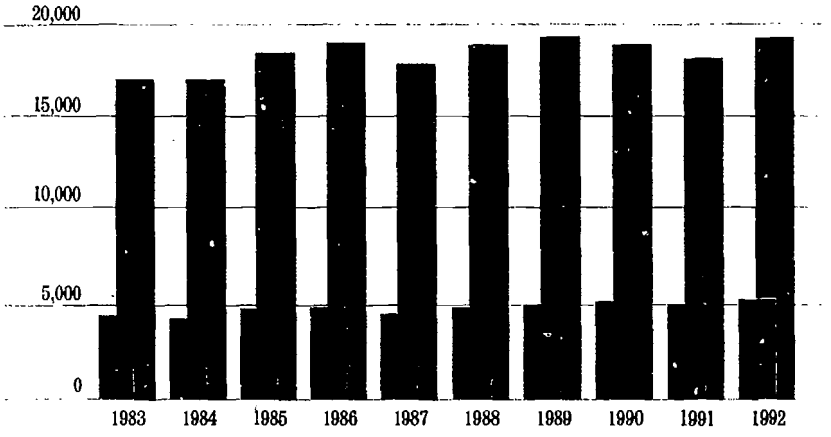
The research fellowships complement the 2,600 postdoctoral appointments for M.D.'s made possible through NIH programs (Figure 16). The HHMI fellowship program should help increase the supply of well-trained physician-scientists highly competitive for NIH career development awards, research project grants, and similar private and public sector support.

A physician who has completed at least two years of postgraduate clinical training and less than two

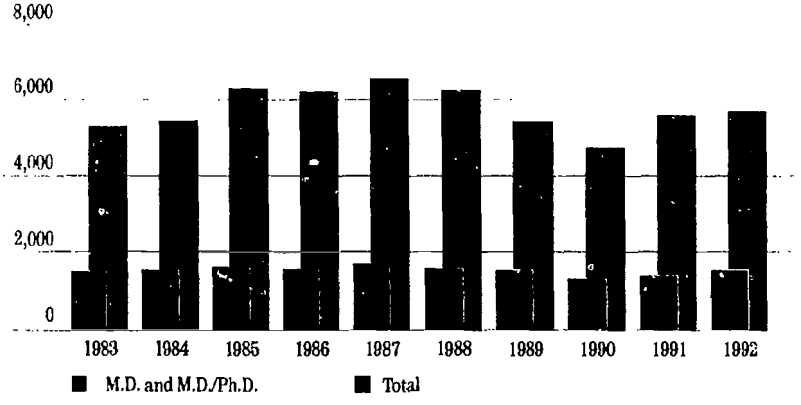
Figure 15

NIH Research Projects, 1983–1992

Competing Applications



Competing Awards



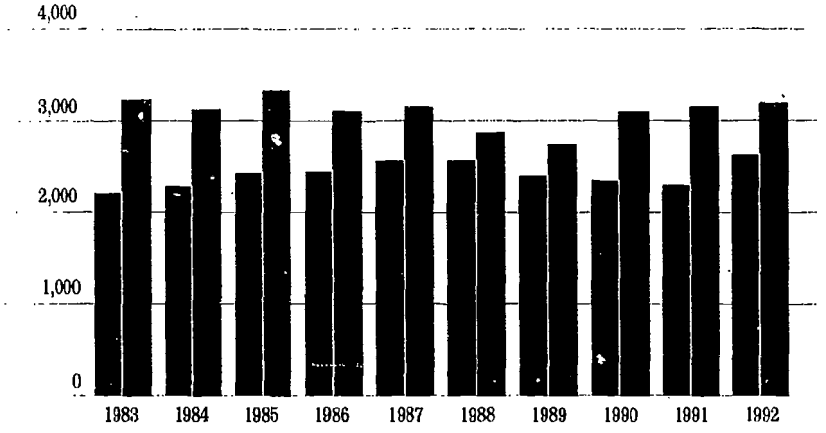
Note: Research Projects include Research Project Awards (R01), New Investigator Research Awards, FIRST Awards, Outstanding Investigator Grants, MERIT Awards, Small Business Innovation Research Grants, Research Program Project Awards (P01), Hazardous Substance Basic Research Grants, U.S.-Japan Cooperative Medical Science Program Awards, and Research Projects Cooperation Agreements.

Source: National Institutes of Health, Division of Research Grants. Analysis by Carol Bleakley 1993.

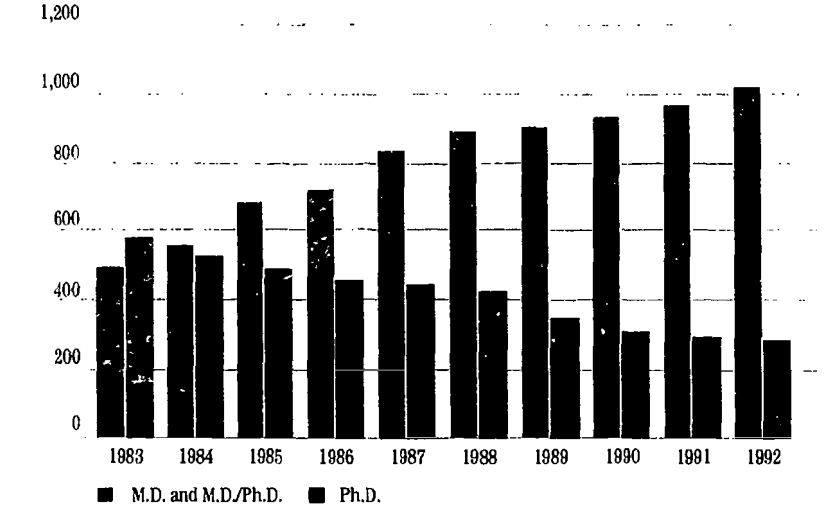
Figure 16

NIH-Supported Advanced Research Training Awards, 1983–1992

Postdoctoral Appointments



Career Development Awards



Note: About 15 percent of the postdoctoral appointments for M.D.'s and 40 percent of those for Ph.D.'s are through individual awards. The remaining appointments are made through institutional awards.

Source: National Institutes of Health, NIH ' 'a Book 1993, Bethesda, Maryland: National Institutes of Health.

years of postdoctoral training in fundamental research is eligible to apply for the fellowship, which provides support for three years of full-time research training in a laboratory of the applicant's choice. Support is provided for fundamental research directed toward an understanding of basic biological processes and disease mechanisms, especially in the areas of the Institute's research program. Awards are made to applicants who have demonstrated superior scholarship and show the greatest promise for achievement in biomedical research. Those who elect to work in HHMI laboratories are appointed as HHMI associates.

Physician postdoctoral fellowship applications are evaluated by a panel of distinguished biomedical scientists from universities and medical centers throughout the United States. In 1993 more than 200 applications were considered. On the basis of the panel's review, the Institute named 25 physician postdoctoral fellows and 6 HHMI associates to receive their research training under the guidance of mentors at 13 universities, research institutes, and hospitals (Figures 17 and 18).

The Institute plans to award about 25 three-year fellowships annually, based on an international competition. Awards will be made on the basis of the applicants' ability and promise and the quality of research training to be obtained through this program. At present, there are 85 physician postdoctoral fellows at 39 institutions who are

Figure 17

Postdoctoral Research Fellowships for Physicians, Program and Award Highlights

Fellowship Terms

- 25 awards annually
- 3 years of support
- $62,000–$77,000 annually
  - $35,000–$55,000 stipend
  - $15,000 research allowance
  - $12,000 institutional allowance

Eligibility

- M.D., M.D./Ph.D., D.O., M.B.B.S., or equivalent degree
- Full-time fundamental research (basic biological processes and disease mechanisms)
- Any academic or nonprofit research institution
- No enrollment in a graduate degree program
- No faculty appointment
- At the start of the fellowship
  - at least 2 years of postgraduate clinical training
  - no more than 2 years of postdoctoral research training
  - no more than 10 years since first medical degree

1993 Awards

- Total number: 31
  - 6 women and 25 men
  - 23 U.S. citizens and 8 foreign citizens
  - 8 M.D.'s and 23 M.D./Ph.D.'s
  - 1 minority underrepresented in the sciences
- Fellowship institutions: 13

All Current Physician Postdoctoral Fellows*

- Total number: 85
  - 22 women and 63 men
  - 69 U.S. citizens and 16 foreign citizens
  - 36 M.D.'s and 49 M.D./Ph.D.'s
  - 4 minorities underrepresented in the sciences
- Fellowship institutions: 39
- Distribution by field
  - 26 cell biology and regulation
  - 22 genetics
  - 20 immunology
  - 14 neuroscience and physiology
  - 3 structural biology

**Awardees who select mentors at HHMI laboratories are appointed as HHMI associates. Of the 31 new awardees, 6 are HHMI associates and 25 are fellows. No awardees appointed as associates are included in the following data.*

Figure 18

Postdoctoral Research Fellowships for Physicians, Educational Origins of 1993 Awardees

Medical Schools

Baylor College of Medicine
Goteborg University (Sweden)
Harvard University, 5
Javeriana University Medical School (Colombia)
Johns Hopkins University
McGill University (Canada)
Medical University of South Carolina
Stanford University
Strasbourg University of Medicine (France)
Tufts University
University College London (United Kingdom)
University of Bonn (Germany)
University of California–Los Angeles
University of California–San Diego, 2
University of California–San Francisco
University of Melbourne (Australia)
University of Michigan–Ann Arbor
University of North Carolina at Chapel Hill
University of Oxford (United Kingdom)
University of Rochester
University of Washington
Vanderbilt University
Washington University, 2
Yale University, 2

Graduate Schools (for M.D./Ph.D.'s)

Baylor College of Medicine
East Carolina University
Goteberg University (Sweden)
Harvard University, 4
Johns Hopkins University
Medical University of South Carolina
Stanford University
Strasbourg University of Science (France)
Tufts University
University of Basel (Switzerland)
University of California–San Diego, 2
University of Cambridge (United Kingdom) 2
University of Melbourne (Australia)
University of Washington
Vanderbilt University
Washington University, 2
Yale University

Undergraduate Institutions

Albany College of Pharmacy of Union University
Brandeis University
Brogardsskolan Gymnasium (Sweden)
Colegio Nueva Granada (Colombia)
College of Charleston
Davidson College
Emory University
Harvard University, 6
Haverford College
Lafayette College
Massachusetts Institute of Technology, 2
Princeton University
State University of New York at Potsdam
Strasbourg University of Science (France)
University of California–San Diego
University of Cambridge (United Kingdom) 2
University of Melbourne (Australia)
University of Michigan–Ann Arbor
University of Wisconsin–Madison, 2
Washington University
Yale University, 2

High Schools

California
Fairfax, Los Angeles
Nicolet, Glendale
University, Los Angeles

Connecticut
Stamford, Stamford

Georgia
Briarcliff, Atlanta

Massachusetts
Belmont, Belmont
Brockton, Brockton
Phillips Academy, Andover

Michigan
West Bloomfield, West Bloomfield

Missouri
Wentzville R-4, Wentzville

New Jersey
Ridgewood, Ridgewood
Summit, Summit

New York
Cardozo, New York City
Cicero, Cicero
George W. Hewlett, Hewlett
Locust Valley, Locust Valley
Mechanicville, Mechanicville

Ohio
Wyoming, Wyoming

Oregon
Wilson, Portland

Pennsylvania
Mount Lebanon, Mount Lebanon

South Carolina
Spring Valley, Columbia

Texas
Westchester, Houston

Wisconsin
Ondossagon, Ashland

Outside the United States
Australia, Luther College, Melbourne
Belgium, Verviers, Verviers
Colombia, Nueva Granada, Bogota
France, Kleber College, Strasbourg
Germany, Geschwister-School-Gymnasium, Daun
Sweden, Brogardsskolan Gymnasium, Kristinehamn
United Kingdom, St. Joseph's College, Bradford
United Kingdom, Orange Hill, London

Figure 19

Postdoctoral Research Fellowships for Physicians, All Current Fellowship Institutions

Albert Einstein College of Medicine
Brigham and Women's Hospital
Case Western Reserve University
Children's Hospital, Boston
Childrens Hospital Los Angeles
Dana-Farber Cancer Institute
Dartmouth College
Duke University Medical Center
Fred Hutchinson Cancer Research Center
Harvard Medical School
Harvard University
J. David Gladstone Institutes
Johns Hopkins University School of Medicine
Julius Maximilians University (Germany)
Massachusetts General Hospital
Max Planck Institute for Experimental Medicine (Germany)
National Institutes of Health
National Jewish Center for Immunology and Respiratory Medicine
New York University Medical Center
Northern California Institute for Research and Education
Northwestern University
Rockefeller University
Salk Institute for Biological Studies
Scripps Research Institute
Stanford University School of Medicine
State University of New York at Buffalo
State University of New York at Stony Brook
University of California–San Francisco
University of Chicago
University of Colorado Health Sciences Center
University of Houston
University of Massachusetts Medical Center
University of North Carolina at Chapel Hill
University of Pennsylvania
University of Washington
Vanderbilt University School of Medicine
Washington University
Whitehead Institute for Biomedical Research
Yale University School of Medicine

being supported through the grants program, at an annual cost of about $6 million (Figure 19).

Thirteen of the physician postdoctoral fellows in the second or third year of their fellowship term participated in the 1993 Meeting of Predoctoral and Physician Postdoctoral Fellows (see Figure 7), held at the Institute headquarters in Chevy Chase. These physician-scientists presented the results of their fellowship research and discussed their work with predoctoral fellows, Institute staff, and invited guests. Additional fellowship accomplishments were reported to the Institute in the fellows' annual progress reports. In the past year the fellows attended 63 regional, national, and international scientific meetings, presenting 29 posters and 23 talks. They published 46 journal articles, 6 chapters of books, and 47 abstracts.

Among its program assessment activities, HHMI will continue to monitor the national participation of M.D.'s and M.D./Ph.D.'s in research and to track the careers of former Institute physician postdoc-

Postdoctoral Research Fellowships for Physicians, 1993 Awardees

Name	Research Mentor	Fellowship Institution	Department
Cell Biology and Regulation			
Jack Leonard Arbiser, M.D., Ph.D.	M. Judah Folkman, M.D.	Children's Hospital–Boston	Surgery
Regulation of basic fibroblast growth factor expression and secretion in cutaneous systems			
Stephen Charles Blacklow, M.D., Ph.D.	Peter S. Kim, Ph.D.	Whitehead Institute for Biomedical Research*	
Thermodynamics and kinetics of bZip dimerization			
David D. Chang, M.D., Ph.D.	Timothy A. Springer, Ph.D.	Dana-Farber Cancer Institute	Pathology
Regulation of cell adhesion			
Philip Arthur Cole, M.D., Ph.D.	Christopher T. Walsh, Ph.D.	Harvard Medical School	Biological Chemistry and Molecular Pharmacology
Catalytic mechanism of lymphoid cell kinase			
Dennis F. Kucik, M.D., Ph.D.	Eric J. Brown, M.D.	Washington University School of Medicine	Internal Medicine
Interactions between integrins and the cytoskeleton in cells of the immune system			
Dedee Frances Murrell, M.D.	Pamela Cowin, Ph.D.	New York University Medical Center	Dermatology
Desmoglein diversity in cell adhesion and pemphigus foliaceus			
Meray Socolovsky, M.D.	Harvey F. Lodish, Ph.D.	Whitehead Institute for Biomedical Research	
Molecular analysis of the cytoplasmic domain of the murine erythropoietin receptor			
Genetics			
Gerald Frank Cox, M.D., Ph.D.	Louis M. Kunkel, Ph.D.	Children's Hospital–Boston*	Genetics
Characterization of DRP-9, a new member of a novel class of proteins with homologies to the triple-repeat motif of dystrophin			
Scott Charles Kogan, M.D.	J. Michael Bishop, M.D.	University of California–San Francisco	G.W. Hooper Research Foundation
A transgenic mouse model of promyelocytic leukemia			
Reinhold Hugo Kreutz, M.D.	Klaus Lindpaintner, M.D., and Bernardo Nadal-Ginard, M.D., Ph.D.	Children's Hospital–Boston	Cardiology
Molecular genetics of primary hypertension in the rat			
Nils-Goran Larsson, M.D., Ph.D.	David A. Clayton, Ph.D.	Stanford University School of Medicine	Developmental Biology
The effect of regulating the expression of nuTFA in human and yeast cells			
Jeffrey Ely Rubnitz, M.D., Ph.D.	Michael L. Cleary, M.D.	Stanford University School of Medicine	Pathology
Mouse models of t(11;19) leukemia			
Michael Joseph Thirman, M.D.	Janet D. Rowley, M.D., and M. Celeste Simon, Ph.D.	University of Chicago	Medicine and Molecular Genetics and Cell Biology
Developmental and genetic analysis of the murine homologue of MLL in hematopoiesis			
Immunology and Microbiology			
Chan R. Beals, M.D., Ph.D.	Dan R. Littman, M.D., Ph.D.	University of California–San Francisco*	Microbiology and Immunology
Effects of the HIV-1 nef protein on the interaction of CD4 and gp160			
Fernando Dangond, M.D.	David H. Hafler, M.D.	Brigham and Women's Hospital	Neurologic Diseases
Role of the p210 protein in HTLV-I–induced T cell proliferation			
Laura Marsha Dember, M.D.	Paul J. Anderson, M.D., Ph.D.	Dana-Farber Cancer Institute	Tumor Immunology
Functional analysis of nucleolysin TIA-1			
Sam Tzeyyue Hwang, M.D., Ph.D.	Steven Rosen, Ph.D.	University of California–San Francisco	Anatomy
Cloning and characterization of dermal endothelial ligand for L-selectin			
Graham John Lieschke, M.B.B.S., B.Med.Sc., FRACP	Richard C. Mulligan, Ph.D.	Whitehead Institute for Biomedical Research	
Use of genetically modified tumor cells to augment antitumor immunity			
Steven Bryant Porter, M.D., Ph.D.	Gary K. Schoolnik, M.D.	Stanford University School of Medicine*	Infectious Diseases and Geographic Medicine
The invasin gene of *Mycobacterium tuberculosis* and its role in macrophage entry			
William M. Ridgway, M.D.	C. Garrison Fathman, M.D.	Stanford University School of Medicine	Medicine
Exploring mechanisms of therapy of autoimmune encephalomyelitis			
Marc Elliot Rothenberg, M.D., Ph.D.	Philip Leder, M.D.	Harvard Medical School*	Genetics
The role of eosinophils in tumor killing			
Eric Joseph Rubin, M.D., Ph.D.	John J. Mekalanos, Ph.D.	Massachusetts General Hospital	Microbiology and Molecular Genetics
Virulence determinants in mycobacteria			
Barry Paul Sleckman, M.D., Ph.D.	Frederick Alt, Ph.D.	Children's Hospital–Boston*	Genetics
Regulation of TCR and Ig gene V to D-J rearrangement			
Naomi Taylor, M.D., Ph.D.	Bartholomew M. Sefton, Ph.D.	Salk Institute for Biological Studies	
Transformation of T cells by overexpression of the *lck* oncogene			
Neuroscience and Physiology			
Phyllis Lynn Faust, M.D., Ph.D.	Mary E. Hatten, Ph.D.	Rockefeller University	
Defects in granule cell neurogenesis in human medulloblastoma formation			
Lawrence J. Hayward, M.D., Ph.D.	Robert H. Brown, Jr., M.D., D.Phil.	Massachusetts General Hospital	Neurology
K^+-induced impairment of Na^+ channel inactivation in periodic paralysis			
Emily Eun-nie Kim, M.D.	Brian Seed, Ph.D.	Massachusetts General Hospital	Molecular Biology
Cloning a sweetness receptor			
Sylvain Lehmann, M.D., Ph.D.	David A. Harris, M.D., Ph.D.	Washington University School of Medicine	Cell Biology and Physiology
Processing of normal and mutant mammalian prion proteins and their role in cell adhesion			
James A. Mastrianni, M.D., Ph.D.	Stanley B. Prusiner, M.D.	University of California–San Francisco	Neurology
Molecular characterization of the phenotypic presentations of prion disease			
David Henry Rowitch, M.D., Ph.D.	Andrew P. McMahon, Ph.D.	Children's Hospital–Boston	Cellular and Developmental Biology
Regulation of Wnt-1 gene expression in mouse brain development			
Structural Biology			
Richard H. Peters, M.D., Ph.D.	Michael A. Weiss, M.D., Ph.D.	Harvard Medical School	Biological Chemistry and Molecular Pharmacology
Structural NMR studies of transcription factor IIS			

Howard Hughes Medical Institute

toral fellows, including their faculty appointments and receipt of research grants. (See Program Assessment.)

Research Resources

The Research Resources program provides support to research and educational organizations serving as unique national resource laboratories and teaching facilities. Included are organizations that provide biological stocks and materials for the biomedical research community.

One new grant was awarded in 1993, and three grants from prior years continue to support research resources activities:

- Jackson Laboratory
  Bar Harbor, Maine
- Cold Spring Harbor Laboratory
  Cold Spring Harbor, New York
- Marine Biological Laboratory
  Woods Hole, Massachusetts
- Human Genome Organisation
  Bethesda, Maryland

Jackson Laboratory

A three-year grant in the amount of $1.2 million was awarded to the Jackson Laboratory in 1993 for support of its Induced Mutant Resource. This service imports, preserves, maintains, and distributes mice that have been altered genetically. The grant provides funds for equipment, personnel, supplies, and other operating costs for collecting genetically altered mice of importance to biomedical research, especially those produced by gene targeting or gene transfer techniques (Figure 20). The mice are produced in research laboratories worldwide, and the Jackson Laboratory develops and preserves them for distribution at modest cost to the international research community.

The Laboratory is the premier world resource for special strains of inbred mice with genetic defects and for mice of established genetic background that have been endowed with specific mutations. Such mice are uniquely valuable as models for human disease and the study of fundamental biological processes. The Laboratory is renowned for providing stocks of known genetic background and free from extraneous diseases and infections.

Through HHMI's support of the Laboratory's central resource, the initial developer of a mutant strain will be relieved of the time-consuming and costly task of making it available to other researchers. The central resource will also make special lines of mice widely available so that investigators with similar research interests need not

Figure 20

Jackson Laboratory, Induced Mutant Resource

Mutant Mouse Strains	Resource Services
■ Models for human genetic diseases or basic biological processes	■ Importation
■ Produced by gene targeting, gene transfer, or chemical mutagenesis	■ Preservation
	■ Maintenance
	■ Distribution

develop mutants independently. In addition, the central resource will preserve especially valuable mutant strains, through frozen embryos or other means.

Cold Spring Harbor Laboratory

A four-year grant in the amount of $1 million was awarded to the Cold Spring Harbor Laboratory in 1991 for support of its expanded program of postgraduate courses. The postgraduate program has been one of enduring quality and scope, known worldwide. This award continues support provided in an earlier grant so that courses could be added in molecular genetics, neurobiology, and structural biology, thus extending the summer program and adding two week courses in the spring and fall. The new grant provides funds for equipment and supplies, instructors and guest lecturers, scholarships for students, and support personnel.

The Laboratory is a world center for biological research and training, especially in the genetics of humans, plants, and bacteria. It serves as an international schoolhouse for modern biology, annually hosting major conferences, seminars, workshops, and courses. Participants include precollege students and teachers, undergraduates, graduate students, postdoctoral fellows, and established scientists at major universities and research centers.

The new Hughes Teaching Laboratories, an integral part of the neuroscience teaching and research facility, was constructed with Institute support. In the summer of 1991, the facility was first used for three courses: Molecular Embryology of the Mouse, Advanced Molecular Cloning, and Molecular Cloning of Neural Genes. Two courses were added the following year: Molecular Approaches to Ion Channel Expression and Function, and Imaging Structure and Function in the Nervous System.

The six Institute-supported courses for 1992 (Figure 21) accepted 95 participants from 235 applicants. The participants, including 42

Figure 21

Cold Spring Harbor Laboratory, Courses Supported by the Howard Hughes Medical Institute

Summer 1992

- Advanced *Drosophila* Genetics
- Imaging Structure and Function in the Nervous System
- Molecular Approaches to Ion Channel Function and Expression
- Molecular Cloning of Neural Genes

Fall 1992

- Macromolecular Crystallography
- Molecular Genetics, Cell Biology and Cell Cycle of Fission Yeast

Summer 1993

- Developmental Neurobiology
- Human Functional Neuroimaging
- Imaging Structure and Function in the Nervous System
- Molecular Approaches to Ion Channel Expression and Function
- Structure, Function and Development of the Visual System

who were awarded partial scholarships, came from the United States and abroad—Australia, Canada, Denmark, Finland, France, Germany, India, Israel, Norway, Spain, Sweden, and the United Kingdom.

Marine Biological Laboratory

A grant of $4 million awarded to the Marine Biological Laboratory in 1988 will continue supporting education and training programs for a total of seven years. The Laboratory has served as a center for research and teaching in basic biology since 1888. Each summer, investigators and advanced students come to work and study, using marine organisms from the surrounding waters. Educational and research programs are closely intertwined. The Marine Biological Laboratory/Woods Hole Oceanographic Institute (MBL/WHOI) Library, which supports the education and research programs with 24-hour access, is one of the world's most comprehensive repositories of biomedical and marine biological information.

The grant provides $3 million for courses in embryology, microbiology, neuroscience, and physiology. In the summer of 1992, it helped to support seven courses (Figure 22). The 203 participants were selected from almost 450 applicants, including graduate students, postdoctoral fellows, and faculty members of universities and research institutions in the United States and abroad—Australia, Bulgaria, Canada, Denmark, France, Germany, Israel, Italy, Kenya, Japan, Mexico, Republic of the Congo, Russia, Switzerland, United Kingdom, and Yugoslavia.

Figure 22

Marine Biological Laboratory, Courses Supported by the Howard Hughes Medical Institute

- Embryology: Cell Differentiation and Gene Expression in Early Development
- Methods in Computational Neuroscience
- Microbial Diversity
- Molecular Evolution
- Neural Systems and Behavior
- Neurobiology
- Physiology: Cell and Molecular Biology

The grant also provides $1 million to support program development at the MBL/WHOI Library. Emphasis has been on electronic information storage, retrieval, and management to support scientific research and education. Grant-supported activities have included establishing a linked network among the research facilities of the Marine Biological Laboratory and Woods Hole Oceanographic Institute and their classroom and laboratory teaching facilities; purchasing computer hardware and software applications, including those used for nucleic acid and protein sequence analyses; and establishing a formal consulting, problem-solving, and education program.

Figure 23

Human Genome Organisation, Americas Office Activities

- Chromosome Workshops
  Chromosomes 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 17, 18, 20, 21, 22, and X.
- Intellectual Property and Ethics Issues Meetings

Human Genome Organisation

In 1990 the Human Genome Organisation (HUGO) received a four-year award of $1 million for the program and operations of its Americas Office and related international activities. These operations include meetings of the HUGO Council, committee workshops, and a scientist exchange program. HUGO serves as a coordinating body for the international human genome project.

Further, HUGO is an international clearinghouse for information on the DNA base sequences and the genetic and physical mapping of human chromosomes. It promotes collaboration among scientists in the exchange of data, samples, and technology relevant to genome research, and fosters studies of model organisms (such as the mouse) to parallel those on the human genome. HUGO plans to establish international training programs on methodology and to encourage public debate on the ethical, legal, and other societal impacts of the human genome project.

In the past year the HUGO Americas Office participated in workshops on 17 chromosomes (Figure 23) and in meetings related to issues of intellectual property and ethics.

Undergraduate Science Education

In 1993 the Institute continued its support of programs at colleges and universities to enhance undergraduate science teaching and learning. Through its Undergraduate Biological Sciences Education Program, the Institute provides grants to strengthen undergraduate education in the biological sciences and in chemistry, physics, and mathematics as they relate to biology. A principal objective of the program is to assist institutions in their efforts to provide students with exciting opportunities in the sciences, thereby stimulating an interest in research and, possibly, in science and teaching careers.

One of the areas supported under the program is student research, in which undergraduates, including women and members of minority groups underrepresented in the sciences, may experience science first-hand during the summer or academic year in laboratories on or off campus.

Major support is also awarded for equipment and laboratory development, which enables institutions to modernize laboratories, expand areas of instruction in contemporary biology, and integrate the teaching of biology with that of chemistry, physics, mathematics, and other relevant fields. In addition, the program supports initiatives that link colleges and universities with elementary and secondary schools, community colleges, and other four-year institutions and provide teachers and students with exposure to modern biology.

Undergraduate Program Directors Meetings

The Institute organizes and sponsors annual meetings of the directors of the undergraduate programs it supports. These meetings are part of the Institute's ongoing program assessment. They enable program directors from a wide range of institutions to present and discuss their programs, to demonstrate educational technology and techniques developed through the grants, and to exchange laboratory manuals, outlines, and other materials. For the Institute as well as the program directors, the meetings provide valuable insight into the challenges faced in implementing these programs and into how the programs have been modified in response to the challenges. The proceedings of the meetings, along with profiles of Institute-supported initiatives, are published and distributed nationally.

The 1992 and 1993 meetings brought together program directors from institutions that received awards in the 1988–1989 and 1991–1992 grants competitions, respectively. Additional meetings are planned for directors from the 1993 awardee institutions and from other competitions.

1993 Meeting

The 1993 program directors meeting focused on institutional strategies for enhancing undergraduate science teaching and learning (figure 24). Topics included ways in which HHMI-funded activities are

augmenting institutional and departmental efforts to strengthen undergraduate science teaching and to offer students, particularly women and members of underrepresented minorities, high-quality training in biology and other sciences. There were demonstrations of interactive computer software for biology education, video presentations, and techniques used in undergraduate and precollege outreach programs. A report of the meeting, *Institutional Strategies for Enhancing Undergraduate Science Education*, was published in early 1994.

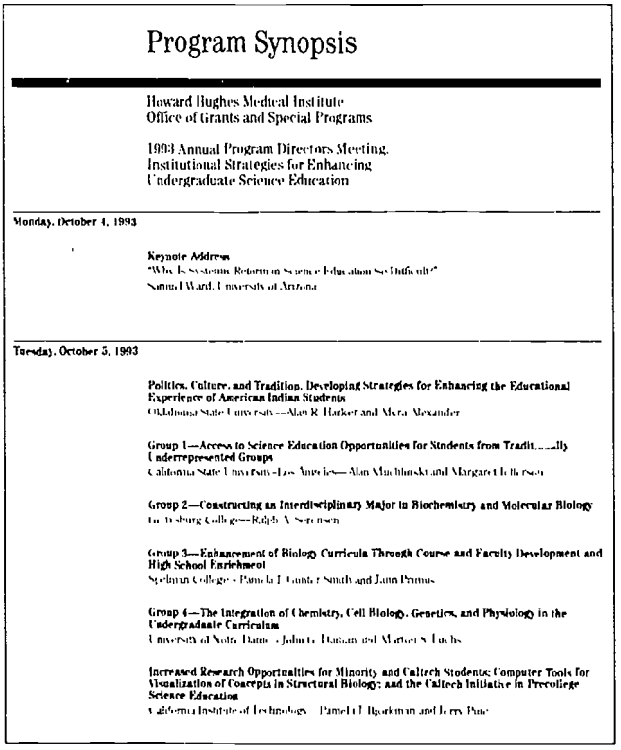
1992 Meeting

The theme of the Institute's second program directors meeting, held in 1992, was undergraduate research and curriculum and laboratory development. A report of the meeting was published in early 1993. Entitled *Enriching the Undergraduate Laboratory Experience*, it summarizes eacn presentation and key issues emerging in the discussions.

One of the issues raised by the program directors concerned the role of laboratory research in undergraduate science education, both as an independent student activity,

Figure 24

1993 Meeting of Undergraduate Program Directors



Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Annual Program Directors Meeting:
Institutional Strategies for Enhancing
Undergraduate Science Education

Monday, October 4, 1993

Keynote Address
"Why Is Systemic Reform in Science Education So Difficult?"
Samuel Ward, University of Arizona

Tuesday, October 5, 1993

Politics, Culture, and Tradition: Developing Strategies for Enhancing the Educational Experience of American Indian Students
Oklahoma State University—Alan R. Harker and Myra Alexander

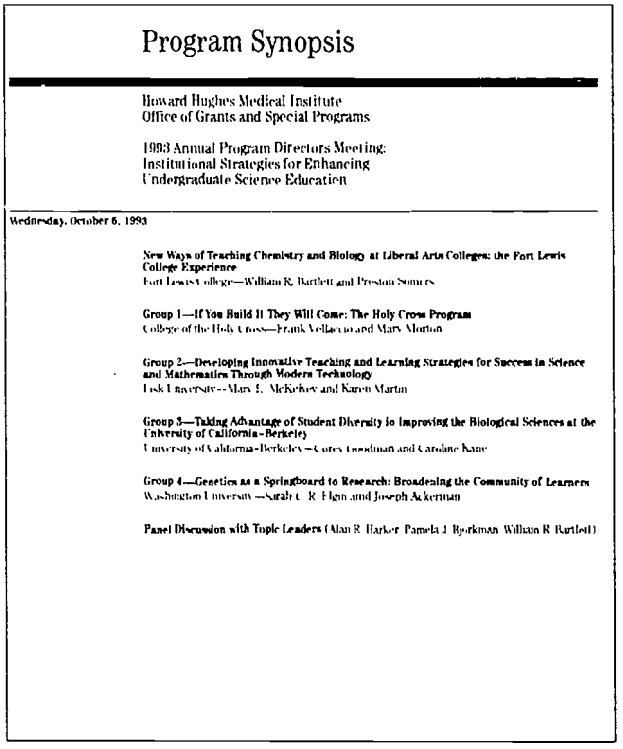
Group 1—Access to Science Education Opportunities for Students from Tradit...lly Underrepresented Groups
California State University–Los Angeles—Alan Mackbinski and Margaret Dobrescu

Group 2—Constructing an Interdisciplinary Major in Biochemistry and Molecular Biology
Gettysburg College—Ralph A. Serensen

Group 3—Enhancement of Biology Curricula Through Course and Faculty Development and High School Enrichment
Spelman College—Pamela J. Gaines Smith and Jann Pittman

Group 4—The Integration of Chemistry, Cell Biology, Genetics, and Physiology in the Undergraduate Curriculum
University of Notre Dame—John L. Hansen and Marcus S. Fuchs

Increased Research Opportunities for Minority and Caltech Students; Computer Tools for Visualization of Concepts in Structural Biology; and the Caltech Initiative in Precollege Science Education
California Institute of Technology—Pamela J. Bjorkman and Jerry Pine



Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Annual Program Directors Meeting:
Institutional Strategies for Enhancing
Undergraduate Science Education

Wednesday, October 6, 1993

New Ways of Teaching Chemistry and Biology at Liberal Arts Colleges: the Fort Lewis College Experience
Fort Lewis College—William R. Bartlett and Preston Somers

Group 1—If You Build It They Will Come: The Holy Cross Program
College of the Holy Cross—Frank Vellaccio and Mary Morton

Group 2—Developing Innovative Teaching and Learning Strategies for Success in Science and Mathematics Through Modern Technology
Tusk University—Mary E. McKechnie and Karen Martin

Group 3—Taking Advantage of Student Diversity to Improving the Biological Sciences at the University of California–Berkeley
University of California–Berkeley—Cathy Cunningham and Caroline Kane

Group 4—Genetics as a Springboard to Research: Broadening the Community of Learners
Washington University—Sarah C. R. Elgin and Joseph Ackerman

Panel Discussion with Topic Leaders (Alan R. Harker, Pamela J. Bjorkman, William R. Bartlett)

usually during the summer, and as an integral part of the introductory and upper-division curriculum. There was general agreement that students, both science majors and others, respond positively to science when they can learn it in a laboratory setting by designing and performing experiments, testing hypotheses, and analyzing results. The program directors discussed curricula that serve to attract and retain students, including women and members of minorities underrepresented in science. Major topics of discussion were allocation of increasingly scarce resources to strengthen science curricula at all levels and strategies to integrate the teaching of biology with that of chemistry, physics, mathematics, and other relevant disciplines.

In one of the plenary sessions, program directors from Bryn Mawr College and neighboring Haverford College described their efforts to develop interdisciplinary bioscience programs using the scientific resources of both institutions. Judith Shapiro, Provost, and Paul Grobstein, Eleanor A. Bliss Professor of Biology, from Bryn Mawr, and Judith Owen, Chair and Professor of Biology, and Slavica Matacic, Professor of Biology, from Haverford, discussed the development of programs and courses available to students from both colleges in such areas as biochemistry, biophysics, and neuroscience. The program directors and their faculty colleagues noted that enhancements in the curriculum, through new faculty appointments, equipment acquisitions, and laboratory development, have helped to strengthen other aspects of their programs, including student research and outreach to teachers and students.

At Case Western Reserve University, the involvement of faculty members from a wide range of fields and academic departments has been a key to the development of interdisciplinary science curricula. Norman Rushforth, Chair and Professor of the Department of Biology, and Hillel Chiel, Professor of Biology, reported on their programs that integrate instructional and research activities in the Colleges of Science, Mathematics, and Engineering with those in the School of Medicine. Some of the areas covered are molecular and cell biology, organismal biology, and population biology. Following the presentation, the program directors discussed the issue of "supermarket" (broad-based) courses versus "boutique" (highly specialized) courses, noting the importance of undergraduate curricula that express a variety of learning styles and can convey the excitement of scientific discovery.

Clifton Poodry, Associate Vice Chancellor and Professor of Biology, and Jerry Feldman, Professor of Biology, discussed their Institute-supported program at the University of California–Santa Cruz that offers, as a principal component, summer research opportunities for undergraduates. Drs. Poodry and Feldman reviewed aspects of the program, including efforts to recruit women and underrepresented minority students, pre-research lab-

oratory training for participating students, and such follow-up activities as guest seminars by distinguished researchers and opportunities for students to present their research. As a group the program directors discussed a range of topics concerning the culture of laboratory science, the benefits of laboratory experience and mentoring for students underserved in the sciences, and the outlook for undergraduates who are considering careers in research and science teaching.

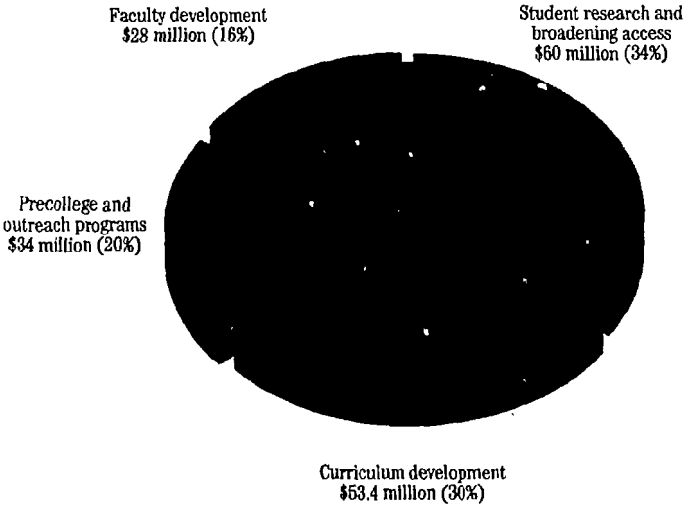
Undergraduate Program Grants, Phase II, 1993 and 1994 Competitions

HHMI's 1993 and 1994 competitions mark a new phase in the undergraduate program. In the first phase, the Institute provided a total of $175.4 million in 1988–1992 to 181 colleges and universities for grants to support undergraduate science education (Figure 25). Institutions were encouraged to develop programs that responded to their particular needs and strengths. Thus, the undergraduate program supports a range of activities in numerous scientific disciplines at participating institutions. Among these activities are student, faculty, and curriculum development and precollege and outreach programs.

Phase II was developed, in part, on the basis of findings from HHMI's ongoing assessment of the undergraduate program. One such finding, discussed extensively by the program directors, has been

Figure 25

Undergraduate Biological Sciences Education Program, Awards to 181 Colleges and Universities ($175.4 million), by Program Component, Phase I, 1988–1992 Competitions



the importance of undergraduate research as a means of attracting and retaining students, including women and members of minority groups underrepresented in science.

At these meetings the program directors have also noted the important role colleges and universities can play in enriching precollege science education. A number of the presentations have focused on grantee-developed activities to provide laboratory and classroom training for students and teachers from elementary and secondary schools and from two- and four-year colleges.

The annual progress reports submitted by grantee colleges and universities are another important source of background for undergraduate program development. Over the five years of the program, the directors have emphasized how grant-supported equipment acquisitions and laboratory development have enabled them to provide instruction in the contemporary biological sciences and other disciplines as they relate to biology. In addition, they point to the energizing effect of equipment and laboratory enhancements on undergraduate research and precollege and outreach programs. They also draw attention to a critical need for continued support to modernize the undergraduate science infrastructure.

The Institute has developed new guidelines and elements for 1993 and 1994 programs, based on information collected through these assessment activities (Figure 26). Support for undergraduate research, including opportunities for women and underrepresented minority students, remains as a central component of the new undergraduate program. Activities to prepare students for laboratory research and enable them to present their findings will also be supported. In addition, precollege and outreach programs in the sciences will continue to be a priority.

Applicant institutions may now request up to the full grant amount

Figure 26

Undergraduate Biological Sciences Education, Program Elements and Guidelines

1988–1992	1993–1995
■ Student and faculty development, supporting undergraduate research experiences, opportunities for women and minority students underrepresented in the sciences, and new faculty appointments, included as program elements	■ Student research, including opportunities for women and minority students underrepresented in the sciences, retained as program element
■ Curriculum and laboratory development, supporting new and revised courses, equipment acquisitions, and laboratory renovations, included as program element	■ Equipment and laboratory development, supporting equipment acquisitions and laboratory renovations for undergraduate laboratory courses, retained as program element
■ Precollege and outreach included as program element	■ Precollege and outreach retained as program element
■ Support for equipment and laboratory renovation limited to 30 percent of total grant amount	■ No limitation on funding for equipment, and funding for renovation limited to 50 percent of total grant amount
■ Five-year grant period	■ Four-year grant period

Figure 27

Undergraduate Biological Sciences Education Program, Invited Institutions, 1994

Andrews University, Michigan
Arizona State University
Auburn University, Alabama
Baylor University, Texas
Boston College, Massachusetts
Boston University, Massachusetts
Brandeis University, Massachusetts
Brigham Young University, Utah
Brown University, Rhode Island
California Institute of Technology
Carnegie Mellon University, Pennsylvania
Case Western Reserve University, Ohio
Catholic University of America, District of Columbia
Clark University, Massachusetts
Clemson University, South Carolina
College of William and Mary, Virginia
Columbia University, New York
Cornell University, New York
Dartmouth College, New Hampshire
Drexel University, Pennsylvania
Duke University, North Carolina
Emory University, Georgia
Florida Institute of Technology
Florida State University
Fordham University, New York
George Washington University, District of Columbia
Georgetown University, District of Columbia
Georgia Institute of Technology
Harvard University, Massachusetts
Howard University, District of Columbia
Illinois Institute of Technology
Indiana University at Bloomington
Iowa State University
Johns Hopkins University, Maryland
Kansas State University
Kent State University Main Campus, Ohio
La Sierra University, California
Lehigh University, Pennsylvania
Louisiana State University and A&M College
Loyola University of Chicago, Illinois
Marquette University, Wisconsin
Massachusetts Institute of Technology
Miami University, Ohio
Michigan State University
Mississippi College
Montana State University
New York University
North Carolina State University
Northwestern University, Illinois
The Ohio State University Main Campus
Oklahoma State University Main Campus
Oregon State University
Pennsylvania State University Main Campus
Polytechnic University, New York
Princeton University, New Jersey
Purdue University Main Campus, Indiana
Rensselaer Polytechnic Institute, New York
Rice University, Texas
Rutgers the State University of New Jersey Newark Campus
Rutgers the State University of New Jersey New Brunswick Campus
Saint Louis University, Missouri
Southern Illinois University at Carbondale
Southern Methodist University, Texas
Stanford University, California
State University of New York at Albany
State University of New York at Binghamton
State University of New York at Buffalo
State University of New York at Stony Brook
State University of New York College of Environmental Science and Forestry
Stevens Institute of Technology, New Jersey
Syracuse University Main Campus, New York
Temple University, Pennsylvania
Texas A&M University
Texas Tech University
Tufts University, Massachusetts
Tulane University, Louisiana
The University of Akron Main Campus, Ohio
The University of Alabama
University of Arizona
University of Arkansas Main Campus
University of California–Berkeley
University of California–Davis
University of California–Irvine
University of California–Los Angeles
University of California–Riverside
University of California–San Diego
University of California–Santa Barbara
University of California–Santa Cruz
University of Chicago, Illinois
University of Cincinnati Main Campus, Ohio
University of Colorado at Boulder
University of Connecticut
University of Delaware
University of Florida
University of Georgia
University of Hawaii at Manoa
University of Houston, Texas
University of Illinois at Chicago
University of Illinois at Urbana-Champaign
University of Iowa
University of Kansas Main Campus
University of Kentucky
University of Louisville, Kentucky
University of Maine
University of Maryland Baltimore County
University of Maryland College Park
University of Massachusetts at Amherst
University of Miami, Florida
University of Michigan–Ann Arbor
University of Minnesota–Twin Cities
University of Mississippi
University of Missouri–Columbia
University of Nebraska
University of Nevada, Reno
University of New Hampshire
University of New Mexico Main Campus
University of New Orleans, Louisiana
University of North Carolina at Chapel Hill
University of North Dakota Main Campus
University of Notre Dame, Indiana
University of Oklahoma Norman Campus
University of Oregon
University of Pennsylvania
University of Pittsburgh Main Campus, Pennsylvania
University of Rhode Island
University of Rochester, New York
University of South Carolina–Columbia
University of South Dakota
University of South Florida
University of Southern California
University of Tennessee–Knoxville
University of Texas at Arlington
University of Texas at Austin
University of Toledo, Ohio
University of Utah
University of Vermont
University of Virginia
University of Washington
University of Wisconsin–Madison
University of Wisconsin–Milwaukee
University of Wyoming
Utah State University
Vanderbilt University
Virginia Polytechnic Institute and State University
Washington State University
Wayne State University, Michigan
West Virginia University
Yale University, Connecticut
Yeshiva University, New York

for equipment for undergraduate science education. The new program also provides up to 50 percent of the total grant amount for renovation of teaching laboratories. Faculty development and curriculum development in the sciences are no longer included as categories.

In the first Phase II competition, held in 1993, 47 grants were made to public and private comprehensive and liberal arts institutions. For the 1994 grants competition, 151 public and private research and doctorate-granting universities were invited to compete (Figure 27). Institutions receiving HHMI awards in 1989–1990 and 1992, and other institutions meeting the assessment criteria, were extended invitations.

Proposals will be reviewed by an external panel of scientists and educators. Their evaluations will then be reviewed by an internal HHMI committee, which will make recommendations to HHMI's Trustees, who will authorize funding. Grants providing approximately $72 million over a four-year period will be announced late in the summer of 1994.

Assessment Criteria

To identify institutions as eligible, HHMI has referred in each competition to the 1987 classification of higher-education institutions by the Carnegie Foundation for the Advancement of Teaching. The Carnegie classifications are based on such factors as the level of degree offered, nature of the educational mission, degree of specialization in particular fields, and amount of annual federal support for research and development. HHMI has also taken into account the institutions' records of preparing students for scientific careers who are from minority groups underrepresented in the sciences. Figure 28 shows the Carnegie classification of institutions that received awards in Phases I and II.

Figure 28

Undergraduate Biological Sciences Education Program, Grantees by Carnegie Foundation Classification, 1988–1993

	1988–1992 Phase I	1993 Phase II
Carnegie Classification		
Research Universities I and II	76	—
Doctorate-Granting Universitites I and II	16	—
Comprehensive Universities and Colleges I and II	23	20
Liberal Arts Colleges I and II	64	27
Schools of Engineering and Technology	2	—
Totals	**181**	**47**

For the 1994 competition, institutions from the chosen Carnegie categories (Research Universities I and II and Doctorate-Granting Universities I and II) were invited to compete, as in the past, on the basis of their records of graduating students who went on to medical school or to the Ph.D. degree in biology, chemistry, physics, or mathematics (Figure 29). Data for this selection, reflecting the most recent 10-year period for which data were available, were provided by the Association of American Medical Colleges,

the National Research Council of the National Academy of Sciences, and the U.S. Department of Education.

New Awards, 1993

In August 1993 the Institute completed a fifth competition for under-

Figure 29

Assessment Criteria

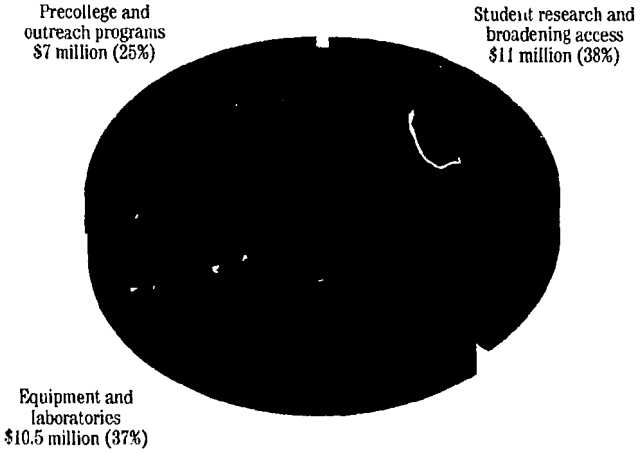
In 1988–1992, institutions were assessed for participation in the Undergraduate Biological Sciences Education Program on the basis of the percentage (calculated with data on total baccalaureate degree production collected by the U.S. Department of Education) and absolute number of graduates from each institution who have:

- Matriculated in medical schools
  Data Source: Association of American Medical Colleges.
- Earned doctorates in biology
  Data Source: National Research Council of the National Academy of Sciences.
- Earned doctorates in chemistry, physics, or mathematics
  Data Source: National Research Council of the National Academy of Sciences.

Note: Assessments for the 1988 and 1989–1990 competitions were based on data for the periods 1976–1986 (for doctorates earned in biology, chemistry, physics, or mathematics). Assessments for the 1991–1992 competitions were based on data for the periods 1979–1988 (for medical school matriculation and doctorates earned in biology, chemistry, physics, and mathematics).

Figure 30

Undergraduate Biological Sciences Education Program, Awards to 47 Colleges and Universities ($28.5 million), by Program Component, Phase II, 1993 Competition



graduate grants and made awards totaling $28.5 million to 47 colleges and universities (Figure 30). The 47 grantees competed within a pool of 175 institutions classified by the Carnegie Foundation as public and private Comprehensive Colleges and Universities I and II, Liberal Arts Colleges I and II, and Schools of Engineering and Technology. The Institute's four-year grants range from $500,000 to $1,400,000 each, and respond to the institutions' proposals for support of a variety of program activities in undergraduate science education. (See pages 48–54 for a list of the grantee institutions and descriptions of their awards.)

Undergraduate Research, Including Opportunities for Women and Minority Students Underrepresented in the Sciences

As noted above, student research is a major activity funded through the undergraduate program (Figure 31). Of the $28.5 million awarded in 1993, a total of $11 million will provide laboratory research experiences for undergraduates at the introductory through upper-division levels. HHMI support will enable some students to work off-campus in laboratories of research universities and private industry and will provide others with close faculty collaboration in campus laboratories. These laboratory experiences will be offered during the summer or academic year and, in some cases, during both periods. Institute funds will also support training to prepare students for laboratory

Figure 31

Student Research and Broadening Access Programs

California State University, Northridge

Opportunities for students, particularly those at the freshman level and transfer students from community colleges, to engage in research experiences, benefit from increased academic and career counseling, and be exposed to the culture of science.

City University of New York Hunter College

Increasing access for students, including women and students from minority groups underrepresented in the sciences, to laboratory research through summer training workshops in molecular biology, neurobiology, and cell structure, followed by academic-year laboratory research experiences.

Morehouse College

Significantly expanded laboratory opportunities for students during the summer and academic year, both on the campus and at a research university with which the College has established a partnership, and opportunities for students to present their research.

Oberlin College

Summer and academic-year laboratory experiences for students, and opportunities to discuss research at an on-campus colloquium with visiting scientists and to present research results at regional or national conferences.

Swarthmore College

Faculty laboratory research experiences for students, including women and members of underrepresented minority groups, with opportunities to travel to scientific meetings, a seminar series on interdisciplinary research, and other activities.

Wellesley College

A program in which women students would be teamed with science faculty mentors and provided summer laboratory experiences spanning several years, including opportunities to present their research at meetings on and off campus.

Figure 32

Equipment and Laboratory Development Programs

Bowdoin College

Equipment acquisitions to enhance student independent research experiences, and introductory, intermediate, and upper-division laboratory courses in such fields as biochemistry, biophysics, genetics, and neuroscience.

Bryn Mawr College

Enhancements in teaching laboratories for programs in organismal biology, neural and behavioral sciences, and other scientific disciplines by computer upgrades and laboratory renovations.

Carleton College

Modern instrumentation to strengthen undergraduate laboratory instruction and student research in such areas as molecular and developmental biology, neuroscience, and related scientific disciplines.

Fort Lewis College

The development of laboratory facilities and the acquisition of scientific equipment for instruction and undergraduate research in biochemistry, cell and molecular biology, physiology, and macromolecular isolation.

University of Puerto Rico Rio Piedras Campus

New equipment to strengthen laboratory instruction in such areas as biochemistry, cell and molecular biology, developmental biology, and genetics, and to enhance introductory-level laboratories in chemistry and physics by using biological examples.

University of Texas at El Paso

Significant enhancements in introductory and upper-division laboratories in cell and molecular biology, immunology, physiology, and plant biology through renovations and new equipment acquisitions.

research and opportunities to present their findings at scientific meetings.

Forty-four of the 47 awardee institutions will use their HHMI grants to attract and retain students in scientific fields by providing them with stipends to participate in laboratory research at their own institutions or at off-campus sites. A major emphasis in many of these programs will be to broaden the access to science for women and students from underrepresented minority groups.

Equipment and Laboratory Development

A total of $10.5 million provides support to 42 grantee institutions for equipment acquisitions and laboratory renovations (Figure 32). These funds will support capital upgrades and enhancements needed to strengthen introductory, intermediate, and upper-division undergraduate courses emphasizing hands-on experimentation. The new equipment and laboratory improvements will provide expanded opportunities for faculty-student research collaboration.

Equipment and laboratory development funds will also support efforts on the part of science departments to integrate the teaching of biological sciences with chemistry, physics, mathematics, and computer science. For example, a number of institutions will use the funds to include biological examples in physical science courses. In addition, several institutions will establish

computer laboratories to supplement course work in the biological sciences by providing expanded instruction in data and computational analysis.

Precollege and Outreach Programs

A total of $7 million was awarded to colleges and universities for collaborative programs with elementary, middle, and high schools and two- and four-year colleges (Figure 33). One of the principal forms of outreach will be opportunities for teachers and students at these schools and colleges to participate in research at college and university laboratories. Many grantee institutions will direct these efforts to schools and colleges with significant enrollments from underrepresented minority groups.

A total of 39 colleges and universities receiving 1993 grants will undertake programs aimed at enhancing teaching and learning in the sciences, especially at the precollege levels. The funds will provide stipends for teachers and students participating in research and laboratory training activities. In addition, a number of programs will provide equipment and materials to enable science teachers to implement new curricula, particularly at rural and inner-city schools. Other supported activities include visiting scientist programs, in-service workshops, and degree programs for teachers.

Figure 33

Precollege and Outreach Programs

City University of New York City College

Outreach programs for students, particularly women and underrepresented minorities, to include such activities as research experiences, counseling, and science career information for high school students; summer research or academic preparation courses for prefreshmen; and a summer transfer program for community college students.

Humboldt State University

A program to increase recruitment and retention in the sciences for Native American students from western states, including California, Nevada, Oregon, Washington, and Montana, through ongoing contact with tribal colleges and schools, support and mentoring at the University, and on- and off-campus laboratory experiences.

Western Maryland College

An expanded outreach program engaging Baltimore area high school students and teachers in studies of the biology of the Chesapeake Bay, using the Bay as a science laboratory.

Wheaton College

A program to attract and retain students, particularly those from inner-city Chicago schools, through laboratory instruction in biology, chemistry, and mathematics, with tutoring and peer counseling by college students from similar backgrounds.

Wofford College

Expansion of a two-week summer residential precollege science program, conducted by College science faculty and students, for gifted 6th-, 7th-, and 8th-graders from Spartanburg, South Carolina.

Xavier University of Louisiana

Summer academic enrichment programs in biology, chemistry, and mathematics for underrepresented minority students in the 9th through 12th grades, primarily from metropolitan New Orleans, and support for junior and high school teachers to develop new teaching materials.

Overview of the Undergraduate Program, Phase I, 1988–1992

Grants Competitions and Awards

The first phase of the undergraduate program began in 1988 with the initial competition in which HHMI invited 81 private liberal arts and comprehensive institutions and 18 public and private historically black institutions to apply for five-year grants to bolster their science programs. Following review of the 99 proposals by external and internal panels of scientists and educators, 44 institutions, including 34 private four-year colleges and 10 public and private historically black institutions, were awarded a total of $30.4 million. (For further information on these grants, see HHMI's *Grants Program Policies and Awards, 1988–1989.*)

In 1989, 101 public and private research and doctorate-granting universities were invited to submit proposals to enhance undergraduate education in biology and related fields. Following review of the proposals, HHMI provided grants totaling $61 million to 51 universities. These awards were paid over a two-year period. (See HHMI's *Grants for Science Education, 1989–1990.*)

In 1991 a total of 98 public and private institutions, including comprehensive and liberal arts colleges and universities and institutions with demonstrable records of educating minority students underrepresented in the sciences, competed for undergraduate awards. Forty-four of these institutions, including 10 with significant presence of underrepresented minority students, received support totaling $31.5 million for a range of program activities. (See HHMI's *Grants for Science Education, 1990–1991.*)

The first program phase was completed in 1992, and a fourth competition was held in which 98 research and doctorate-granting universities were invited to submit proposals. HHMI awarded grants totaling $52.5 million to 42 of these institutions. (See HHMI's *Grants for Science Education, 1991–1992*, and *1993 Undergraduate Program Directory, A Listing of Program Directors and Grants Awarded at 181 Colleges and Universities, 1988–1992.*)

Undergraduate Research: Opportunities for Women and Minority Students Underrepresented in the Sciences

Of the total funding of $175.4 million provided in the first phase of the undergraduate program, approximately $60 million has been used at 170 of the 181 grantee institutions for programs to recruit and retain students in the sciences, especially those underrepresented in scientific fields, such as women, blacks, Hispanics, and Native Americans. The principal student activity supported under the program is undergraduate research, providing opportunities for students, many with no prior laboratory experience, to learn scientific concepts, terminology, and techniques while assist-

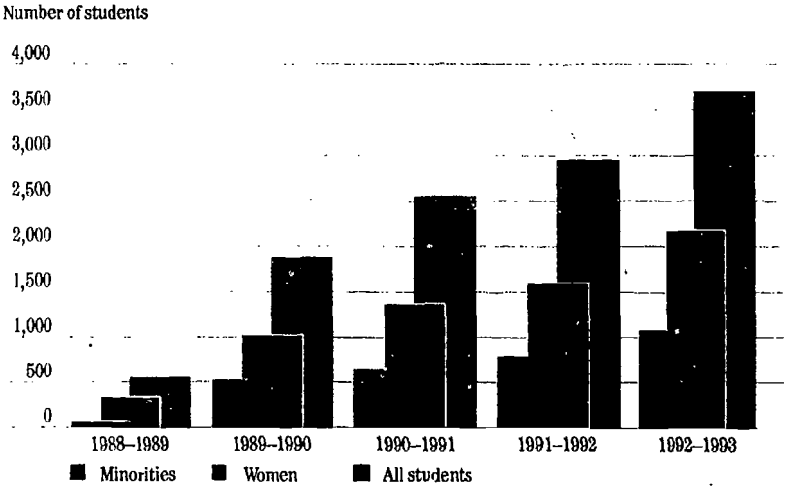
ing scientists in research projects on or off campus. At a number of institutions, th se research experiences have b.:en enhanced by prior training activities and subsequent opportunities for students to present and publish their research findings.

Since its inception in 1988, the undergraduate program has supported over 11,500 undergraduates conducting research (Figure 34). Of this total, 56 percent are women and 27 percent are students from minority groups underrepresented in scientific fields. Most of the students (92 percent) conducted research at their own institutions, and a limited number (8 percent) worked off campus at other universities or colleges, in government laboratories, or with private corporations (Figure 35). Forty-five percent of these research experiences took place during summer, 36 percent during the academ-

Figure 34

Undergraduate Research, 1988–1993

Student Participation Trends



Student Participation—Total

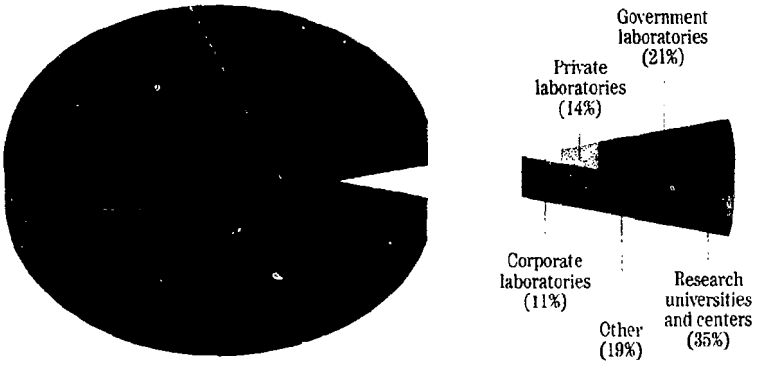
	Number	Percent
All students	11,522	100%
Women	6,449	56
Minorities	3,158	27

ic year, and the rest anned both periods (Figure 35).

Grantee institutions have reported a significant impact of undergraduate research opportunities in attracting student interest in the sciences and helping to retain that interest through the college years

Figure 35

Undergraduate Research Sites, 1988–1993

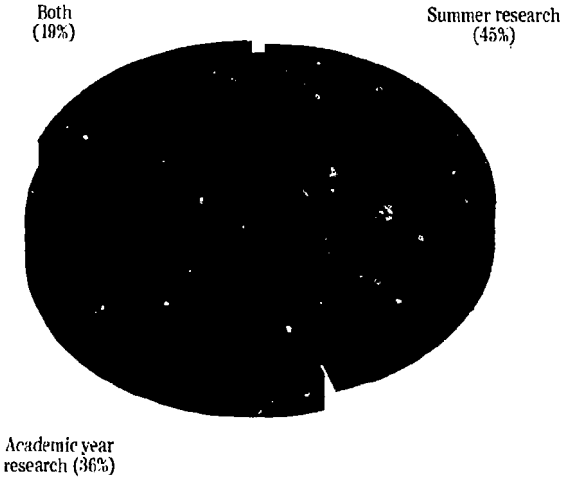


All research sites

Off-campus research sites

Figure 36

Undergraduate Research by Academic Period, 1988–1993



and beyond. According to a number of participating students, HHMI-supported research experiences have been major factors in acceptances into outstanding graduate and medical programs and in receipt of national fellowships. For example, several undergraduates supported though this program have gone on to receive fellowships under HHMI's highly competitive predoctoral fellowship program.

Faculty Development in the Sciences

In the initial program phase, a total of $28 million has been used by 98 of the 181 awardee institutions for science faculty development, including the appointment of new faculty members, programs to engage research faculty in undergraduate teaching, and other activities. Since 1988, HHMI funds have enabled 55 colleges and universities to appoint 169 faculty members in a range of scientific disciplines. These HHMI-supported appointments include 82 women (49 percent) and 21 faculty members from minority groups underrepresented in scientific areas (12 percent) (Figure 37). These appointments are providing departments with opportunities to develop new courses in important areas of modern science and to update and expand curricula.

The scientific disciplines in which HHMI-supported faculty have been appointed include cell or molecular biology, biochemistry/biophysics, and neuroscience (Figure 38). In several cases the new appointments have enabled institutions to bridge science departments, such as biology and chemistry, in the development of interdisciplinary programs. The new faculty members have begun to distinguish themselves at their colleges and universities, which are reporting important contributions in teaching, research, and institutional service.

HHMI provides funds for activities that enrich the current faculty scientists' knowledge of their fields and enhance their ability to convey

Figure 37

New Faculty Appointments, 1988–1993*

	Number	Percent
Faculty Appointments	169	100%
Underrepresented Minorities	21	12
Women	82	49

**Of the 169 Institute-supported appointments, 39 are non-tenure track.*

Figure 38

New Faculty Appointments, by Scientific Field, 1988–1993

Field	Number of Appointments
Cell or molecular biology	41
Biochemistry/biophysics	26
Neuroscience	22
General biology	11
Chemistry	10
Genetics	5
Physics	5
Physiology	4
Other biological and scientific fields	45
Total	**169**

Figure 39

Curriculum and Laboratory Development, Selected Course Areas, 1988–1993

Area	Number of Courses
General biology	299
Chemistry	252
Biochemistry	218
Molecular biology	218
Cell biology	189
Neuroscience	159
Physiology	134
Laboratory techniques	120
Genetics	116
Physics	103
Topics in biological sciences	102

new knowledge to students. Science faculty members have received support to participate in workshops, seminars, professional meetings, and training programs in the sciences.

Curriculum and Laboratory Development and Equipment

A total of $53.4 million has been directed to the development of science curricula and laboratories, enabling nearly all of the 181 grantee institutions participating in the initial program phase to enhance the quality of instruction in the biological sciences and other disciplines as they relate to biology. HHMI grant support in this area is principally directed to the acquisition of modern scientific instruments and to laboratory renovation. The program also supports the development of new experiments for use in courses, laboratory manuals, and other instructional materials.

Since 1988 HHMI has supported the development of approximately 2,500 courses covering a wide range of scientific disciplines, such as genetics, molecular and cell biology, and neuroscience (Figure 39). Approximately 30 fields of biology and other disciplines are represented. Numerous grantee institutions are using their awards to relate biology teaching to chemistry, physics, mathematics, and computer science. In such cases biological examples are integrated into laboratory courses in the physical sciences and other areas.

Another important objective of HHMI's support of curriculum and laboratory development is the enhancement of opportunities for hands-on laboratory research in undergraduate science courses. Grantee colleges and universities are developing teaching laboratories at the introductory through upper-division levels, providing undergraduates with research experiences that may be continued in faculty laboratories. Institutions report that for many students these research experiences are stimulating interest in science majors and careers.

Precollege and Outreach Programs

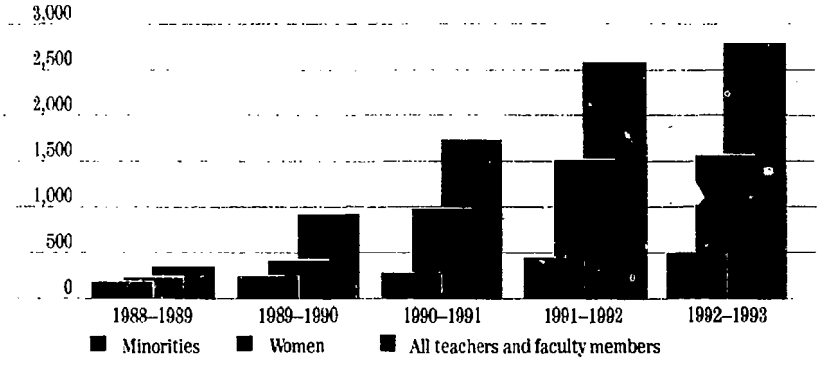
In the first program phase, HHMI awarded $34 million to 170 of the 181 grantee colleges and universities to develop or expand linkages with precollege and other institutions. The objective of these initia-

Figure 40

Outreach Program Participants, 1988–1993

Teacher Participation Trends

Number of teachers and faculty members

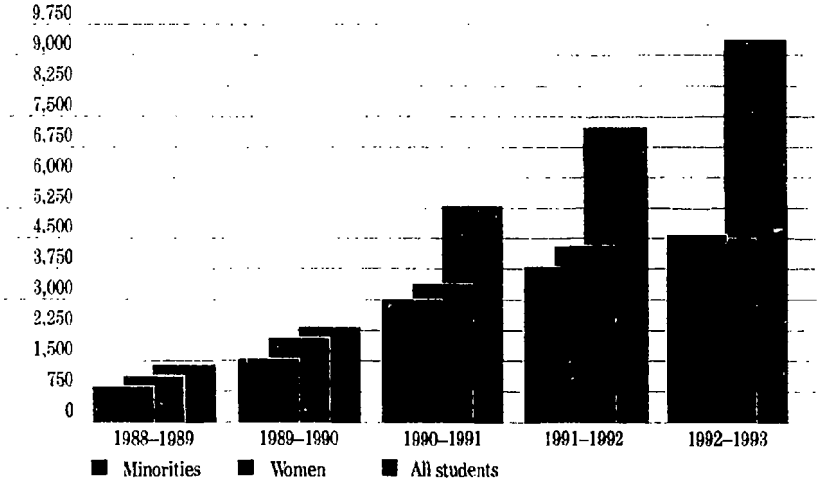


Teachers and Faculty Members—Total

	Number	Percent
All teachers	8,239	100%
Women	4,630	56
Minorities	1,525	19

Student Participation Trends

Number of students



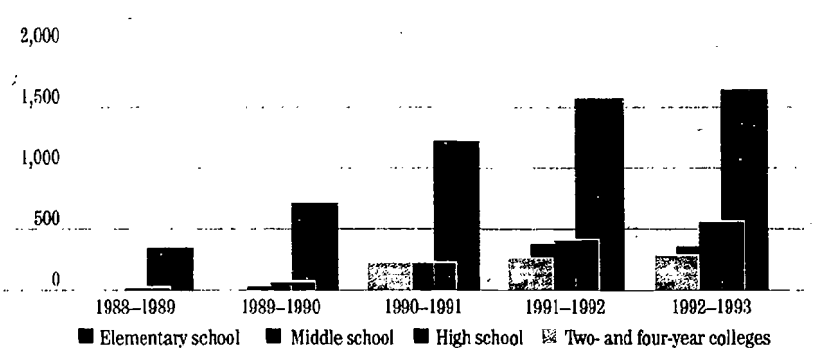
Student Participation—Total

	Number	Percent
All students	25,371	100%
Women	13,718	54
Minorities	14,940	59

Figure 41

Outreach Program Participants by Level, 1988–1993

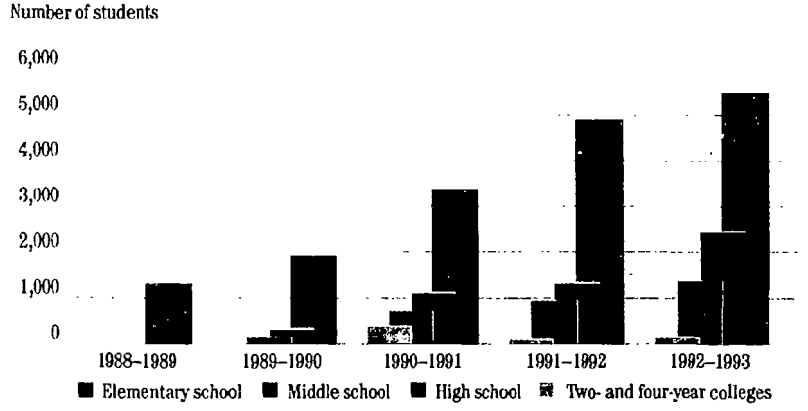
Teacher Participation in Outreach Programs by Teaching Level



Teacher Participation—Total

	Number	Percent
All teachers	8,239	100%
Elementary school	887	11
Middle school	1,228	15
High school	5,435	66
College	689	8

Student Participation in Outreach Programs by Educational Level



Student Participation—Total

	Number	Percent
All students	25,371	100%
Elementary school	5,245	21
Middle school	3,209	12
High school	16,654	66
College	263	1

tives is to enhance the quality of the institutions' science programs. They are also intended to attract and retain students in the sciences, particularly women and students from underrepresented minority groups. Programs include summer and academic-year laboratory experiences for teachers and students, summer science camps, equipment loans, and curriculum development, as well as classroom training for students in biology and chemistry, physics, mathematics, and other areas as they relate to the biological sciences.

Since 1988, approximately 8,200 teachers, of whom 56 percent are women and 19 percent are minority group members, have participated in HHMI-supported outreach activities (Figure 40). In addition, about 25,000 students have been involved, including 59 percent minority students and 54 percent women.

Teachers from elementary, middle, and high schools, faculty members from two- and four-year colleges, and students from these institutions have benefited from HHMI's precollege and outreach support (Figure 41). Of the participating teachers, approximately 66 percent have been from high schools. Also significantly represented have been elementary and middle school teachers and two- and four-year college faculty. Students from high schools again accounted for 66 percent.

Colleges and universities have reported on the laboratory activities of precollege students participating in HHMI-supported outreach programs. A number of these students have received recognition for their research through such activities as the Westinghouse Science Talent Search and local, regional, and national science fairs. Many have also been accepted into leading undergraduate science programs. In addition, a number of teachers from elementary and secondary schools have attributed improvements in their science teaching to participation in HHMI programs.

Undergraduate Biological Sciences Education Program, 1993 Awards

Amherst College $500,000
Amherst, Massachusetts

Bates College $500,000
Lewiston, Maine

Bowdoin College $550,000
Brunswick, Maine

Bryn Mawr College $600,000
Bryn Mawr, Pennsylvania

California State University–Los Angeles $650,000
Los Angeles, California

California State University–Northridge $700,000
Northridge, California

Carleton College $850,000
Northfield, Minnesota

City University of New York City College $650,000
New York, New York

City University of New York Herbert H. Lehman College $500,000
Bronx, New York

City University of New York Hunter College $650,000
New York, New York

Clark Atlanta University $550,000
Atlanta, Georgia

College of the Holy Cross $550,000
Worcester, Massachusetts

Colorado College $650,000
Colorado Springs, Colorado

Concordia College–Moorhead $550,000
Moorhead, Minnesota

Fisk University $550,000
Nashville, Tennessee

Fort Lewis College $500,000
Durango, Colorado

Gettysburg College $500,000
Gettysburg, Pennsylvania

Hampton University $500,000
Hampton, Virginia

Haverford College $600,000
Haverford, Pennsylvania

Hobart and William Smith Colleges $550,000
Geneva, New York

Humboldt State University $800,000
Arcata, California

Knox College $500,000
Galesburg, Illinois

Morehouse College $1,000,000
Atlanta, Georgia

Oberlin College $500,000
Oberlin, Ohio

Ohio Wesleyan University $500,000
Delaware, Ohio

Saint Joseph's University $500,000
Philadelphia, Pennsylvania

St. Mary's University $650,000
San Antonio, Texas

Saint Olaf College $500,000
Northfield, Minnesota

San Diego State University $500,000
San Diego, California

Smith College $600,000
Northampton, Massachusetts

Southern University and A&M College at Baton Rouge $700,000
Baton Rouge, Louisiana

Swarthmore College $650,000
Swarthmore, Pennsylvania

Tougaloo College $500,000
Tougaloo, Mississippi

Tuskegee University $500,000
Tuskegee, Alabama

Union College $500,000
Schenectady, New York

University of Puerto Rico Cayey University College $600,000
Cayey, Puerto Rico

University of Puerto Rico Mayaguez Campus $500,000
Mayaguez, Puerto Rico

University of Puerto Rico Rio Piedras Campus $500,000
Rio Piedras, Puerto Rico

University of Texas at El Paso $850,000
El Paso, Texas

Ursinus College $500,000
Collegeville, Pennsylvania

Wellesley College $850,000
Wellesley, Massachusetts

Wesleyan University $500,000
Middletown, Connecticut

Western Maryland College $500,000
Westminster, Maryland

Wheaton College $550,000
Wheaton, Illinois

Williams College $500,000
Williamstown, Massachusetts

Wofford College $700,000
Spartanburg, South Carolina

Xavier University of Louisiana $1,400,000
New Orleans, Louisiana

Undergraduate Biological Sciences Education Program, 1993 Grant Summaries

Amherst College, Amherst, Massachusetts
$500,000 in support of a program to attract and retain students in the sciences, including women and minority students underrepresented in scientific fields, to include such components as academic-year laboratory research experiences, a science dormitory for student researchers, travel to scientific meetings, symposia to present research, and enhanced mentoring and advising.

Bates College, Lewiston, Maine
$500,000 in support of the following: (1) student research experiences in faculty laboratories both on and off campus, opportunities to attend scientific meetings, and other activities; (2) laboratory equipment to enhance undergraduate interdisciplinary teaching in the neurosciences and other areas of the biological sciences; and (3) outreach programs for rural elementary and junior high schools that may include: laboratory experiences for high school science teachers with College faculty, activities in the sciences for elementary and junior high school students, particularly girls and members of minority groups underrepresented in the sciences, and local public science education using the College's planetarium.

Bowdoin College, Brunswick, Maine
$550,000 to support a program of (1) equipment acquisitions to enhance student independent research experiences and introductory, intermediate, and upper-division laboratory courses in such fields as biochemistry, biophysics, genetics, and neuroscience; (2) student development and research experiences, to include summer and academic-year opportunities in faculty laboratories, workshops, and seminars to attract and retain students in the sciences, including students from minority groups underrepresented in scientific fields; and (3) outreach to teachers at high schools in rural Maine, to provide laboratory experiences, equipment to develop science classes at their home schools, and ongoing contact with College faculty.

Bryn Mawr College, Bryn Mawr, Pennsylvania
$600,000 in support of activities for attracting and retaining women in the sciences through (1) enhancements in teaching laboratories for programs in biology, neural and behavioral sciences, and other scientific disciplines by computer upgrades and laboratory renovations; (2) undergraduate summer research opportunities with College faculty, to include student stipends, research supplies, travel to conferences, and participation in interdisciplinary seminars and discussion series, and a summer research program for students from historically black colleges to conduct research in Bryn Mawr laboratories; and (3) science enrichment workshops in biology and neural and behavioral sciences for Philadelphia public school science teachers from all grade levels, to include stipends and mini-grants for teachers.

California State University–Los Angeles, Los Angeles, California
$650,000 in support of (1) a research training program in the biological sciences for freshmen and sophomores, especially women and students from underrepresented minority groups, to include academic preparation for research through workshops and seminars, tutoring and group study activities, faculty/peer advising and mentoring, and research participation with faculty mentors, and (2) equipment purchases to enhance undergraduate laboratory research training and experience in the biological sciences and related disciplines.

California State University–Northridge, Northridge, California
$700,000 to support (1) summer and academic-year research experiences in faculty laboratories for introductory-level students; enhanced academic advising and peer tutoring for freshmen and transfer students; student travel to scientific meetings; and other activities, and (2) a program to provide training and materials to develop student research programs in the biological sciences to science teachers from Los Angeles junior and senior high schools with significant minority enrollments.

Carleton College, Northfield, Minnesota
$850,000 in support of (1) modern instrumentation for undergraduate laboratory instruction and student research in molecular and developmental biology, neuroscience, and related scientific disciplines; (2) opportunities for undergraduates to engage in summer research with college faculty, to include student stipends, research supplies, and travel to scientific meetings to present research; and (3) academic and research training in science for entering freshmen; (4) a summer research program for high school students from San Antonio, Texas; and (5) an introduction to mathematics and principles and methods of scientific research for middle school students, including those from underrepresented minority groups.

City University of New York City College, New York, New York
$650,000 in support of (1) programs of student research and broadening access for students that may include the following activities: freshman research preparation and participation, upper division research, and various broadening access activities; (2) outreach programs for students, particularly women and underrepresented minorities, to include such activities as research experiences, counseling, and science career information for high school students, summer research or academic preparation courses for prefreshmen, and a summer transfer program for community college students; and (3) laboratory instrumentation for cell and molecular biology courses and biology and chemistry modules.

City University of New York Herbert H. Lehman College, Bronx, New York
$500,000 in support of the following: (1) renovations and equipment for undergraduate teaching laboratories to introduce students to modern scientific principles and research in introductory and advanced level biological courses; (2) summer outreach programs for 11th- and 12th-grade students and prefreshmen, especially those from underrepresented minority groups; and (3) an academic year program for freshmen and sophomores, to include research, advising, and other academic development.

City University of New York Hunter College, New York, New York
$650,000 in support of the following: (1) increasing access to laboratory research through summer training workshops in molecular biology, neurobiology, and cell structure, followed by an academic year research program for undergraduates; (2) renovation of an undergraduate facility and acquisition of scientific instrumentation to support laboratory training in neurobiology and molecular immunology and basic research techniques; and (3) an outreach program, to include summer training workshops for local high school biology teachers and follow-up activities for high school students.

Clark Atlanta University, Atlanta, Georgia
$550,000 to support the following: (1) research training and laboratory experiences for students, beginning with a prefreshman course in mathematics and scientific principles and techniques, followed by summer and academic-year research opportunities with faculty members and at research universities, industrial laboratories, and other sites; (2) renovations and equipment acquisitions to permit the expansion of a laboratory course in cell biology; and (3) summer laboratory training in genetics for biology teachers from Atlanta high schools and equipment and materials for teachers to develop curricula at their home institutions.

College of the Holy Cross, Worcester, Massachusetts
$550,000 to support (1) outreach activities with Worcester public high schools, to provide teachers with laboratory and classroom training in the biological sciences and other fields as they relate to biology, and to develop precollege science curricula; (2) equipment acquisitions to enhance courses in such areas as biochemistry, cell biology, genetics, immunology, introductory biology, and neurobiology; and (3) student research during the summer and academic year in faculty laboratories, and opportunities for students to present their research.

Colorado College, Colorado Springs, Colorado
$650,000 to support a program of (1) summer and academic-year student research experiences in on- and off-campus laboratories, with opportunities for students to participate in scientific meetings, present their research, and other activities; (2) outreach activities, to include summer laboratory and classroom training for students, particularly black, Hispanic, and Native American students from high schools in Colorado, New Mexico, and Arizona, and an extension of this program in scientific analysis and writing for College students; and (3) equipment acquisitions for student research and laboratory courses in genetics and molecular biology.

Concordia College–Moorhead, Moorhead, Minnesota
$550,000 in support of (1) on-campus laboratory experiences for students working during the summer in faculty-student research teams; (2) equipment and renovations for laboratories to enhance teaching and learning in such disciplines as molecular genetics and developmental biology, plant physiology, and human anatomy and physiology; and (3) expansion of programs with local schools and a tribal college to increase the participation of Native Americans in science through on-campus laboratory experiences for teachers and faculty-teacher collaboration in precollege biology curriculum development.

Fisk University, Nashville, Tennessee
$550,000 in support of (1) a program for juniors to include individualized instruction on the basic principles and applications of various biological and biochemical techniques in the life science research, supplemented with lectures, mentoring, and other activities, followed by independent research with faculty mentors, and opportunities to travel to scientific meetings, and (2) laboratory equipment and instrumentation for student research and general undergraduate biology courses.

Fort Lewis College, Durango, Colorado
$500,000 in support of (1) development of laboratory and classroom facilities and the acquisition of scientific equipment for instruction and undergraduate research in biochemistry, cell and molecular biology, physiology, and macromolecular isolation; (2) increased opportunities for undergraduates, especially women, Native Americans, Hispanics and blacks to participate in summer research with College faculty; and (3) expanded research experiences for high school or community college science teachers.

Gettysburg College, Gettysburg, Pennsylvania
$500,000 in support of (1) an outreach program that will bring kindergarten through 12th-grade teachers from local school districts, including those serving rural students, together with College science faculty to engage in interdisciplinary, problem-based learning in the biological and physical sciences, and (2) provide equipment to schools to enable students to perform classroom experiments in modern biology.

Hampton University, Hampton, Virginia
$500,000 in support of (1) a program to attract and retain underrepresented minority students in scientific fields by providing a prefreshman program of laboratory and classroom training in molecular biology, laboratory research experiences, and opportunities to present research; (2) equipment acquisitions and laboratory renovations to support student research; and (3) activities to develop high school students' interest in science, including laboratory experiences in biology and chemistry, visits to research laboratories, and guest scientific lectures.

Haverford College, Haverford, Pennsylvania
$600,000 in support of (1) programs for students, including women and members of minority groups underrepresented in the sciences, to provide summer and academic-year laboratory experiences, interdisciplinary study and research in the biological sciences, and seminars and symposia on biomedical topics; (2) equipment acquisitions to modernize laboratory courses and introduce new experiments in such fields as biochemistry, biology, and biophysics; and (3) outreach initiatives, including laboratory and classroom training, for teachers and students from Philadelphia area middle and high schools, particularly those with significant minority enrollments.

Hobart and William Smith Colleges, Geneva, New York
$550,000 in support of (1) equipment acquisitions and renovations for undergraduate laboratories, such as introductory biology and a microcomputer laboratory, and (2) a summer research program based on laboratory research groups composed of one faculty member, two upperclassmen, two underclassmen, and one prefreshman.

Humboldt State University, Arcata, California
$800,000 to support (1) a program to increase recruitment and retention in the biological sciences on the part of Native American students from western states, including California, Nevada, Oregon, Washington, and Montana, through ongoing contact with tribal colleges and schools, support and mentoring at the University, and on- and off-campus laboratory experiences; (2) equipment acquisitions for teaching laboratories in such areas as molecular biology, physiology, and microbiology; and (3) faculty-student laboratory research and opportunities for students to attend scientific meetings and present their research.

Knox College, Galesburg, Illinois
$500,000 in support of (1) instrumentation to develop laboratory courses in such areas as immunology, genetics, and structural and cell biology with a view to imparting scientific principles and techniques to students preparing for independent research experiences; (2) summer research opportunities for undergraduates, particularly those from underrepresented minority groups; and (3) an outreach program that could include training in mathematics and physics for underrepresented minority high school students from the Chicago area.

Morehouse College, Atlanta, Georgia
$1,000,000 in support of a program to provide students from minority groups underrepresented in the sciences with the following: (1) precollege outreach activities for high school students from Atlanta and throughout the United States that include classroom training in science, mathematics, and general study skills and hands-on laboratory experiences at the College or at off-campus sites, and a prefreshman program in the sciences; (2) student research experiences from the sophomore through senior year that include summer and academic-year research at the College and at another institution, as well as opportunities for students to present their research ; and (3) laboratory courses in the areas of plant sciences, molecular genetics, biochemistry, and ecology, enhanced with new equipment and renovations.

Oberlin College, Oberlin, Ohio
$500,000 in support of (1) laboratory renovations and equipment acquisitions to expand and enhance teaching in areas that could include general introductory biology, chemistry, and neuroscience; (2) summer and academic-year laboratory experiences for students, including women and students from minority groups underrepresented in the sciences and opportunities for students to discuss research at a colloquium with visiting scientists and present research results at regional or national conferences; and (3) a program to interest biology majors in science teaching by linking them with College faculty and with local high school teachers in developing instructional materials on specific biological topics to be presented by the students in high school classrooms.

Ohio Wesleyan University, Delaware, Ohio
$500,000 to support (1) equipment acquisitions and renovations for a teaching laboratory in botany, microbiology, and zoology, or in chemistry, physics, or mathematics; (2) on-campus student summer research, mentoring, and opportunities for students to present research; and (3) outreach opportunities for precollege teachers and students in the biological sciences and other disciplines as they relate to biology.

Saint Joseph's University, Philadelphia, Pennsylvania
$500,000 in support of (1) a summer research program for undergraduates from Saint Joseph's University, women's colleges, and historically black institutions from the Philadelphia area, to provide student stipends, research supplies, and student travel to professional meetings, and (2) new and upgraded equipment to enhance instruction in the core science curriculum and to implement new laboratory curriculum improvements in upper-division courses, such as biochemistry and molecular genetics or physiology.

St. Mary's University, San Antonio, Texas
$650,000 to support (1) renovations and equipment acquisitions to support the development of laboratory teaching in the biological sciences and other disciplines as they relate to biology, such as biochemistry, molecular biology, genetics, and organic, inorganic, and physical chemistry; (2) summer research experiences for students at off-campus biomedical research laboratories, and student development in the sciences; and (3) laboratory experiences and other opportunities in the sciences for students at San Antonio high schools, including those serving significant numbers of underrepresented minority students.

Saint Olaf College, Northfield, Minnesota
$500,000 in support of (1) a summer research program consisting of undergraduate laboratory experiences, support for underrepresented minority students, and research opportunities for Minneapolis community college students; (2) equipment for undergraduate laboratory instruction in introductory and upper-level biology and chemistry courses; and (3) outreach initiatives to enhance science education at the elementary and precollege level, including a program to link teachers from rural and inner-city elementary schools with College faculty.

San Diego State University, San Diego, California
$500,000 to support (1) equipment acquisitions and renovations for introductory and upper division teaching laboratories in disciplines that could include biostatistics (with an undergraduate computer laboratory), general biology, cell and molecular biology, microbiology, and physiology; (2) programs for students, including women and underrepresented minorities, such as training for prefreshmen and transfer students, undergraduate support, and other activities; and (3) outreach to San Diego schools that may include laboratory experiences for secondary-school science teachers and activities for primary and middle school students.

Smith College, Northampton, Massachusetts
$600,000 in support of (1) equipment acquisitions for undergraduate laboratories, such as cell biology and regulation, immunology, neuroscience, and other scientific disciplines; (2) a summer undergraduate research program, to include student stipends, research supplies, and travel to present research results; and (3) the integration of two outreach programs to provide access for high school girls into undergraduate science programs, through activities such as a girls' summer residential science program and the provision of resources and experiences for high school teachers and counselors.

Southern University and A&M College at Baton Rouge, Baton Rouge, Louisiana
$700,000 to develop an outreach program for precollege students in the Baton Rouge area to attract academically talented 10th-, 11th-, and 12th-grade students, particularly females and those from minority groups underrepresented in the sciences, into careers in research or medicine.

Swarthmore College, Swarthmore, Pennsylvania
$650,000 in support of (1) research experiences in faculty laboratories for students, including women and members of underrepresented minority groups, opportunities to travel to scientific meetings, a seminar series on interdisciplinary research, and other activities; (2) new instruments to equip laboratories for courses in areas such as physiology and molecular biology; and (3) outreach activities, to include summer research experiences in College laboratories for teachers and students from local high schools, including those with significant enrollments of underrepresented minority students.

Tougaloo College, Tougaloo, Mississippi
$500,000 to support (1) new equipment and laboratory renovations to provide students with hands-on, experiment-oriented instruction in areas of the biological sciences including genetics, molecular biology, and physiology, and to upgrade teaching in chemistry and physics; (2) support for students that includes opportunities to participate in laboratory experiences during the summer and academic year; and (3) summer and weekend laboratory and classroom training in science and mathematics for students and teachers from high schools in the Jackson area.

Tuskegee University, Tuskegee, Alabama
$500,000 in support of (1) renovation of biology and chemistry teaching laboratories and creation of a learning center emphasizing computer-based instruction in biology and chemistry, and (2) expansion of a program that provides students with prefreshman laboratory and classroom training in the sciences, ongoing courses and seminars to strengthen research skills, and research experiences at university, government, and other off-campus laboratories.

Union College, Schenectady, New York
$500,000 to support (1) laboratory renovations and equipment acquisitions to strengthen teaching in such areas as biochemistry, molecular genetics, protein structure and function, and physics, using biological examples; (2) precollege and outreach programs that could include summer science workshops for elementary, middle, and high school teachers, local support groups for science teachers, and other activities; and (3) laboratory research opportunities for students, including those from minority groups underrepresented in the sciences.

University of Puerto Rico Cayey University College, Cayey, Puerto Rico
$600,000 to support a program to attract and retain Hispanic students in the sciences, to include (1) faculty mentoring and summer research experiences for students in on-campus laboratories during their freshman year and opportunities to work in laboratories at research institutions in the United States during the sophomore year; (2) renovations and instrumentation to enhance laboratories for science courses in such areas as biochemistry, cell and molecular biology, and developmental biology, and for undergraduate and precollege research experiences; and (3) a summer training program in scientific principles, methodology, and techniques for students prior to their freshman year.

University of Puerto Rico Mayaguez Campus, Mayaguez, Puerto Rico
$500,000 to support a program to (1) renovate a laboratory facility for undergraduate instruction in such areas as cell physiology, virology, immunology, and molecular genetics, and acquire equipment for courses in majors and nonmajors general biology, and genetics and structural biology; (2) enhance student research experiences to provide opportunities for students to attend scientific meetings; and (3) conduct introductory workshops in molecular biology for local high school biology teachers.

University of Puerto Rico Rio Piedras Campus, Rio Piedras, Puerto Rico
$500,000 to support (1) research opportunities for undergraduates on campus and in off-campus laboratories of pharmaceutical companies and government agencies, a peer tutoring program in chemistry, physics, and mathematics for undergraduates, and expansion of pre-freshman summer workshops in mathematics to enhance quantitative skills, problem-solving abilities, and analytical reasoning; (2) enhancement of laboratory courses and introduction of molecular biology techniques through equipment acquisitions; and (3) production of educational science videos for elementary and intermediate school students, a mathematics research seminar and symposium for junior and high school students during the summer and academic year, and a science competition for junior high and high school students throughout Puerto Rico.

University of Texas at El Paso, El Paso, Texas
$850,000 to support (1) equipment acquisitions and laboratory enhancements for courses at the introductory through upper-division levels in cellular and molecular biology, immunology, physiology, and plant biology; (2) laboratory training and research experiences for students in their sophomore through senior years including on-and off-campus laboratory opportunities and support for travel to scientific meetings; (3) a student development program in the sciences that provides prefreshman workshops in the sciences and in general study skills and continues through the undergraduate years with faculty and peer mentoring, science seminars and symposia, and preparation for and assistance in applying to graduate or medical school.

Ursinus College, Collegeville, Pennsylvania
$500,000 in support of a program to include (1) scientific instrumentation to support student laboratory experiences in cell and molecular biology and organismal systems and a new approach to introductory biology teaching through a team approach to scientific problem solving, and (2) initiatives to prepare undergraduates, especially underrepresented minority groups, for upper-level curriculum in the sciences through financial and academic support for incoming students, a prefreshman bridge program, and tutoring activities.

Wellesley College, Wellesley, Massachusetts
$850,000 in support of programs to attract and retain women in the sciences, to include the following components: (1) summer research opportunities, in collaboration with a faculty mentor, for women and minority students underrepresented in the sciences; (2) equipment acquisitions to strengthen classroom and laboratory instruction in biology and chemistry at the introductory level; and (3) programs to enhance the quality of precollege science education.

Wesleyan University, Middletown, Connecticut
$500,000 to support (1) equipment acquisitions and renovations for a teaching laboratory in botany, microbiology, and zoology, or in chemistry, physics, or mathematics; (2) on-campus student summer research, mentoring, and opportunities for students to present research; and (3) outreach opportunities for precollege teachers and students in the biological sciences and other disciplines as they relate to biology.

Western Maryland College, Westminster, Maryland
$500,000 in support of (1) updated and enhanced laboratory instrumentation for undergraduate courses in molecular modeling and cell biology, and other courses in biology and biochemistry; (2) an expanded outreach program engaging Baltimore-area high school students and teachers in studies of the biology of the Chesapeake Bay, using the bay as a science laboratory; and (3) broadening opportunities for student laboratory experiences through on- and off-campus collaborations, to include student stipends, housing, and travel to present research results.

Wheaton College, Wheaton, Illinois
$550,000 to support (1) a program to attract and retain students, particularly those from minority groups underrepresented in the sciences at inner-city Chicago schools, through laboratory instruction in biology, chemistry, and mathematics, tutoring, and peer counseling by college students from similar backgrounds; and (2) acquisition of laboratory equipment and computers for data analysis, simulations, and other applications.

Williams College, Williamstown, Massachusetts
$500,000 in support of (1) equipment and renovations for introductory biology laboratories and classrooms, and equipment for interdisciplinary biology programs in neuroscience, biochemistry and molecular biology, or biophysics, and for a science and mathematics resource center; (2) outreach activities, such as the expansion of a high school outreach program and development of an elementary school outreach program involving curriculum development and a summer camp for children in grades one through six; and (3) an expanded summer research program for undergraduates.

Wofford College, Spartanburg, South Carolina
$700,000 to support the following activities: (1) expansion of a two week summer residential precollege science program for gifted 6th-, 7th-, and 8th-graders from seven school districts in Spartanburg, South Carolina; (2) the acquisition of instructional laboratory instrumentation for teaching undergraduates the analysis of biological, chemical, and physical systems; and (3) a summer research program to include research teams consisting of College faculty, Wofford undergraduates, and middle/high school students.

Xavier University of Louisiana, New Orleans, Louisiana
$1,400,000 to support a program for attracting and retaining students in the sciences, including women and members of underrepresented minority groups, through the following activities: (1) academic development and other support for biology and chemistry majors, to include financial assistance for freshmen, academic advising for biology and chemistry students through counseling and tutoring, and placement into summer laboratory research programs, and (2) summer academic enrichment programs in biology, chemistry, and mathematics for students from the 9th through 12th grades primarily from metropolitan New Orleans, and support for junior and high school teachers to develop new teaching materials.

Precollege and Public Science Education

The Institute has developed several initiatives in precollege science education, principally to encourage students to choose scientific careers, to provide research opportunities and new teaching tools to teachers, and to address national concerns about the low level of general scientific knowledge and interest among both school-age and adult populations. Among the factors considered in the development of these programs are the major findings of the Institute-supported National Research Council study *Fulfilling the Promise—Biology Education in the Nation's Schools*. In addition, new national initiatives in science education and the results of precollege-oriented outreach activities currently supported under the Institute's undergraduate science education program have been taken into account.

The Institute's initiatives are designed to stimulate the scientific community to work with teachers, school administrators, other educators, and students at all school levels. The main objectives are to stimulate children's interest in science and to improve science education through revision of curricula, improvement of classroom practices, enhancement of teacher education (initial and continuing), and augmented teacher recruitment. The newest Institute initiative in precollege science education encourages a larger role for practicing scientists in every aspect of education reform, from textbook development to teacher training.

Precollege Science Education Initiative for Museums

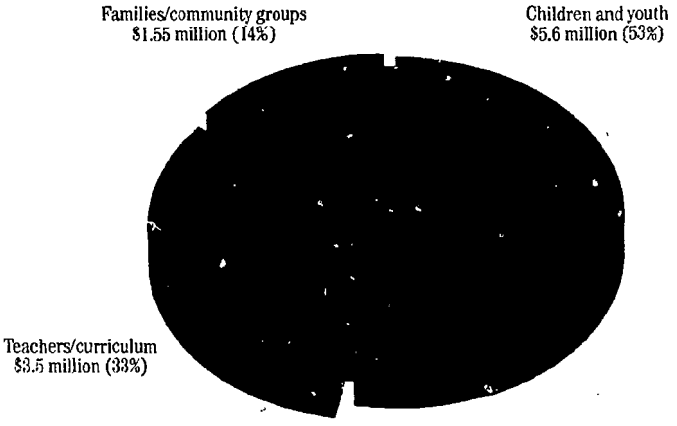
In 1991 the Institute announced its first round of competition for a program in the area of elementary and secondary school education—a program of precollege science education grants for museums. The first awards, totaling $6.4 million, were made in June 1992 to 29 institutions, including children's and youth museums, natural history museums, and science and technology centers. In 1992 the Institute announced a second round of competition, extended to include not only science museums but also aquaria, botanical gardens, and zoological parks. A total of $4.25 million was awarded in August 1993 to 22 institutions.

Throughout the science museum program, the Institute has awarded $10.65 million to 51 institutions, including science museums, aquaria, botanical gardens, and zoos (Figure 42). Of this amount, approximately 53 percent is going to children's and youth activities, 33 percent to teachers and curriculum development, and 14 percent for science outreach to families and communities.

With a major focus on elementary school-age children, this initiative complements the precollege outreach activities funded through the Institute's undergraduate science education program. These have been geared primarily to secondary school students and teachers. The new initiative is intended to further the efforts of museums and related

Figure 42

Precollege Science Education Initiative for Museums, Awards to 51 Institutions Including Aquaria, Botanical Gardens, and Zoos ($10.65 million), by Program Component, 1992 and 1993 Competitions



institutions in developing science education programs for children and youth, for teachers, and for families and community groups.

Natural history museums, aquaria, botanical gardens, and zoos offer a variety of education programs for children on topics related to organismal biology, ecology, genetics, and evolution—subject areas widely recommended for emphasis in the early and middle school grades. These institutions also employ interactive exhibits to foster certain types of learning styles (e.g., curiosity-motivated and exploratory learning) that are not easily nurtured in formal school settings. For many children and their families, living collections are the primary source of informal science education.

Museums and related institutions also train teachers and assist them in instructing their students to develop problem-solving skills and curiosity in settings where they can enjoy learning through exploration. Further, these institutions play significant roles in stimulating parental and communal involvement in the science education of children and youth. Among the activities of particular interest to the Institute are those involving disadvantaged and underserved minority youth and those bringing museum programs to families and youth groups in rural and urban areas with limited science resources.

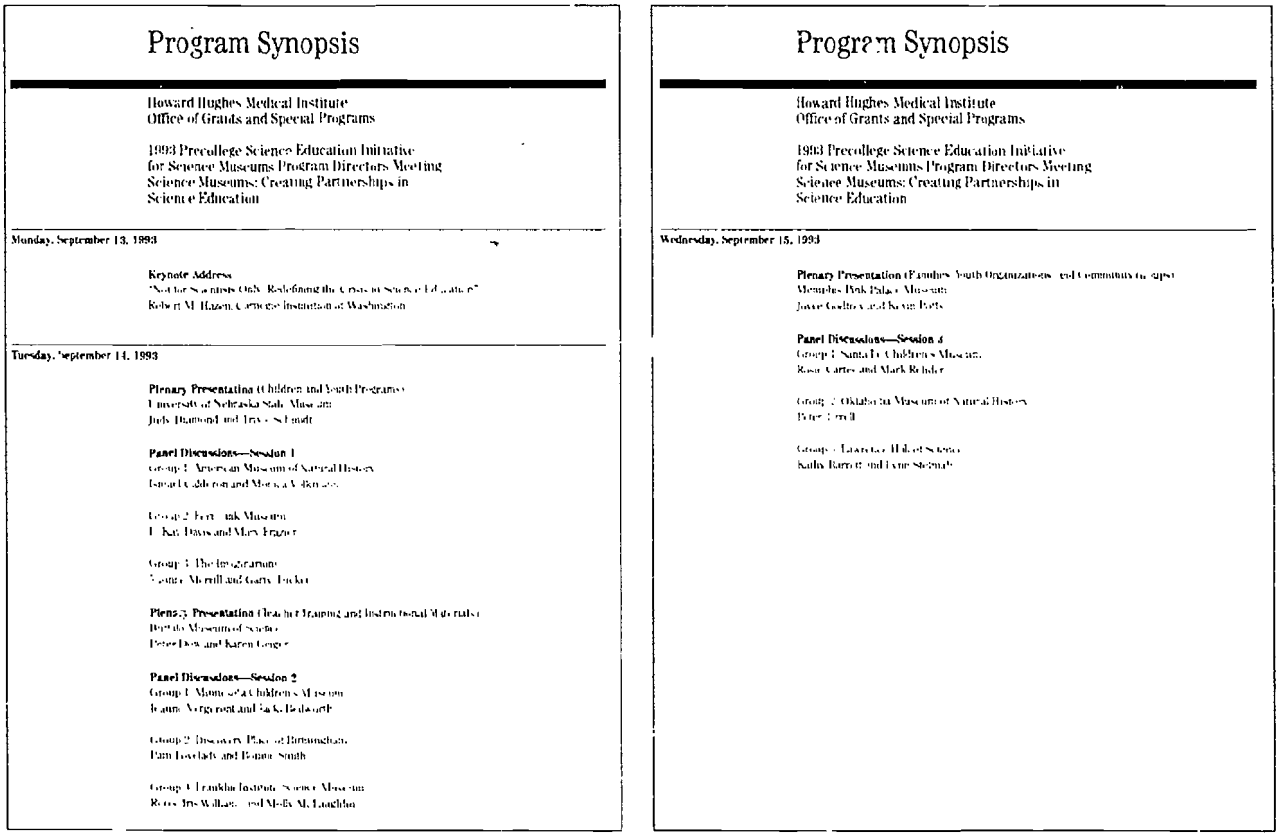
Science Museum Program Directors Meeting

A meeting of the science museum program directors was held September 13–15, 1993. There were 57 attendees from 29 museums that received Institute awards in 1992. The meeting focused on how museums can create partnerships in science education at the state and local levels with schools, families, youth organizations, and community groups (Figure 43).

The keynote address was given by Dr. Robert Hazen, a geophysicist at the Carnegie Institution of Washington and coauthor of *Science Matters*. Dr. Hazen made a strong case for science education activities through which average citizens, regardless of vocation, will come to understand the scientific concepts reported in the news and relevant to their daily lives in matters of health, the environment, and even the economy. Museums meet a special need in regard to this goal because

Figure 43

1993 Precollege Program Directors Meeting



Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Precollege Science Education Initiative
for Science Museums Program Directors Meeting
Science Museums: Creating Partnerships in
Science Education

Monday, September 13, 1993

Keynote Address
"Not by Scientists Only: Redefining the Crisis in Science Education"
Robert M. Hazen, Carnegie Institution of Washington

Tuesday, September 14, 1993

Plenary Presentation (Children and Youth Programs)
University of Nebraska State Museum
Judy Diamond and Tess Schmidt

Panel Discussions—Session 1
Group 1: American Museum of Natural History
Susan Chaikin and Marcia Weinstein

Group 2: Fort Worth Museum
E. Kay Davis and Mary Frazier

Group 3: The Exploratorium
Jeanne Merrill and Gary Becker

Plenary Presentation (Teacher Training and Instructional Materials)
Portland Museum of Science
Peter Dow and Karen Gregor

Panel Discussions—Session 2
Group 1: Miami Museum of Children's Museum
Jeanne Vergeront and Jack Redenbach

Group 2: Discovery Place of Birmingham
Pam Brooks and Bonnie Smith

Group 3: Franklin Institute Science Museum
Rose Ann Wallace and Sheila M. Laughlin

Program Synopsis

Howard Hughes Medical Institute
Office of Grants and Special Programs

1993 Precollege Science Education Initiative
for Science Museums Program Directors Meeting
Science Museums: Creating Partnerships in
Science Education

Wednesday, September 15, 1993

Plenary Presentation (Families, Youth Organizations, and Communities at Large)
Memphis Pink Palace Museum
Jeanie Gaultney and Susan Potts

Panel Discussions—Session 4
Group 1: Santa Fe Children's Museum
Rose Cartes and Mark Rehder

Group 2: Oklahoma Museum of Natural History
Peter Farrell

Group 3: Lawrence Hall of Science
Sally Barrett and Lynne Steenblik

of their emphasis on interactive exhibits and their connection with young audiences and their families.

The diversity of the institutions and communities involved in this initiative has produced a variety of approaches to forming science partnerships. Underlying similarities were evident, however, as participants described strategies, challenges, successes, and future objectives of their programs. In many of the sessions, discussion focused on collaboration with schools, recruitment of girls and minorities for programs, orchestration of effective outreach endeavors, and changing the perception of the museum's role in science education.

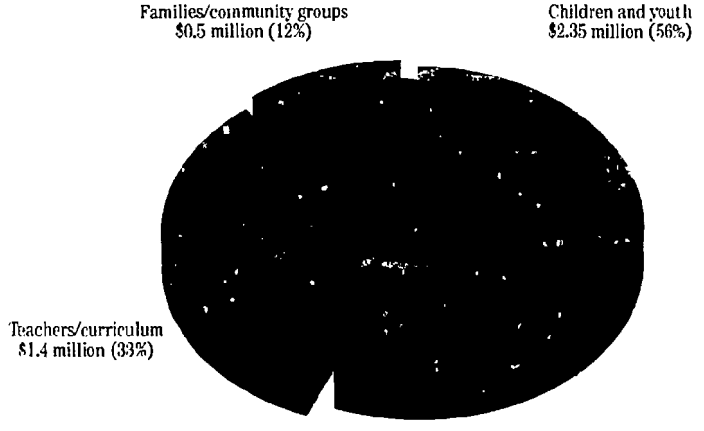
The meeting was enormously beneficial to the participants, many of whom do not have the resources to attend national conferences. It provided an exceptional opportunity to meet colleagues and consult on program activities. It is clear that Institute support will have a constructive impact as the museums develop science education programs addressed to elementary school children and their parents and teachers. Institute support has been an important catalyst for such programs in the institutions' communities. Conference proceedings will be published early in the spring of 1994.

Awards, 1993

Under the museum program, a total of $4.25 million was awarded in

Figure 44

Precollege Science Education Initiative for Museums, Awards to 22 Institutions, Including Aquaria, Botanical Gardens, and Zoos ($4.25 million), by Program Component, 1993 Competition



August 1993 to 22 institutions (Figure 44). Recipients included children's and youth museums, natural history museums, science and technology centers, aquaria, botanical gardens, and zoos. The awards were made on the basis of reviews by an external panel of scientists, educators, and museum program experts, with final determinations by the Institute management and Trustees. Over the next five years, these awards will support curriculum enhancement, teacher training, and science activities for young people, with special attention to minority and disadvantaged populations, both urban and rural.

Children's and Youth Programs

The 1993 grants to museums and related institutions are supporting programs designed to enhance young people's interest in biology and related disciplines and their understanding of these fields. All the projects encourage the participation of girls and of minorities underrepresented in the sciences. Of the $4.25 million, over half—$2.35 million—is dedicated to activities for children and youth. Among the approaches being supported are those that encourage the involvement of students in after-school and summer science activities, including educational programs that ease the transition of underserved minority youth from elementary to secondary school, and programs for youth in both rural and urban areas (Figure 45).

Figure 45

Children's and Youth Programs

Audubon Institute, New Orleans, Louisiana
A yearlong life science immersion program will be provided for 540 upper-elementary public school students over the five-year grant period. The program will also include professional development activities for classroom teachers at participating schools and a family component for adult role models to engage in science activities with their children.

Chicago Academy of Sciences, Chicago, Illinois
Science Scene: KIDS and TEENS is an outreach program that aims to enhance biology and ecology education for 324 disadvantaged minority teenagers and children. The Museum's resources will be combined with those of Northwestern University Medical School and the social service resources of the Chicago Housing Authority. Science Scene will create an environment conducive to science learning and inquiry.

Children's Museum, Boston, Massachusetts
Inquire Within: A Personalized Approach to Environmental Exploration will be developed in collaboration with the Boston public schools. Participants will be approximately 400 5th-grade students and teachers, and the children's families will also take part. The explorations start with developing an understanding that one's body responds to environmental stimuli.

Pratt Museum, Homer, Alaska
Homer High School, using the skeletal remains of a salvaged whale as well as human and marine resources unique to the area, will develop a multidisciplinary approach to science education. Study of the natural history of whales will range from local marine biology to broader issues of ocean conservation. Through an interdisciplinary, hands-on approach, current regional work in marine science will be explored.

South Dakota Discovery Center, Pierre, South Dakota
An outdoor ecostudy area will be developed on five-acre Discovery Island in the Missouri River. The Center will prepare a K–12 science education program to study (1) water quality and its effects, (2) the biology of the wetlands, (3) the ecology of the Missouri Basin, and (4) advanced topics in high school biology. Eventually the program will be available to all of the area's rural and reservation schools.

A number of the funded proposals involve organized collaborations between museums, aquaria, botanical gardens, zoos, and schools. In such coupling, activities may take place at either site—e.g., field trips, classes, demonstrations, sponsor-

Figure 46

Teacher Training and Curriculum Enhancement

Academy of Natural Sciences, Philadelphia, Pennsylvania

Teaching resource kits, containing materials from the Academy's collection, and curriculum materials will be developed to enable science teachers to introduce object-oriented instruction into their classrooms. The project is directed to middle school teachers and students, grades 5–8, in the Philadelphia area.

Missouri Botanical Garden, St. Louis, Missouri

Forty elementary teachers each year will learn organismal and ecological biology, practicing with participants in a summer science camp and incorporating instructional improvements in their classrooms. In addition, 240 inner-city children will be trained in these fields. A hands-on investigative approach to teaching will be used throughout.

National Aquarium in Baltimore, Baltimore, Maryland

Support will go to the Baltimore public schools to implement STARS (science: thinking, application, and research skills), a new science curriculum designed to meet the needs of urban children. The Aquarium will enhance the background of elementary school teachers through workshops, field experiences, and kits. Enrichment classes will be provided for 2nd- to 5th-grade students, 89 percent from minority groups.

New York Hall of Science, Corona, New York

Seventh-grade life science teachers will be trained in microbiology and furnished with materials, equipment, and a support system. Topics of teacher training will include microscopes, collection and maintenance of microorganisms, pathogens and the immune response, and the ethics of genetic engineering. A hands-on, interactive approach to teaching and learning science will be used.

Staten Island Children's Museum, Staten Island, New York

Staten Island elementary school teachers will be supplied with training and tools to teach science in an imaginative and engaging fashion. The Children's Museum will offer science resources for hands-on science experiments, teacher training in the use of visual and dramatic arts for teaching science to elementary school children, and an eight-week Museum residency at each school.

ship of science clubs, and loans of materials, exhibits, or artifacts. Another significant focus is on projects that involve students in a variety of science-related experiences—research experiments, docent or "explainer" activities, exhibition-related opportunities, etc.—beginning in elementary school and continuing through the secondary school years. In many of these programs, efforts will be made to involve older children in teaching science to younger ones.

Teacher Training and Curriculum Enhancement

The Institute's initiative for precollege science education is intended, in part, to provide opportunities for pre-service preparation and in-service training for teachers of biology and related disciplines. Many of the activities funded in 1993 involve development or distribution of instructional materials and/or teacher training, with the primary focus on in-service initiatives. Of the $4.25 million, $1.4 million is dedicated to teacher- and curriculum-related activities (Figure 46). Through support from the Institute grants, a significant number of institutions will develop inquiry-based instructional materials and kits, with an emphasis on distribution to teachers working with limited resources in rural and urban environments. In many cases, the Institute's grant will enable biology educators to establish and maintain precollege science education programs.

Family and Community-Oriented Programs

Recognizing that parental and community involvement in science education will foster young people's interest in science, the Institute designated family and community-oriented science education activities as a major priority for the 1993 initiative (Figure 47). Of the $4.25 million, $500,000 is for family and community group activities. The new grants are supporting a variety of exciting approaches involving families, youth organizations, and community groups in the educational activities of museums and related institutions. Some of the projects provide opportunities for parents and other child care providers (after-school program directors, church groups, Girl and Boy Scout leaders, etc.) to be involved in learning science with children. Several grants will support outreach efforts that bring museum resources to rural families and youth groups with limited science teaching resources.

Evaluation and Assessment

Each year, grantee institutions are required to submit an annual program report containing information that focuses on both quantitative and qualitative measures. The numbers and types of participating students, teachers, and families are tracked for each grant recipient, and the status of development of curricular materials is assessed. In addition, efforts will be made to determine more subtle, qualitative, and long-term impacts of the programs, such as levels of involvement and interest in learning science among families, participating schools, and the general community.

Figure 47

Family and Community-Oriented Programs

Health Adventure, Asheville, North Carolina

Biomedical Sciences Discovery Saturdays will rely on retired biomedical scientists from the North Carolina Center for Creative Retirement to conduct weekly sessions. Participants will be disadvantaged and minority children in grades K–4 and their parents or grandparents. The goal is to reach 2,000. Families in remote areas will be involved through Traveling Trunks, a community outreach program.

Sacramento Science Center, Sacramento, California

The Community Partnership Science Project, addressed to K–9 students at risk for school dropout, is a multiyear, inquiry-based, hands-on program of science instruction. It includes introductory science experiences in youth centers, a summer science camp, volunteer work, and paid employment at the Museum. The project is targeted to youth in North Sacramento, an economically depressed area with a 65-percent minority population.

Woodland Park Zoological Gardens, Seattle, Washington

Volunteers from a local African American church will be trained as docents. By extending contacts with the minority community, the zoo hopes to become a community-wide educational resource. During the grant period, the zoo will offer hands-on classroom presentations and field trips for some 500 5th- and 6th-graders. Community outreach programs will be conducted in environmental and wildlife conservation.

Precollege Science Education Initiative for Biomedical Research Institutions, 1994 Competition

Hands-on laboratory experience is increasingly recognized as necessary to learning science and preparing to teach science. It instructs one to observe, hypothesize, and theorize, and to develop methods by which to generate knowledge. It

Figure 48

1994 Precollege Science Education Initiative for Biomedical Research Institutions

Program Areas

- Student research or hands-on science opportunities
- Teacher training
- Curriculum development and implementation

Goals

- Enhancing precollege education in biology and related fields
- Attracting students to biology and related sciences by providing opportunities to work with scientists in clinical and basic research settings
- Developing programs rich in scientific content that incorporate teaching methods appropriate to the subject matter and the populations to be served
- Increasing interest in science education and research careers among girls and minorities, including African Americans, Hispanics, Native Americans, and other groups underrepresented in the sciences
- Using the extensive resources of medical schools, academic health centers, and research institutions to provide teachers with increased knowledge, technical resources, and professional support
- Establishing long-term partnerships between science-rich institutions and school systems to improve and revise precollege science education

Eligibility

- Among the 258 biomedical research institutions invited by HHMI to submit proposals are:
  - 121 medical schools
  - 85 academic health centers
  - 52 independent research institutions

Awards

- Approximately $5 million in total grants
- Five-year awards from $100,000 to $500,000
- Grant awards will be announced in June 1994

promotes the concept of biology as an experimental science, not just something to be learned through lectures and reading. Finally, the collection and interpretation of data are best taught by trial and error, with opportunities for analysis of results and modification of experimental design.

The use of laboratories in teaching biology, however, is limited and has been declining nationally for many years. Some reasons for this decline are reductions in school resources for supplies, equipment, and laboratory space; lack of laboratory experience in teacher preparation; and the drive to include more curricular content every year, with resulting demands on students' time during the school day. In response to this educational deficit, more institutions of higher education have opened the doors of their laboratories to high school teachers and students, thus offering them both research experience in well-equipped and exciting environments and exposure to working scientists as mentors to students and partners to teachers.

Precollege outreach is a growing activity of undergraduate and graduate academic institutions. In recent years medical schools, teaching hospitals, and independent research institutions have also taken an interest in providing science education outreach to schools in their communities, recognizing that the future of precollege science education is dependent, in part, on the active participation and interest of scientists and engineers.

Virtually every community with a medical school or research organization views that institution as among its most respected and economically important assets. The faculty and staff include many trained professionals who can influence educational policies and practices, especially as they pertain to preparing young people for future careers in medicine and biological research. In addition, many medical schools are located in inner cities and thus offer opportunities to youth currently underserved in mathematics and the sciences.

With these facts in mind, the Institute expanded its support for precollege science education to include other science-rich institutions with a potential for science education outreach to students and teachers (Figure 48). The 1994 grants competition is open to medical schools, academic health centers, and independent research institutions. Since the purpose of the initiative is to provide hands-on research experience and science education for students and teachers, eligible institutions must have an active research program with staff members on site who are willing to give their time and effort to the program. Within an academic health center, research hospitals as well as medical schools qualify and were invited to compete.

As with the 1992 and 1993 awards, proposals will be evaluated by an external panel of scientists, science educators, research and education administrators, and others with relevant expertise. The advisory panel's evaluations and recommendations are reviewed by the Institute management. Recommendations are then made to the Trustees, who authorize funding. It is anticipated that up to $5 million will be awarded under this initiative in June 1994. All grants will have a five-year term and are expected to range from $100,000 to $500,000.

Woodrow Wilson National Fellowship Foundation, National Leadership Program for Teachers

The Woodrow Wilson National Fellowship Foundation, based in Princeton, New Jersey, was established after World War II to encourage people to enter college teaching. To date, more than 18,000 fellowships have been awarded to this end. In the mid-1970s the Foundation created a teacher fellowship program in which selected liberal arts graduates were recruited and trained for secondary-school teaching careers. These fellows obtained teaching experience and completed graduate studies.

In the early 1980s the Foundation switched its training emphasis altogether from college teachers to precollege teachers. Earlier teacher fellowship programs were replaced with a program for exceptional secondary school teachers, called the Science and Mathematics Leadership Institutes. The purpose is to create cadres of teacher leaders to disseminate new knowledge and approaches to teaching on a nation-

Figure 49

Woodrow Wilson National Fellowship Foundation, National Leadership Program for Teachers

Award

- $1.6 million
- Three-year grant term (June 1993–August 1996)

Summer Biology Institute at Princeton University

- Four-week institute
- Fifty teachers selected in national competition
- Intensive research and lecture experience in biology. Past institutes included these topics:
  - A Further Look at Biotechnology
  - Immunology and Vaccine Development
  - Evolutionary Biology
- Development of curricular materials and laboratory manuals for dissemination. Previous laboratory exercises included:
  - Demonstrations using *Agrobacterium* tumors
  - Clonal lineage experiments with transposons in tobacco plants
  - Characterization of HLA types
  - Examination of antibiotic resistance of bacteria
  - Isolation of DNA

One-Week Summer Outreach Institutes

- Twenty-eight sites
- Approximately 40 teachers per site
- Site selection based on present lack of opportunities for teacher training
- Master teachers selected from four-week summer institutes to present and explain materials

al basis. Participants are selected through a national competition on the basis of demonstrated leadership abilities. Some are chosen to take the results of the four-week institute into the field the following summer and teach one-week summer outreach institutes around the country.

HHMI awarded a three-year grant of $1.6 million to the Foundation to fund summer institutes for high school biology teachers (Figure 49). The award will support an intensive four-week summer institute in biology for 50 such teachers. In 1994 the program will be extended to various sites around the country, through outreach by teachers who have attended the summer institute. Through these institutes, participants who have been recognized locally for their excellence in teaching are given the opportunity to interact with other exceptional teachers.

Precollege Science Education Initiative for Museums—Overview, 1992 Awards

The 29 institutions receiving funds in 1992 submitted their first set of annual program reports in May 1993. For many institutions, the first school year of the Institute-funded program was just ending, and for others offering summer courses, emphasis was on planning rather than implementation. The reports, however, give a preliminary view of

Figure 50

Museum Program: Teacher Participation, 1992 Awards

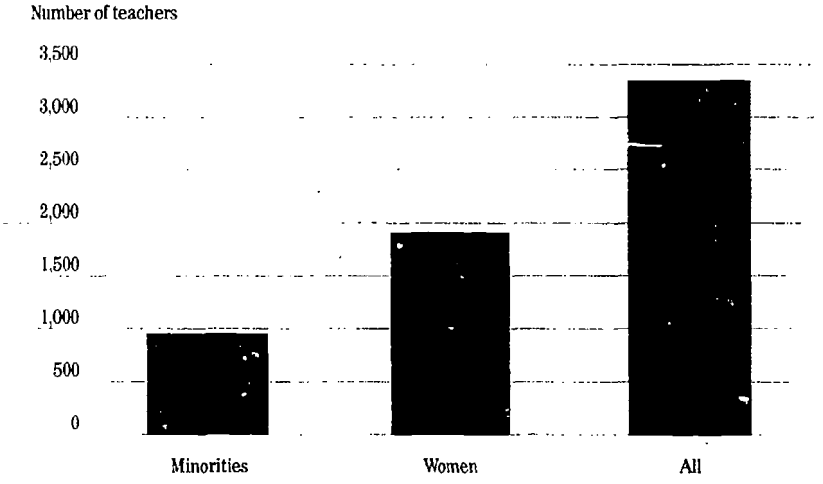


Figure 51

Museum Program: Student Participation, 1992 Awards

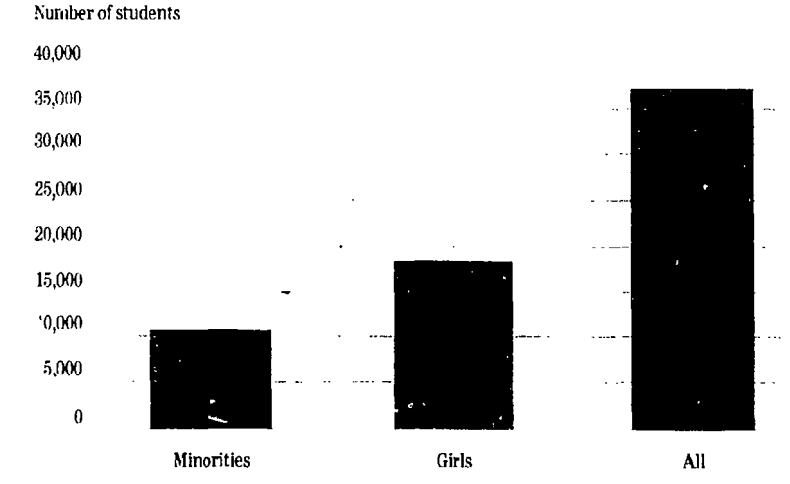


Figure 52

Museum Program: Student Participation by Grade Level, 1992 Awards

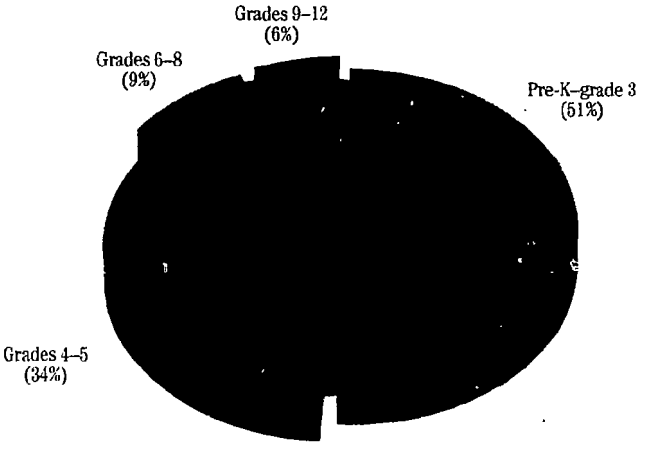
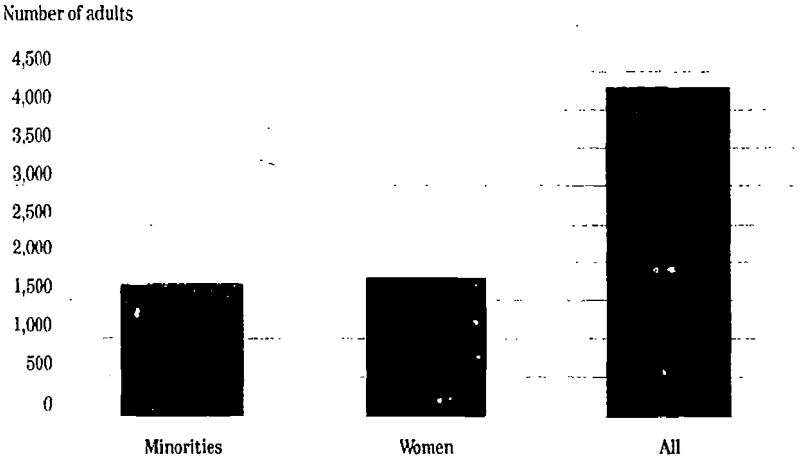


Figure 53

Museum Program: Adult (Family) Participation, 1992 Awards



the magnitude and diversity of the programs.

In the first year of the initiative, about 37,000 students, 3,370 teachers, and over 4,300 adults (family) participated in Institute-funded program activities. Of the teachers, 28 percent were minority and 56 percent women (Figure 50). Of the student participants, 28 percent were minority children and 50 percent were girls (Figure 51).

Over half of the students involved in the science education programs (51 percent) were very young—pre-kindergarten to 3rd grade—confirming the Institute's commitment to provide exposure to science at the earliest school levels. An additional 34 percent of the children were in grades 4 and 5, and 9 percent were in grades 6 and 8. Only 6 percent were in grades 9 through 12 (Figure 52).

Nearly half of the children entering the museum programs did so through other schools. The remainder took part, in general, on site at the museum. Other venues for museum outreach included programs offered in community centers, shopping malls, and libraries. Minority participation in family-centered programs was close to 40 percent (Figure 53). Participation often took the form of classes or workshops, or collaboration with teachers and museum staff members in outreach programs.

The second reporting year (1994) will provide more comprehensive data. Some trends will

Figure 54

Summary of Local Science Education Grants, 1990–1995

Year(s)	Program	Awards (total to date)
1990–1994	Montgomery County Public Schools Student and Teacher Intern Program at the National Institutes of Health	$611,000
1990–1993	Cold Spring Harbor Laboratory Biotechnology Program with the Montgomery County Public Schools	$219,500
1990–1995	Howard Hughes Medical Institute Summer Research Fellowship Program at the National Institutes of Health	$360,000
1990–1995	Carnegie Institution of Washington First Light Program	$65,000
1992, 1993	Maryland Science Week	$15,000
1993–1995	Chesapeake Bay Foundation Science and Environmental Education Program with the Montgomery County Public Schools	$75,000*
	Total	**$1,345,000**

**First year of a three-year program.*

begin to emerge regarding participation rates and participant characteristics, the nature of the programs, and early successes and failures.

Figure 55

Montgomery County Public Schools, Maryland, Student and Teacher Intern Program at the National Institutes of Health, 1992–1993

Participation

- Three teacher interns and 16 student interns in 1992–1993

Examples of Student Research Projects in NIH Laboratories

- Role of the GFAP Basal Promoter in Astrocytes

  Solmaz Tadjer-Ardebili
  Bethesda-Chevy Chase High School

  Franklin Hempel, Ph.D., and
  Michael Brenner, Ph.D., preceptors
  National Institute of Neurological Disorders and Stroke

- Nitric Oxide Protection

  Robert Levendosky
  Albert Einstein High School

  Paul Russell, Ph.D., preceptor
  National Eye Institute

Examples of Teacher Research Projects in NIH Laboratories

- A Study of the Binding Potential of One Class of Tetrahydro-β-Carbolines to the GABA/Benzodiazepine Receptor Complex in Rat Frontal Cortex and Cerebellum

  Howard Edward Schneck
  Bethesda-Chevy Chase High School

  Esther Sternberg, M.D., preceptor
  National Institute of Mental Health

- Studying the Murine Leukemia Virus to Advance Understanding of Reverse Transcriptase

  Alix E. Pratt
  Albert Einstein High School

  Judith Levin, Ph.D., and Robert Crouch, Ph.D., preceptors
  National Institute of Child Health and Human Development

Local Precollege Education Initiatives

Since 1990 the Institute has awarded over $1.3 million to local precollege science education activities in the Washington metropolitan area (Figure 54). These activities range from intensive year-long research experiences for high school students and teachers to Saturday science programs for elementary school children. In addition, the Institute annually supports Maryland Science Week activities through the Maryland Science Center in Baltimore. By providing unique opportunities for students and teachers to gain hands-on experiences in the science classroom and the research laboratory, the Institute's local science education initiatives address national concerns at the local level regarding the state of science education.

In 1993 the Institute awarded three grants for the continuation of precollege life-science education projects initiated over the last several years in the greater Washington, D.C., area, the local community of the Institute headquarters. A primary goal of these grants is to increase the interest of girls and minority group members in pursuing science and science-oriented careers.

In many of the local science education programs funded by the Institute, partnerships between schools and scientific and educa-

tional resources are unlocking doors to new ways of learning science. Among participating institutions are the National Institutes of Health, Carnegie Institution of Washington, DNA Learning Center of Cold Spring Harbor Laboratory, and Chesapeake Bay Foundation.

Two of the 1993 grant awards link area high school students and teachers with biologists at the National Institutes of Health in Bethesda, where participants are involved in intensive research experiences for a full year. The Montgomery County Public Schools Educational Foundation, Inc., received a $150,000 Institute grant to extend the student and teacher intern program initiated as a pilot project in 1990. The grant gives 16 students and 3 teachers from Montgomery County high schools an opportunity to work in NIH laboratories full time in the summer and part time during the school year. A grant of $16,000 was also awarded in 1993 to the Office of Education at NIH in support of activities related to the student and teacher intern program (Figure 55).

Under three-year grants to the Cold Spring Harbor Laboratory ($46,500) and the Montgomery County Public Schools Educational Foundation, Inc. ($173,000), the Institute has supported week-long biotechnology laboratory training institutes for Montgomery County high school biology teachers. To date, approximately 48 teachers have participated. In addition, the grants provide for a van and its stock of sets of equipment for conducting classroom laboratories using recombinant DNA technology. Under this biotechnology program, the teacher participants are working to develop curricula and

Figure 56

Howard Hughes Medical Institute Summer Research Fellowship Program at the National Institutes of Health, 1992–1993

Summer 1993 Fellows

- 27 first-time
- 12 returning

Stipends

- High school students, $2,000
- Returning college students, $2,500

Examples of Student Research Projects in NIH and FDA Laboratories

- The Expression of *p53* in the *myc*-Induced Tumors of Transgenic Mice

  Jocelyn Gibbon
  II-B Woodlawn Secondary Program
  Arlington, Virginia

  Steven Bauer, Ph.D., preceptor
  U.S. Food and Drug Administration

- Adeno-Associated Virus as a Delivery System of Protective Genes Against HIV

  Guang-Shing Cheng
  Harvard University
  (Winston Churchill High School, Class of 1992)

  Mary E. Klotman, M.D., preceptor
  National Cancer Institute

- Nucleotide Binding to Cystic Fibrosis Transmembrane Conductance Regulator and Associated Proteins

  Charles Andrew Fox
  University of Maryland
  (Jewish Day School, Class of 1991)

  Harvey B. Pollard, M.D., Ph.D., preceptor
  National Institute of Diabetes and Digestive and Kidney Diseases

student laboratory exercises on microbiology and bioethics.

The Institute is also supporting summer research experiences for high school students and undergraduates under the local grants program (Figure 56). Through a five-year grant awarded in 1990 to the Foundation for Advanced Education in the Sciences at NIH, about 35 local high school students each year spend their summers doing biology research in NIH laboratories at Bethesda, Maryland. The grant also enables several of the participants to return to NIH laboratories after their first or subsequent years in college.

Figure 57

Chesapeake Bay Foundation Science and Environmental Education Program with the Montgomery County Public Schools

Award

- $295,000
- Three-year grant term (August 1993–August 1996)
- Collaborative program between the Montgomery County Public Schools and the Chesapeake Bay Foundation for science and environmental education activities

Field Programs for Elementary Students

- Approximately 2,000 County students each year
- Sixteen Bay-wide programs of field experiences aboard boats, along streams, and in watershed marshlands
  - Take physical, chemical, and biologic samples
  - Make observations, operating spectrophotometers and other equipment
  - Learn aquatic chemistry, oyster productivity, fish migration, and changes in disease rates of aquatic animals
  - Learn how to keep records and to collate and analyze data

Training for Secondary Science Teachers

- Summer teacher training workshops
- Environmental science as a focus
- Six weeks

Global Ecology Program for Students

- Grades 9–12
- Four-year program in mathematics and science at Poolesville Junior/Senior High School
- Interdisciplinary investigation of the earth's ecosystem at the local, regional, national, and international levels

A $295,000 three-year grant to be shared by the Chesapeake Bay Foundation and the Montgomery County Public Schools supports a collaborative program for science and environmental education activities (Figure 57). The Bay Foundation and the County schools have worked together on science programs since 1975. Each year, about 2,000 County students will join Foundation educators and scientists in 16 Bay-wide programs of field experiences aboard boats, along streams, and in watershed marshlands. Trip activities include taking physical, chemical, and biologic samples, making observations, operating spectrophotometers and other equipment, and learning aquatic chemistry. Students are taught how to keep records accurately and to collate and analyze data, particularly data concerning trends in aquatic chemistry, oyster productivity, fish migration, and aquatic-animal disease rates. County teachers take part in the summer teacher training workshops, which

will be expanded under the Institute grant.

The grant also supports collaboration between the Chesapeake Bay Foundation and the Global Ecology Program at Poolesville Junior/ Senior High School in Montgomery County, an innovative four-year program in mathematics and science that encompasses an interdisciplinary investigation of the earth's ecosystem with emphasis on biochemistry. Because the program features the Chesapeake Bay in its curriculum, strong cooperation with the Chesapeake Bay Foundation will enhance the effort.

A new local activity established by the Institute is a series of holiday lectures for high school students. The lectures are held in the conference center at Institute headquarters in Chevy Chase, Maryland. The speakers are scientists who are known to be effective in communicating science to the general public

Figure 58

Howard Hughes Medical Institute Holiday Lectures on Science

Howard Hughes Medical Institute Holiday Lectures on Science

Monday, December 20 and Tuesday, December 21, 1993

10:00 a.m. – 12:15 p.m.

HHMI Conference Center
4000 Jones Bridge Road
Chevy Chase, MD
20815-6789

This first in an annual series of Howard Hughes Medical Institute Holiday Lectures on Science for high school students will be delivered by

- Stephen K. Burley, M.D., D.Phil., Howard Hughes Medical Institute Associate Investigator and Associate Professor and Co-head of the Laboratory of Molecular Biophysics at The Rockefeller University in New York City, and
- John Kuriyan, Ph.D., Howard Hughes Medical Institute Investigator and Professor of Molecular Biophysics at The Rockefeller University.

Monday, December 20

Molecular Anatomy: First Visions of New Worlds
Stephen K. Burley

Leonardo da Vinci and Christopher Columbus were both four years old in 1456 when Halley's Comet lit up the night sky of their native Italy, heralding a new age of discovery built upon the science of observation. Today, structural biologists are seeing for the first time many of the molecules of life and making their own excursions into a metaphorical new world. Instead of ships and scalpels, however, they are using experimental tools derived from physics and chemistry to dissect and understand the functions of proteins and DNA in the cell.

The Evolution and Variation of Protein Structure
John Kuriyan

The voyage of the young naturalist Charles Darwin aboard the HMS Beagle exposed him to tropical wildlife almost unimaginable in its variety and splendor. The thrill of seeing undreamed-of plants and animals is difficult to recapture, but some of that excitement is regenerated in the modern field of structural biology. Although protein molecules are about a billion times smaller than a typical plant or animal, each has a precise and often beautiful three-dimensional structure that has evolved to carry out a specific function. These structures and functions change over evolutionary time, much like the external forms of the living organisms of which they are a part.

Lunch
12:15 - 1:30 p.m.

Tuesday, December 21

The Central Dogma: DNA Makes RNA Makes Protein
Stephen K. Burley

Throughout a cell's life, its DNA blueprint is consulted and interpreted in response to developmental and environmental signals. Access to this information is orchestrated by ensembles of transcription factors, assemblies of proteins that recognize specific DNA sequences and dictate whether the enzyme RNA polymerase manufactures a messenger RNA copy of the gene. Subsequently, this RNA message is translated by a large RNA-protein complex, a ribosome, into a linear chain of amino acids that folds up to create the protein needed by the cell. Despite the tremendous complexity of these biochemical processes, structural studies of the macromolecular machines responsible for both transcription and translation are already yielding important insights.

Structure and Function of DNA Polymerases
John Kuriyan

In order to pass genetic information to their offspring, all living cells must at some time make a duplicate copy of the genetic information encoded in their chromosomes. At the heart of this replication process are enzymes known as DNA polymerases. These enzymes catalyze the polymerization of new nucleic acid strands based on the information encoded in the original strand. X-ray crystallographic analysis of the proteins that carry out this essential task is now beginning to lead to a detailed structural understanding of the replication process.

Lunch
12:15 - 1:30 p.m.

and reaching out to students at the precollege level.

The first lectures in the series were given in December 1993 by Drs. Stephen K. Burley and John Kuriyan, Howard Hughes Medical Institute investigators at the Rockefeller University. Under the title "Da Vinci and Darwin in the Molecules of Life," they focused on the three-dimensional structure of biologically important molecules and their role in health and disease (Figure 58). Approximately 190 students from 80 high schools in the Washington, D.C., area heard first-hand about exciting advances in biomedical research.

For additional information on the local program grants, including summaries of the research projects undertaken by the student-teacher interns and the summer research student fellows at the National Institutes of Health and the Food and Drug Administration, see *Community Partnerships in Science Education, Washington, D.C., Metropolitan Area Precollege Science Education Initiatives, January 1994.*

Precollege Science Education Initiative for Science Museums, 1993 Awards

Academy of Natural Sciences $100,000
Philadelphia, Pennsylvania

Arizona Museum of Science and Technology $250,000
Phoenix, Arizona

Audubon Institute $150,000
New Orleans, Louisiana

California Museum of Science and Industry $175,000
Los Angeles, California

Chicago Academy of Sciences $350,000
Chicago, Illinois

Children's Discovery Museum of San Jose $175,000
San Jose, California

Children's Museum $275,000
Boston, Massachusetts

The Exploratorium $175,000
San Francisco, California

Health Adventure $100,000
Asheville, North Carolina

Irvine Natural Science Center $125,000
Stevenson, Maryland

Milwaukee County Zoo $200,000
Milwaukee, Wisconsin

Missouri Botanical Garden $125,000
St. Louis, Missouri

National Aquarium in Baltimore $125,000
Baltimore, Maryland

National Zoological Park $125,000
Washington, D.C.

New Jersey State Aquarium at Camden $300,000
Camden, New Jersey

New York Botanical Garden $175,000
New York, New York

New York Hall of Science $400,000
Corona, New York

Pratt Museum $250,000
Homer, Alaska

Sacramento Science Center $225,000
Sacramento, California

South Dakota Discovery Center and Aquarium $175,000
Pierre, South Dakota

Staten Island Children's Museum $125,000
Staten Island, New York

Woodland Park Zoological Gardens $150,000
Seattle, Washington

Precollege Science Education Initiative for Science Museums, 1993 Grant Summaries

Academy of Natural Sciences, Philadelphia, Pennsylvania

$100,000 to produce teaching resource kits and curriculum materials that will enable middle school science teachers to introduce object-oriented, inquiry-based instruction into their classrooms. The kits will contain natural history specimens from the Academy's exhibit collection. Accompanying curriculum guides will provide lesson plans and suggested activities to promote inquiry and discussion. Up to 400 teachers will be trained, and 40,000 students, grades 5–8, will be reached in the greater Philadelphia area.

Teachers will receive pedagogic orientation and training in the use of the kits. Real specimens will be used to stimulate learning in such topics as animal behavior, life cycles, and relationships between animals and their habitats, drawing on the Academy's expertise in aquatic ecology research. The lessons will be designed to encourage all students to participate, including those who do not thrive in traditional classroom settings.

Arizona Museum of Science and Technology, Phoenix, Arizona

$250,000 to create Desert Web, a five-year interactive science outreach program for minority and disadvantaged children, including those studying English as a second language. Teacher workshops will cover the integration of hands-on experiments and projects into the 1st- through 3rd-grade curriculum in targeted school districts of the Phoenix area. Desert Web will include in-service class time of Museum staff members.

The program will use desert-related sciences to encourage students to explore, question, and investigate the world around them. Participating teachers will receive 16 hours of initial instruction and 2 hours of subsequent workshops. By infusing interactive exhibitry and experimentation into school curricula, Desert Web will attempt to breach the linguistic and cultural barriers affecting some segments of the Arizona population.

Audubon Institute, New Orleans, Louisiana

$150,000 to conduct FUN-SCIENCE!, a yearlong life science immersion program for students at the Audubon Zoo and the Aquarium of the Americas, operating entities of the Audubon Institute. Beginning with two neighborhood schools, the program will offer experiential science education for 540 upper-elementary students from public schools over the five-year grant period. A majority will come from minority groups (chiefly African American) typically underrepresented in the sciences. The program will also include professional development activities for classroom teachers and a family component for adult role models to engage in science projects with their children.

FUN-SCIENCE! will explore life science concepts of ecosystems, adaptation, reproduction, growth, and development through the overarching themes of survival, species interdependence, and conservation. Students will work closely with zoo keepers, aquarists, curators, researchers, and technicians and, through this interaction, will experience first-hand the tools and practice of professional science.

California Museum of Science and Industry, Los Angeles, California

$175,000 to provide a comprehensive educational program for the Museum's increasingly diverse clientele of children, families, and teachers. To achieve its goals, the Museum has formed a partnership with the Los Angeles Unified School District and the University of Southern California.

Through two live programs, the Museum expects to reach annually over 40,000 children and adults, including as many as 80 teachers. Your Insides Out! features hands-on activities and experiments in human biology. Science Comes Alive! is an established interactive assembly program addressing more complex physiological problems.

A program for science teachers will develop and present in-service workshops. Through the University of Southern California, an informal science education course will be offered for undergraduate, graduate, and continuing education credit. The live programming and the workshops will cover topics in human biology such as genetics, the brain, and immunology.

Chicago Academy of Sciences, Chicago, Illinois

$350,000 to develop Science Scene: KIDS and TEENS, an outreach program that aims to enhance biology and ecology education for disadvantaged minority teenagers and children. Science Scene will combine the resources of the museum with those of Northwestern University Medical School and the Chicago Housing Authority. It will cover themes and create an environment conducive to science learning and inquiry. KIDS will offer informal workshops in science education to 300 5th- and 6th-grade students from a housing development. In the TEENS component, Northwestern medical students will mentor 24 economically disadvantaged teens from the Chicago public schools, and the Academy will offer training in biology and ecology.

Science Scene will use mentoring to build self-esteem, hands-on experiential learning to generate natural curiosity, and family and teacher involvement to create a supportive environment. As a learning experience, the teens will work in the museum and lead the workshops for the younger children. The program will provide each age group with appropriate teacher role models who can encourage the students to work for their education.

Children's Discovery Museum of San Jose, San Jose, California
$175,000 to create and implement BioSITE, a comprehensive environmental research program serving 1,400 low-income, primarily Hispanic children, families, and teachers in downtown San Jose. The Museum's 11-acre site on the banks of the Guadalupe River affords an opportunity to study both large- and small-scale variables—manmade and naturally occurring—and their impact on a unique urban ecosystem. During the school year, 140 4th- and 5th-graders will participate weekly in an in-depth field work experience.

Children's Museum, Boston, Massachusetts
$275,000 to support Inquire Within: A Personalized Approach to Environmental Exploration, involving collaboration between the Children's Museum and the Boston public schools. Approximately 400 5th-grade students and teachers, together with the children's families, will participate in the five-year development, testing, and dissemination of materials and activities. The project includes summer institutes and workshops to train teachers in biology and environmental science; family guides and environmental monitoring kits for children; teachers guides and kits for monitoring body reactions in the schoolyard environment; and a special program of visits to the Museum's floating urban environmental education center.

Children will first develop an understanding that their bodies respond to environmental stimuli. Anatomy, biology, physiology, meteorology, and ecology will be addressed through inquiry-based investigations. For example, students will increase their understanding of human anatomy and physiology through measurement of lung capacity and pulse under varied environmental conditions, using both technologic and child-made instruments.

Exploratorium, San Francisco, California
$175,000 to develop a multitiered program to enrich education in the biological and biomedical sciences in the San Francisco Bay area. The curriculum will focus on perception and the senses; neurobiology and the brain; genetics, reproduction, and development; and human body systems. The project will also develop a model exhibit-based teacher education curriculum with a strong interdisciplinary science base to support the needs of middle-school science education nationwide. A Biology Teacher Institute will be added to the existing Regional Science Resource Center, offering a summer component and academic-year workshops.

Through various workshops, the project will develop a solid core of biology teachers for the middle schools. The Exploratorium's biology staff will work annually with 200 other teachers in the existing middle and high school Teacher Institute program. By the end of the project, over 60 middle school biology teachers will have received intensive training, and 400 additional science teachers will have interacted significantly with the staff.

Health Adventure, Asheville, North Carolina
$100,000 to conduct a two-part Appalachian biomedical sciences initiative. Biomedical Sciences Discovery Saturdays will draw on retired scientists from the North Carolina Center for Creative Retirement to teach and enhance weekly sessions. Participants—the goal is to reach 2,000—will be disadvantaged and minority children in grades K–4 and their parents or grandparents. Families in remote areas will be involved through Traveling Trunks, a community outreach program.

Inquiry-based biomedical science activities should stimulate interest in science, health, and the miracle of life. These activities will employ the museum's new interactive exhibits, which feature hands-on exploration and experimentation. Areas to be covered relate to light and vision, sound and hearing, the bones and movement, the brain and creativity. Specially designed materials to take home should foster a continuing interest in science and the scientific outlook.

Irvine Natural Science Center, Stevenson, Maryland
$125,000 to support Natural Connections, a program to train volunteers to work with small groups of inner-city elementary school children in outdoor science activities. Selected from the Outdoor Biology Instructional Strategies curriculum, the activities will be focused on the characteristics and ecology of plants and animals.

Sessions for 3rd graders will be held twice each season in schoolyards and local neighborhoods, with teenage volunteers from high school science classes as leaders. During the summer, eight weekly sessions for 8- through 10-year-olds will be offered at recreation centers, aided by adults recruited from the local community. In the course of the five-year project, over 600 volunteers and 2,000 children from 20 pairs of schools and 10 recreation centers are expected to participate. Natural Connections is modeled on the Denver Audubon Society's successful Urban Education Project.

Milwaukee County Zoo, Milwaukee, Wisconsin
$200,000 to support the Educational Opportunities project to stimulate interest in science and promote scientific literacy for urban minority students in grades 3–8. Coordinated with the Milwaukee public schools, the project will address age-appropriate learning objectives in zoology, morphology, botany, and ecology. It will employ curriculum resource packets for classroom activities, six learning zones at the Zoo, a teacher training component, and a minority internship program.

At the Zoo, students will explore the scientific method with teachers and interns in living laboratories. The learning zones are an aquarium, an aviary, reptiles, primates, felines, and animals of Australia. The curriculum includes specific activities in language arts, mathematics, and social studies for pre- and postvisit classroom preparation and reinforcement. Training sessions will assist teachers in integrating the resource packets and Zoo experiences into the classroom curriculum. Female and minority role models are emphasized.

Missouri Botanical Garden, St. Louis, Missouri
$125,000 to improve elementary science instruction in St. Louis. The first component of the program is a teacher training effort in which 40 elementary teachers will learn organismal and ecological biology, practicing new knowledge and skills with participants in a summer science camp and incorporating instructional improvements in their classrooms. The second component will train 240 inner-city children in summer science camps. Concepts to be taught include organism, population, community, ecosystem, structural components of the biosphere, and energy relationships. A hands-on investigative teaching approach will be used throughout the program.

National Aquarium in Baltimore, Baltimore, Maryland
$125,000 to provide support to the Baltimore public school system in implementing STARS (science: thinking, application, and research skills), a new science curriculum designed to meet the needs of urban children. The Aquarium will enhance the background of elementary school teachers through workshops, field experiences, and kits of support materials. Enrichment classes will be provided for 2nd- to 5th-grade students, 89 percent of whom are members of minority populations.

The weeklong in-service workshops will introduce the teachers to life science as it relates to the STARS curriculum. Grade 2 teachers will study vertebrate and invertebrate structure, classification, and adaptation. Sessions with live animals and artifacts will reinforce lectures and Aquarium observations. Grade 5 teachers will study the natural and human history of the Chesapeake Bay through lectures, observations, and hands-on activities.

National Zoological Park, Washington, D.C.
$125,000 to conduct multilevel science education that targets minority populations in five Washington, D.C., area schools. The program, concerning endangered species conservation, will focus on 3,600 students in the 4th, 5th, and 6th grades. Activities include (1) Scientist in the Schools, an interactive lecture series, (2) teacher/scientist workshops to develop multisensory activities for students, (3) class visits to Zoo laboratories and theme-related participation with scientists, (4) computer-assisted learning in Zoo-based conservation biology, and (5) selected student participation in five-week summer enrichment programs.

For most endangered species, the conservation "puzzle" includes ecosystem, behavior, genetic makeup, and reproductive and health status. The multisensory activities will integrate important concepts of conservation biology. The aim of the program is to promote repeated direct contact between scientist and student, teacher and family, while correcting misconceptions about science and scientists.

New Jersey State Aquarium at Camden, Camden, New Jersey
$300,000 to support the Camden Aquarium Urban Science Enrichment Program, a five-year elementary and secondary school project integrating three components: a summer Science Camp, an after-school Ecology Club, and a high school junior staff program. The project will provide science enrichment activities for underserved and disadvantaged urban children in Camden. Forty-two students will participate the first year. By the 5th year there will be over 120 participants. Assuming a high percentage of returnees, an estimated total of 400 students will be involved.

The project will focus on the biology and aquatic ecology of New Jersey and nearby areas. In particular, students will investigate the habitats and adaptations of plants and animals common to southern New Jersey; properties of fresh-water, salt, and estuarine systems; the role and importance of soil in filtration; pollution; conservation; and emerging technologies. Through hands-on activities, field trips, role playing, role modeling, and high-impact demonstrations, students will be encouraged to increase their knowledge and develop a more positive attitude toward science.

New York Botanical Garden, Bronx, New York

$175,000 in partial support of the Children's Adventure Project, designed to offer children immediate experiences with plants and nature in a safe, discovery-oriented environment. The project has two components: the Adventure Garden, where visitors interact with living plant collections integrated with explanatory exhibits; and Adventure Trails, a series of activity-based walks through 250 acres of natural ecosystems. The project targets urban children in grades K–6, especially those from the immediate community, which primarily comprises minorities underrepresented in science.

Three learning objectives are proposed: plants have life requirements, plants experience life processes, and nature is always changing. Using activity-based and inquiry techniques, children will interact directly with living plant collections in a variety of settings and will learn about the work of plant scientists. The project will include play activities to engage children who prefer different styles of learning. By immediately transferring lessons learned in the Adventure Garden to a real scale on the Adventure Trails, children will be better equipped to apply the concepts they have learned to classroom and real life experiences.

New York Hall of Science, Corona, New York

$400,000 to train 350 7th-grade life science teachers in microbiology and to provide materials, equipment, and an ongoing teacher support system. By enhancing instruction in microbiology, recently added to the state's 7th-grade science curriculum, the New York Hall of Science plans to build a critical mass of life science teachers for systemic reform of 7th-grade life science instruction in the New York City schools. Altogether 350 teachers will be trained, each of whom will teach about 100 students per year, making a total of 85,000 students who will benefit during the grant period alone.

Topics of teacher training will include magnification and microscopes, collection and maintenance of microorganisms, fungi as an approach to teaching the microbial world, microbes as pathogens and the immune system response, classroom use of instructional videotapes and the videomicroscope, and the ethics of genetic engineering. A hands-on interactive approach to teaching and learning science will be used. A Hall of Science exhibit, Hidden Kingdoms: The World of Microbes, will serve as a resource for project activities.

Pratt Museum, Homer, Alaska

$250,000 to initiate an inventive, uniquely Alaskan marine science program at Homer High School. Using the skeletal remains of a locally salvaged whale and applying human and marine resources unique to the area, the program will develop a multidisciplinary approach to science education. The planning phase will involve development of an instructional program with emphasis on ocean conservation. Then students, scientists, and Museum staff members will study the whale and assemble the skeleton, suspending it in the school commons for exhibition. Through an outreach program, other schools and the general public will be introduced to the whale, illustrating the results of collaborative, project-oriented science education. Participants in the project will include 65 high school students, 10–15 resource people, and 2 instructors. Eventually, all the students and teachers in the district will have access to the educational portion of the program.

Study of the natural history of whales will range from local marine biology to broader issues of ocean conservation. Through analysis, research, bone preservation, skeletal articulation, and engineering, students will be directly involved in museum work. Through an interactive, student-centered teaching approach, the group will explore current regional work in marine science.

Sacramento Science Center, Sacramento, California

$225,000 to support the Community Partnership Science Project, addressed to K–9 students at risk for school dropout. The multiyear program includes introductory science experiences in community-based youth centers, followed by Summer Science Camp, volunteer experience, and paid employment at the Museum. The project is targeted to youth in North Sacramento, an economically depressed area with a 65-percent minority population. It will address their needs through inquiry-based, hands-on science instruction in five sponsoring community centers.

Twenty community science programs will be offered annually, reaching 3,660 K–8th-graders over the grant term. Thirty 6th- to 8th-graders will attend Summer Science Camp annually; 10 7th- and 8th-graders will be trained as youth volunteers each year; and high school students will serve as paid explainers at the Museum. Integration of biology with physical and earth sciences will be emphasized. Featured activities will involve health, life sciences, and connections with other disciplines and curricula areas.

South Dakota Discovery Center and Aquarium, Pierre, South Dakota

$175,000 to develop an outdoor ecostudy area on Discovery Island, a five-acre succession island on the Missouri River, formed as a result of sedimentation from the Oahe Dam and the channeling of the river. The Center will also prepare a K–12 science education program that uses the ecostudy area to study the biological communities of the wetlands, water quality and its effect on flora and fauna, ecology of the Missouri River Basin, and advanced topics in high school biology.

A K–12 integrative science program will feature hands-on experiments in which students make predictions, collect data, and interpret findings. Initially three rural and two reservation pilot schools will test the program, and eventually it will be available to all rural and reservation schools (122,609 students, including 6,882 Native Americans). An interpretive exhibit and guided walks will be available to all Center visitors.

Staten Island Children's Museum, Staten Island, New York

$125,000 to provide Staten Island elementary school teachers with training and tools to teach science in an imaginative and engaging fashion. The Children's Museum will offer three interrelated components to four schools: permanent science resource centers (stationary or mobile) stocked with equipment and materials for hands-on science experiments, combined with Museum-designed activities, graphics, games, art projects, etc., for use during and after school; teacher training in the use of visual and dramatic arts for teaching science to elementary school children; and an eight-week Museum residency at each school, culminating in a family science festival. The curriculum will be developed for 3rd- to 5th-graders in collaboration with school and district leaders. It is expected that 12–20 classes will participate during each year of the grant.

The science content of the program will be derived from two Museum exhibits, Bugs and Other Insects and Wonder Water, and will comply with state and local curriculum requirements. Strategies for Survival includes metamorphosis, camouflage, adaptation of body parts, and reproduction. Water and Life includes the vital biological functions of water, plant and animal adaptations, and the role of the water cycle in the ecosystem. These topics will be investigated through a variety of hands-on classroom projects, including arts-based techniques.

Woodland Park Zoological Gardens, Seattle, Washington

$150,000 to conduct community outreach programs in environmental and wildlife conservation. Volunteers from a local African American church will be trained as docents so that visitors to the Zoo will find a staff more nearly reflective of the local population. By establishing more contacts with the minority community, the Zoo hopes to improve its ability to address the entire community and encourage minority groups to use the Zoo as an educational resource.

During the grant period, the Zoo plans to offer hands-on classroom presentations and field trips for some 500 5th- and 6th-graders, many of whom are minority students. The children will examine animal specimens, build models, participate in live animal demonstration programs, and conduct field observations.

International Program

In view of the contributions of scientists abroad to advances in biomedical sciences, the Office of Grants and Special Programs added an international focus in 1991 with its program of research grants for biomedical scientists in selected countries. Formerly the international activities were folded into other programs, including the predoctoral and physician postdoctoral fellowships, which are open to U.S. citizens and noncitizens for study in the United States and to U.S. citizens for study abroad. Further, the Research Resources grants to the Cold Spring Harbor and Marine Biological Laboratories support summer courses for scientists and students from all over the world.

Research Grants

The international program provides grant support to promising biomedical scientists who have made significant contributions to fundamental research—that is, to the understanding of basic biological processes and disease mechanisms. These are outstanding scientists whose research careers are still developing, rather than those in later phases of distinguished careers. Awardees must hold a full-time academic or research appointment at a university, medical school, research institution, or other nonprofit scientific institution, and must not have significant administrative responsibilities.

The five-year grants not only provide funds for the scientist's

Figure 59

International Research Scholars, Program and Award Highlights

Selected Countries

- Spring 1991 awards
  - Canada
  - Mexico
- Fall 1992 awards
  - Australia
  - New Zealand
  - United Kingdom

Grant Terms

- Five-year term
- $90,000 to $100,000 annually*
  - equipment (40 percent limit)
  - personnel**
  - supplies
  - travel (5 percent limit)
  - indirect costs (10 percent limit)

Eligibility Criteria

- Selected countries
- Significant fundamental research contributions
- Career still developing
- No major administrative responsibilities
- Not U.S. citizen or permanent resident

Continuing Awards

- Canada
  - 11 grants for 14 scientists
  - 7 institutions
  - $5.8 million five-year total
- Mexico
  - 10 grants for 10 scientists
  - 4 institutions
  - $5.0 million five-year total
- Australia
  - 5 grants for 5 scientists
  - 4 institutions
  - $2.4 million five-year total
- New Zealand
  - 2 grants for 2 scientists
  - 2 institutions
  - $975,000 five-year total
- United Kingdom
  - 21 grants for 22 scientists
  - 12 institutions
  - $10.0 million five-year total

**In Mexico 22 percent of each grant is allocated to the International Research Scholar's department, for shared resources.*

***Technicians, graduate students, and postdoctoral associates. In Mexico the grant may also provide the International Research Scholar an annual salary supplement of $10,000.*

Figure 60

International Research Grants, Program Highlights

Selected Countries

- Fall 1994 awards
  - Belarus
  - Czech Republi
  - Estonia
  - Hungary
  - Latvia
  - Lithuania
  - Poland
  - Russia
  - Slovak Republic
  - Ukraine

Grant Terms

- Research at the Scientist's Own Institution
  - 40–60 five-year awards
  - $10,000 to $75,000 annually*
- Grants Involving International Research Collaboration
  - 40–60 five-year awards
  - $10,000 to $75,000 annually**

Eligibility Criteria

- Eligible Scientist
  - publication in an English language peer-reviewed journal
  - career still developing
  - no major administrative responsibilities
  - affiliation with a nonprofit institution in a selected country
  - fundamental research
  - not a U.S. citizen
- Collaborating Scientist
  - not a resident of a selected country
  - affiliation with a nonprofit institution
  - significant fundamental research contributions

**Grants will provide funds for equipment, personnel (including the eligible scientist), travel, and supplies. Up to 25 percent of each grant may be allocated to the department of the eligible scientist for shared resources. Up to 10 percent is for indirect costs.*

***Grants will provide funds for equipment, personnel (including the eligible scientist, but excluding personnel in the laboratory of the collaborating scientist), supplies, and travel. Up to 15 percent of each grant may be allocated to the department of the eligible scientist for shared resources. Up to 10 percent is for indirect costs of the collaborating scientist's institution.*

laboratory—for equipment, personnel, supplies, and travel—but also contribute to science education through use of grant funds for trainees' stipends and travel and through the availability of equipment and supplies for their research. Moreover, in recognition of the limited resources available in some circumstances and the importance of the intellectual environment in which the scientists conduct their research, a portion of the award in certain countries provides shared resources for the awardees' departments. In all cases, considerable flexibility is allowed in the allocation of funds and in the research itself, to enable the scientists to follow promising new leads in their fields.

Eligible Countries

The first two rounds of awards, the International Research Scholars program, went to investigators in a small number of countries. For the first round, Canada and Mexico (as our immediate neighbors) were selected. Awards to 24 scientists were announced in 1991 (Figure 59). The second round of awards, announced in 1992, went to 29 scientists in Australia, New Zealand, and the United Kingdom. The current competition includes 10 countries of Eastern Europe and the former Soviet Union (Figure 60).

Application and Selection Process

To select candidates for the International Research Scholars program, the Institute solicited nominations

from its own investigators and advisers and from other scientists knowledgeable about biomedical research in the designated countries. The eligible nominees were evaluated by biomedical scientists throughout the United States, and the nominees most highly rated were invited to apply.

For the international program competition involving Eastern Europe and the former Soviet Union, any scientist who meets stated eligibility criteria may apply. The applications, which include a research plan summarizing ongoing or planned work that Institute funding would enhance, are evaluated by an external peer review panel. On the basis of these evaluations and the program goals, the Institute's management selects awardees to be recommended to the Trustees for authorization of funding.

Grant Awards

For the first two competitions, the 49 five-year grants provide annually $90,000 to $100,000, for a total of $24.3 million (Figure 59). These grants included two group awards, so a total of 53 scientists were selected as International Research Scholars in Australia, Canada, Mexico, New Zealand, and the United Kingdom.

For the international program competition involving 10 selected countries of Eastern Europe and the former Soviet Union, two types of five-year grants will be awarded: (1) grants for research at the scientist's own institution and (2) grants involving international research collaborations (Figure 60). There will be 40 to 60 grants of each type. They will range from $10,000 to $75,000 per year, for an annual total of $3 million. The amount of a grant will depend on the needs of the applicant and the economic conditions prevailing at the time the award is made. These awards will be announced at the end of 1994.

Grant Activities

The International Research Scholars in Canada and Mexico were highly productive in the past year, publishing more than 100 articles. (Progress reports listing the articles of the scholars in Australia, New Zealand, and the United Kingdom are not yet available.) In addition, research summaries from all of the Scholars have appeared in the Institute's *Annual Scientific Report* and annual *Research in Progress*.

The Scholars have also participated in scientific meetings held at the Institute's headquarters and conference center in Chevy Chase, Maryland. As a result of the Scholars' interactions with one another and with Institute investigators, these meetings have fostered a number of research collaborations across national boundaries.

The grants in Canada and Mexico have contributed to the stipend support of 75 graduate students and 50 postdoctoral associates. In addition, the grants in Mexico provide for shared departmental resources. The departments reported that

Figure 61

U.S. and Mexican Science Academies, Joint Activities Grants

- Annual symposium in Mexico on biomedical research frontiers
  - October 1992:
    - Molecular Biology of Parasites
- Annual laboratory course
  - Summer 1991:
    - Methods in Computational Neuroscience
      Dr. James Bower, California Institute of Technology
  - November 1992:
    - Molecular Cloning of Neural Genes
      Dr. James Boulter, Salk Institute for Biological Studies
      Dr. Ricardo Tapia, National University of Mexico
  - December 1993:
    - Molecular Biology of Parasite Gene Expression
      Dr. John Swindle, University of Tennessee, Knoxville
- Visiting Scientist Program
  - July 1993–January 1994: structural biologists

these funds were used to purchase major equipment as well as small equipment, computers, chemicals, and journal subscriptions, and to provide stipends and travel funds for students.

Other International Activities

U.S. and Mexican National Academies

In the summer of 1991, the Institute announced grants of $600,000 to the U.S. National Academy of Sciences and $100,000 to the Mexican Academia de la Investigacion Cientifica, for joint activities over four years. These activities promote the exchange of scientific information and encourage cooperation between scientific communities in the two countries, particularly in the life sciences.

Under the grants, scientists from both countries convene for lectures and discussions at an annual symposium on a topic at the frontier of biomedical research (Figure 61). The October 1992 symposium was on the molecular biology of parasites. The next symposium, scheduled for the spring of 1994, will address human genome research.

The grants also provide support for an annual laboratory course conducted in Mexico City (Figure 61). Graduate students, postdoctoral associates, and more advanced scientists throughout Mexico are selected to participate. The third laboratory course, Molecular Biology of Parasite Gene Expression, was scheduled for December 1993. It was organized by Dr. John Swindle of the University of Tennessee, Knoxville.

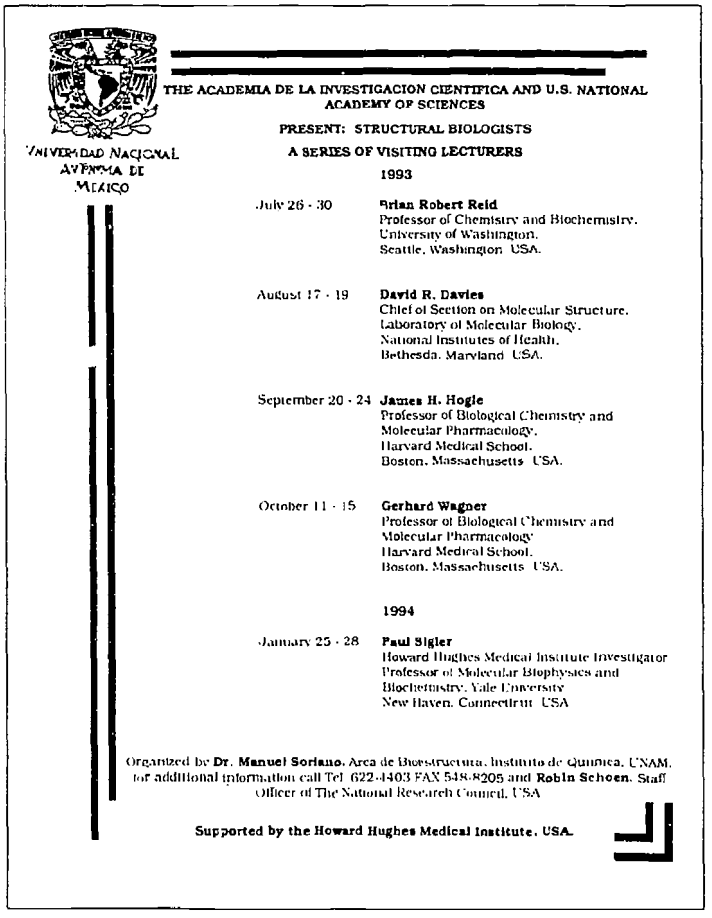
Another activity supported by the Institute grant is the visiting scientist program (Figure 62). Between July 1993 and January 1994, five leading U.S. structural biologists each spent three to five days in Mexico lecturing and visiting laboratories.

International Education Activities

The Institute also supports biomedical research and education internationally through its Research Resources grants. These include grants to the Human Genome

Figure 62

U.S. and Mexican Science Academies, Announcement of Visiting Scientist Program



UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

THE ACADEMIA DE LA INVESTIGACION CIENTIFICA AND U.S. NATIONAL ACADEMY OF SCIENCES

PRESENT: STRUCTURAL BIOLOGISTS

A SERIES OF VISITING LECTURERS

1993

July 26 - 30 — **Brian Robert Reid**
Professor of Chemistry and Biochemistry.
University of Washington.
Seattle, Washington USA.

August 17 - 19 — **David R. Davies**
Chief of Section on Molecular Structure.
Laboratory of Molecular Biology.
National Institutes of Health.
Bethesda, Maryland USA.

September 20 - 24 — **James H. Hogle**
Professor of Biological Chemistry and
Molecular Pharmacology.
Harvard Medical School.
Boston, Massachusetts USA.

October 11 - 15 — **Gerhard Wagner**
Professor of Biological Chemistry and
Molecular Pharmacology
Harvard Medical School.
Boston, Massachusetts USA.

1994

January 25 - 28 — **Paul Sigler**
Howard Hughes Medical Institute Investigator
Professor of Molecular Biophysics and
Biochemistry, Yale University
New Haven, Connecticut USA

Organized by **Dr. Manuel Soriano**, Area de Bioestructura, Instituto de Química, UNAM, for additional information call Tel 622-4403 FAX 548-8205 and **Robin Schoen**, Staff Officer of The National Research Council, USA

Supported by the Howard Hughes Medical Institute, USA.

Organisation in support of its Americas Office and related activities. Grants to the Cold Spring Harbor and Marine Biological Laboratories also benefit the international scientific community, through wide participation in the special courses these institutions offer. Among the participants in grant-supported courses in 1993 were 107 students from abroad, in addition to those from U.S. institutions.

The Institute's graduate fellowship programs also serve an international constituency. Among the 395 current predoctoral and physician postdoctoral fellows are 5 students pursuing graduate study or postdoctoral research abroad and 56 citizens of other countries who are in graduate school or conducting postdoctoral research in the United States.

Figure 63

International Program, All Current International Research Scholars

1991 Awards

Canada

Alan Bernstein, Ph.D.
Head, Division of Molecular and Developmental Biology, and Associate Director, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto

Molecular Genetic Approaches to Hematopoiesis and Development

Barton Brett Finlay, Ph.D.
Assistant Professor, Biotechnology Laboratory and Departments of Biochemistry and Microbiology, University of British Columbia, Vancouver

Host-Pathogen Interactions in Microbial Pathogenesis

Jack Fred Greenblatt, Ph.D.
Professor, Banting and Best Department of Medical Research and Department of Molecular and Medical Genetics, University of Toronto

Transcriptional Regulatory Mechanisms

Sergio Grinstein, Ph.D.
Head, Division of Cell Biology, The Research Institute of the Hospital for Sick Children, Toronto; Professor, Department of Biochemistry, University of Toronto

Ionic Homeostasis in Resting and Activated Leukocytes

Philippe Gros, Ph.D.
Professor, Department of Biochemistry, McGill University, Montreal

The Multidrug Resistance (*mdr*) Efflux Pumps: Structure, Function, Regulation

Alexandra Leigh Joyner, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Associate Professor, Department of Molecular and Medical Genetics, University of Toronto

Targeted Mutagenesis and Molecular Genetic Analysis of Mouse Developmental Genes

James Douglas McGhee, Ph.D.
Professor, Department of Medical Biochemistry, University of Calgary

Control of Lineage-Specific Gene Expression During Early Development

Tim R. Mosmann, Ph.D.
Professor and Chair, Department of Immunology, University of Alberta, Edmonton

Cytokine Functions in Immune Class Regulation

Anthony James Pawson, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto

Biochemical and Genetic Control of Signal Transduction

Randy J. Read, Ph.D.
Associate Professor, Department of Medical Microbiology and Infectious Diseases, University of Alberta, Edmonton

Protein Crystallography and Rational Drug Design

Janet Rossant, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto

Genetic Control of Cell Lineage Development in the Early Mouse Embryo

Jean-Pierre Roy, M.D.
Assistant Professor, Department of Neurology and Neurosurgery, Montreal Neurological Institute of McGill University

Contribution of Area MSTd to the Spatial Function of the Parietal Cortex

Terry P. Snutch, Ph.D.
Assistant Professor, Biotechnology Laboratory and Division of Neuroscience, University of British Columbia, Vancouver

Molecular Dissection of Neuronal Signal Transduction

Lap-Chee Tsui, Ph.D.
Senior Scientist, Department of Genetics, The Research Institute of the Hospital for Sick Children, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto

Molecular Genetics of Cystic Fibrosis and Other Genetic Diseases

Mexico

Carlos Federico Arias, Ph.D.
Associate Professor, Department of Molecular Biology, Institute of Biotechnology, National University of Mexico, Cuernavaca

Molecular Biology and Epidemiology for the Control of Rotavirus Diarrhea

Edmundo Calva, Ph.D.
Associate Professor and Chairman, Department of Molecular Biology, Institute of Biotechnology, National University of Mexico, Cuernavaca

Molecular Biology of the *S. typhi ompC* and *C. Jejuni ent* Genes

Gabriel Cota, Ph.D.
Investigator, Department of Physiology, Biophysics, and Neurosciences, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City

Calcium Channels and Hormone Secretion in Pituitary Cells

Alberto Darszon, Ph.D.
Professor, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca

Involvement of Ionic Channels in Sperm Function

Gabriel Guarneros Peña, Ph.D.
Professor, Department of Genetics and Molecular Biology, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City

Control of Bacterial Protein Synthesis by a Lambda Phage-Directed Transcript

Luis Rafael Herrera-Estrella, Ph.D.
Professor and Chairman, Department of Plant Genetic Engineering, Center for Research and Advanced Studies, National Polytechnic Institute, Irapuato

Molecular Studies of Two Key Enzymes Involved in Carbon Assimilation in Plants

Paul Modesto Lizardi, Ph.D.
Professor, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca

Simple and Sensitive Assays for the Detection of Human Pathogens

M. Esther Orozco, Ph.D.
Professor, Department of Experimental Pathology, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City
Entamoeba histolytica: Molecules Involved in Adherence and Damage to the Target Cell

Lourival Domingos Possani, Ph.D.
Professor and Chairman, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca
Chemical and Functional Characterization of Scorpion Toxins

Ranulfo Romo, M.D., Ph.D.
Professor, Department of Neuroscience, Institute of Cellular Physiology, National University of Mexico, Mexico City
Representations and Transformations of Tactile Signals in Somatic and Frontal Motor Cortices of Behaving Primates

1992 Awards

Australia

David Douglas Lawrence Bowtell, Ph.D.
Wellcome Trust Senior Research Fellow, Howard Florey Institute of Experimental Physiology and Medicine, University of Melbourne
Control of Cellular Differentiation in Mammalian Development

Suzanne Cory, Ph.D.
Senior Principal Research Fellow and Joint Unit Head, Molecular Biology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville
Genetic Control of Hematopoietic Differentiation

Alan Frederick Cowman, Ph.D.
Wellcome Australian Senior Research Fellow, Immunoparasitology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville
Molecular Mechanism of Drug Resistance in Malaria

David James Kemp, Ph.D.
Deputy Director, Menzies School of Health Research, Casuarina
Chromosome Deletions in Relation to Cytoadherence and Gametocytogenesis in *Plasmodium falciparum*

Grant Robert Sutherland, Ph.D., D.Sc.
Director, Department of Cytogenetics and Molecular Genetics, Adelaide Children's Hospital; Affiliate Professor, Department of Pediatrics, University of Adelaide Medical School; Honorary Consultant Geneticist, Queen Victoria Hospital, Adelaide
Studies of the Human Genome: Positional Cloning and Unstable DNA

New Zealand

Edward Neill Baker, Ph.D.
Professor of Biochemistry, Department of Chemistry and Biochemistry, Massey University, Palmerston North
Structural and Functional Analysis of Binding Proteins and Hydrolases

Warren Perry Tate, Ph.D.
Professor of Biochemistry, University of Otago, Dunedin
Translational Stop Signals and Cellular Regulation

United Kingdom

Rosa Susan Beddington, D.Phil.
Senior Group Leader, Medical Research Council National Institute for Medical Research, London
The Molecular Basis of Mammalian Gastrulation and Early Organogenesis

Adrian Peter Bird, Ph.D.
Professor of Genetics, Institute of Cell and Molecular Biology, University of Edinburgh
The Biological Significance of DNA Methylation

Gerard Bricogne, Ph.D.
Research Scientist, Senior Grade, Division of Structural Studies, Medical Research Council Laboratory of Molecular Biology, Cambridge

Stuart Graham Cull-Candy, Ph.D.
Professor of Pharmacology, University College London, University of London
Amino Acid Receptor Channels and Synaptic Transmission in the Cerebellum

Christopher Martin Dobson, D.Phil.
University Lecturer, Department of Chemistry, University of Oxford; Deputy Director, Oxford Centre for Molecular Sciences
NMR Studies of Protein Folding and Recognition

Michael Anthony John Ferguson, Ph.D.
Reader in Biochemistry, Medical Sciences Institute, University of Dundee
Structure, Biosynthesis, and Function of Glycosyl-Phosphatidylinositols of the Parasitic Protozoa

Frank G. Grosveld, Ph.D.
Head, Laboratory of Gene Structure and Expression, Medical Research Council National Institute for Medical Research, London
Studies on the Regulation of the Human Beta-Globin Domain

Nicholas Dixon Hastie, Ph.D.
Head, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh
The Role of the Wilms Tumor Gene (*WT1*) in Normal Development and Cancer

Christopher Francis Higgins, Ph.D.
Principal Scientist, Imperial Cancer Research Fund Laboratories, Institute of Molecular Medicine, University of Oxford; Fellow, Keble College, Oxford
The Multidrug Resistance P-Glycoprotein and Related ABC Ion Channels/Transporters

Jonathan Alan Hodgkin, Ph.D.
Staff Scientist, Senior Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge
Molecular and Genetic Analysis of Nematode Sex Determination

David Ish-Horowitz, Ph.D.
Principal Scientist and Head, Developmental Genetics Laboratory, Imperial Cancer Research Fund Developmental Biology Unit, Oxford; Honorary Lecturer, Department of Zoology, University of Oxford
Embryonic Patterning in *Drosophila* by Transcriptional Regulation and Transcript Localization

Alec John Jeffreys, D.Phil.
Royal Society Wolfson Research Professor, Department of Genetics, University of Leicester
Variation and Mutation in the Human Genome

Robert Roger Kay, Ph.D.
Staff Scientist, Senior Grade, Cell Biology Division, Medical Research Council Laboratory of Molecular Biology, Cambridge
Molecular Basis of Pattern Formation in *Dictyostelium*

Roger John Keynes, M.B.B.Chir.
University Lecturer, Department of Anatomy, University of Cambridge
Cell-Cell Repulsion During Neural Development and Regeneration

David Philip Lane, Ph.D.
Professor of Molecular Oncology, Cancer Research Campaign Laboratories, Department of Biochemistry, University of Dundee
The Function of the p53 Suppressor Gene

Andrew Gino Lumsden, Ph.D.
Professor of Developmental Neurobiology, Division of Anatomy and Cell Biology, United Medical and Dental School, Guy's Hospital, University of London
Cellular and Molecular Mechanisms of Hindbrain Development

Michael Samuel Neuberger, Ph.D.
Senior Scientist, Special Appointment Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge
Expression and Function of the B-Cell Antigen Receptor

Simon Edward Victor Phillips, Ph.D.
Professor of Molecular Biophysics, Department of Biochemistry and Molecular Biology, University of Leeds
Structural Studies of Protein-Nucleic Acid Complexes

James Cuthbert Smith, Ph.D.
Head, Laboratory of Developmental Biology, Medical Research Council National Institute for Medical Research, London
Gradients and Thresholds in the Establishment of the Vertebrate Body Plan

Alain Robert Townsend, M.B.B.S., Ph.D.
Professor, Department of Clinical Medicine, Institute of Molecular Medicine, University of Oxford
The Biochemistry of Endogenous Antigen Presentation

Richard Henry Treisman, Ph.D.
Principal Scientist, Imperial Cancer Research Fund, London
Transcription Factors in Growth Factor Action

Veronica van Heyningen, D.Phil.
Senior Scientist, Special Appointment Grade, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh; Honorary Fellow, Department of Biochemistry, University of Edinburgh
Molecular, Genetic, and Functional Studies on *PAX6* and Other Aniridia-Associated Genes in the WAGR Region

Program Assessment

Assessment within the grants program has two principal objectives: to document and measure key outcomes of the Institute's various grants initiatives, and to assist in the development of new initiatives through studies of national trends in science education, the national research enterprise, and public and private support for science. Assessment activities are organized generally around the principal areas of the grants program.

The initial focus has been on outcomes for the activities in graduate and undergraduate science education, largely through analysis of annual progress reports submitted by individual fellows and institutional grant recipients. Data from these reports are presented in previous chapters. For the area of precollege science education, the first annual reports from science museums and related institutions are reviewed in the chapter "Precollege and Public Science Education."

In addition, several studies of national trends and conditions relevant to grants program planning and evaluation have been completed or are under way. In conjunction with these internal activities, the Institute is working with several federal agencies and private organizations to draw on existing national databases and develop new ones. These will be used for long-term monitoring of the careers of Institute-supported fellows, assessments of educational institutions, and analyses of national trends.

Overview

Graduate Education in the Biological Sciences

In the graduate area, the Institute monitors the progress of its predoctoral, medical student, and postdoctoral fellows through information provided in their annual reports. As students proceed through their fellowship years and beyond, the Institute will continue to track their training and subsequent professional activities by monitoring advanced degrees received, additional research training, indicators of research involvement and productivity, academic appointments, and other career outcomes. Much of this information will be derived through mail surveys of fellows. National longitudinal databases will provide additional information on progress of the Institute's fellows as well as normative data on relevant national cohorts for purposes of comparison.

Medical Student Fellows. An extensive tracking system for participants in the Institute's Research Training Fellowships for Medical Students program and those in the Howard Hughes Medical Institute–National Institutes of Health Research Scholars program is already well developed through a five-year grant to the Association of American Medical Colleges. The grant enables the AAMC to use a variety of national databases to track the educational progress and long-term careers of the Institute's

fellows and scholars and, for comparison, those of a number of national cohorts of other M.D. and M.D./Ph.D. graduates. This tracking project and some preliminary results were summarized in *Grants for Science Education, 1991–1992.*

A special section later in this chapter provides an in-depth update of the medical student tracking project. Data are presented on the numbers of 1992–1993 medical students and 1993 M.D. graduates known to have been enrolled in M.D./Ph.D. dual-degree programs, including those supported through the Medical Scientist Training Program (MSTP) of NIH. The section also presents findings from the tracking project on elapsed time from medical school matriculation to graduation, expressed interest in careers involving research, years of clinical training, and recent M.D. graduates with earned doctoral degrees. Data on these subjects are presented for each of five M.D. graduating classes (1988 through 1992) and, within each class, for several discrete groups: the Institute's fellows and research scholars, students who have had MSTP support, other students in M.D./Ph.D. programs, those expressing strong interest in research careers, and other M.D. graduates.

Predoctoral and Postdoctoral Fellows. A parallel effort to track the progress of the Institute's predoctoral and postdoctoral fellows is currently under development and will be initiated during 1993–1994. This tracking will be based primarily on fellows' responses to annual surveys concerning educational and career outcomes to date and plans for the future. National databases may also be used as data sources in this assessment effort, again possibly for making comparisons. The surveys are also being used to develop cumulative directories of the Institute's fellows.

Undergraduate Science Education

Program assessment in the undergraduate area has focused on the institutions receiving grant support through the Institute's undergraduate grant program, using annual progress reports and several national databases. Each college or university receiving an Institute award submits an annual report detailing the Institute-supported activities. These reports provide data on student development in the sciences, covering such topics as involvement in research and acceptance into graduate or medical school. The Institute is particularly interested in monitoring the participation of women and minority students underrepresented in the sciences.

The annual progress reports also cover science faculty, curriculum and laboratory development, and a variety of outreach programs. Data from these reports are summarized in the previous chapter on undergraduate science education.

Precollege and Public Science Education

Because the Institute's grant initiatives under the precollege and public science education program were

only recently begun, the associated assessment activities are in the early stages. Nonetheless, each major initiative within the program is to have an assessment component. Planning and development of assessments for precollege and public science education will take into account experience gained from assessments in the areas of gradua, · and undergraduate science education.

Local Precollege Initiatives. Local precollege initiatives are profiled in the chapter on precollege and public science education. In 1992–1993 one of these initiatives was formatively evaluated—the Student and Teacher Intern Program at the National Institutes of Health. This program provides research opportunities in NIH laboratories for students and teachers from high schools in Montgomery County, Maryland. The evaluation was conducted by the Montgomery County Public Schools and NIH with the support of the Office of Grants and Special Programs. Specifically, evaluation was undertaken to determine how administration of the program might be improved and to document its short-term impact on both student and teacher participants.

Four aspects of the program were examined: (1) the participant selection process, (2) program operation, (3) p · m activities, and (4) costs. Data were collected using focus groups of 1992–1993 student interns and a sample of preceptors from the three most recent years of the program. Individual interviews were conducted with teacher interns from the two most recent years, and with science resource teachers whose schools applied but were not accepted. Group interviews were conducted with administrators from NIH and Montgomery County public schools. Finally, evaluators observed meetings and special events such as scientific presentations and an alumni banquet (Figures 64 and 65).

Figure 64

Program-Sponsored Activities for Student and Teacher Interns

- Working in a research laboratory
- Making an oral presentation of research findings at a dinner symposium
- Developing outreach activities to strengthen science education in other Montgomery County public schools
- Participating in poster presentations
- Participating in an NIH scientist seminar series

Figure 65

Data Collection Methods for Evaluation of the Student and Teacher Intern Program

- Focus groups:
  - 1992–1993 student interns
  - preceptors selected from three program years
- Interviews with teacher interns who participated and teachers whose schools were not accepted in the program
- Interviews with program administrators from NIH and Montgomery County public schools
- Observations of special events such as presentations and an alumni banquet

Based on the results of the evaluation, several changes have been made in the 1993–1994 program. These include improvements in the process for selecting students and teachers, reduction of the time teachers will spend in research and continuing education activities (with no compromise of the quality of the experience), and more efficient use of program funds. Other efforts are being made to implement additional recommendations regarding the type and duration of program activities and channels of communication among students, teachers, preceptors, and administrators. These changes are expected to enhance the experience for everyone involved. The program continues to be evaluated through annual reports provided to the Institute and through routine data collection by the NIH Office of Education.

Education and Career Outcomes of Physician-Scientists

The Institute of Medicine, in its report *Biomedical and Behavioral Research Scientists: Their Training and Supply*, emphasized the importance of evaluating fellowship and training programs designed to increase the number and quality of medically trained research scientists, noting that little research had been done in this area. Program evaluation for clinical investigators, the report pointed out, involves the complexities of training and tracking the academic physician-scientist. Until recently, little information has been available on the long-term educational and career outcomes of physician-scientists generally and of M.D./Ph.D.'s in particular.

The Institute has two grant programs that support the education and training of physician-scientists: (1) Research Training Fellowships for Medical Students and (2) Postdoctoral Research Fellowships for Physicians. (See the previous chapter "Graduate Science Education.") The Research Scholars Program, operated jointly by the Institute and NIH, is also aimed at attracting medical students to research.

In order to assess the outcomes of the Institute programs for medical students, and to explore the factors affecting career outcomes of physician-scientists, the Institute in 1989 awarded a five-year grant to the Association of American Medical Colleges. The grant has enabled the AAMC to use existing national databases to track the educational progress and subsequent careers of the Institute's fellows and scholars.

The AAMC project is also tracking a number of other study groups of M.D. graduates to provide a context in which to assess the outcomes for the Institute's fellow and scholar populations. A variety of educational and career outcomes are monitored annually for each group studied, beginning in the year the M.D. is awarded and continuing through mid-career. This long-term tracking is designed to provide measurements of career

progress, with emphasis on indicators of involvement in research.

In addition to long-term tracking of the Institute's fellows and scholars, the AAMC study has provided annual information on the nation's supply, demographic characteristics, and educational patterns of M.D./Ph.D.'s generally. Findings have been presented in the three latest editions of the annual *Grants for Science Education*.

Overview of the Medical Student Tracking Project

The primary objective of the tracking project is to follow the progress of the Institute's fellows and scholars by annually monitoring a variety of key educational and career outcome measures. To place the findings in a broader context, the project also monitors these outcome measures for four independent comparison groups: students in dual-degree M.D./Ph.D. programs who were supported through the NIH Medical Scientist Training Program (MSTP), other medical school graduates reported to have been in M.D./Ph.D. programs but not in the MSTP, graduates who have not been in such programs but who expressed significant interest at graduation in a career involving research, and all other M.D. graduates.

A variety of educational and career outcome measures are monitored annually for each of the groups under study. Analysis begins the year the M.D. is received, and all measures are updated in each subsequent year. Thus, each new class of M.D. graduates is tracked as an independent cohort, with all outcome data for each cohort updated annually.

Because analysis begins with receipt of the M.D. degree, meaningful data are not yet available on certain outcomes for the Institute's fellows and, in some cases, for the scholars as well. Only in the most recent year or two have sufficient numbers of fellows received their M.D. degrees to allow for collection of meaningful data on early outcomes. In addition, other outcomes being monitored (e.g., appointment to medical school faculty) require a relatively long postfellowship period before occurring in meaningful numbers. Therefore, several of the studies presented here include data on the Institute's fellows and scholars, while others do not. Within the next few years, the numbers of students in the Institute's study groups who earn the M.D. should be sufficient for early analyses in all areas, and the results will be reported as they become available.

The remainder of this section presents several of the primary findings to date from the medical student tracking project. These concern the size of the national pool of M.D./Ph.D. students and graduates in recent years, the average number of years from matriculation in medical school to graduation with the M.D. degree, interest expressed at graduation in careers involving research, average years of clinical training, early data on appointments to medical school faculty positions, and numbers of recent M.D. gradu-

ates with earned doctoral degrees. Some of these data are preliminary and subject to change, since the tracking systems are still being refined and the study of some of the outcomes will require more time.

The Annual Pool of Students in M.D./Ph.D. Programs

Through the Institute's grant to the AAMC, annual data are gathered on the size and characteristics of the national pool of M.D./Ph.D. students and graduates. Informal surveys have estimated the number of medical students enrolled in M.D./Ph.D. programs in selected years. The MSTP, principal single source of funding for M.D./Ph.D. candidates, provides a starting point for such an estimate. The MSTP supports approximately 750 full-time–equivalent students each year, and informal studies have suggested that they comprise about one-half of all those enrolled in dual-degree programs.

Until recently, however, comprehensive data concerning numbers of students enrolled or M.D. graduates emerging from dual-degree programs have not been systematically available. The numbers actually earning doctoral degrees have also been largely unknown. Our studies indicate that the number of students enrolled in M.D./Ph.D. programs in recent years has exceeded 1,500 and that nearly 40 percent of all graduates from these programs have received MSTP support. Between 75 and 90 percent of recent graduates from dual-degree programs have actually earned the doctoral degree.

In the last three editions of *Grants for Science Education*, data were presented on medical students reported to have been enrolled in M.D./Ph.D. programs during the academic years 1989–1990, 1990–1991, and 1991–1992. Some of these early findings were based, in part, on medical school reports to the AAMC of dual-degree student enrollment. Such reporting, however, was known to be incomplete. Under the Institute's grant, the AAMC initiated an ongoing effort to ensure complete, accurate, and timely reporting. The AAMC has also continued to work with NIH to improve the data on students receiving MSTP support. As a result, the data concerning the numbers of medical students enrolled in, and graduating from, dual-degree programs are significantly improved for the academic years 1989–1990 through 1992–1993 and, to a limited extent, for earlier years as well.

Data currently available from the AAMC and NIH indicate that a total of 2,400 medical students were reported to have been enrolled in M.D./Ph.D. programs during the 1992–1993 academic year. Of those, 1,155, or 48 percent, are known to have received MSTP support at some point (Figure 66). In any one year, the program supports approximately 750 full-time–equivalent students. The number of participants, particularly among continuing students, is expected to increase somewhat, once complete data on students supported for the first time during 1992–1993

Figure 66

Students Reported to Have Been Enrolled in M.D./Ph.D. Dual-Degree Programs:[1] Continuing Students and M.D. Graduates, Academic Year 1992–1993

Dual-Degree Program[2]	Continuing Students		M.D. Graduates		Total Enrollment	
	No.	%	No.	%	No.	%
With MSTP support	1,025	50%	130	39%	1,155	48%
With other or no support	1,042	50	203	61	1,245	52
Totals[3]	**2,067**	**100%**	**333**	**100%**	**2,400**	**100%**

[1]Data represent M.D. students reported by their medical schools to have been enrolled in M.D./Ph.D. programs.

[2]"With MSTP support" indicates students listed by their medical school, in reports to the National Institutes of Health, as supported through the NIH Medical Scientist Training Program award to that school. Such support could have been for any year(s) from 1978 through 1992.

"With other or no support" indicates students listed by their medical school, in reports to the Association of American Medical Colleges, as enrolled in an M.D./Ph.D. program (and not subsequently reported as withdrawn from the program), but who are not on the NIH rosters of those having received MSTP support.

[3]These data do not represent the M.D./Ph.D. population per se; only students reported to have been enrolled in such dual degree programs. Some of the graduates will not complete the Ph.D. until one or more years following the M.D. Other students and graduates may have permanently dropped the Ph.D. component of their studies. Also, there may be students enrolled in M.D./Ph.D. programs who are not reflected in these data because they are not reported to be so enrolled. Finally, many M.D.'s who also hold the Ph.D. earn the doctorate before entering medical school, and so are never enrolled in dual-degree programs.

become available from NIH (in about a year). However, no significant increase in the estimated proportion of M.D./Ph.D. students receiving MSTP support is expected to result from this information.

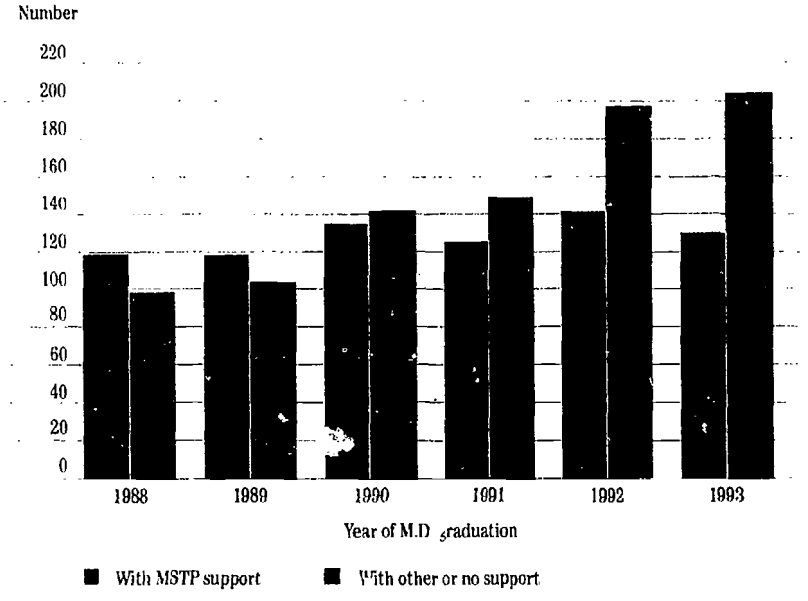
Of the 2,400 medical students reported to have been in M.D./Ph.D. programs in 1992–1993, 333 were awarded the M.D. degree in 1993. Of these, 130, or 39 percent, are known to have received MSTP support at some time during their enrollment in medical school.

In addition to information on the M.D. graduates of 1992–1993, data have been assembled for the graduating classes of 1988 through 1993 on the annual number of M.D. graduates reported to have been enrolled in M.D./Ph.D. programs (Figure 67), including those known to have received support through the MSTP. The historical data identify approximately 200 to 325 such students awarded the M.D. degree each year, with somewhat less than one-half (in the most recent three years) known to have received MSTP support at some point during their enrollment in medical school.

From 1988 through 1992, the number of new medical school graduates reported annually to have

Figure 67

M.D. Graduates, 1988–1993, Identified as Having Been Enrolled in M.D./Ph.D. Programs



been enrolled in dual-degree programs increased notably, particularly among those not supported through the MSTP. This observation may reflect real growth in the annual number of such graduates emerging from M.D./Ph.D. programs, or it may represent, at least in part, an artifact of the improved reporting (noted above) by the medical schools.

In 1993, for the first time, the data for the graduating class do not show a notable increase in the number of reported graduates from M.D./Ph.D. programs. Because the improved reporting systems have been in place for at least three years, the most recent data suggest that no substantial change occurred in the number of such graduates in 1992–1993. Over the next several years, data on enrollment in M.D./Ph.D. programs collected through this project should provide a consistent and accurate picture of the annual pool of such dual-degree students and graduates.

It should be noted that these data on enrollments and graduations do not represent the entire pool of M.D./Ph.D. graduates per se, for several reasons. Rather, they represent M.D. students and graduates identified as having been enrolled in M.D./Ph.D. programs on the basis of their receipt of MSTP support and/or of medical school reports to the AAMC. While receipt of the M.D. is confirmed for

the graduates, receipt of the Ph.D. is not. Some of the graduates will not be awarded the Ph.D. formally until one or more years after the M.D. Also, some of the continuing students and graduates may have permanently dropped the Ph.D. component of their studies. However, most of the recent M.D. graduates known to have been enrolled in M.D./Ph.D. programs have earned doctoral degrees, as will be seen below. (See also *Grants for Science Education 1991–1992*, page 71.)

There may be other medical students enrolled in and graduating from M.D./Ph.D. programs who are not reported to the AAMC by the medical schools. Finally, other analyses from this project indicate that many M.D./Ph.D.'s earn the doctorate well before the M.D. and thus never enter a dual-degree program. (See data presented below and data in *Grants for Science Education 1991–1992*, page 73.)

Elapsed Years from Medical School Matriculation to M.D. Graduation

The length of time required to complete medical education and training affects significantly the point at which a new M.D. can begin clinical practice. The substantial additional time required to complete a concurrent doctoral degree prolongs the point at which M.D./Ph.D. graduates from dual-degree programs enter the post-medical school stages of their careers to begin productive research, clinical work, or both. This additional time has been suggested as a possible deterrent to students' entering dual-degree programs, and thus as potentially limiting the supply of new M.D./Ph.D.'s.

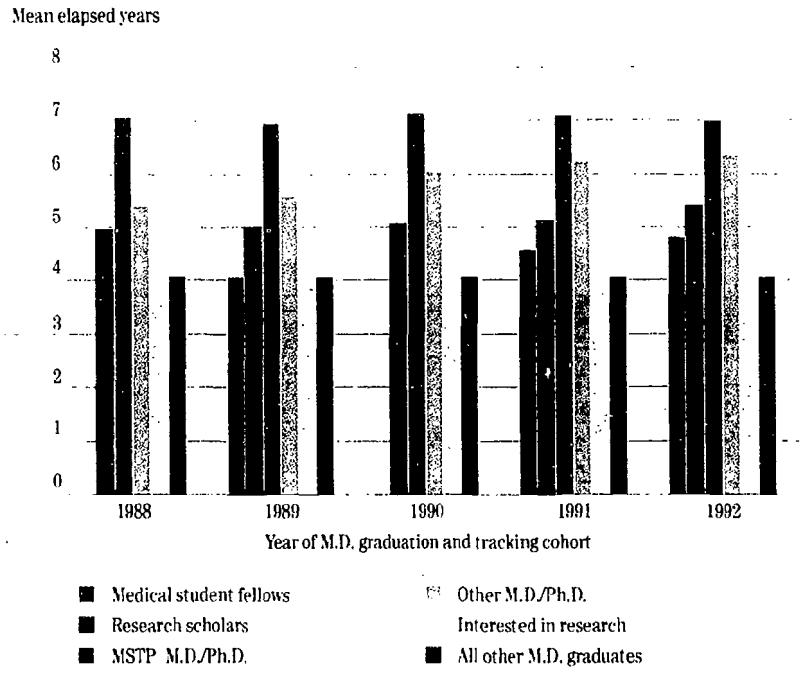
It is therefore of interest to examine the elapsed time from matriculation in medical school to receipt of the M.D. degree. Figure 68 presents these data as averages for six study populations in each of five recent M.D. graduating cohorts (1988 through 1992).

The population with the greatest average elapsed time is that of students in M.D./Ph.D. programs who are known to have been supported through the MSTP. This group has consistently averaged about seven years of elapsed time from matriculation to M.D. Seven years is typically the time taken by most dual-degree students to complete both an M.D. and a doctoral degree concurrently. These data thus suggest that most of the M.D. graduates enrolled in M.D./Ph.D. programs who are supported by MSTP funds are in fact completing both degrees, a finding that will be directly confirmed in a later section on earned doctoral degrees.

The average elapsed period that is next longest is consistently found for the students who are reported to have been in M.D./Ph.D. programs but who did not receive MSTP support. Interestingly, this group's average elapsed time has steadily increased from about 5.4 years for those graduating in 1988 to an average 6.4 years for those graduating in 1992. This finding suggests that a greater proportion of such non-MSTP M.D./Ph.D. students have been completing the doctoral

Figure 68

Elapsed Years from Matriculation to M.D. Graduation, 1988–1992, by Year of Graduation and Tracking Cohort



degree portions of their studies in recent years, but that this proportion is lower than that for dual-degree students with MSTP support. This interpretation is supported by preliminary data on earned doctoral degrees.

The students not reported to have been in M.D./Ph.D. programs but who indicated significant interest at graduation in a career involving research, and all other M.D. graduates, have consistently averaged 4.1 to 4.2 elapsed years in medical school, strongly suggesting essentially uninterrupted medical study for nearly all M.D. graduates in each of these two populations. As will be seen in the earned doctorate data, only very small percentages of these groups have earned doctoral degrees (and most did so before entering medical school).

Finally, the Institute's research scholars and medical student fellows appear preliminarily to have taken, on average, approximately one-half to one year longer to graduate from medical school than the four years generally required. Since the research scholars must take a one-year leave of absence from medical studies during their scholarship year at NIH, one might expect their average elapsed time to be about 5.0 years, presuming no

further time is spent in other activities, including the earning of a doctoral degree. The mean elapsed time for the research scholars is in fact very close to 5.0 years. The most recent data available on earned doctorates indicate that, as of June 1992, very few of these students had earned such degrees.

Only the most recent two cohorts of M.D. graduates (1991 and 1992) contain any students who participated in the Institute's Research Training Fellowships for Medical Students program. These students' mean elapsed times from medical school matriculation to M.D. graduation were approximately 4.5 years. Most but not all of these students also must take a one-year leave of absence from medical studies to participate in the fellowship program. However, some medical schools (e.g., Duke University) permit the fellowship year to be included as one of the four years of medical study. Because the fellowship program has had substantial enrollment from such schools, the average elapsed time for the students in the program could be expected to be somewhat shorter than that for the research scholars but longer than the four years required for medical study, and this is the pattern actually observed to date. As will be noted in the section on earned doctorates, little or no meaningful doctoral degree data are yet available for the two most recent graduating classes.

Interest in Research Careers as Expressed at M.D. Graduation

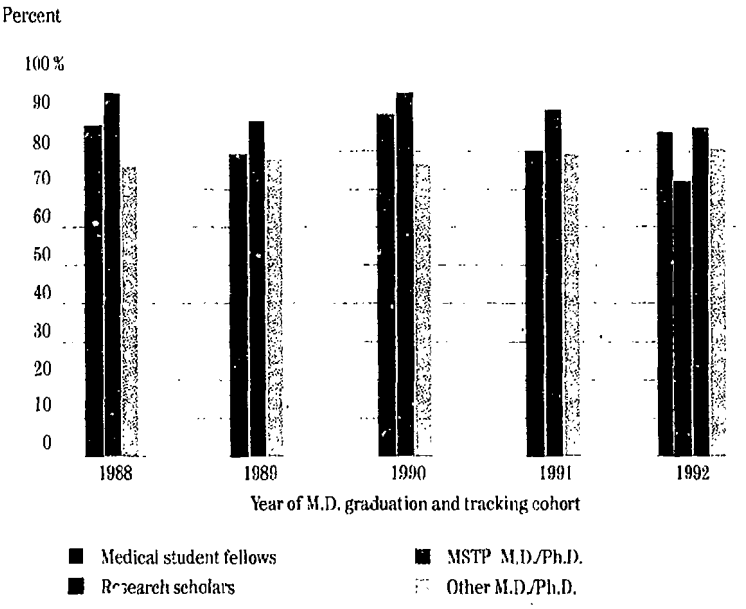
Students graduating from medical school are surveyed on a host of issues relevant to medical education, training, and practice. Known as the Graduation Questionnaire, this survey is designed and administered by the AAMC. Participation is voluntary, and approximately two-thirds of M.D. graduates respond.

One item on the survey explores the graduate's level of expectation "to be involved in research during your medical career." These self-reported expectations at M.D. graduation indicate preliminary levels of interest in careers involving scientific research. The data were examined for each of the cohorts involved in the tracking project and are presented in Figure 69. (No data are presented here for the tracking cohorts of students "Interested in research" or for "All other M.D. graduates," because 100 percent and 0 percent of these two groups, by definition, have shown interest.)

Approximately 14 percent of all graduates who respond to the Graduation Questionnaire typically expect to be "exclusively" or "significantly" involved in research. In contrast, at least three-quarters of each of the M.D. graduate cohorts tracked in this study from 1988 through 1992 (who responded to the questionnaire) indicated such expectation. The group with the highest percentage of members who expressed interest in research (85 to 95 percent) comprised the graduates from M.D./Ph.D. pro-

Figure 69

Expressed Interest in Research at M.D. Graduation, 1988–1992, by Year of Graduation and Tracking Cohort



grams who received MSTP support. About 75 to 80 percent of the graduates enrolled in dual-degree programs but not supported by the MSTP reported interest.

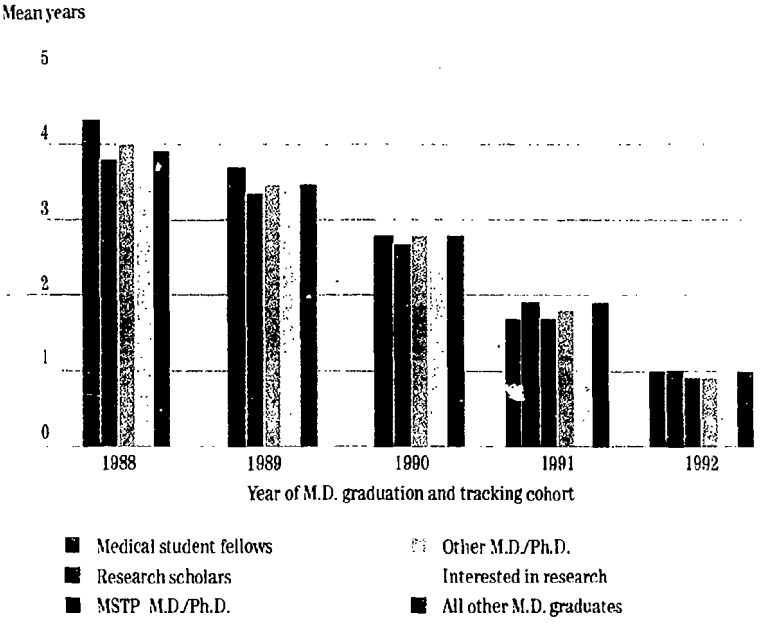
The Institute's research scholars who have earned M.D. degrees have typically expressed interest in research to an extent equal to, or somewhat above, that reported by the non-MSTP dual-degree program graduates but not quite to the extent of the MSTP-supported graduates. Finally, only the most recent year's data (1992) cover a sufficient number of medical student fellows to provide meaningful results in this area. Approximately 85 percent of the fellowship students who graduated in 1992 expressed a significant or exclusive interest in a research career. The group's level of interest was roughly comparable to that of the MSTP-funded dual-degree graduates. The assessment program will continue to examine this issue.

Years of Clinical Training Following Receipt of the M.D. Degree

An extended period of clinical training following receipt of the M.D. degree is requisite to becoming a physician. The clinical training period may be equally important to the physician-scientist, who must be prepared to integrate the clinical and research aspects of his or her work. Until recently, however, little or no data were available on the

Figure 70

Years of Clinical Training Since M.D. Graduation, 1988–1992, as of Academic Year 1992–1993



amount of time spent in clinical training by recent M.D./Ph.D.'s.

Figure 70 presents the average number of years to date (i.e., through the 1992–1993 academic year) spent in clinical training by each of the six study groups of the tracking project in the five most recent M.D. graduating cohorts (1988 through 1992) for which data are currently available. The data on clinical training are provided through the AAMC's Graduate Medical Education program, wherein all hospitals and other institutions offering accredited internship programs provide information annually on all students so engaged.

These data indicate that, with only slight and largely nonsystematic variations, the following groups are pursuing equal average amounts of formal clinical training: the Institute's research scholars and medical student fellows, students who have been in M.D./Ph.D. programs, other M.D. graduates expressing substantial interest in careers involving research, and all other M.D. graduates. Thus, recent M.D./Ph.D. students appear on average to have pursued a period of clinical training approximately equal in length to that undertaken to date by the average M.D graduate. The only possible systematic exception may be among dual-degree students sup-

ported by MSTP funds. At present, these students have averaged very slightly less time in clinical training than, say, the group "All other M.D. graduates."

Finally, with each additional year following M.D. graduation, the average length of clinical training appears to increase by slightly less than one year. For example, the graduating class of 1992 has had one year to date to pursue clinical training, and the average length of such training is almost precisely 1.0 year. The class of 1991 had two years for clinical training, and its students' means are slightly less than 2.0 years. Similarly, means of just under 3.0 are found for the class of 1990.

However, the class of 1989, which had four years for clinical training, currently averages approximately 3.5 years (with a little variation among the groups), and the oldest graduating class in the tracking analysis (1988) averages around the 4.0-year mark (with slightly more variation), though having had fully five years for clinical training since M.D. graduation. Thus, in each of the six populations, it appears that very few students forego or postpone their first three years of clinical training. Beyond this point, it appears that some students, but not large numbers, withdraw from or begin to defer this work.

Preliminary Data on Appointments to Faculty Positions in Medical Schools

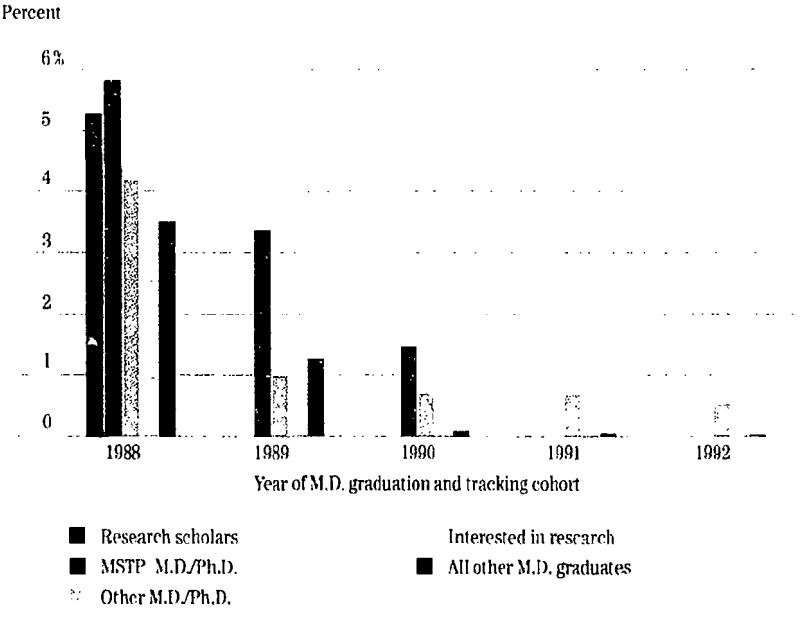
The AAMC maintains a database on all persons appointed to faculty positions in medical schools. Such a position is one possible career step, or outcome, for the M.D./Ph.D., and is often an indicator of some level of involvement in research. Therefore, it is of interest to monitor for each of the tracking populations the proportion appointed to medical school faculty positions. The data on medical school faculty appointments through academic year 1992–1993 are presented in Figure 71. (These results must be considered very preliminary when viewed as career outcome measures. They are subject to substantial change in coming years, because even first faculty appointments are often received more than five years after M.D. graduation.)

Within four years after receipt of the M.D. degree, very low percentages of the populations tracked in the study have been appointed to a faculty position at a medical school. Five years after graduation, these proportions appear to rise considerably (as represented by the class of 1988), ranging from about 3.5 to 6.0 percent. The highest percentages that have received medical school faculty appointments to date are found, for the most part, among M.D. graduates who were enrolled in M.D./Ph.D. programs and supported by MSTP funds.

In future years these percentages are expected to increase for all

Figure 71

Percentage of M.D. Graduates, 1988–1992, Who Have Held Faculty Appointments at Medical Schools as of Academic Year 1992–1993



classes and study groups as they complete their postgraduate clinical training and postdoctoral research work. The data for those years will be examined for appointments in clinical departments as compared with those in more research-oriented ones, once the numbers are sufficient to make such distinctions statistically meaningful.

Doctoral Degrees Earned as of June 1992

Data on the numbers of M.D. graduates who earn a doctorate are essential to quantifying the nation's pool of M.D./Ph.D.'s. Information on how and when the two degrees are earned will aid in distinguishing the relative contributions of the various educational pathways leading to the two degrees, and in identifying any differences in career outcomes among M.D./Ph.D's following different routes. Of particular interest in this regard are the career outcomes of dual-degree recipients graduated from M.D./Ph.D. programs as compared with outcomes for those who earn the two degrees independently. Finally, the disciplinary fields of the doctorates indicate the general scientific (and other) areas of training acquired by M.D./Ph.D's. Thus, receipt of an earned doctorate is one of the primary edu-

cational outcomes to be monitored in the longitudinal career tracking of M.D. graduates in each of the study groups in this project, particularly the Institute's fellows and scholars, and students known to have been in M.D./Ph.D. programs.

The definitive source of information on earned doctorates is the Doctorate Records File. This is the national database of all earned doctoral degrees awarded by U.S. institutions from 1920 to the present. The DRF is maintained by the National Research Council for the National Science Foundation, National Institutes of Health, Department of Agriculture, and National Endowment for the Humanities.

Selected information from the DRF has been used for several years to track all M.D. graduates' receipt of earned doctorates from 1988 through 1992. Recent M.D. graduates in each study group of the tracking project were checked against the DRF to determine how many are known to have earned the Ph.D. (or equivalent) at any time through June 1992.

The DRF data that were used in this analysis include the year of receipt and the general disciplinary area of each doctorate. Because the DRF data are currently available only through June 1992, all analyses presented here are limited to the M.D. graduating classes of 1988 through 1992.

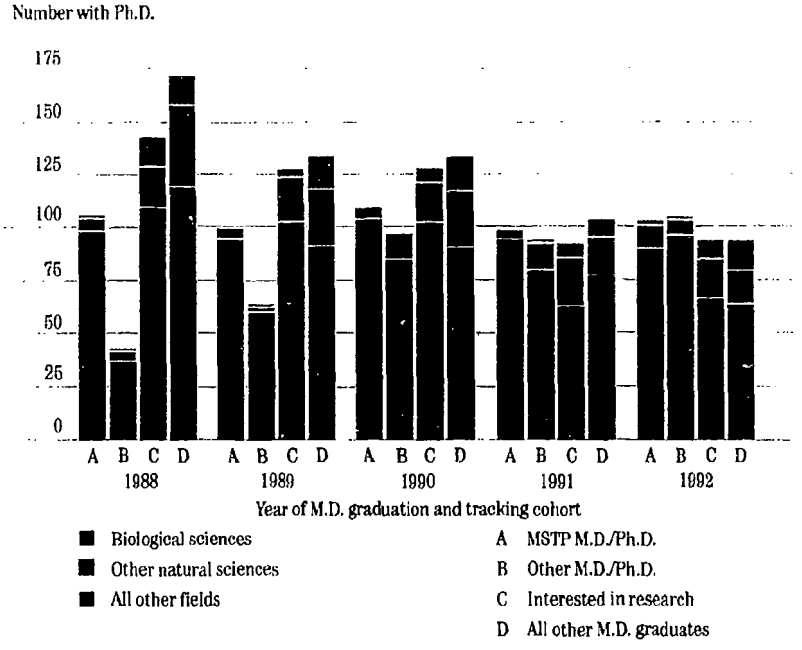
Data obtained through the DRF analysis provide the numbers of M.D. students in each of the tracking project's study groups who received, in addition to the M.D. degree, a doctoral degree at any time through June 1992. This analysis thus locates dual-degree program students, including those with or without MSTP support, who have earned both degrees. It also locates other recent M.D. graduates with a Ph.D. who were not identified as having been in dual-degree programs--students who entered medical school with a Ph.D. and those who independently earned the doctorate (during or prior to June 1992) after receiving the M.D. degree. This analysis thus provides unique and essentially complete data on the recent pool of M.D./Ph.D.'s.

Beginning with the graduating class of 1988, M.D. graduates who were enrolled in dual-degree programs with MSTP support have accounted for approximately 100 new M.D./Ph.D.'s from each class (Figure 72). In the three oldest classes studied (1988 through 1990), M.D. graduates who expressed significant interest in research, and all other M.D. graduates, have accounted for the greatest absolute numbers of M.D./Ph.D.'s. However, in the two most recent classes (1991 and 1992), each of the four study groups has produced approximately equal numbers (90 to 100) of such new dual-degree holders.

The study group of students reported to have been in M.D./Ph.D. programs but without MSTP support appears to have accounted for an increasing number of new M.D./Ph.D.'s since 1988. This growth, however, may be an artifact of the better reporting of such stu-

Figure 72

M.D. Graduates, 1988–1992, with Doctoral Degrees as of June 1992: Numbers and Ph.D. Fields by Year of M.D. Graduation and Tracking Cohort



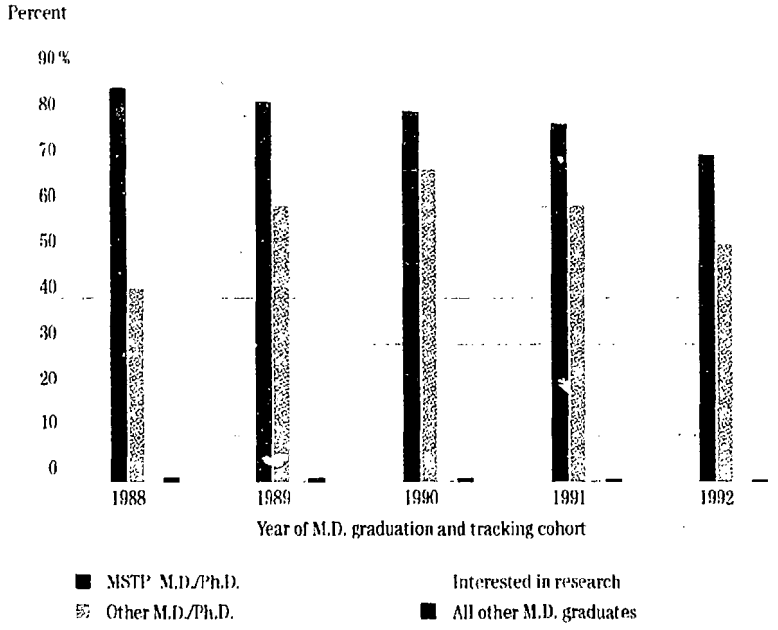
dents noted earlier. Beginning with the class of 1990, when consistent reporting began, the number of dual-degree holders in this group has been nearly constant at approximately 90 to 100 each year.

No data on earned doctoral degrees are presented here for the Institute's fellows or research scholars. Through June 1992, only two such students are known to have earned the Ph.D. degree. Future years' data from the tracking project will be necessary to determine how many of these students earn doctoral degrees.

In all study groups and all class years, a large majority of M.D./Ph.D.'s earned their doctoral degree in the biological sciences (Figure 72). On a proportional basis, this applies most to students known to have been in dual-degree programs, either with or without MSTP support. Among those interested in research and all other M.D. graduates, the numbers and proportions with Ph.D.'s in other natural sciences and mathematics are somewhat greater, though doctorates in the biological sciences predominate among these study groups as well. Only the latter two study groups, however, contain appreciable numbers of M.D./Ph.D.'s holding doctorates in fields

Figure 73

M.D. Graduates, 1988–1992, Who Had Earned a Doctoral Degree as of June 1992



other than the sciences and mathematics.

In proportional terms the highest percentages of M.D. graduates holding an earned doctoral degree by June 1992, in each of the classes from 1988 through 1992, are found among those in dual-degree programs and supported by MSTP funds (Figure 73). Approximately 70 to 90 percent of these graduates are known to have earned a Ph.D. by that time. The proportion increases steadily, reaching nearly 90 percent among such students from the class of 1988. These results indicate that as many as 20 percent of M.D./Ph.D.'s may complete the doctoral degree two or more years following award of the M.D., and that eventually 90 percent or more of all such MSTP students may earn the doctoral degree. Future data from the tracking project will monitor this trend.

By far the next highest percentage holding an earned doctorate is found among the other students known to have been in M.D./Ph.D. programs. This proportion also shows steady increase since M.D. graduation for the classes of 1990 through 1992. In the prior two classes (i.e., those of 1988 and 1989), this proportion appears to be lower. This result may be an artifact of the incomplete reporting of these students prior to the 1990 class, or may represent actual recent increase in

the proportion of such students earning the doctoral degree.

The two other study groups have provided absolute numbers of M.D./Ph.D.'s equal to or greater than the groups known to have been in dual-degree programs. On a proportional basis, however, less than 10 percent of those expressing interest in research, and only about 1 to 2 percent of all other M.D. graduates collectively, from each of these five graduating classes, had earned doctoral degrees by June 1992.

Sequence and Timing of the M.D. and Ph.D. Degrees

Reporting in the *Journal of the American Medical Association* (264: 1919–1920, 1990) on the first annual symposium on the education of physician-scientists, E. Krill and A. Skolnick noted the dearth of comparative information on the careers of graduates from dual-degree programs and on those of M.D./Ph.D.'s who earned the two degrees independently. The authors noted that no comprehensive longitudinal studies of career outcomes among either group had been conducted. In order to address this issue, one must determine the sequence and timing of the two degrees.

Analyses to date have focused on determining the numbers of M.D./Ph.D.'s who earned the two degrees in each of three sequences: earned the Ph.D. three or more years prior to the M.D., earned the two degrees approximately coterminously, or earned the Ph.D. two or more years after the M.D. Results from these analyses are presented for selected study groups tracked in this project. In subsequent years, analysis will begin to focus on longer-term career outcomes.

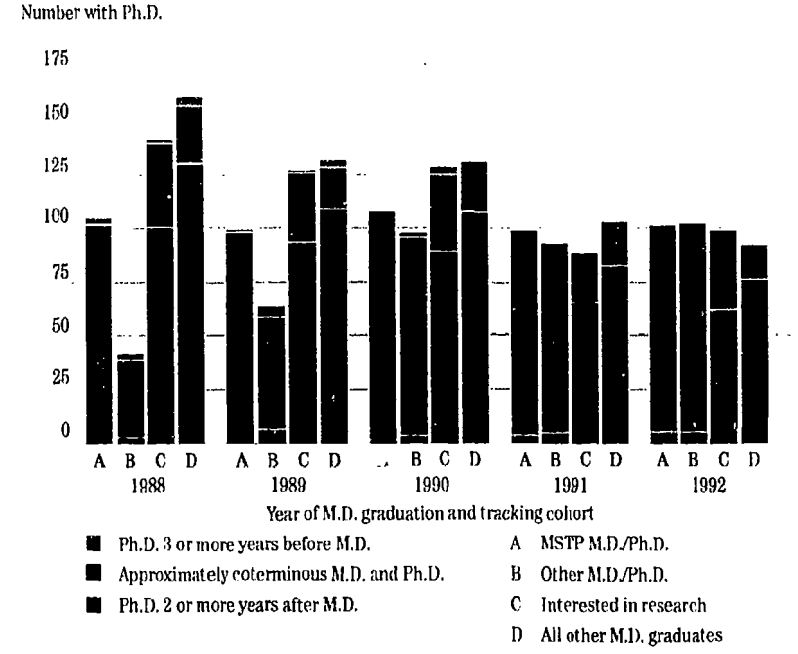
Nearly all of the M.D./Ph.D.'s among recent M.D. graduates identified as having been enrolled in dual-degree programs, with or without MSTP support, earned the Ph.D. more or less concurrently with the M.D. (Figure 74). Specifically, they earned the Ph.D. fewer than three years prior to, and fewer than two years following, award of the M.D. Generally the timing of the two degrees was within the expected range for graduates of such programs.

In sharp contrast, most of the M.D./Ph.D.'s in the other study groups earned the Ph.D. degree three or more years before the M.D. Thus, most of these M.D./Ph.D.'s appear to have entered medical school after completing, or nearly completing, their doctoral work.

However, as many as 25 percent of recent M.D. graduates not reported to have been in M.D./Ph.D. programs earned the two degrees more or less coterminously, within the range of timing expected for dual-degree programs (suggesting a need for confirmation of their reported status during medical school). Even so, as noted, the number of M.D./Ph.D.'s who earned the doctorate well before the M.D. degree far exceeds the number who coterminously earned the two degrees.

Figure 74

Sequence and Timing of M.D. and Doctoral Degrees: M.D. Graduates, 1988–1992, with Doctoral Degrees as of June 1992



Finally, as suggested in the analysis of the percentages of each class and study group holding earned doctorates (Figure 73), the classes of 1988 through 1990 now have a few M.D./Ph.D.'s who earned the doctoral degree two or more years after the M.D. degree. As noted, the analyses presented here are limited to doctoral degrees awarded by June 1992. In future years, more M.D. graduates in these five classes may earn doctoral degrees, raising both the absolute number of M.D./Ph.D.'s and the proportions of the various study groups holding both degrees. These and other analyses emerging from the tracking program will be reported as they become available.

Policies and Procedures for Grant Applications

Grants and fellowships awarded by the Howard Hughes Medical Institute are administered by its Office of Grants and Special Programs. The awards are made under specific initiatives, each with its own objectives and guidelines.

In brief, graduate fellowships, grants for undergraduate and precollege science education, and grants for research in selected countries abroad are awarded on the basis of applications or proposals reviewed by outside panels of scientists and educators. The panels' evaluations are reviewed by an internal scientific committee, which makes recommendations to the Institute's Trustees for authorization of funding. The Trustees and Institute management annually review current grants policies, initiatives, and possible directions for program development.

The Institute does not award grants for research in the United States; nor does it award institutional training grants or support conferences or publications. Policies and procedures for the several program areas are described below.

The Institute Grant-Making Process

Institute grants and fellowships support science education at all levels in the United States and its territories. The six main program areas are graduate, undergraduate, and precollege science education, research resources, special programs (local initiatives), and the international program (Figure 75).

Most of the competitions are announced publicly at the start of the grant cycle. Program announce-

Figure 75

The Grants Cycle

	Graduate	Undergraduate	Precollege	Research Resources	Special (Local)	International
Announcement	Broad	Limited		None		Broad
Application	Open competition	Invitation only		Ad hoc		Nomination or open competition
External review	External review panels of 15–20 members from academia, government, and industry (review panels convened by NRC for the predoctoral fellowship program)					
Internal review	Management/Trustees					
Awards	$14.6	$25.2	$4.8	$1.5	$0.5	$4.8
Payment	Biannual	Annual				
Assessment	Annual financial reports/progress reports/grantee meetings					

The HHMI grant-making process varies somewhat from program to program (top). Operations, however, are broadly similar in each phase of the grants cycle (left, descending). A call for applications, for example, is made in all programs, though some target different types of institutions or different regions from one competition to another. The Awards row shows totals for fiscal 1993 in millions. If all Institute grants are included, the grand total is $51.4 million.

ments give information on the objectives, eligibility requirements, and application process, and provide an application form. All fellowships under the graduate programs are offered in open competition, while the institution-based grants (undergraduate and precollege) go to specific types of institutions that are invited to apply. The local initiative and resource awards are generally by invitation only, and the international awards are limited to selected regions.

For the graduate fellowship programs, applications are due several months after announcement. They typically include verification of eligibility, a proposal or research plan, the applicant's credentials, letters of recommendation, and a proposed budget. Additional materials such as publication reprints or educational transcripts may be required. The completed applications are examined by the grants staff to ensure completeness and eligibility. An exception is the predoctoral fellowship program, for which, in view of the large number of applicants (up to 1,600 annually), the National Research Council manages the review under an Institute grant.

For the undergraduate, precollege, and international programs, proposal deadlines follow the announcement by several months. Executive summaries, narrative descriptions of the proposed program, and budget summaries and detail are required. Institutions must also submit institutional and departmental data and, as appropriate, letters of commitment from collaborating institutions. They are asked to designate a program director.

For the graduate, undergraduate, precollege, and international programs, applications and proposals are assigned to external panel members for review and evaluation. Selection of the reviewers, usually no more than 20 per competition, is based on professional credentials and expertise in a field germane to the program area. Panelists are generally scientists and educators in academia, government, and industry who are asked to serve for a set term.

An internal scientific committee next reviews the panel evaluations. The committee, in turn, makes recommendations to the Institute Trustees, who authorize funding of the specific awards. For the fellowships, however, authorization is via the fiscal-year program budget. The Trustees do not authorize the specific awards in these cases.

Following the Trustees' authorization, grants are announced to the awardees and the press. Awardee institutions are then asked to complete and sign a document, *General Terms and Conditions*, and for graduate programs, to name a fellowship officer. For the undergraduate and precollege programs, awardee institutions must also develop an accepted budget. As an adjunct to *General Terms and Conditions*, an information booklet setting forth detailed policies and procedures is issued annually for each program.

Beginning in fiscal 1995, payments will be sent to institutional and international grantees annually

and to the fellowship institutions biannually. For the institutional grants, spending is governed by the previously agreed-upon budget. For the fellowships, the policies on amounts and uses of funds are specified in the information booklets.

Grant recipients are assessed annually. Program and financial report forms are sent to each grantee for completion. These inform the staff of grant-funded activities and expenditures during the reporting year. In addition, annual meetings convene fellows and program directors at Institute headquarters in Chevy Chase to meet one another and invited guests, to hear presentations, and to exchange information and ideas. The international research awardees participate each year in one of the scientific meetings of Institute investigators.

Finally, the Institute publishes annual reports on progress, finances, and program directions.

Graduate Education in the Biological Sciences

The Institute supports graduate education through fellowships to individual students and physicians. As mentioned above, it does not award institutional training grants. There are three graduate fellowship programs.

Predoctoral Fellowships in Biological Sciences

These fellowships provide support for up to five years of full-time study toward the Ph.D. or Sc.D. degree in specific areas of the biological sciences. They are awarded to individual students through an international competition. Processing and review of the fellowship applications are managed by the Fellowship Office of the National Research Council/National Academy of Sciences. The application deadline is in early November each year, and awards are announced by early April.

Research Training Fellowships for Medical Students

Fellowships awarded under this program enable medical students in the United States to undertake a year of full-time fundamental research. Awards are based on a national competition. The application deadline is in early December each year, and the awards are announced by early April.

Postdoctoral Research Fellowships for Physicians

These fellowships provide support for three years of full-time research for physicians who have completed at least two years of postgraduate clinical training and no more than two years of postdoctoral research training by the start of the fellowship. Awards are based on an international competition. The application deadline is in early January each year, and awards are announced by the end of July.

For program announcements and fellowship applications contact:

Predoctoral Fellowships in Biological Sciences

Hughes Predoctoral Fellowship Program
National Research Council
Fellowship Office
2101 Constitution Avenue
Washington, DC 20418

Research Training Fellowships for Medical Students

Howard Hughes Medical Institute
Office of Grants and Special Programs/MED
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8884
Fax: (301) 215-8888

Postdoctoral Research Fellowships for Physicians

Howard Hughes Medical Institute
Office of Grants and Special Programs/POST
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8884
Fax: (301) 215-8888

Research Resources

This program provides support to research and educational institutions in the United States that serve as national resource laboratories and teaching facilities, including those supplying unique biological stocks and materials. The Institute limits the grants to organizations whose activities not only serve the biomedical research community as a whole, but also coincide with specific Institute interests. All proposals are rigorously evaluated to ensure that the awards respond to demonstrated needs.

Undergraduate Biological Sciences Education Program

Grants under this program are intended to strengthen undergraduate education and research in the biological sciences and such related fields as chemistry, physics, and mathematics, in U.S. academic institutions. Proposals are submitted by invitation only.

A principal objective of the program is to attract and retain science students, including women and members of minority groups underrepresented in the sciences. One approach is through the support of stimulating research experiences. Another objective is to strengthen undergraduate science education by providing for the acquisition of modern equipment and for laboratory renovation. Another is to forge stronger links among educational institutions at all levels by providing

opportunities in the sciences for teachers and students.

Competing institutions are assessed on the basis of their records of having graduated students who went on to matriculate in medical school or to earn doctoral degrees in biology, chemistry, physics, and mathematics (during the most recent 10-year period for which data are available). Institutions are invited to compete based on data from the Association of American Medical Colleges, the National Research Council, and the U.S. Department of Education. In addition, a number of institutions are invited to participate on their record of having graduated students from minority groups underrepresented in the sciences who went on to medical school or to earn doctorates in biology or related fields.

1994 Undergraduate Program Competition

For the 1994 competition, invitations to compete have gone to public and private universities classified by the Carnegie Foundation for the Advancement of Teaching as Research Universities I and II and Doctorate-Granting Universities I and II. Research I universities receive annually at least $33.5 million in federal support for research and development and award at least 50 Ph.D. degrees each year. Research II universities receive annually between $12.5 million and $33.5 million in federal support for research and development and award at least 50 degrees each year. Both groups offer a full range of baccalaureate programs, are committed to graduate education through the doctoral degree, and give high priority to research. In addition to offering a full range of baccalaureate programs, the mission of doctorate granting institutions includes a commitment to graduate education through the doctorate. Doctorate-granting I universities award at least 40 Ph.D. degrees annually in five or more academic disciplines. Doctorate-granting II universities award annually 20 or more Ph.D. degrees in at least one discipline or 10 or more Ph.D. degrees in three or more disciplines.

Precollege and Public Science Education

Through this grants program, the Institute explores avenues of support for precollege and public science education. Initiatives are designed to address the level of scientific knowledge and interest of both schoolchildren and adults.

In 1987 the Institute awarded a grant to the National Research Council to support a comprehensive study of biology teaching at the elementary and secondary levels. In September 1990 the NRC reported the results in *Fulfilling the Promise—Biology Education in the Nation's Schools.* The major findings and recommendations have been carefully considered in developing the precollege and public initiatives. Guidance is also provided through results of the precollege-oriented

outreach activities of the Institute's undergraduate program.

The precollege initiative currently under way provides support to science museums, aquaria, botanical gardens, and zoological parks.

Awards to children's museums, general science and natural history museums, and science and technology centers support science education programs for children and youth, their teachers and families, and community organizations. Grants were awarded in 1992 and 1993 for five-year periods. The 1993 awards were the first to include aquaria, botanical gardens, arboreta, and zoos.

Competitors were selected after consultation with numerous experts in the field. Reviewers took into consideration existing relationships with educational organizations, as well as experience in conducting high-quality science education programs at the precollege level.

Precollege Science Education Initiative for Biomedical Research Institutions

An initiative for biomedical research institutions is the Institute's latest effort in the area of precollege science education. It will enable science-rich institutions to work in collaboration with schools, youth organizations, and community groups. The objective is to develop educational activities that focus specifically on biology or integrate biology with other scientific disciplines. It will build on the unique resources that biomedical research institutions can offer, through educational activities of a less traditional nature, to stimulate interest in science, particularly among young people.

The 1994 grants competition was open to biomedical research institutions that the Institute had invited to apply. These comprise about 250 medical schools, academic health centers, and independent research institutions. The selection was made after consultation with the Association of American Medical Colleges, Association of Academic Health Centers, Association of Independent Research Institutions, and several databases.

Local Initiatives

The Institute's local science education grants address national concerns regarding the state of science education by providing unique opportunities at the local level for students and teachers to gain hands-on experiences in the science classroom and research laboratory. The primary recipients are public school students and teachers of Montgomery County, Maryland, though some awards may benefit those in the greater Washington area. The Institute works closely with school officials and local research institutions in developing the projects. Although the Institute will consider unsolicited requests, the grants are intended to support objectives through well-defined science education programs in the local community.

International Program

International Research Scholars Program

The important contribution of scientists abroad to advances in biomedical science stimulated the Institute to launch in 1991 a limited program of international research grants. Small and experimental, the program is limited to specific selected countries. The first grants are supporting the research of scientists in Canada and Mexico; and the second competition, announced in 1992, was for awards to Australia, the United Kingdom, and New Zealand.

Each grant supports research expenses, with considerable flexibility, for a term of five years. The recipients are promising scientists who have made significant contributions to fundamental biomedical research and are still developing. They must hold appropriate full-time academic or research appointments, and may not be citizens or permanent residents of the United States.

Nominations of candidates are requested from officials of leading biomedical organizations in the eligible countries and from Institute investigators, review boards, and advisers. Eligible nominees are evaluated by a large panel of scientists with appropriate expertise, and those rated highest are invited to submit a brief research proposal. An external review panel evaluates the proposals and ranks the candidates. Then the Institute's management, weighing the rank order and the Institute's overall objectives, recommends awards to the Trustees for authorization of funding.

Research Grants for Eastern Europe and the Former Soviet Union

In 1994 an international program of research grants was directed at biomedical researchers in 10 selected countries of Eastern Europe and of the former Soviet Union. Forty to sixty awards will fund scientists in their own institutions, and an equal number will involve international collaboration. The competition involves an open application process and then follows review procedures comparable to those for the International Research Scholars Program.

Other International Activities

Other than the 1991 and 1992 awards described above, the Institute has made only one grant under the International Program. This is for joint activities by the U.S. National Academy of Sciences and the Mexican Academia de la Investigacion Cientifica. Few additional awards are anticipated. Applications should only be submitted after consultation with the grants program management.

Program Assessment

Program assessment activities involve research by various public and private agencies external to the Institute, as well as internal analyses. The external activities are gen-

erally conducted through contracts for specific research projects. Thus, there is no grants program as such for program assessment.

Unsolicited Proposals

Although the Institute will consider unsolicited requests, grants are intended to support specific objectives through well-defined programs. Thus the Institute will only be able to fund a small fraction of unsolicited proposals. The grants program does not support research projects in the United States. Rather, the Institute directly employs independent investigators in Institute laboratories at leading universities, research hospitals and academic medical centers.

Initial correspondence to the Institute concerning support for science education should be in the form of a brief letter outlining (1) the specific need and the approach proposed, (2) the institution's special capabilities for implementation, (3) the qualifications of the proposed director, (4) the general plan of action to meet the objectives, and (5) the estimated budget, timetable, and existing funds for the project.

Further information on the Institute's research programs, copies of the annual report, and other publications are available from the Office of Communications.

Correspondence and inquiries concerning the grants program should be directed to:

Joseph G. Perpich, M.D., J.D.
Vice President for Grants and Special Programs
(301) 215-8890

Barbara Filner, Ph.D.
Graduate Science Education Program and
International Research Scholars Program
(301) 215-8884

Stephen A. Barkanic
Undergraduate Science Education Program
(301) 215-8872

David L. Davis–Van Atta (acting)
Precollege and Public Science Education Program
(301) 215-8873

David L. Davis–Van Atta
Program Assessment
(301) 215-8872

Howard Hughes Medical Institute
Office of Grants and Special Programs
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
Fax: (301) 215-8888

For publications and information on the Institute, contact:

Howard H[illegible]s Medical Institute
Office of Communications
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8862

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Selected Grants Publications

General Publications

Grants for Science Education (annual)

Community Partnerships in Science Education, Washington, D.C., Metropolitan Area Precollege Science Education Initiatives, 1994 (annual)

Meetings of Grantees

Graduate Education Fellows Meetings

Meeting of Medical Student Fellows, Program and Abstracts (annual)

Meeting of Predoctoral and Physician Postdoctoral Fellows, Program and Abstracts (annual)

Undergraduate Program Directors Meetings

Attracting Students to Science: Undergraduate and Precollege Programs, 1992

Enriching the Undergraduate Laboratory Experience, 1993

Institutional Strategies for Enhancing Undergraduate Science Education, 1993

Precollege Science Education Program Directors Meeting

Science Museums: Creating Partnerships in Science Education, 1994

Program Announcements

Graduate Science Education Program

Predoctoral Fellowships in Biological Sciences (annual)

Research Training Fellowships for Medical Students (annual)

Postdoctoral Research Fellowships for Physicians (annual)

Undergraduate Biological Sciences Education Program

Undergraduate Biological Sciences Education Program (annual)

Precollege and Public Science Education Program

Precollege Science Education Program (annual)

International Program

International Program (biennial)

Information Booklets

Graduate Science Education Program

Information for Medical Student Fellows and Fellowship Institutions (annual)

Information for Predoctoral Fellows and Fellowship Institutions (annual)

Information for Physician Research Fellows and Fellowship Institutions (annual)

Undergraduate Biological Sciences Education Program

Information for Colleges and Universities Awarded Undergraduate Grants (annual)

Precollege and Public Science Education Program

Information for Science Museums and Biomedical Research Institutions Awarded Precollege Grants (annual)

International Program

Information for International Research Scholars and Grantee Institutions (biennial)

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Howard Hughes Medical Institute
Office of Grants and Special Programs
4000 Jones Bridge Road
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