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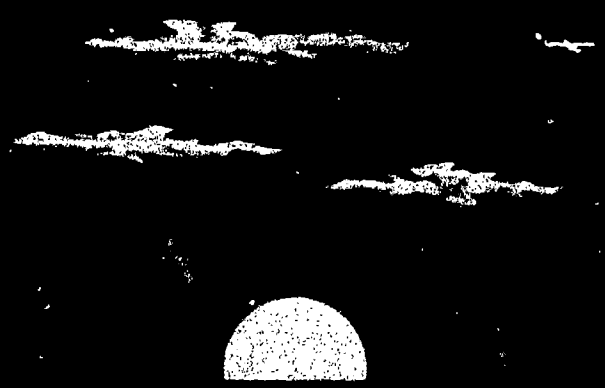
ABSTRACT

The Division of Human Resource Development of the National Science Foundation (NSF) has the responsibility for broadening the participation of minority groups underrepresented in science, engineering and mathematics. This publication highlights a selection of model projects funded by the NSF to accomplish that mandate. The projects are presented in three sections concerning: an NSF precollege focus, an undergraduate focus, and faculty development and research initiatives. Within these sections 32 projects are presented from 5 minority targeted programs: (1) Comprehensive Regional Centers for Minorities; (2) Alliances for Minority Participation; (3) Research Careers for Minority Scholars; (4) Research Improvement in Minority Institutions; and (5) Minority Research Centers of Excellence. Program descriptions and goals, individual project profiles, and summary statistical data on programs are presented. Two appendices contain a list of Education and Human Resource minority-targeted projects by program and a list of other NSF publications of interest. (MDH)

Gateway

TO DIVERSITY IN THE SCIENTIFIC AND TECHNOLOGICAL WORKFORCE



Division of Human Resource Development Directorate for Education and Human Resources National Science Foundation

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The Foundation has TDD (Telephonic Device for the Deaf) capability, which enables individuals with hearing impairment to communicate with the Division of Personnel and Management about NSF programs, employment, or general information. The telephone number is (202) 357-7492.

Acknowledgments

We wish to acknowledge the work of Dr. Elmima Johnson, Staff Associate, and Dr. Roosevelt Calbert, Deputy Director in the Division of Human Resource Development, who served as the editors of this publication. Writers included L. Voss, B. Sprungman, L. Davis, and Drs. Calbert and Johnson.

We also wish to acknowledge the cooperation of the project directors who were interviewed for this publication and to recognize the dedication and commitment of staff of the Directorate for Education and Human Resources (EHR) and the staff in the individual projects, who are collectively responsible for the success of NSF's targeted minority programs in the Division of Human Resource Development.

Gateway to Diversity
in the
Scientific and Technological Workforce

Directorate for Education & Human Resources
National Science Foundation
September 1992

Foreword

Message from the Assistant Director

This publication is the result of several discussion sessions in the Directorate for Education and Human Resources (EHR) on strategies to highlight NSF activities focusing on minorities that are underrepresented in science and engineering. It is the successor to an earlier publication that combined all the existing minority-focused programs into one program announcement. Each of these documents illustrates the NSF's long-term strategy to increase the participation and achievement of minorities in science, engineering, and mathematics (SEM) through systemic and comprehensive approaches.

To broaden the public's understanding that the increased participation of minorities in SEM and other disciplines is essential to the nation's welfare, and that many segments of the population are involved in this effort, this publication profiles model programs that encourage alliances and coalitions among the Federal, academic, industrial, and other private sectors. The material in this publication clearly demonstrates the NSF's leadership in developing programs to train students and faculty at all educational levels.

We are pleased about the enthusiasm of the project directors who agreed to be profiled and their realization that this document is an important way to demonstrate accomplishments and accountability for these key NSF minority programs.

Luther S. Williams
Assistant Director
Education and Human Resources

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Executive Summary

The National Science Foundation's (NSF) Division of Human Resource Development (HRD), within the Directorate for Education and Human Resources, has primary responsibility for broadening participation of minority groups underrepresented in science, engineering, and mathematics (SEM). The NSF minority programs reflect the Foundation's growing commitment to develop the resources of the scientific and technological community as a whole and to ensure an adequately trained research and development workforce in the next decade.

The Education and Human Resources Directorate has five major long-range goals.

- To help ensure that a high-quality school education in science is available to every child in the United States and is of sufficient quality to enable those who are interested and talented to pursue technical careers at all levels;
- To help ensure that the educational pipelines carrying students to careers in science, mathematics, and engineering yield enough well-educated individuals to meet the needs of the U.S. technical workforce;
- To help ensure that those who select science and engineering careers have available the best possible professional education in their discipline;
- To help ensure that opportunities are available at the college level for interested nonspecialists to broaden their scientific backgrounds; and
- To support informal science education programs and to maintain public interest in, and awareness of, scientific and technological developments.

The Division of Human Resource Development is one of the six divisions of the Education and Human Resources Directorate. HRD activities reflect NSF's commitment to developing the resources of the scientific and technical community as a whole. Objectives of the programs profiled in this publication are as follows:

- To increase opportunities for participation in the nation's scientific and technical enterprise for investigators who are minorities; young persons who are minorities; and faculty from predominantly undergraduate colleges and universities;
- To strengthen the capabilities of institutions that have significant minority enrollments; and
- To foster comprehensive approaches and build effective coalitions that address the development of scientific and engineering talent, drawing from underrepresented minority groups on a nationwide basis.

NSF's goals are to increase the number of minorities underrepresented in NSF-supported fields receiving B.S. degrees to more than 50,000 annually by the year 2000 and to increase the minority Ph.D. attainment to more than 2,000 annually by the same year.

Minorities that are underrepresented in science and engineering are: Blacks, Hispanics, American Indians, Native Alaskans, and Native Pacific Islanders (Micronesian and Polynesian).

This publication highlights a selection of model projects among numerous such projects funded by the NSF Directorate for Education and Human Resources in five minority targeted programs: Comprehensive Regional Centers for Minorities (CRCM); Alliances for Minority Participation (AMP); Research Careers for Minority Scholars (RCMS); Research Improvement in Minority Institutions (RIMI); and Minority Research Centers of Excellence (MRCE).

Program descriptions and goals, individual project profiles, and summary statistical data on programs are presented in the following pages.

Introduction

The historical roots of mathematics and science can be traced to Africa and Egypt, then to the great explorers of the Mediterranean of Hispanic ancestry and to the courageous people who found a way to cross the land bridge from Asia to North America. Thus, mathematics and science are a part of the heritage of today's minority students who are underrepresented in science, engineering, and mathematics.

Mathematics, physics, and engineering were the tools that the ancient Egyptians utilized in building the great pyramids and their magnificent seafaring ships. Even chemistry—the effects of salt water on their wooden ships—and the biology of barnacles were subjects their scientists and engineers had to master.

The precursors of today's meteorologists were consultants to yesterday's explorers. Navigators were employed to chart courses around hidden atolls and "sea monsters." Today our technology—like our array of communications and remote sensing satellites—assists us, but the necessity of understanding and best utilizing these assets rests on scientists and engineers of all ages. The participation of today's students is valuable in meeting tomorrow's scientific and technological challenges.

In the 1980s, in response to a growing concern that the United States was no longer providing its children with the intellectual tools needed for the 21st century—particularly in mathematics and the sciences—the National Science Foundation (NSF) developed a new generation of education and human resources programs.

The aggressive actions of NSF in establishing these minority education programs have set a high standard. The programs are successful models for national education reform. Other agencies have begun replicating these programs. NSF's minority programs will have a ripple effect over the next ten years as the nation pursues excellence in education.

The NSF minority programs also offer a model that private companies are interested in supporting. In search of successful models, industry is aware of how these programs encourage initiative and excellence. The concept has been successful in attracting minorities into science. NSF-funded research programs serve as a beacon to students who are interested in careers in the sciences.

Career Access Opportunities in Science and Technology

The National Science Foundation's Career Access Opportunities in Science and Technology (CAREER ACCESS) program supports Comprehensive Regional Centers for Minorities (CRCM), Partnerships for Minority Student Achievement (PMSA), and Summer Science Camps (SSC). CAREER ACCESS enhances the kindergarten through 12th grade science and mathematics preparation of underrepresented students in an effort to increase the number of students prepared to enroll and succeed as science, engineering, and mathematics (SEM) majors in college. The objective of the program is to improve the education of underrepresented minorities at the precollege level by strengthening student science, mathematics, and technology literacy through curriculum reform, teacher enhancement, student enrichment, and other activities.

In fiscal year (FY) 1991, the restructuring of the CAREER ACCESS program had four major accomplishments: First, all existing projects were examined and funding for weaker projects was terminated. Second, new and more demanding standards of performance were set for project awardees and for the program. Third, the program—which initially provided activities for kindergarten through undergraduate students—was restructured to focus exclusively at the precollege level to increase the number of minority students who are adequately prepared and motivated to pursue SEM majors in college. The fourth achievement provided two new initiatives in FY 1992: Partnerships for Minority Student Achievement, to encourage school districts to take the lead in regional changes in education; and Summer Science Camps, to provide a mechanism to increase summer enrichment opportunities for middle school students nationwide.

Comprehensive Regional Centers for Minorities

The Comprehensive Regional Centers for Minorities Program supports the establishment of coalitions of colleges, universities, school districts, business, industry, and other organizations that are designed to substantively improve the precollege experience of minority students in science and mathematics. The goal of the CRCMs is to stimulate systemic improvement in precollege education in regions with significant minority population in a way that results in an increase in the number of minority high school students with strong interest, confidence, and skills to pursue further study in science, engineering, and mathematics.

These large-scale projects are supported at a level of up to $1 million per year for up to five years. Each CRCM establishes measurable objectives on which its progress is evaluated annually. The centers are in the process of setting up databases in concert with NSF's Division of Research, Evaluation and Dissemination (DRED) that will provide the base for evaluation. The Centers are also judged on the awardee's ability to manage the CRCM in a manner that maximizes achievement of the program goals.

The database measures the success of a project by the number of program participants; the attitudinal, motivational, and academic enhancement that the programs provide; and the number of participants who complete educational programs leading to careers in science and technology.

The Division of Human Resource Development (HRD) has created a set of activities and projects that have an excellent chance of meeting the objectives of the program, which are described below.

Saturday Science and Mathematics Academies. This 10-week program activity was first offered at Clark Atlanta University in 1978 and because of its success was included in the CRCM program plan. The Saturday Academies are academic enrichment programs providing instruction in hands-on laboratory science, mathematics, computer applications, and communications skills for third through eighth grade students. The courses are taught by college professors and high school teachers and are designed to stimulate interest in SEM careers.

Several Saturday Academies offer students an opportunity to write articles, as well as poetry, on topics related to science and mathematics and their lives. Their creative works are published in a newsletter that provides recognition to the students and to the CRCM project.

Summer Institutes for Junior High School Students. This activity provides instruction in laboratory science, mathematics, computer applications, communications skills, and weekly career seminars in which scientists and engineers talk to students about their careers. Undergraduate and graduate students serve as tutors and counselors in the program, and help participants explore SEM careers.

Summer Science, Engineering, and Mathematics Institutes. This is a six-week high school summer residential program activity to enhance skills in math, computer science, laboratory science, and communications. Students also receive opportunities to attend local seminars to hear presentations given by scientists and engineers and to participate in field trips.

Pre-Freshman Bridge Programs. These special intervention programs, consisting of six weeks, eight hours per day of intense work on chemistry, mathematics, physics, and computer science, are designed to increase the retention rate of minority students in the undergraduate science and engineering pipeline. They ensure that all participants possess the prerequisite skills necessary to ensure a successful freshman year. Throughout the year, special lectures, seminars, and activities are conducted to support the goal.

Instructional Improvements and Curriculum Revisions utilize K-12 teacher workshops, material development activities, regional conferences, summer teacher enhancement internships, and curriculum reviews.

Industry-based mentor programs, after-school programs, career days, science fairs, and science clubs are also among the projects and activities that have been effective in meeting CRCM goals.

Figure 1 illustrates CRCM program student participants by grade level for academic year 1991-1992. During this period there were more than 3,400 participants in grades K through 6, approximately 4,400 students in grades 7 through 9, and more than 4,700 participants in grades 10 through 12. Figure 2 shows the geographic distribution of the 12 CRCM Centers and 2 prototypes.

Figure 1: Comprehensive Regional Centers for Minorities

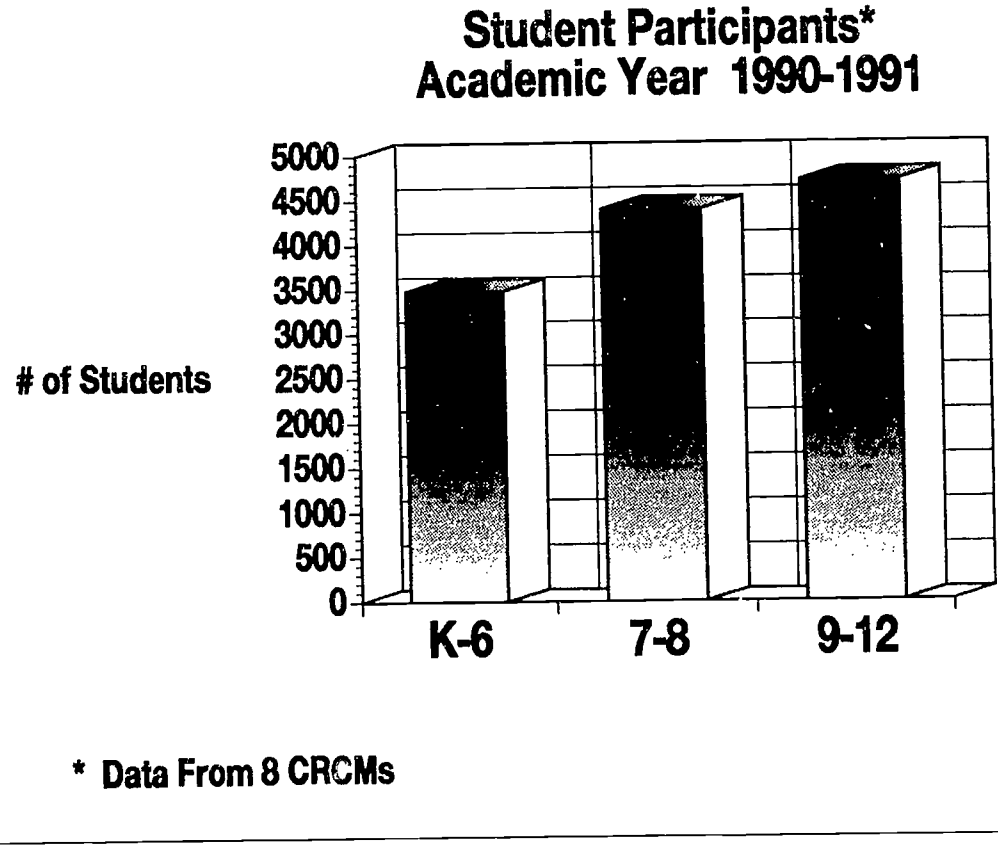


Figure 2: Comprehensive Regional Centers for Minorities in Science and Engineering

Comprehensive Regional Centers for Minorities (CRCM) FY 1991

Twelve Existing Centers

1. California State University at Los Angeles
2. Clark Atlanta University
3. Florida A&M University
4. Loyola University of Chicago
5. Maricopa County Community College District
6. Minorities in Science and Engineering Center at Cincinnati
7. Montana State University
8. PATHS/PRISM at Philadelphia
9. University of Missouri in St. Louis
10. University of Puerto Rico, Rio Piedras
11. University of Texas at San Antonio
12. University of Texas at El Paso

Two Prototypes

1. Morgan State University
2. New Mexico Highlands University

Clark Atlanta University

The Atlanta University Center—in cooperation with the Georgia Institute of Technology and Georgia State University—was awarded a five-year NSF grant to establish the Atlanta Comprehensive Regional Center for Minorities (ACRCM) in Science and Technology in the fall of 1988. The ACRCM is composed of Clark Atlanta University, Morehouse College, Morris Brown College, and Spelman College—all Historically Black Colleges and Universities (HBCU)—and is reaching out to the local and regional community with their scientific resources and expertise.

Dr. Melvin R. Webb, a professor of biology as well as Dean of the College of Education at Clark Atlanta University, is the principal investigator of the Center. Dr. Webb is assisted with program planning and implementation by six other project directors, one from each of the participating institutions. Eleven Clark Atlanta University faculty members contribute to the programs, along with 40 student staff members who provide tutoring and mentoring.

The Center has two primary objectives: the implementation of precollege and informal education activities for students, and the revision and update of science, engineering, and mathematics (SEM) and career information available to secondary school teachers, counselors, and community members. Major activities under each of these components are described as follows:

The precollege component consists of Saturday Science Academies; the Summer Institute for Junior High School Students; Pre-Freshman Bridge Programs; and the Summer Science, Engineering, and Mathematics Institute. In 1992, 480 precollege minority students participated in these CRCM activities.

An innovative element of the Summer Science, Engineering, and Mathematics Institute is the student-produced newspaper, *Expressions*. It not only promotes their programs and recognizes their sponsors, but most importantly it provides students with an avenue for voicing their concerns.

Dr. Webb explained the importance of students having an outlet for creative expression to enable them to manage the pressures of high school life: "Students have the opportunity to see themselves as scientists and engineers through the publication. In addition to articles on Center programs, students write about their concerns—from environmental problems to alcohol and drug abuse. One section is devoted to students' poetry and prose."

Additional Center projects that are not typical of SEM programs include an improvisational theater workshop called "Scenes from Science." Students also create murals related to science topics.

This project offers programs for teachers including the seminars and workshops on Curriculum Review and Revision. A mathematics workshop was provided for middle school teachers along with two science workshops for elementary and middle school teachers. The Center's "Cheap Science" workshop—utilizing discarded household items—may lead to a workbook on inexpensive materials and hands-on exercises to use in elementary school science classrooms. Thirty teachers were involved in the CRCM's teacher inservice programs in 1992.

A further development of this program was the incorporation of the Saturday Science Academy concept into the Atlanta public schools. Also, as a result of the project's work with the science and mathematics coordinators in the Atlanta Public School System, all students are now required to take algebra.

The Center plans to develop informal education activities with science-related facilities that include the Atlanta Botanical Gardens, SCITREK, ZOO Atlanta, and the Fernbank Science Center. Another project under way is a Junior Museum/Science and Mathematics Tutorial Center, which is funded by other Federal and local sources. The Center will be located in one of the oldest housing project in America, which is adjacent to Clark Atlanta University.

The project has also established the Office of Science and Technology Careers to promote the pursuit of careers in science and technology at the precollege, undergraduate, and graduate levels. The office has materials and information on opportunities for summer internships, research and academic enrichment experiences, and graduate fellowships and assistantships. Future plans include adding audiovisual equipment and computers to the office to enable students to examine recruitment materials available on video tapes and computer disks.

Dr. Webb attributes the success of the Atlanta CRCM in part to three activities. First, there is a monthly directors' meeting to develop and review program plans. Directors also submit written reports twice a year to Dr. Webb that highlight and justify any deviations from the original plans.

Next, an executive committee composed of senior administrators from the cooperating institutions and

the Atlanta public schools monitors the progress of the CRCM. This committee evaluates schedules, resources, and the technical status of selected milestones for each aspect of the program.

Finally, the CRCM's National Advisory Committee, composed of industry and government representatives, reviews program activities, writes critiques and reports, and recommends changes to improve the program.

A computerized database has been created that tracks the long-term impact of the program on each student participant. The ACRCM measures its success by the number of program participants; the attitudinal, motivational, and academic enhancement that the programs provide; and the number of participants who complete educational programs leading to SEM careers.

NSF funding has assisted the CRCM in acquiring support from other sources including the Office of Naval Research Historically Black Colleges and Universities (HBCU) Initiative in the Mathematical and Physical Sciences, the Howard Hughes Medical Institute Undergraduate Initiatives in the Biomedical Sciences program, and the IBM Computer Laboratory Demonstration Center for Pre-Service and Inservice Teacher Training.

Dr. Webb's work has resulted in increasing the close cooperation among the Center's partners and the community. Through the CRCM's Resource Center for Science and Engineering, Clark Atlanta University is sharing its scientific resources—both human and material—with the local community and the region. One program will produce and disseminate minority-centered science recruitment materials to parents and provide a series of high school counselor awareness workshops. In 1992, the Parents' Orientation Programs attracted 350 participants.

The CRCM programs have been, and continue to be, a highlight of Dr. Webb's career. "Directing this Center has given me an opportunity to work on programs of national significance and with exceedingly talented and dedicated people.

"The Center's programs change the attitudes of students towards science and mathematics by exposing them to intellectually honest activities in science, mathematics, computer science, and creative expression. The students learn that they can participate in, and contribute to, science and mathematics—and they can succeed if they so choose." Dr. Webb stresses, "There is no secret to it, it doesn't require a particular talent. It just takes a willingness to work at it." With a commitment of funding from a variety of sources for at least a decade, he believes the CRCM programs could achieve systemic change in our schools nationwide.

Loyola University of Chicago

Chicago's Comprehensive Regional Center for Minorities program, known also as the Access 2000 Chicago Partnership, is a collaborative effort among area universities, public schools, government agencies, and local organizations—both private and nonprofit.

Access 2000 is a vehicle for dialogue and cooperation among the partners as they work toward their goal of increasing the participation of underrepresented minorities in SEM professions. Their main objective is to quadruple the number of African-American and Hispanic students completing SEM baccalaureate degrees in Chicago between 1990 and 2000.

To reach its goal, Access 2000 intends to help increase from 250 to 1,000 the number of underrepresented minority students who receive SEM baccalaureates in Chicago by the year 2000. The program is well on its way to meeting that goal. In 1991, 1,490 students were involved in 19 full-time out-of-school SEM activities. It is projected that in 1992, 1,645 students will have participated in 25 SEM activities.

Spearheading the Chicago effort are dedicated co-principal investigators Dr. Eric Hamilton and Dr. Dorothy Strong. In addition to directing the CRCM at Loyola University of Chicago, the host institution, Dr. Hamilton of Loyola's Mathematical Sciences Department is also a computer expert. Dr. Strong is Director of Mathematics for the Chicago Public Schools.

According to Dr. Hamilton, the Chicago CRCM is successful in encouraging partnerships because staff members are more than willing to share the recognition for the program's accomplishments. They offer to potential partners more than they ask of them. They also offer administrative and program leadership to leverage the work of each partner and to best utilize available resources. Each partner receives credit and is a winner in the process.

Access 2000 currently offers 39 different SEM programs and activities to enrich the education of students and teachers. The programs include Club PreMed, Holistic Tutoring Center, Chemistry Camp, Saturday Academy, AAAS Science Day, JETS Design Competition, Loyola/Aspira PREP, Problem-Based Learning, and Math/Science Centers, as well as

science fairs, teacher workshops, and inservice training.

Four of the activities—the algebra activities, Argonne's Chicago Science Explorers, the Young Scholars Program, and the Black Churches' Project—are described below.

Thanks to Dr. Dorothy Strong, who lends assistance to the Chicago CRCM at no cost, a critical program was instituted that increases awareness of the role of algebra as the "pump" for minority students to proceed in SEM careers. In cooperation with the Chicago Algebra Project and the Parent Community Council, Dr. Strong has arranged training for Chicago public school teachers using the Bob Moses Algebra Model and the Chicago Algebra Framework. Reaching nearly 2,500 students and 1,100 teachers, the Algebra Project received $51,000 of the $290,000 CRCM funds in 1991. Additionally, CRCM funds supported a combined teacher training and algebra instruction activity during the summer of 1992 for 30 teachers who worked with 50 students as part of their training.

Access 2000 also cooperated with the National Society of Hispanic MBA's to cosponsor an algebra program for 7th- and 8th-grade students. Finally, Access 2000 hosted an "Access to Algebra" national meeting that brought together other CRCM personnel and directors of mathematics departments from six major cities.

Argonne's Chicago Science Explorers program reaches over 22,000 minority children each year at a cost of approximately one million dollars, with a core grant made by the Department of Energy, supplemented by the Chicago CRCM. In addition to student enrichment, the program offers teacher training in science. It provides teaching and reading materials to accompany videotapes produced by a Chicago public broadcasting service. Teachers may sign up for the program, receive the curriculum, and show the videotapes. The Argonne National Laboratory, which helps develop some of the videotapes, also has its scientists speak in classrooms and invites teachers and students to the laboratory.

The Loyola Young Scholars Program offers activities in mathematics and computer science for 35 students at a cost of $80,000. The learning environment is stimulating and challenging. This project is responsible for nearly doubling statewide participation in the upper level AP Computer Science Examination by underrepresented minorities.

The Center's involvement in the Chicago Urban League's Black Churches' Project is an effort to support children in neighborhoods beset by poverty, violence, and school failure, using an often underutilized vital resource in the community. Several Chicago churches serve as sites for after-school tutorials, summer schools, computer classes, and science activities. This collaborative effort reached over 600 students in 1991 at a cost of $140,000 to the Chicago CRCM.

Beyond the creative educational programs, the project has introduced an innovative administrative function that serves to increase minority students in the SEM pipeline. It is called the Chicago Area Science Program Application Resource (CASPAR). Initiated in March 1992, CASPAR represents a systematic, unified effort to encourage children to participate in summer science programs.

CASPAR consists of a document that details all the summer science programs in the Chicago area, a summary chart, and an application form. Students are encouraged to apply directly to programs of interest and may use the CASPAR application to apply to Access 2000 for admission to one or more of the programs. Access 2000 then forwards the applications to the appropriate institutions. Thus, the Chicago CRCM has become an application clearinghouse for SEM activities.

Additionally, the CRCM acts as a recruitment service, a function once handled individually by each CRCM partner. Not only does CASPAR serve as a tool to raise the visibility and viability of summer science programs, it helps the Center in the allocation of funds to programs that best serve students.

In response to the NSF charge to nurture, encourage, motivate, and challenge minority youngsters to pursue SEM careers, Access 2000 has produced evaluation instruments to measure success in achieving the goal. In February 1991, Access 2000 began the development of six attitudinal instruments in English and Spanish for 1st- through 12th-grade students. These instruments were indexed to 15 variables that assess the degree to which participating students have been "nurtured, encouraged, motivated and challenged." The instruments reflect the success of each program and detect student attitudinal changes over one or several years when given as pre- and post-measures. Project investigators from other CRCMs have requested copies of the instruments for use in their programs.

In addition to the attitudinal surveys, Access 2000 tracks students served in out-of-school programs. About 2000 students are part of this database, which is now six months old.

The Chicago CRCM staff works closely with the community. They send CASPAR applications to parent community councils, and one of their Holistic Tutoring Centers is located in a local church.

Dr. Hamilton also receives strong support from his university. He is on indefinite leave from his department at Loyola University Chicago to work for the project. The university also contributes administrative support services to the program.

For Dr. Hamilton, who is particularly interested in computer consulting and research, the position with Access 2000 is an opportunity to use his skills in a unique way. He enjoys the interesting work and the challenge of bringing so many people together to make positive contributions to the SEM education of minority students.

Although Access 2000 does not keep track of all the publicity it receives, many articles have been written about the Center's activities. "Argonne's Chicago Science Explorers program has had a ton of articles written in local and national publications," says Hamilton. More than 15 articles have been written on the university's Young Scholars' project, and the CRCM itself has been featured in several articles. The Black Churches' Project was highlighted in a two-page article in the *New York Times*.

Despite the many successes of Access 2000, Dr. Hamilton has some concerns. Many students are turned away annually for certain programs that receive five times more applicants than available positions, while other programs must search for students. The system is currently operating at capacity, and additional funding alone would not be sufficient. Institutional resources would have to be expanded and more staff trained.

Concerning systemic change on a national level, Dr. Hamilton suggested that NSF programs focus on algebra. "Algebra instruction is probably the most systemically oriented, single strategy of this CRCM. It should be a national priority."

Dr. Hamilton explained, "The national CRCM effort is an important program. It has a very noble mission. We make the difference for a lot of students; that is what it is all about!"

Maricopa County Community College District

In Arizona's Maricopa County, thanks to the Comprehensive Regional Center for Minorities, the options for students to pursue studies in science, engineering, and mathematics will not be limited.

That is the conviction of Dr. Alfredo G. de los Santos, Jr., Vice Chancellor of Educational Development, Maricopa Community Colleges; Dr. Kathleen K. Church, Vice Provost and Senior Vice President of Academic Programs, Arizona State University, both CRCM co-principal investigators; and Dr. Ernesto Ramirez, Jr., Director of the Maricopa County Community Colleges' CRCM. It is coupled with their determination to double over a five-year period the number of Hispanic, African American, and American Indian students in the Phoenix area proficient in science and engineering skills.

"Our kids," as Dr. Ramirez calls them, are the 2,382 minority student participants (K-12) eager to explore the world of science, and to gain access to undergraduate college classes that will prepare them for SEM careers. Minority student enrollment in CRCM programs is approximately 76 percent Hispanic, 10 percent African American, and 8 percent American Indian.

From all indications, the program seems well on the way to achieving Dr. Ramirez's goal of unlimited options. After little more than a year, results are encouraging: a 26 percent increase in the number of high school graduates proficient to pursue studies in SEM, an increase of 19 percent and 11 percent, respectively, in the number of 8th- and 9th-grade students enrolled in algebra I, and a 12 percent increase in the number of high school graduates attending college.

The Maricopa County CRCM has achieved these remarkable results through a systematic approach to the problem of underachievement of minority students. Their approach targets the entire student environment: parents, teachers, and the community, as well as the students themselves.

Indeed, the Maricopa County CRCM has identified parents as crucial in supporting and reinforcing the schools' attempts to improve minority performance. They have used various model programs in their endeavor to develop the Families Achieving Mathematics Excellence manual and the short training program to facilitate its use by teachers. "When children sit down with parents in the Families Achieving Science Excellence (FASE) and our other family math programs, a new and synergistic relationship is created between that parent and child," explained Dr. de los Santos, who also serves as the principal investigator for the CRCM project.

Just as important are the teachers providing this education for the world of tomorrow, some 268 of

whom have been involved through the program. Thanks to the spillover effects of improving teacher skills, the educational experience for approximately 8,889 students has been enhanced. No grade level has been neglected; there are hands-on mathematics training for teachers of grades 4-6, hands-on science training provided for teachers from kindergarten through the 8th grade, and a variety of teacher training components available at the high school level.

The program also provides a summer school physics course that does not require calculus and one in life sciences to instruct teachers. Finally, for teachers who have completed the training program, an onsite follow-up service has been added to ensure the availability of expert scientific information. Advice is also available to teachers developing lesson plans.

The heart of the program clearly lies with the students and the direct services they receive through the program. "We follow our students closely," said Dr. de los Santos.

By the 6th grade, students have mastered basic arithmetic concepts. During 7th and 8th grades, they strengthen those skills, and algebraic concepts are introduced. By 9th grade, they will be ready to pursue freshman algebra, and by the time they graduate from high school, ideally, they are ready to enroll in calculus. Students have the opportunity to participate in the Algebra Club (grades 6-8), which gives youngsters a taste of the joys of mathematics. Comparable strides are being made in other curriculum areas, with the enhancement of skills in the life and physical sciences through summer training programs for teachers.

NSF funds are being used not only to strengthen and reinforce the curriculum, but to provide bilingual materials, after-school tutoring, and precollege motivational experiences. The program also sponsors five summer science and math camps throughout the metropolitan Phoenix area, featuring hands-on experiments in botany, astronomy, physics, chemistry, and environmental science using real-life applications.

The summer camps focus on providing hands-on experience. For example, in the summer of 1992, student teams designed and built models of energy-efficient homes from plywood, then "landscaped" those homes with replicas of native plants, forming natural habitats attractive to local wildlife.

To verify the key role of direct services to students in the Center's program, the Maricopa CRCM has developed a relational database system to keep track of each student in the system. "Students are tracked from their first day to their last," said Dr. de los Santos, "wherever they might move within the state. Tracking is just one component of our efforts to achieve the objectives we have set for ourselves. This is the goal we are continually striving for."

Both Dr. de los Santos and Dr. Ramirez stress the hard work and collaboration that have made the Maricopa County Community College CRCM a reality. The plan to apply for the grant was born in the "Think Tank," an educational consortium that began in Phoenix in 1988 to address issues of students at risk of dropping out of high school.

The grant brings together 11 institutions in the Maricopa County Community College District, in cooperation with Arizona State University and 17 public school districts in Maricopa County. Dr. de los Santos is quick to credit the success of the program, in part, to the relationships formed at the time of the grant preparation. "The quality of the relationship, at both a professional and personal level, between the Maricopa Community College District and Arizona State is second to none," he said. "The same is true of our relationships with school superintendents and school principals."

Another crucial set of ties has been formed with industry. "We prepare many mid-level managers for Maricopa County businesses. We included major industry players with backgrounds in SEM in our deliberations on the proposal, and the grant proposal contained letters of support from 30 different industries, including Motorola, Intel, and the Salt River Project," Dr. de los Santos added.

From proposal to reality, the program has generated enormous enthusiasm at all educational levels. "Our elementary, junior high, and high school teachers have shown great enthusiasm, and they are spreading the word to their colleagues," said Dr. Ramirez. "Moreover, there is a high level of enthusiasm among our own faculty, who are involved in teacher training. And finally, there is the enthusiasm of the children, and our college students who work with them as tutors. They are so enthusiastic, it's contagious!"

With such community response, it is easy to understand Dr. Ramirez's optimism about "our kids." In an atmosphere where analytic learning is encouraged and horizons pushed back as far as one can see on a desert landscape, it is possible to believe with him that, contrary to previous generations, "our kids'" options will not be limited.

Montana State University

In 1991, the Alliance of States Supporting Indians in Science and Technology (ASSIST) received a five-year NSF grant to establish a CRCM project to meet the special needs of American Indians in the Northwest region. Because of the serious health concerns—high rates of diabetes, hypertension, and alcoholism—faced by American Indians, the CRCM works to recruit, retain, and graduate American Indian students in the sciences, including biomedical science/health-related fields and to enhance teacher-training techniques. The ASSIST CRCM has a unique advantage in reaching this population because it works in concert with 18 of the 24 tribal community colleges located in Montana, Wyoming, North Dakota, South Dakota, Minnesota, Idaho, Oregon, and Washington.

The rural isolation of American Indian schools in the Northwest is prominent and poses problems for teachers and students. In Montana alone, there are over 100 one-room schools. Recruiting and retaining teachers with science and mathematics knowledge are especially difficult tasks. Keeping teachers abreast of new teaching methods and current on many subjects is also a problem.

To prepare American Indian children for the world of the future and to increase the number who enter science and engineering careers requires teachers who can motivate students to enter these fields. For students, the problem is also serious. Half of the American Indian students do not complete high school, because of boredom, personal problems, family needs, or an unwillingness to travel long distances each day to obtain an education.

Making systemic changes under these difficult conditions is the goal of Dr. Patrick Weasel Head and Dr. David Young, co-principal investigators of the CRCM at Montana State University, the leading institution in the Alliance. The American Indian Research Opportunities (AIRO) Program, which houses ASSIST, has been actively working with tribal community colleges since 1982 to reverse the poor conditions of the 300,000 American Indians living on reservations. Currently, ASSIST has over 50 programs that support teachers and encourage students to enter the science and mathematics pipeline.

In 1991, there were 10,868 American Indian students enrolled in Montana schools in grades K-8. Dr. Weasel Head projects that at least 5,500 (50 percent) of these students will be taking some type of college preparatory program in grades 9-12 by the end of the five-year ASSIST program. In addition, the number of American Indian students in Montana completing high school will increase from 542 in 1991 to 677 in 1996. For baccalaureate degrees in science, mathematics, and engineering, the Center's goal is an increase from 45 to 81 in the same time span.

ASSIST programs focus primarily on precollege students and teachers and on significant interaction with the tribal community colleges. Two goals of the programs are to demystify science and to improve the transition between education levels, while tracking student progress. A few notable ASSIST programs are described below.

Adopt-A-School. In this program, tribal community colleges agree to adopt schools in grades K-12 and help the schools plan science fairs, career days, science academies, or other science-based activities. The program increases communications between tribal community college instructors, undergraduate students, precollege teachers, young students, school district administrators, and community members.

Science-By-Mail. In this program, more than 30 American Indian scientists and tribal college instructors in the region became pen pals to students in grades 4-9. The Museum of the Rockies at Montana State University, which offers the service, also provides students with challenging science project kits and sponsors the Science-By-Mail Day for students and teachers who seek stimulating science experiences. This is one of the CRCM's most successful programs because it fuels interest in the sciences particularly, among 4th- through 6th-grade students. Studies by the Alliance indicate a major leak in the science and mathematics pipeline beginning in the 8th grade; therefore, a program that focuses on students before they reach that grade level is considered crucial to gain and retain students in the pipeline.

Saturday Science Academy. This program is designed to sustain the interest sparked by the summer science classes. Fourth through sixth graders study under student role models from tribal community colleges and aid guest instructors who teach science lessons. The program goes further than most enrichment programs of this kind because it emphasizes that science has always been a part of the Indian culture, except that such scientists are called by different names. For example, a field trip to study plants might include an ecologist and a tribal herbalist, both of whom explain the value of plants for food and medicine.

Involving Students in the Process of Science. This program creates opportunities for students to utilize personal computers to design experiments, acquire experimental data, and organize and analyze the data during an inservice teacher training workshop. It is aimed at junior and senior high school students in science, biology, chemistry, earth science, and physics classes. Each of 12 teachers from reservations brings a student to an inservice science workshop held at a tribal community college. The students benefit by working as peers with their instructors and scientists and serve as laboratory assistants upon returning to their schools. As part of the program, each participating school receives a personal computer and a data acquisition system.

Using Computers to Teach. This precollege preparation program in chemistry allows students to conduct chemistry experiments utilizing a computer. The program could have national implications for courses taught by computer, especially in rural areas.

After one year of operation, Center staff point to three positive results. First, the co-principal investigators found a need to clarify where the leaks occurred in the American Indian science and mathematics pipeline. The response has been to develop a comprehensive tracking system to collect and monitor information on students.

Second, the co-principal investigators have observed increased interaction between area K-12 schools and tribally controlled community colleges. The schools are talking to the tribal colleges, something they did not do before. Dr. Young believes the new dialogue will lead to more students applying to tribal community colleges. Even parents are choosing to attend college.

Third, the Alliance is finding that participation and support from other Federal programs are increasing, and that requests for ASSIST's involvement in other mathematics and science initiatives are becoming common.

Dr. Weasel Head and Dr. Young continue their efforts to encourage people to work together in the network. They are actively supporting teleconferencing, an alternative approach for reaching rural schools. Montana State University wants to link the tribal community colleges, the high schools, and major four-year science institutions with each other, so they can offer science enrichment activities. Such an effort is well timed because the tribal community colleges are involved in a pilot project to study the benefits of linking all 24 tribal institutions. Because of rising travel costs, teleconferencing also could facilitate discussions among ASSIST project directors. ASSIST may also explore cooperative efforts with the Spokane Star Schools, a program that provides about 200 rural schools with telecommunication dishes to establish down-link capability.

ASSIST is making a special effort to involve parents in their children's education. They believe the school districts, the community, and the parents must be involved in a holistic approach to education. Dr. Young commented, "Parents need to be empowered to say, Why are we not graduating more math and science individuals? If you look at the population in the tribal colleges, you will find that more parents are enrolling. Many are single parents. They are developing a strong appreciation for education."

A unique parental program exists at one of the colleges. Middle school female students are invited to the college and are asked to bring their fathers or uncles for a weekend of science and mathematics tutoring activities on computers. At other sessions, male students are invited with their mothers or aunts to science and mathematics activities. The college then follows up by providing students and their parents with information to help with science and mathematics activities at home.

Dr. Weasel Head and Dr. Young are dedicated to helping American Indian youth rise above the hardships of the past and present. Perhaps some of the Native American students in the program today will be the lead scientists and engineers of tomorrow who find cures for diseases as their ancestral medicine men did in the past.

Morgan State University

In 1990, Morgan State University (MSU) received a three-year $490,000 NSF grant to establish a prototype CRCM in the Baltimore metropolitan area.

Participating institutions and schools included Morgan State University, Towson State University, Bowie State University, Prince George's Community College, Baltimore City Public Schools, and Prince George's County Public Schools. Today, this prototype CRCM continues to link participants with each other and with local businesses, government agencies, and clubs to increase the number of minorities in the science and mathematics education pipeline.

Dr. Eugene DeLoatch, Dean of the MSU School of Engineering and principal investigator for Morgan State's CRCM, divides the precollege program into three categories: academic preparation, teacher enhancement, and informal education.

The academic preparation category includes classroom activities for students and projects such as the Bridge Programs, the Saturday Science Academies, and the Summer Mathematics and Science Institutes.

The second category focuses on teacher enhancement with in-service training sessions and Saturday Teacher Workshops.

Third, the informal education category includes community outreach, with Family Mathematics, Science Nights for Adults, Career Awareness, and Mentoring programs. Equally important are the science and mathematics activities sponsored by Mathematics, Engineering and Science Achievement (MESA) and Academic Champions of Excellence (ACE) clubs. Together, the three categories of activities provide strong support to the precollege science and mathematics pipeline.

The program functions at three pipeline levels. Recognizing that a cadre of good teachers is crucial to success, the program emphasizes teacher inservice training and science and mathematics awareness in grades K-6.

At the middle school level, CRCM programs introduce students and teachers to career exploration. Students become part of a mathematics chain with the hope that by the end of 8th grade, they will be prepared for algebra courses.

Finally, at the high school level, students are encouraged to take algebra and biology. They then move on to chemistry and physics in the sciences and to algebra II, geometry, and calculus in mathematics. By the time students complete high school, they have the option to choose a science or mathematics career; they are not precluded from making that choice for lack of the necessary course requirements.

The CRCM's main role is to stimulate and leverage the resources of people and organizations in the community and thus to produce systemic change. The key agents of change are the teachers.

"I am extremely excited about the enthusiasm I see among teachers towards the hands-on innovations we use in in-service training. It's exciting to see the light come back into the teachers' eyes. They are generating change in the whole system," Dr. DeLoatch ardently reported.

Like most new initiatives, this one has witnessed a few unanticipated results. Foremost among them is the sense of awe shared by teachers. Much of the CRCM's work has been centered on space activities. Teachers learn about tracking satellites, about weather, and about how data are transmitted from satellites to Earth. Most teachers find learning about computers, data reception, and computer mapping fascinating. They understand the rapid pace of technology and scientific knowledge and realize their responsibility in teaching for the future.

During the summer of 1992, a CRCM workshop sparked teachers' interest in the use of weather satellite data in the classroom. Images of the day's cloud patterns were downlinked by a satellite dish at Morgan State University and then transmitted to the teachers' computers. Teachers learned how to interpret the data and design activities for students.

The workshop was sponsored by the National Aeronautics and Space Administration's (NASA) Johns Hopkins University Space Grant Consortium, of which the MSU CRCM is a member. The consortium also provides space science internships for secondary mathematics and science teachers. They receive graduate credit through the Center for Excellence in Mathematics and Science Education, an effort supported by the CRCM.

The linkages between the CRCM and the many support groups also affect students directly. The Center for Excellence serves as the CRCM's conduit for the Baltimore Science Fair. Additionally, the CRCM is linked to MESA and ACE clubs and funds their science and mathematics projects. The club projects offer students as young as 10 years old the excitement of science and the "doability" of mathematics, and keep them involved through their regular meetings.

The MESA and ACE clubs benefit the CRCM in other ways too. Through MESA and ACE, the program funds the Family Mathematics program to excite parents and help them understand the challenges their children face. The science and mathematics clubs act as an important resource to find teachers and students for the CRCM programs. Middle and high school students are placed in the database to expose them to as many linking interventions as possible and to track their performance in science and mathematics courses until they complete high school.

This idea of linking is crucial to program success. Dr. DeLoatch explains, "We match these students with our programs so that we can pass the students from one program to another. By the time they complete 8th grade, they should be ready for algebra and biology courses. Then, they could proceed from biology to chemistry to physics and from algebra to geometry to algebra II to calculus. We track the students and suggest activities and programs in which they might want to participate each summer

and each academic year, whether to move from an ACE club to a Saturday Science Academy, for example. The ultimate goal is to pass on to students a high level of interest in science and mathematics."

Dr. DeLoatch helps community members understand the intent of the programs and how one program overlaps another, and then encourages organizations to shape and link their programs to interface with each other. Dr. DeLoatch explained the CRCM's intervention strategy: "We will not fund duplication, but we will fund the interface of programs to create a continuous pipeline. We hand off students from one program to another."

Dr. DeLoatch also emphasizes collaboration, saying that "to reach students, one cannot bypass key people in the effort." Teachers and parents are critical to the effort in grades K-6. Parents, teachers, and the community are especially important to students in grades 7-12.

He hopes to move from a prototype to a full-fledged CRCM. He would like to see the current number of 800 students in the prototype program expand to 3,000.

Dr. DeLoatch also hopes to significantly influence the education process in the region by having the CRCM programs adopted in a systemic way by local public school districts. To this end, he has initiated an experiment with students in one high school, adding 40 students fror the freshman class each year until 160 students are selected. These students' educational endeavors will be closely tracked as they pursue their education.

The school chosen for the experiment historically has had few students selecting science and technology careers. The CRCM will place a computer graphics laboratory in the school and establish teams of two students each to share a computer. The goal: to challenge students in science and mathematics from the freshman year onward to see if they choose science and mathematics programs at the undergraduate level. Dr. DeLoatch believes it may take a decade to obtain valid results from the experiment.

The MSU CRCM will monitor both the experimental group and a control group, a class that does not receive the benefits of the programs. Comparison of the results from the two groups should bolster claims that the Center does achieve results, and that it is worthwhile to adopt some of its programs and teaching methods. "Systemic change is likely to come," according to Dr. DeLoatch, "as the CRCM program produces proof. People will find it difficult to ignore the results."

With time, additional funds will be needed to operate the CRCM. Dr. DeLoatch hopes that matching funds from industry and other government agencies will be available for their programs as the CRCM moves out of the prototype stage. Industry and government currently provide in-kind services and other forms of support that greatly contribute to the quality of the students' experience.

The programs are strengthened by the resources available in an urban setting. For example, Martin Marietta provides tours of its facilities, Westinghouse and the Maryland Science Center provide speakers, and the Department of Defense Career Exploration Program in Engineering and Science offers activities for the students.

Though the CRCM does not receive funds from other sources for its programs, additional funds are funneled through it to link existing community programs.

Through networking and involvement in the Center's activities, university faculty members are getting to know teachers in public schools. This linkage between two educational levels will certainly benefit students.

Students are not the only benefactors of the intervention programs. The universities also benefit by enhancing their image and by helping to produce better prepared students. "In some ways it may appear that we are exerting additional effort but it really is a part of our job," says Dr. DeLoatch. As long as students' lives are changed for the better, the participating institutions will be willing to go the extra mile."

Thanks to NSF, these extra efforts are occurring nationwide through other CRCMs. "Although there is much to learn from other CRCM Program Directors at their yearly meetings," Dr. DeLoatch cautions, "we must never forget the regional differences among the CRCMs and their individual goals and objectives. It is when programs are individually tailored to meet student needs that they are truly beneficial."

Dr. DeLoatch insists that "we must get students involved and keep them involved after school, on the weekends, and through the summer. Let science and mathematics become second nature to them."

Philadelphia PATHS/PRISM

The Philadelphia Alliance for Teaching Humanities in the Schools (PATHS) and the Philadelphia Renaissance in Science and Mathematics (PRISM) are programs of the Philadelphia Partnership for

Education, which includes colleges and universities, foundations, and corporations in partnership with the School District of Philadelphia. CRCM program funding made possible the extension and expansion of proven programs under PATHS/PRISM.

"We teach students that the historical roots of mathematics and science can be traced beyond the famous Greek and Roman contributions to Africa and Egypt," explained Stephen Cox, director of the NSF project. "It is part of African American history and part of their heritage." Just as the construction of the great pyramids and shipbuilding challenged the ancestors of today's African-American students, Philadelphia's PATHS/PRISM programs involve students in the search for solutions to today's technological challenges.

The CRCM coordinates educational activities throughout metropolitan Philadelphia with the goal of significantly increasing minority student participation in science, engineering, and technology. The project involves five metropolitan school districts; seventeen universities, colleges, and community colleges; museums; corporations; and minority professional organizations.

The Center built upon a base of successful existing programs. The initial program was the Philadelphia Regional Introduction for Minorities to Engineering (PRIME), a 20-year program that offered a variety of support activities to African Americans and Hispanics. Through the CRCM, PRIME exceeded its 1989 five-year expansion plan in two years (PRIME Universities Program (PUP) grew from 540 students to 1,100 students). Ninety-five percent of the PRIME high school graduates are enrolled in four-year college programs.

The development of the CRCM was based on research and experience, which indicated that to prepare students for SEM careers, a more effective introduction to mathematics and science in the middle schools was required. To accomplish this, it was perceived that middle school teachers would need further enrichment in science and mathematics and students should be required to study algebra by the 8th grade.

As a result, the CRCM established the goal of providing workshops for 177 middle school teachers in transition mathematics and algebra. Teachers in the Algebra Project workshop staffed the summer Algebra Project for students, utilizing technology to convey mathematical concepts. K-8 teachers were also taught to incorporate the use of manipulatives in the instructional process. In addition, the Center is presently assisting high school teachers (who will affect over 1,000 students) in integrating science, mathematics, and technologies into their courses.

Since many certified algebra teachers have been transferred to the high schools, the program offers middle school teachers mathematics enrichment for graduate credit to help them move toward mathematics certification. The Algebra Project has significantly influenced both schools and students. Students, having been introduced to algebra and transition mathematics prior to high school, acquired more interest in these subjects. Initially, in the 1989-1990 academic year, approximately 500 students were enrolled in transition mathematics and algebra in the School District of Philadelphia. This number increased to 2,000 in 1991. "The Center has dedicated itself to improve the understanding and participation of African-American, Latino, and Native American students at all levels of the mathematics pipeline," said Mr. Cox.

The program's success was in part responsible for the Superintendent of the School District of Philadelphia mandating that algebra be taught in the 8th grade, affecting 3,000 to 4,000 8th graders.

The Center has many strategies for capturing student interest. Its program integrates technologies and humanities into SEM courses. When science was taught across the curriculum, subjects that were perceived as abstract and irrelevant by students acquired new meaning and significance. This integration of the humanities and science courses was a departure from the traditional curriculum and met with some initial resistance. However, science, mathematics, history, and literature are now viewed as an integral whole rather than as separate components vying for student time and interest.

The success of Center programs has attracted additional funding and sponsors. Organizers have leveraged NSF funding into support from local foundations, such as the William Penn, the Pew Charitable Trusts, the Ford, and the Merck Foundations.

In addition, industry contributes to the program. "Many of our organizers had previously worked in industry and had many contacts that helped us obtain the business community's support," said Mr. Cox. Private industry provides scientists and engineers who establish one-on-one mentoring relationships with youth. Eight hundred and seventeen students have participated in the mentoring program, which attempts to match them with mentors of similar backgrounds.

The CRCM also has formed a consortium of colleges and universities to pull students into the

pipeline. "We were able to build a large coalition of universities and colleges, because the logical continuation of our precollege efforts focused a well-prepared pool of students for undergraduate SEM curricula," explained Mr. Cox.

"We were losing students at different joints in the pipeline," said Mr. Cox. "The key is strategic intervention in students' lives." The Center has strengthened and expanded existing summer enrichment programs, as well as developed new programs, to bring entering first-year college students into the college environment. Participants have numbered 389 thus far. Several campuses offer residential programs from two to ten weeks in length. Living on campus demystifies the college experience and gives students a sense of ownership of the college—a sense of already belonging when they arrive in the fall. Participants are also introduced to student services such as tutoring, mentoring, and counseling, as well as assistance with study skills and activities related to the humanities. In addition, approximately 1,560 students participate in commuter and residential summer enrichment programs prior to the post-12th-grade level.

The overall effect of the hands-on experience in science and mathematics, student exposure to scientists and engineers as role models and mentors, and the integration of SEM into the general curriculum have made participation in the sciences familiar and natural for students. Continuing science courses in college takes on a certain logic. Science and mathematics becomes part of the students' past and future.

University of Texas at El Paso

The Comprehensive Regional Center, developed under UTEP leadership, includes six cooperating colleges and universities and seven school districts, representing 85 elementary and secondary schools. With a focus on precollege programs to involve underrepresented minority students in science, engineering, and mathematics (SEM) careers, the Center reaches out to the 81 percent of the minority students, mostly Hispanic, in these schools.

Business and community involvement in the programs has been extensive. Approximately 100 area scientists serve as mentors in Project LIFT-OFF for middle school and senior high students. An IBM employee who is on loan to UTEP for one year spends 25 percent of his time on CRCM-related activities, including establishing better bonds with industry. In addition, UTEP has a 10-year history of raising money from industry for its outreach programs. For 1992, in addition to its NSF funding, the project has received $100,000 from industry to pay for its precollege programs.

In keeping with its Center's emphasis on industry, business, and community involvement, CRCM is advised by a regional board made up of key administrators from the participating school districts, teachers, representatives from the cooperating colleges and universities, two regional business leaders, a regional civic leader, and a statewide public education leader.

In the summer of 1990, during its first year of operation, the Center served 1,773 precollege students. In 1991 with an expanded number of program activities available, the Center served 2,763 precollege students. Following a shift in program focus to more systemic, school-based programs for precollege students, the El Paso CRCM predicts that approximately 3,600 students will participate in its activities in 1992. Faculty member participation for 1992 is projected at 25, with 700 precollege teachers in the program.

Current programs offered are the Science Day Camps, a five-day program with periodic follow-up activities; Project LIFT-OFF, a five-year program with ongoing activities; and the Science/Engineering Institutes, with one- or two-week activities.

Held at elementary schools, the summer Science Day Camps provide students with hands-on science activities and examples of job-related applications of science and mathematics. In 1991, 33 camps in five school districts served nearly 1,500 students in grades 2-6. This represented 52 percent more students than in 1990.

Project LIFT-OFF identifies young people with potential in math and science at the 7th grade level and monitors them until they enter college. In 1990, 88 students were involved in Project LIFT-OFF. The program has grown to include 328 student participants in 1992.

The project links the students with mentors—practicing professionals in the region—who take them to laboratories and other science-related job sites. These visits enable minority students to see the variety of careers available, and to meet minority scientists who have succeeded in those careers. The mentors are linked with students for an extended period, and serve as advisors they can turn to as they move through the education pipeline. The ratio of mentors to students is approximately one to one.

Participants in Project LIFT-OFF take part in special programs that offer hands-on experiences in science and mathematics. In one 1991 summer

project, students designed and built cardboard canoes and raced them competitively in the university pool. Other engineering projects have included building a hot air balloon, building a telescope, and designing, building, and racing soap box derby cars.

Project LIFT-OFF publishes a newsletter entitled *Starlog* for the student participants, the "Rising Stars" of the project, that contains articles on students' design projects and activities and future events. A booklet identifying the local professionals serving as mentors is also produced by the project annually.

Junior and senior high students participate in the Summer Science or Engineering Institutes. These programs enhance students' skills in laboratory science, mathematics, computer science, and communications. In 1991, three two-week programs served 150 students in grades 7-10.

These programs will be expanded from three at three institutions to twelve at four institutions. Additionally, two six-week summer institutes will be conducted for students planning to enter science and engineering undergraduate programs in the fall. In total, the CRCM will lend support to 14 summer institutes. Students served will increase from 150 to nearly 550, a 73 percent growth in the number of students served.

In the fall of 1991, the El Paso CRCM joined with an area collaborative to improve student achievement and undertake research and evaluation on issues of school improvement. The CRCM will continue to work on teacher enhancement with school district administrations and teachers, focusing on curriculum change.

When asked to identify the project's most important contribution, Dr. Riter expressed his satisfaction that Center programs and professionals have raised minority students' awareness of their ability to enter science careers. "NSF funding has made possible a whole spectrum of summer activities encouraging these young people to pursue careers in science and engineering," he said.

Dr. Riter cited two unanticipated results of the summer programs: the growing interest in them and the employment they have provided for undergraduate minority students. Even with 200 slots for precollege students in the programs, the Center was forced to turn down 150 applicants. There is a great deal more interest in SEM programs than people anticipated. "All that was needed," according to Dr. Riter, "was for the students' interest to be stimulated." The Center primarily employs undergraduates, supervised by faculty, to teach in the programs, and because these students must work to finance their own education, the summer programs are an empowering experience for them.

"There is a double benefit here for NSF in employing students. First, the programs will attract underrepresented minority students to pursue careers in science and engineering. The second benefit is that jobs which reinforce their own education and make them feel good about themselves are a powerful way to support underrepresented minority students who are already enrolled in science and engineering programs," said Dr. Steven Riter, co-principal investigator of the CRCM at the University of Texas at El Paso (UTEP). Dr. Riter is Dean of UTEP's School of Engineering.

Working as CRCM mentors and teachers also provides students with leadership opportunities. One of the stated goals of the NSF Minority Programs is to help create leaders.

Parental support has been good, according to Dr. Riter. Many of the parents do not read or speak English, and they may not understand the benefits of the outreach programs. Nevertheless, they have allowed their children to participate even when they were needed at home.

UTEP has created a unique method of assisting students with their homework. A published flyer says: "Stumped by science homework? Just call Science Studio KTEP 88.5 FM on your dial—talk radio with smart answers!" Not only can students tune in on Saturdays at 11 a.m., but they can also call the KTEP Listener Line anytime with their problems, and a UTEP science professor will return the call.

There is also strong support within the university. The UTEP President, Dr. Diana Natalicio, sees the University's mission as improving education in the El Paso area in general, and Dr. Riter is in complete agreement with this view. In fact, when asked about the influence of NSF funding and the project on his career, he replied that the Center has changed the direction of his professional activities. NSF support has resulted in his making a personal commitment to precollege education; he now focuses on the ability of students before they arrive at the university.

Dr. Riter added, "What we have said, frankly, is that we have a broader role. We need to be involved with secondary school education in the El Paso area because ultimately these are the kids we are going to teach. We are not responsible for secondary education, but we have an obligation to do whatever we can to improve it and to assure that students in the system have as much of a chance as possible to come to our university, or any university, and succeed."

Partnerships for Minority Student Achievement (PMSA)

One of two new initiatives in FY 1992 under CAREER ACCESS is Partnerships for Minority Student Achievement (PMSA). PMSA is a comprehensive precollege program that builds on NSF's strategy of forging alliances and partnerships for systemic reform. School systems with significant minority student populations are required to establish partnerships with institutions of higher education, business and industry, professional organizations, community-based organizations, and other educational organizations that can be advantageous in facilitating program objectives.

This activity is intended to (1) focus on the needs of underrepresented minority students; (2) require the direct participation of the school system as the unit of change; (3) provide support for an integrated, systemic approach to enhancing all major components of the educational system; and (4) actively identify successful models in the public and private sector and support their replication.

In FY 1992, PMSA received 17 proposals and will make four awards. The awards will range from $400,000 to $500,000 and these projects will receive a total of $5.6 million over a three-year period. The four school systems represented in these awards—Prince George's County, Maryland; Rochester, New York, City School District; Santa Ana, California, Unified School District; and Durham, North Carolina, City and County Schools—serve more than 100,000 underrepresented minority students.

Summer Science Camps (SSC)

The second new initiative under CAREER ACCESS is the Summer Science Camps (SSC) program, which supports residential and commuter enrichment projects for minority students in grades 7-9. Eligible organizations include school districts, museums, colleges, universities, and nonprofit youth-centered and/or community-based organizations.

Activities include classroom and hands-on experiences that provide for an integrated study of SEM within the natural environment; expanded counseling regarding career opportunities in these disciplines; interaction with role models in these fields; and activities that strengthen family and peer support for student interest in these areas.

FY 1992 was the first year of SSC program operations. Approximately 150 proposals were received and 28 awards will be made, for a total of $1,975,000. The average award amount for these three-year continuing grants was $70,000 for commuter projects and $100,000 for residential ones. The projects will receive a total of approximately $6.2 million over a three-year period. These projects will serve a total of 1,700 middle school minority students in 17 states in commuter and residential projects ranging from four to six weeks in length.

Alliances for Minority Participation

The Alliances for Minority Participation (AMP) program supports the establishment of comprehensive approaches to increase the quantity and quality of education of underrepresented minorities successfully completing science, engineering, and mathematics (SEM) baccalaureate degree programs.

A goal of the program is also to increase the number of minority students continuing in graduate studies in SEM fields. This near-term objective facilitates AMP's long-term goal of increasing the production of minority Ph.D. degrees in SEM fields, including entry into faculty positions. AMP activities include student enrichment, academic enrichment, curriculum improvement, and enhancement of institutions with significant minority SEM enrollment. **AMP program activities are directed toward the overall NSF goal of producing 50,000 minority baccalaureates annually in SEM fields and 2,000 doctoral degree recipients annually, both by the year 2000.**

AMP reaches out to all undergraduate minority students regardless of their grade point average and starts as soon as they graduate from high school, involving them in Bridge Programs to prepare them for college entrance in the fall.

Some of the AMP activities and programs are described as follows.

Summer Bridge Program. The program activity is for incoming freshmen during the summer prior to their college entrance. It features academic work in areas that will assist students in passing traditional "gatekeeping" courses, such as calculus, biology, physics, organic chemistry, and English.

Peer Study Groups. The peer self-help network offers undergraduate students the opportunity to study together under the direction of a mathematics, engineering, or science instructor for critical courses such as calculus, physics, and chemistry. Peer study groups encourage students to work at a more advanced level and foster cooperative learning.

Undergraduate Summer Research and Graduate Preparation Institute. This program for upper level students features academic programs in research methodology, experimental design, mathematics or statistics, and related topics that are customized to the students' needs and academic fields of interest. Students also receive orientation to the Graduate Record Exam (GRE) and guidance concerning preparing for and applying to graduate programs.

Faculty-Directed Undergraduate Student Research Projects. This program activity gives students hands-on opportunities to serve as apprentice researchers to a faculty member's research project.

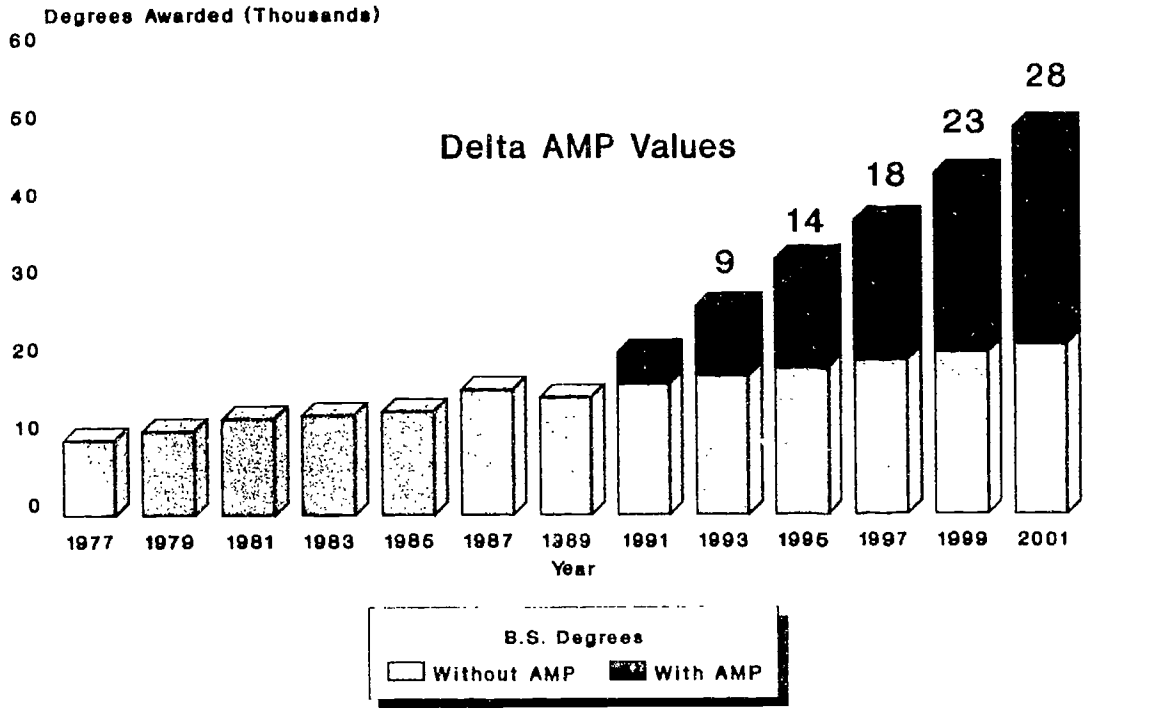
Summer Internships. These programs offer students opportunities to work with scientists in government laboratories and participating corporations.

Graduate Level Mentorships. After being matched to a science, mathematics, or engineering instructor, a student receives guidance about the pursuit of a doctoral degree, orientation to the customs of academe, and advice on the student's research project.

Minority Experts Database. The database stores resumes of minority graduates and other professionals and provides on-line updates of available employment opportunities. The database is becoming a comprehensive directory of opportunities in residency, internship, fellowship, and scholarship programs. The information includes all the government programs and may well be the first time so much information has been accumulated in one place and made available free of charge to students.

Figure 3 compares SEM baccalaureate degree attainment for minority students from 1977 to 2001. There is a significant increase beginning in 1991, when the AMP program was implemented.

Figure 3: National Science Foundation
*Alliances for Minority Participation B.S. Degree Production in SEM**



SEM Science, Engineering, and Mathematics

Arizona State University

One of the goals of the Coalition to Increase Minority Degrees (CIMD) is to encourage and support almost 5,000 underrepresented minority students annually in pursuing baccalaureate degrees in SEM by the year 2000. Reaching this goal would contribute 10 percent of the NSF national goal of 50,000 annually by the year 2000. CIMD also plans to assist minority students in obtaining 182 science, mathematics, and engineering doctorate degrees per year by the year 2000, a fourfold increase over the current regional number.

CIMD received an NSF Alliances for Minority Participation (AMP) grant in 1991. Headquartered at Arizona State University, CIMD combines the resources and abilities of 75 institutions and organizations serving minority students in Arizona, Colorado, New Mexico, western Texas, and Utah who are underrepresented in SEM.

Some of the key partners are 35 major colleges and universities in the region; 8 professional organizations including the American Indian Science and Engineering Society, Society of Hispanic Professional Engineers, and the National Society of Black Engineers; Federal laboratories and government agencies, including Sandia and Los Alamos; and 26 corporations.

Dr. Gary D. Keller Cardenas, the AMP Program Director at Arizona State University, coordinates the program and is assisted by co-principal investigators representing each of the major minority groups in the region. The co-principal investigators are Dr. Albert L. McHenry, Dr. Fred Begay, and Dr. Antonio A. Garcia.

Although the program is open to students representing all minority groups, the largest number of student participants are Hispanic and American Indian. The current ethnic distribution of minority students in the program is Hispanic, 69 percent; American Indian, 18 percent; African American, 9 percent; and Pacific Islander, 4 percent.

CIMD has clearly defined its future direction. The organization provides underrepresented minority students from junior high school through the doctoral level with a continuous set of academic and support programs and enrichment activities in SEM. The Coalition gained program cohesion by using a $40,000 NSF planning grant to build consensus among its members regarding the purpose and goals of the program.

The planning grant allowed Dr. Keller Cardenas to take an existing three-year-old academic structure that addressed precollege and graduate students and add programs that reach students in pursuit of baccalaureate degrees. Attempting to create a continuous pipeline, CIMD offers an expansive selection of programs and activities.

College students are offered Summer Bridge Programs for incoming first-year students, Peer Study Groups, Undergraduate Summer Research and Graduate Preparation Institutes, and Faculty-Directed Individual and Group Undergraduate Research Projects, as well as summer internships and graduate-level mentorships.

Because the results of each program are monitored regularly, midcourse change can be implemented quickly when necessary. If a project is not effective, it can be phased out, and a potentially successful program can be funded at the start of the new cycle.

The premier graduate program of the CIMD is Project 1000, a national initiative designed to recruit, retain, and graduate underrepresented minority students in master's and doctoral programs. Students receive free GRE workshops, a toll-free number offering bilingual counseling and academic advice, and a common application for a total of 71 comprehensive doctoral-granting institutions nationwide.

The Minority Experts Database also has been established by CIMD. The database stores resumes of minority graduates and other professionals and provides on-line updates of available employment opportunities.

In addition to the CIMD programs, a state-of-the-art student tracking and data management system called MAESTRO (Management and Evaluation of Student Tracking Objectives) has been created. Menu-driven and object-oriented, MAESTRO ensures both the integrity of detailed project evaluation and the replicability of the Coalition's comprehensive and longitudinal approach. The system contains 2,500 variables to help monitor and track program participants.

Although the NSF AMP component of the CIMD program is only six months old, the AMP program director already has observed some unanticipated results. One is the strong faculty support for the program. The Coalition's efforts have bound the faculty together in a common cause. "They are turned on," said Dr. Keller Cardenas. "Their level of enthusiasm and interest on behalf of underrepresented students is beautiful to behold."

Another unplanned result is the development of a comprehensive computer directory of academic

support opportunities in SEM for minority students. The directory includes information regarding residency, internship, fellowship, and scholarship programs sponsored by the government, private institutions, and foundations. It may well be the first time such extensive information on this subject has been accumulated in one place and made available free of charge to students.

Beyond the AMP funds, CIMD has obtained substantial support and cost-sharing contributions from participating institutions. Some of the support comes from foundations such as the Carnegie Corporation of New York, the Pew Charitable Trusts, the Alfred P. Sloan Foundation, the American Honda Foundation, and the ARCO Foundation.

The primary focus is to join committed faculty and students to pursue exciting academic work. Funding is used to buy chemicals and materials for laboratory research projects and to provide stipends to student participants. CIMD is also dedicated to preparing students to qualify for scholarship funds available through other sources.

"It is very exciting," said Dr. Keller Cardenas of the AMP program. "We have the opportunity to work with wonderful peop'e from other institutions and regions who have sim.lar objectives, and most importantly, to help students achieve their goals."

Jackson State University

The Mississippi Alliance for Minority Participation (MAMP) project places strong emphasis on undergraduate research and education and links eight state universities in Mississippi in this effort. MAMP's research foci are in the fields of chemistry, biology, physics, mathematics, computer science, and engineering. The members of MAMP are Alcorn State University, Delta State University, Jackson State University, Mississippi State University, Mississippi University for Women, Mississippi Valley State University, University of Mississippi, and University of Southern Mississippi.

MAMP is designed to focus on the whole student, thus ensuring higher success rates for minority students' college attendance and degree completion. Bridging programs facilitate the successful transition from high school to college and from undergraduate to graduate study. The summer program, open to approximately 200 students, starts with High School-to-College Bridge courses that provide instruction in all science and engineering subject areas. Over 11,000 students identified through the American College Test (ACT) are contacted by mail with follow-up by telephone. The overall goal of the MAMP program is to increase the number of bachelor of science degrees earned by minority program students from the current rate of 240 annually to 543 annually within five years.

Some students come from as far away as Ohio, Michigan, and Minnesota. Once in college, students receive strong support in their course work, research efforts, and personal lives. Students participate in an annual IMAGE Conference, interdisciplinary seminars, a scientific tools course, summer internships, and attend professional conferences. Research opportunities abound for students through summer and academic-year undergraduate research projects. Moral and educational support comes from minority role models and mentors, student support teams, and tutoring and study groups. Finally, a Graduate Record Examination (GRE) workshop helps students prepare for the GRE and graduate school.

Statewide implementation of the effort at eight Mississippi universities is coordinated by the project director, Dr. Richard Sullivan, Chairman of the Chemistry Department at Jackson State University. Dr. Sullivan has a site coordinator on each campus to oversee local program implementation.

According to Dr. Sullivan, the major effort of the recently launched (November 1991) MAMP program is the High School-to-College Summer Bridge activity that stresses successful movement of students from high school to college. Since many of the students are the first in their families to consider college, the summer program orients students and their parents to college life. Eight courses, ranging from three to six weeks, operate each summer. Students are not graded, although the course work is intense.

In addition to being tutored in analytical, writing, and speaking skills, students are guided in personal life skills and encouraged to take personal responsibility for their learning—to take charge of their careers in college. The community is involved in the bridge program through volunteers who take individual students to church, movies, and the mall. During the Fourth of July weekend, community volunteers invite students into their homes for the holiday.

One of Dr. Sullivan's goal is to improve the way introductory science courses are taught at the universities. Introductory science and engineering courses are being partially or entirely restructured by faculty to make them more meaningful by placing emphasis on teaching concepts that are portable rather than on rote memory. The "constructivist"

concept of learning allows students to use personal experiences, intuition, and mistakes to learn. Teachers on the campuses are being enlisted to teach the new courses and to turn them into "gateway" rather than "gatekeeper" courses, thus drawing more students into science and engineering careers.

Dr. Sullivan believes minority students at the undergraduate level are often misperceived by faculty. To reduce problems created by lack of cultural understanding, the universities hold cultural diversity workshops to raise the level of faculty awareness of people with orientations that differ from their own.

Although a statewide networking infrastructure was in place before MAMP received the grant, the NSF support also helps coordinate program efforts statewide.

Additional funding is being sought through private and other public sources to offer sustained precollege activities that are essential to increasing the number of minority students in the science and engineering pipeline. An industrial linkage component also leverages NSF and state funds by increasing business and industrial support for science and engineering education.

Mississippi universities participate in a broad base of industrial and governmental partnerships that provide undergraduate research opportunities for students. A unique plan to attract new industrial participation will place two grant-funded students at new industrial sites that agree to sponsor at least one additional intern and to fund all interns in subsequent years. Ultimately, Dr. Sullivan believes the best way to increase minority graduates in SEM is to enroll as many minority students as possible in college and, more important, to provide the emotional and academic support the students need to graduate.

To date, there have been no real surprises for the Alliance. Dr. Sullivan was pleased to see the attendance rate for the first Summer Bridge Program at his university 10 percent higher than originally expected.

Computers are used to network with other alliance programs, and the university database is accessible to other institutions. This database tracks precollege students interested in science and engineering and those who enter at the undergraduate level. In addition, MAMP will support a nationwide database for monitoring, evaluating, and reporting outcomes of all NSF Alliance projects.

Of particular interest to prospective industrial employers will be the development of a database to include science and engineering professionals and their employers from both the public and private sectors, as well as statistical information that can be used as "predictors" of applicants' probability of success.

An evaluation team has been created to review and publish the results of the program. In the interim, articles about MAMP have appeared in the *Black Collegiate* and the *Chronicle of Higher Education.*

University of California, Irvine

Cooperation, diversification, and planning for the future characterize the California Alliance for Minority Participation in the Sciences (CAMP). The University of California system is cooperating with the California State University System, the independent colleges and universities of California, the California Community Colleges, public school districts, and private enterprise in forming the unique partnership known as CAMP.

CAMP's goal is to promote a common vision: to increase the number of underrepresented minority students successfully completing undergraduate and graduate degrees in SEM across California and to develop an educational pipeline for access to SEM careers that will continue beyond the duration of the NSF grant.

Throughout the NSF grant application process, CAMP received solid support from University of California at Irvine's (UCI) top administrators, including the UCI Chancellor, Dr. Jack Peltason, who will become President of the University of California System in the fall of 1992. Chancellor Peltason said of CAMP: "With its scale encompassing the entire educational continuum in the state of California, we believe that the Alliance represents a model program of great value unprecedented in its potential to achieve its stated goals."

Dr. Eloy Rodriguez, professor in the Department of Developmental and Cell Biology at UCI, is the principal investigator of the CAMP project. As a student, he personally experienced some of the barriers to education that today continue to hamper underrepresented minority students. Co-principal investigators are the Executive Vice Chancellor of UCI, Dr. L. Dennis Smith, and Dr. Ralph Cicerone, nationally known for his work in atmospheric chemistry and global environmental change.

While Dr. Rodriguez is committed to students, he is also dedicated to his research. He operates the

Research Laboratories of Phytochemistry and Toxicology, an on-campus greenhouse lab that houses the important medicinal plants he studies. As a biochemist, he often travels to exotic places to collect medicinal plants for research. During the summer of 1992, several students accompanied him to the Amazon as research assistants. In the future, he plans to expand the number of students who can participate in this experience in hands-on science.

The goals of CAMP are ambitious: to double the number of minority degree graduates by the close of the century—3,500 bachelor's, 500 master's, and 150 doctoral degrees; to identify and remove barriers to education; to develop alternate sources of income so the program will continue without pause after the NSF grant has terminated; to create incentive programs for primary and secondary students; and to move students from the community college system, where most of them begin their education, into a university to obtain bachelor's and graduate degrees.

The philosophy that forms the foundation of these goals is the belief that students will want to become scientists—biological, chemical, or physical—only after they become excited about science. This excitement can best be generated, said Dr. Rodriguez, "by rubbing shoulders with scientists. Don't talk about science to students, help them do science," he contends.

CAMP will identify likely candidates for the program while they are still in elementary school and will monitor and encourage them all the way through high school and into college.

Not all of the students will enter CAMP's programs with a strong background in science. Consequently, CAMP is developing strategies to improve student performance. As Dr. Rodriguez said, "We want CAMP to entice more minority students and to improve the quality of their work. We explain to students, 'We don't want you to be just a passenger on the boat; we want you to steer it—to be its captain.'" Dr. Rodriguez also believes that writing is as much a gatekeeper as physics, chemistry, and calculus. Therefore, the CAMP project utilizes computers to help students improve their writing skills.

During the summers—usually free time for students—programs, activities, and classes are held to encourage student interest in the sciences.

Student identification and recruitment are only parts of the project. To provide incentives and training for students requires competent, qualified scientists to teach them. The minority faculty members recruited for the program will provide excellent role models for the students.

Herbert Carter, former Executive Vice Chancellor of the California State University System, stated in a *Los Angeles Times* article, "Those of us in education have been struggling with the issues of how to best engage the minds of young people who have lots of things tugging them in different directions. It is clear that education best occurs between teachers and students. That's where it all happens, on a one-to-one basis. The students will be able to relate to some of the best faculty in the world."

CAMP is a cooperative project between a diversity of institutions, both public and private, and this cooperation extends far beyond the five-year NSF grant. Six hundred science professors from the California State University System and independent universities throughout the state have enthusiastically agreed to participate in the project. Public school districts link the project to students and parents, and private enterprise provides internships, mentors, and permanent employment opportunities. It is truly an effort where all facets of the students' communities are involved.

Dr. Rodriguez explained the importance and the necessity of UC's involvement. "The University of California system is one of the premier research institutions in the world. UC campuses have produced top scientists and engineers in all fields of scientific research, development, and management in government, industry, and academia. UC has an obligation—and has made a strong commitment—to contribute to the recruitment and retention of students from underrepresented minority groups."

In an effort to reach as many minority students as possible, 80 percent of the five-year $5,000,000 grant is dedicated to supporting students in their quest for an education. The remaining 20 percent supports the infrastructure to encourage students to attend and to remain in college.

With NSF's help, CAMP has been able to form an alliance of diverse institutions and groups united by the common goal of enhancing the opportunities for minorities to contribute to the scientific knowledge base. It is providing encouragement and incentive directly through researchers themselves to a group of Americans who have too long been under-represented in the scientific and engineering community.

Research Careers for Minority Scholars

The Research Careers for Minority Scholars (RCMS) program provides support to four-year colleges and universities to implement research enrichment programs in science, engineering, and mathematics (SEM). The program includes stipends for qualified minority students to enable them to pursue career paths in SEM fields. Students are especially encouraged to seek careers leading them to higher education faculty positions.

In 1987, only 12 Institutions of Higher Learning (IHLs) graduated 20 or more African Americans with baccalaureate degrees in the biological sciences. Of those 12 institutions, 10 were Historically Black Colleges or Universities (HBCUs). Only 12 IHLs graduated 10 or more African Americans with baccalaureates in physical and environmental sciences in 1987. Of those 12 institutions, 10 were HBCUs. In 1987, only 1 percent of the SEM faculty on IHLs campuses were African American.

Based on these facts, RCMS was initiated in 1989 to encourage SEM departments to vigorously recruit minorities into the pipeline and retain them in these SEM disciplines through graduate school leading to faculty positions.

Support can be provided for student research experiences, tuition, counseling, mentoring, and other academic enrichment activities. Although the goals of the RCMS program are similar to those of the Alliances for Minority Participation (AMP) program, and its activities may also serve as AMP components, RCMS efforts tend to be smaller in scale and more departmentally oriented.

In the first two years of this program, the participating institutions retained 96 percent of their scholars, including 9 percent who received SEM degrees. In 1992, 35 colleges and universities participated in the program. By the end of 1992, more than 500 students will be involved nationwide.

Figure 4 illustrates the disciplinary analysis of existing RCMS projects. Figure 5 gives a breakdown of student participant status for 1991 and 1992.

Figure 4:

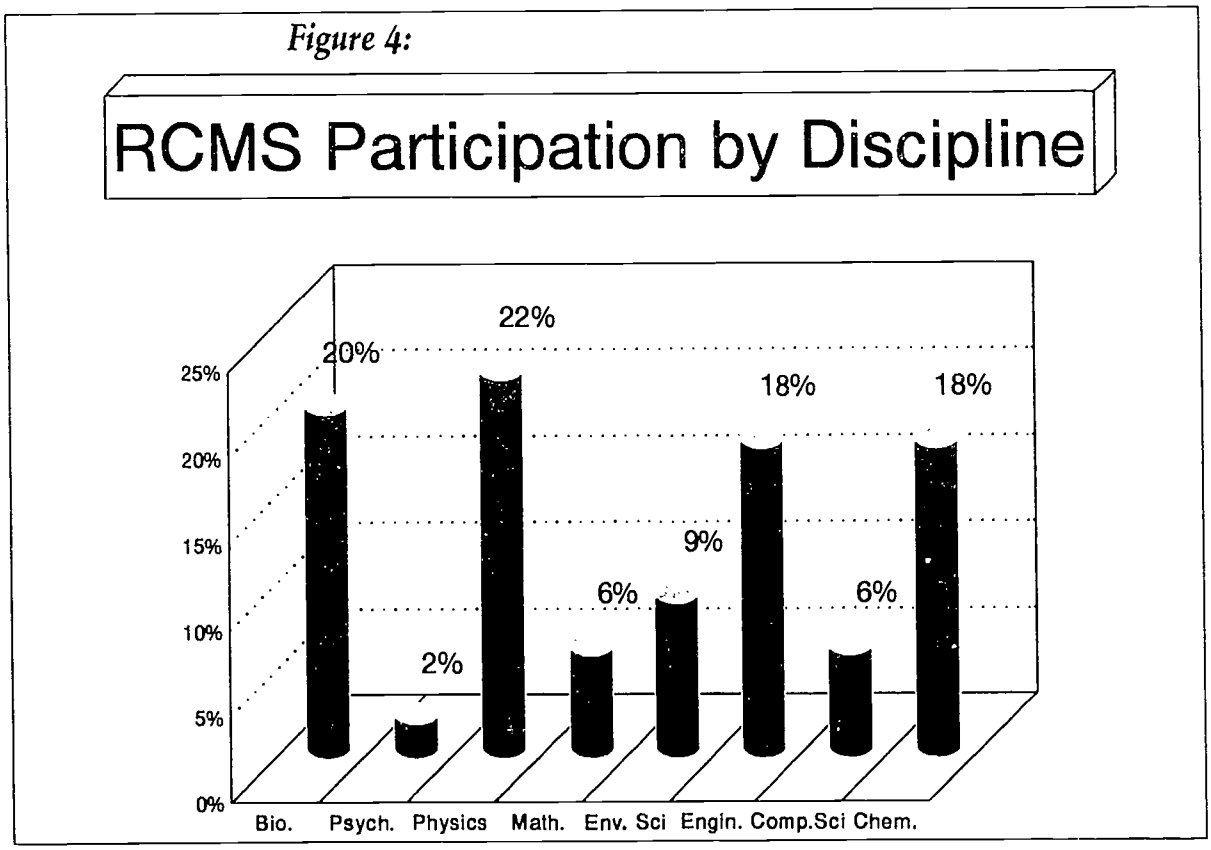
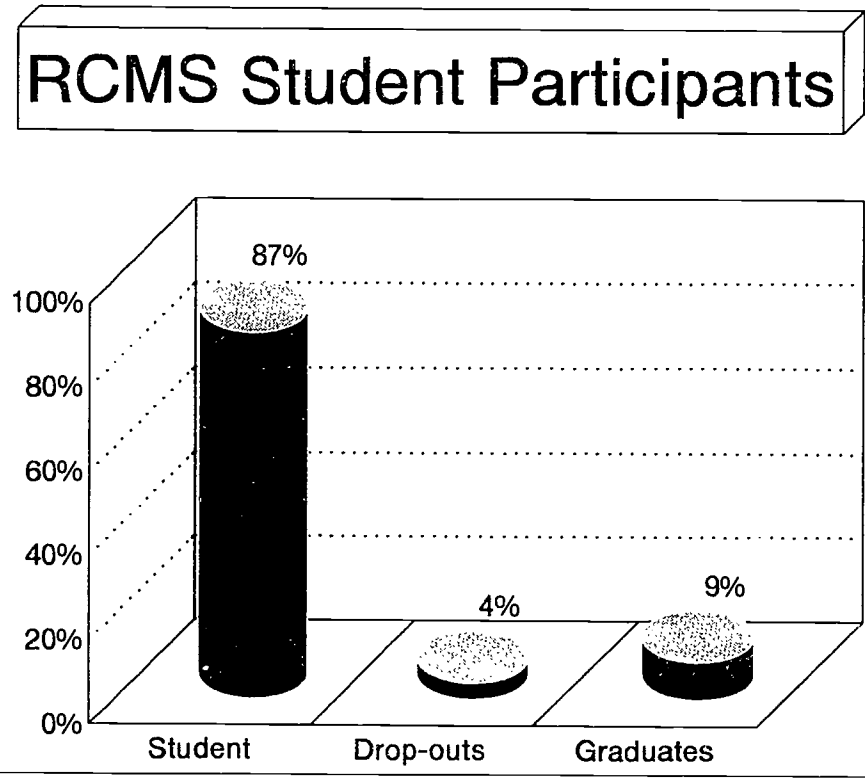


Figure 5:



Texas A&M University

"This research experience really provides students with an added dimension to their education. The NSF Research Careers for Minority Scholars program has a chance to demonstrate nationally that research experience is extremely important—not just to encourage people to enter graduate school, but to help empower them to become leading scientists and engineers," explained Dr. Carl Erdman, principal investigator of Texas A&M University's RCMS program.

The RCMS program at Texas A&M is a joint effort between the colleges of engineering and science. It is designed to link the best minority undergraduates from those colleges with Texas A&M research faculty to foster undergraduate research experience. In its first year at the university, RCMS drew interest and support from more than 100 engineering and science professors. This large number of professors allows students to select the faculty mentor with whom they will conduct research.

Lori Cardenas, the program coordinator, explained, "In our program, the freshmen and sophomore students attend seminars, meet faculty, and find out what kind of research is being performed in the areas that interest them. Then, in their junior years, they choose their own mentors and begin research. "Programs at other schools match students up with professors who are in their areas but do not give the students the chance to choose." At Texas A&M, students make their decisions by interviewing professors as well as consulting the graduate students who work with them.

Faculty members are enthusiastic about working with students who have selected their research projects. A benefit for the faculty is that these students already have scholarship funding and travel money. Professors can be reimbursed for special supplies and laboratory costs for the students.

Student interest is strong, too. For the past three years, over 100 students have applied for the program. Openings have increased from 25 in the program's first year to 56 for the 1992-1993 school year. There is a strong feeling among program administrators that the number of slots should be expanded to 100. The student response and the high caliber of the applicants—many who are turned away have grade point averages in the 3.5 range—may be partially attributable to students' wanting to participate in a program funded by NSF, according to Dr. Erdman.

Students are also attracted by the opportunity to devote themselves full-time to completing their degrees and pursuing research. Without RCMS scholarship funding, many would have to take part-time jobs to support their studies, which would delay progress toward obtaining their baccalaureate degrees.

One of the goals of the program is to encourage graduate study and careers in engineering specialties including aerospace, chemical, civil, electrical, industrial, mechanical, nuclear, oceanic, and petroleum engineering, as well as computer science, biology, chemistry, mathematics, applied mathematics, microbiology, physics, and zoology. More than 50 percent of the students in A&M's program have continued in graduate studies—approximately five times the percentage in the general population. Of twenty-two graduates in the 1990 to 1991 school year, one has already received a master of science degree; nine are currently enrolled in engineering or science graduate programs; one is attending medical school; one is attending pharmacy school; and one is working as a research assistant at Texas A&M and is a graduate applicant for the fall of 1993.

Continuing to the graduate level, however, is not the only measure of success for students in the program. Dr. Erdman stressed that even those who do not continue their schooling immediately are very marketable upon completing this program. These are minorities with a baccalaureate degree from Texas A&M, research experience, and a grade point average of 3.5 or better. "These students are the prime hiring targets of industry," Dr. Erdman contended.

One of the eight 1992 graduates who has opted for a career before continuing her studies graduated with a bachelor of science degree in chemical engineering. She was hired by a chemical company at a starting salary of $42,000, and the company guaranteed that it would finance her pursuit of a master's degree. Her employer, VOP Chemical Company of Willowbrook, Illinois, is also contributing matching funds to the scholarship fund she started for Hispanic female chemical engineering undergraduates who, as she did, need financial assistance to complete college.

The success of the RCMS program has raised awareness of the needs of women and minority students, and it has inspired confidence that such programs really work. "The NSF RCMS grant is a very positive factor when we seek additional financial support. The capabilities and accomplishments of the RCMS students verify the success of our program." said Dr. Erdman. The NSF "stamp of approval" likely contributed to Texas A&M's receiving U. S. Department of Education funding for fellowships for minority students and a General Electric Foundation grant that provides stipends for students to participate in summer research projects on campus.

The enthusiasm for the RCMS program has resulted in such an outpouring of volunteer efforts that the program is extremely cost-effective. It may be the largest program of its kind operating at the lowest cost per student in the country. The only full-time program employee is the coordinator.

The feeling of community extends to the students' neighborhoods. Under the outreach component of RCMS, students working on research at the university visit elementary and secondary public schools to describe their research as well as to discuss the program and the research opportunities for interested students.

Student participants would probably agree with Dr. Erdman when he says the program is fun for him, as well as rewarding. He enjoys the students and the positive reputation their accomplishments give to minority student programs in general. RCMS has provided the impetus for a range of other activities in science and engineering within Texas A&M and in conjunction with other institutions.

On an even larger scale, Erdman feels that this program's focus on research will bring about systemic change: "You should ultimately see a change nationally, in that students will perform more research as part of their undergraduate programs. Research experience raises the quality of the students' education. The requirements of thinking and finding problems, struggling with the solutions, and then writing reports, demand that students master the skills that will be required to meet tomorrow's science and engineering challenges."

University of Maryland, Baltimore County

The University of Maryland, Baltimore County (UMBC) RCMS program is part of the Meyerhoff Scholarship Program, a full-time, year-round program for academically talented African American students who excel in the study of science and technology.

Students, who are competitively selected, receive a four-year academic scholarship along with a personal computer and software. They benefit also

from summer internship opportunities, field trips, cultural events, and relationships with adult mentors. Students attend a six-week summer program before the freshman year, and in subsequent summers they each take summer courses or hold paid internships in research laboratories either on the UMBC campus or at other institutions and agencies. During the academic year, all of the program participants are enrolled as full-time students. In their first three years of study, the students work alongside faculty in research laboratories in the sciences and engineering, preparing for specific and substantial research projects during their senior year. In exchange for the benefits provided through the program, the Meyerhoff students pledge to pursue doctorates in the sciences or in engineering.

Dr. Freeman A. Hrabowski, the University's Interim President and a mathematician, launched the Meyerhoff Scholarship Program in 1989 with a major grant from the Robert and Jane Meyerhoff Foundation. Dr. Hrabowski continues to oversee the students in this program with the assistance of Susan N. Boyer, Earnestine B. Baker, and several other staff members. To be eligible for the Meyerhoff Program, students must be African Americans who have combined Scholastic Aptitude Test (SAT) scores of approximately 1200, including a math SAT of about 650, and a high school grade point average (GPA) of 3.5.

In the program's first year, 19 students were successfully recruited. Four years later, the program received 380 nominations from high schools across Maryland and in the region, resulting in acceptance of 43 new outstanding students in 1992. Currently, 113 students are participating in the Meyerhoff Scholarship Program, including 20 in RCMS, who have a mean college GPA of approximately 3.4. Eleven UMBC faculty members have been designated specifically as mentors or advisers for the RCMS students, helping to nurture their academic interests. Mentors for the Meyerhoff students are African Americans for the most part, and include faculty from UMBC and other nearby institutions who have expertise in the students' varied fields of interest.

The major contribution of the RCMS program goes beyond helping students to achieve academic excellence. It also offers students a level of personal attention they otherwise would not receive at most other universities, and it allows them to interact with a peer group of African American students. Often isolated in high school from other African-American students because of their academic achievements, the Meyerhoff students find that the program provides a environment where they can interact comfortably with other academically talented African-American students. "I can talk to anybody here, knowing that they just won't judge me," says Angela Hodge, of Upper Marlboro, Maryland. Other comments include: "This is the best group of black kids that I have ever been with." "I never knew there were so many smart kids like this." "It is cool to be smart in this group." "This is neat." Students find themselves in an enriching, warm, and supportive environment.

Many local businesses and government agencies support the Meyerhoff Program by providing paid internships and research experiences for the students. IBM, with 14 paid internships, is considered an outstanding supporter. The program's National Advisory Board meets each year to help shape the direction of the program and to identify possible new sources of funding. Additional support is essential for the program's continued success, given that students are turned away each year because of insufficient funds.

NSF funding has been particularly helpful in developing the RCMS program and allowing UMBC to extend the benefits of the Meyerhoff Scholarship Program to more students. Twenty RCMS students are funded by NSF in the Meyerhoff Scholarship Program, and other students receive funding through grants from Meridian Health Care, the National Aeronautics and Space Agency, the National Security Agency, and the Eli Lilly Foundation.

Support comes in many other forms, too. Each year, for example, Apple Computer, Inc., has donated computers worth approximately $50,000; UMBC's office that oversees the Freshman Experience gives students special support; UMBC's Learning Resources Center and Chemistry Tutorial Center both help students, as needed, with their course work; the Counseling Center and the Office of Residential Life offer nonacademic counseling; local and national media, through the coverage they have given the Meyerhoff Program, are instrumental in generating interest in it; and public and private school teachers enthusiastically spread the word about the program.

The RCMS scholars are encouraged to "give back" to the community. Some students tutor local children in science and mathematics. Others give speeches at career day programs and explain what it means to be an aspiring young minority student and to be successful in science. Many of the students have been invited to schools to speak about their

visions for the future. These students have proven so effective, in fact, that some of them have accompanied Dr. Hrabowski and other staff to meetings with potential sponsors.

In another form of community involvement, the students and their parents have organized a support group known as the Family Association. They meet regularly and conduct such activities as a Welcome Dinner in the fall, at which parents of continuing Meyerhoff students share their impressions of the program with the parents of incoming students and tell them what to expect. The Family Association also plays an instrumental role in recruiting and selecting new students for the program.

Maceo Thomas, a 20-year-old biochemistry major conducting research on histamines, has a paper in progress to be published with his mentor from the St. Thomas Hospital in London, where the research was conducted.

The RCMS program should produce its first graduates in 1993. In so doing, this model project will be making a substantial contribution to elevating the quality of our science and engineering workforce.

Faculty Development and Research Initiatives

Research Improvement in Minority Institutions

The Research Improvement in Minority Institutions (RIMI) program provides grants to strengthen the research capabilities of predominantly minority institutions, and institutions with substantial minority enrollments, that have graduate programs in science and programs in engineering. The RIMI program supports faculty research, the acquisition of research equipment, and cooperative research projects between academic institutions and industry to encourage greater student and faculty research involvement.

The RIMI program was originally called Research *Initiation* in Minority Institutions and provided $20,000 to $40,000 to assist new research scientists. In FY 82, the name was changed to Research *Improvement* in Minority Institutions to focus on research needs of minority institutions instead of just individual scientists. More substantive awards of up to $250,000 were made available for up to three years. Institutions with greater than 50 percent minorities and graduate programs in science and/or engineering were eligible to apply.

In FY 85, the RIMI budget increased to $5 million. In addition, the eligibility criteria expanded to a 20 percent requirement of students from one minority group. Awards were increased to up to $500,000 for up to five years.

The RIMI program not only provides the opportunity for universities to develop research infrastructures, but also funds the purchase of scientific equipment needed to spring out into the mainstream of national and international research.

Figure 6 is a disciplinary analysis of the current RIMI projects. Figure 7 shows the number of project participants from 1988 to 1991 by academic level. **Figure 8 illustrates that 123 baccalaureate, 48 masters, and 16 doctoral degrees in science, engineering, and mathematics were earned by RIMI participants from 1988 to 1991.**

Figure 6:

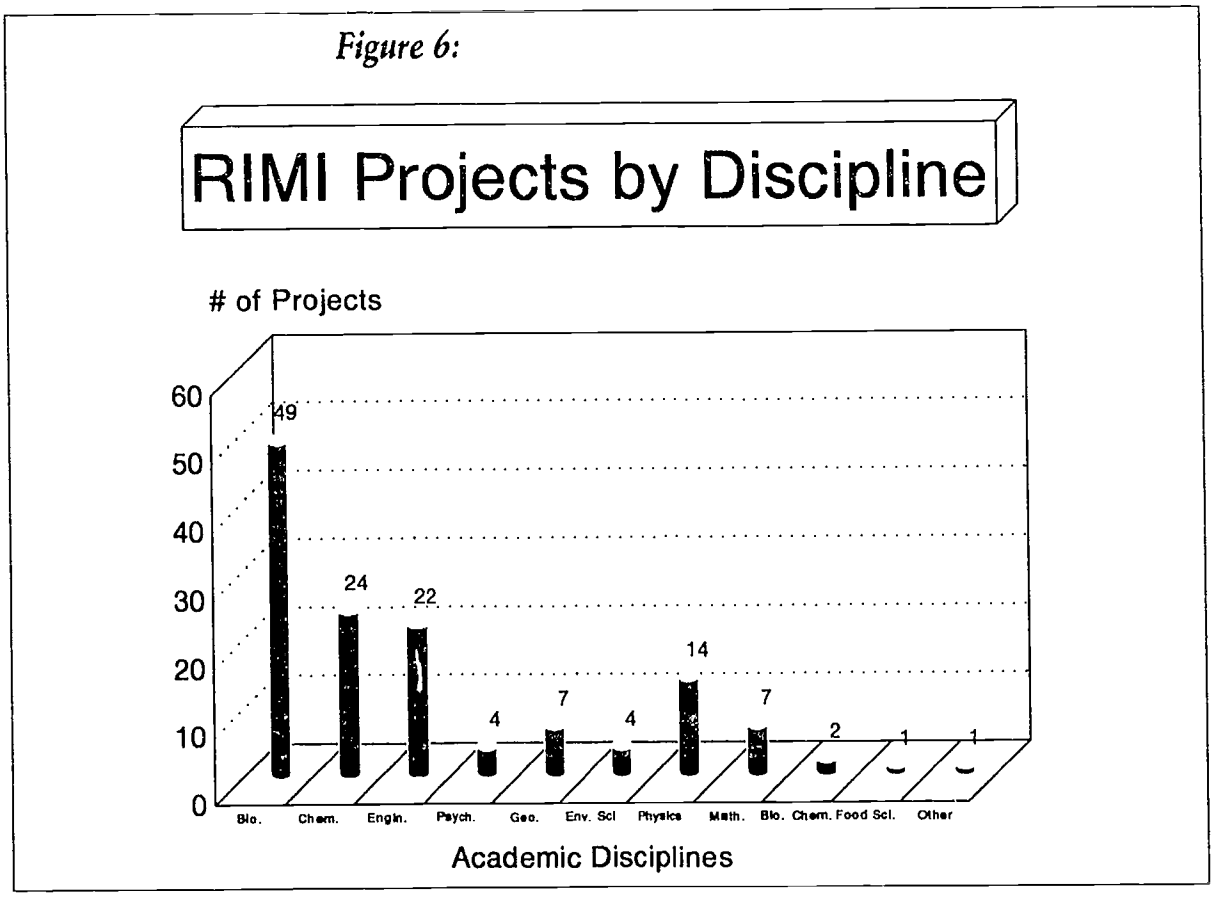


Figure 7:

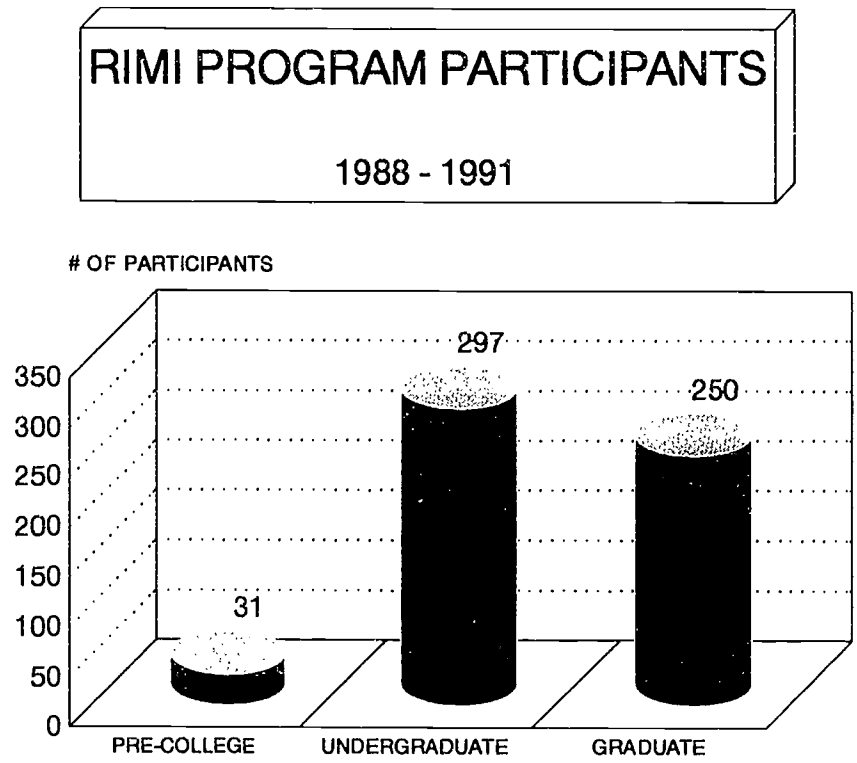
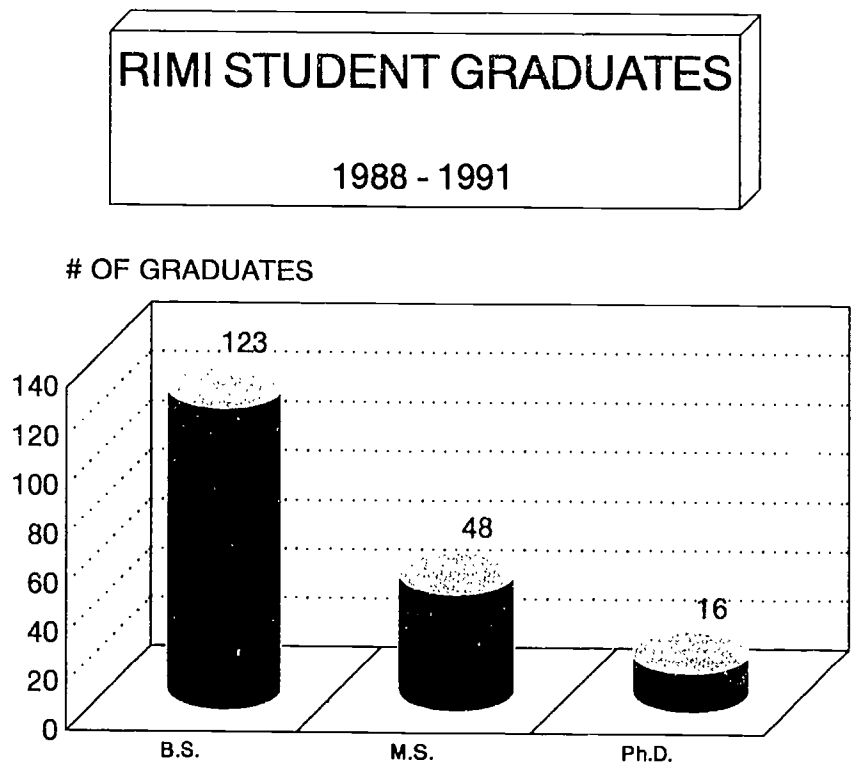


Figure 8:



Clark Atlanta University Investigation of Bridged Organometallic Complexes on Metal Oxide Supports

Clark Atlanta University (CAU), one of the Historically Black Colleges and Universities in Georgia, has used the RIMI program for a project on the fundamental aspects of catalysis. Since over half of the nation's gross national product is directly or indirectly tied to catalysis, research in this area is vitally important to the nation's economic competitiveness.

Because Black colleges have few start-up funds available, CAU RIMI funds have proven critical in fostering multidisciplinary research. "The RIMI program has been essential to get things off the ground with new faculty," says Dr. Eric A. Mintz of CAU's Chemistry Department. Consequently, CAU has requested a series of small RIMI grants rather than one large project. The grants allow CAU faculty to initiate their research programs at a more rapid pace, to support students and procure chemicals, and to provide faculty salaries in the summer.

CAU's three-year RIMI project, which began in October 1991, is designed to investigate bridged organometallic complexes on metal oxide supports. The goal is to develop methods to prepare ligands that have two, three, or four cyclopentadienyl groups connected by bridges incorporating either hetero atoms or carbon atoms.

Five minority chemistry students—two graduate students in their second year and three undergraduates in their sophomore year—are being trained via this project. The students are doing research in organic and organometallic synthesis of bridged ligands and bridged organometallic complexes.

Success in developing the project also required project investigators, Dr. Mintz and Dr. Mark B. Mitchell of the Chemistry Department, to acquire spectroscopic equipment and supplies, to design and fabricate heating and pumping systems for the infrared reaction cell, and to determine the initial thermogravimetric and infrared results for the initial alumina substrate to be used in the experiments.

A gas chromatograph/mass spectrometer (GC/MS), acquired through a donation from the Coca-Cola Company, allowed the researchers to add GC/MS capability to their infrared decomposition studies. A microreactor was installed in the gas chromatograph to carry out a variety of rapid screenings of the decomposition of organometallic compounds as a function of temperature. A diffuse reflectance infrared fourier transform (DRIFT)-controlled environment cell was purchased and its vacuum integrity and optical throughput checked. Dr. Mintz and Dr. Mitchell designed, purchased, assembled, and verified the temperature control system, obtaining good control under vacuum, where thermal losses were confined to the sample support. To conduct the experiment, the interface from the controlled environment cell to the pump station was fabricated and interfaced to the cell.

By developing a strategic plan for faculty research improvements and infrastructure support, Clark Atlanta University has been highly successful in obtaining funds for its projects. Its success is attributed to a willingness by the university leadership to give faculty members the freedom to do their jobs. The CAU faculty has much more independence than faculty in many other institutions.

According to Dr. Mintz, there is a conscious effort to use RIMI grants to strengthen the university's instrumentation to support a wide array of research disciplines. For example, the mass spectroscopy instrument is utilized in environmental studies as well as in Dr. Mintz's work. CAU's strategic plan, therefore, helps eliminate the internal territorial barriers and infighting that can occur in institutions of higher education.

Two presentations have been given on the RIMI-supported research at recent meetings of the American Chemical Society (ACS). The topics of the presentations were "Synthesis and Reactivity of Transition Metal Complexes Incorporating New Tri-Penta Substituted Cyclopentadienyl Ligands" and "Synthesis of Aminosubstituted Cyclopentadienyl Ligands: Application to Organometallic Chemistry." Manuscripts are now in preparation to describe this work further.

Ultimately, the greatest benefits from the RIMI grants, Dr. Mintz explained, are twofold: long-term infrastructure support and quality training of students. The students will have a major role in helping to advance the sciences while strengthening the competitive posture of the nation.

City College of New York Turbulent Fluctuation in Collisional Plasma

"Turbulent phenomena are one of the last great frontiers of traditional science," said Dr. Joseph A. Johnson III, principal investigator of the RIMI

project in the City College of New York (CCNY) Department of Physics. Dr. Johnson has been studying turbulent flow in collisional plasmas. High-density collisional plasmas have properties similar to those of gases. Until now, research has offered little understanding of the turbulent physics of these plasmas.

Dr. Johnson's work has resulted in two papers this year. Three more will be submitted for publication next year. His findings violate the popular consensus on turbulent flow. "They will have an important influence on the development of the physics of turbulent flow," he said. He has made two major discoveries: first, the fluctuations in a collisional turbulent plasma are characterized by unique spectral behaviors and low fractal dimension; second, the increase in dimensionality, and thereby complexity, in a collisional turbulent plasma is both sensitive to the strength of a weak magnetic field and independent of its orientation.

Dr. Johnson has been using computerized analytical models to determine the significance of nonlinear or chaotic elements and the correspondence between macroscopic and microscopic elements. In other words, he hopes to ascertain whether events on a small scale influence flow on a large scale, and vice versa. His analytical models address the extent to which significant elements may occur and the potential number of independent variables. "We want to know whether there's a tendency towards patterning, whether there is an underlying simplicity that would give us a basis for predicting behavior," he said.

In examining the flow of a plasma versus a fluid and the effect of a magnetic field on turbulence, Dr. Johnson found a few surprises. For example, he discovered that a magnetic field increases the complexity of an already turbulent plasma. Research also showed a one-to-one correspondence between macroscopic and microscopic phenomena in the fluctuation of optical-line emissions.

To implement his research program, Dr. Johnson had to computerize the interface between the actual experiment and the analysis. Funding from the RIMI program enabled him to upgrade his laboratory's computing capability and purchase a high-powered 24-watt argon ion laser. Without the added equipment, his research could not have been competitive. As Dr. Johnson said, "If I want to be in this game, I have to have the tools of the game."

The support allowed Dr. Johnson to initiate research in a topic area that previously had not been fully investigated. "RIMI funding allows us to do exciting work that grabs the attention of the scientific community." Because the experiment exists and the hardware is there, we can take advantage of other resources and involve more students beyond what the RIMI grant supports. The RIMI funding is there for the core research. One student, whose work follows the RIMI-supported research, is supported by a National Aeronautics and Space Administration (NASA) grant.

"We can leverage the RIMI grant because we're funded to do exciting work," Dr. Johnson said. "The source is also important. NSF has a built-in validating process. You could argue that support from the National Science Foundation is the most directly credible source. NSF is the premier science funding agency because it cuts across all the sciences."

In addition to funding Dr. Johnson's research, the RIMI grant has supported three Ph.D. physics students. Degree work for all three is partially based on the research funded by this grant.

"The key to sending more students into science and engineering is exposure to first-class science, science on the frontier," said Dr. Johnson.

Students in Dr. Johnson's lab are selected from undergraduates who perform well in science classes. When colleagues recommend extraordinary students, he matches them with a research experience. "The undergraduates participate as partners. We get them as freshmen, and from the beginning they are part of the team. We keep their assignments appropriate to their level, but we expect them to contribute. By the time they're seniors, they are doing valuable work. They learn procedures, library and other research skills—all tools they'll need."

Students complete a manufacturer-supported certification process to demonstrate their competence with laboratory equipment. "It's exciting for them to use all this fancy stuff. They learn to use expensive, fragile, delicate equipment. They start with equipment specifically related to their task, but the graduate students try to familiarize themselves with each piece of equipment in the lab," he said.

"One Ph.D. student, supported by the RIMI grant while an undergraduate, performed research to determine nitrogen dioxide density by measuring the amount of fluorescent light that could be passed through it. He had to build an instrument to record the measurements. His efforts led to new science. The results were not publishable, but the work was important, and the student knew it," Dr. Johnson said.

The RIMI grant has given us the resources to let students participate, and they benefit from the pleasure of success. They're doing high-quality research, and the work gives them a sense of what they'll be doing several years down the road, should they decide to pursue a research career.

The findings of Taskforce 2000 have people concerned about future science. NSF took action. Their aggressiveness has set a high standard. Other agencies are copying NSF—but NSF did it first. They did it with conviction and persistence. NSF's efforts will have ripple effects over the next 10 years in the Federal support community.

"The NSF programs offer a model that private companies are showing an interest in supporting. They're looking for successful models, and the NSF programs have worked to encourage excellence and initiative. The concept has been successful in drawing minorities and women into science. The research work serves as a beacon to students who want to see science as an option. Without NSF programs, that option might not be available to them," explained Dr. Johnson.

Hampton University Distribution of Larval Fish Prey Organisms in Northwest Atlantic Nursery Areas

If you looked at it from the viewpoint of fish larvae, you could say: "This is a fine mesh you've got me in."

That inside joke belongs to the Hampton University students who use fine mesh nets to collect fish larvae for their marine science research. They are interested in testing the correlation between the larval distribution of commercial fish and the copepod population, which is a preferred food for fish that inhabit the Gulf of Maine and Georges Bank.

Hampton University is known for its undergraduate and graduate work in marine and environmental science. In 1990, it received an NSF RIMI grant to encourage minority student involvement in marine science research.

In the first year of the three-year study, the team compared the developmental stages of copepod samples collected with special plankton nets of two mesh sizes, fine .053 mm and coarser .333 mm nets. After sorting the copepods according to species, life stage, and sex, the researchers concluded that there was a strong correlation between the copepod samples of the two nets. Research of this type is expected to help explain the fluctuations in commercial fish abundance.

The National Marine Fisheries Service (NMFS) of the National Oceanographic and Atmospheric Administration (NOAA) is assisting the university in its research. The NMFS has extensive data on larval fish abundance and distribution and on adult copepods. However, very little direct information is available on the smaller zooplankton. As a result, marine biologists cannot directly test for correlations between the distributions of larval fish and their actual prey. The link between zooplankton and larval fish is critical in the early life history of fish. The RIMI study is contributing data to this critical link.

As a result of previous work with NOAA, Dr. Robert A. Jordan, the principal investigator for the RIMI grant, has acquired good plankton samples preserved since 1980. Hampton University students have processed the data on those samples and are now shifting their emphasis to 1992 samples. The recent samples were collected in cooperation with the NMFS, which placed a Hampton marine science minority graduate student on one of its research cruises in June 1992.

Hampton University is the only U.S. university performing this kind of fine mesh research. Most of the data on larval fish and their environment are available in the NMFS files, but some unanswered questions still remain. The RIMI researchers are working on the missing piece of the puzzle. When they have acquired their data, a student from the university will travel to the NMFS Northeast Fisheries Center Laboratory in Narragansett, Rhode Island, to use its data files for more extensive data analysis.

Dr. Jordan has always placed emphasis on acquiring research microscopes needed for various projects. He bought three research-level stereoscopes called Zeiss SV8 dissecting microscopes with the RIMI grant. The equipment is especially helpful in conducting this type of research because of the small size of the animals under study. The stereoscopes allow researchers to conduct more exacting and thorough research.

In addition, a National Institutes of Health (NIH) grant helped Dr. Jordan obtain an inverted compound Zeiss microscope. And, with a grant sponsored by the U.S. Geological Survey, he obtained a research-quality stereo microscope. As part of another development grant, the university obtained several student-grade microscopes and another research-grade compound microscope.

Consequently, the Department of Marine and Environmental Sciences has the best microscopes at the university. Because of the quality of its equipment, the department has received requests to help other departments at the university with their research.

Much of the work in marine science is performed as a collaborative effort among government agencies and academia. Hampton University cooperates with the Virginia Marine Resources Commission, the data agency that regulates marine fisheries primarily in the Chesapeake Bay. Commission staff assist in organizing conferences and interacting with students.

An integral part of Hampton's program is the internship component. The students spend one summer obtaining hands-on experience in a government agency, industry lab, or another college. The internship gives them the opportunity to explore various research careers while being involved in a current study they can conduct successfully. Because Hampton has one of the few undergraduate marine science programs in the United States, government agencies are eager to visit the campus and provide internships.

Hampton also collaborates with the Federal Fish and Wildlife Service, the National Park Service, and the Environmental Protection Agency. Two of its students spent two months at a Fish and Wildlife Service wildlife refuge. At the refuge, they conducted some research, but generally they managed the refuge and provided educational services for tourists. There are potential job opportunities for these students with the wildlife refuge after graduation.

Hampton University recently established a relationship with another refuge, on the Eastern Shore of Virginia, that is providing a house that can double as a field lab. So far, several field trips to the refuge have been undertaken in conjunction with marine science courses. Consideration is now being given to transforming the field lab into a permanent research facility.

Of the 5,500 students at Hampton University, 30 are undergraduate majors in marine science and 5 are graduate students. A total of seven students have participated in the RIMI study since 1990. Three of the undergraduate students earned their bachelor of science degrees in marine science. All three enrolled in graduate school. One student is expected to receive her masters degree in environmental science and a fellowship award from the Environmental Protection Agency to support further study in marine science.

Hampton University has a variety of programs to attract students to its undergraduate and graduate marine science program. During the summer, the university offers short-term programs, including the NSF Young Scholars Program, which offers groups of precollege students projects requiring field trips lasting several weeks. University science professors give classroom presentations and local students visit the university laboratory.

The arrangement with the NMFS scientific research vessels was an unexpected development. Dr. Jordan always wanted to develop a cooperative effort with the NMFS research vessel team, but unfortunately much of the funding for that type of work had been eliminated. Working with the NMFS Pascagoula Laboratory research vessel is a great opportunity for the university's minority graduate students.

"It is a challenge on this campus to attract students to science rather than business," said Dr. Jordan. Opportunities on the NMFS research vessel help draw students into science, engineering, and mathematics courses. NMFS will bring the students who worked on the vessels to Florida next fall to share their experiences. These experiences are critical for students, allowing them to see the relevance of their studies. Students have presented the results from their ocean studies in on-campus presentations.

The marine science laboratory has proven valuable beyond the research conducted there. It has given Hampton University the ability to employ students. The three professors in the department have many positions for students as research assistants and interns. The employment of undergraduate students is of great benefit to the university's ongoing projects.

With the assistance of NSF, Hampton University minority students are undertaking frontline marine research, helping to assure the environmental integrity and quality of life from the tiniest of plankton to the largest of ocean mammals.

New Mexico State University
Adsorption Behavior and Properties of Tailored Smectites

How to decontaminate the Earth of toxic chemicals and rapidly handle accidental spills from oil tankers are among the problems being tackled by

New Mexico State University with the support of a RIMI grant.

This project, which began in 1989, is an interdisciplinary environmental engineering effort involving teams of Hispanic students and professors from chemistry and environmental engineering. The project seeks to understand how clay materials coated with a film of organic molecules can be "tailored" to absorb deadly pollutants from contaminated underground and surface water as well as from oil spills in lakes and oceans.

The university's work has tremendous waste management implications. According to Dr. Fernando Cadena, an environmental engineer and co-principal investigator, the most precious resource in New Mexico is water and the most abundant resource in the state are soils that have absorbent properties.

About 90 percent of the Western states depend on groundwater supplies. New Mexico's water is continuously threatened by underground and surface contamination from gasoline. As unleaded gasoline replaces leaded gasoline, the situation improves. But the potential for underground water contamination is heightened because benzene, a carcinogenic chemical, is being added to unleaded gasoline to boost its power. About 3 to 6 percent of unleaded gasoline is benzene.

Since the EPA estimates that 35 percent of the existing U.S. underground storage tanks (USTs) commonly used to store gasoline or other petrochemical or petroleum-based products either leak or are not liquid-tight, as many as 75,000 to 100,000 USTs are leaking hazardous chemicals into the earth. The number is expected to increase by 350,000 in the 1990s. The RIMI project focuses on the elimination of benzene from groundwater.

The process is best explained by using a simple example. "Imagine that you are trying to remove oil in water using a paper towel," said Dr. Cadena. "It's difficult. However, if you coat that paper with a thin layer of oil, it becomes compatible with the oil in the water and it sucks the oil right out. What we are doing with clay is similar. We are taking clay and other natural minerals and applying a thin or molecular layer of other organic materials which we attach or tailor to the soil so that the soil becomes more compatible with the pollutants we want to remove. The pollutants we are removing are aromatic compounds, such as benzene, toluene and xylenes—carcinogenic compounds generally found in oil and chemical spills. Every type of natural fuel contains these types of pollutants. Once they enter the aquatic environment, they are very difficult to remove. The greatest advantage of the technique we employ is that we can selectively target the pollutant that we want to remove from water."

Dr. Cadena sees the major application of the technology as a chemical barrier for USTs. New USTs could be built in a layer of soil tailored with the compounds that would adsorb any leaks. "In cases where the water is already contaminated, we propose to pump the water out of the ground and pass it through a series of reactors with tailored soils. The water would pass through these minerals and would be returned to its original location," Dr. Cadena said.

Beyond its relevance to pollution control, the work performed by New Mexico State University contributes to basic and applied interdisciplinary research. The program employs ten Hispanic students and two professors from the Environmental Engineering and Chemistry Departments. Dr. Gary Eiceman is the co-project investigator from the Chemistry Department. Of the nearly 12,000 students enrolled at the university, about 320 undergraduates and 60 graduate students are enrolled in civil engineering. The Civil Engineering Department has specialties in environmental engineering, hydrology, and structural engineering.

Asked about the greatest accomplishment of the RIMI project, Dr. Cadena said, "we have generated outstanding professionals." Six students have graduated with master's degrees and one with a doctoral degree. Graduates of the civil engineering program have jobs with Eastman Kodak, Los Alamos National Laboratory, and Phillips Petroleum. One student who received a doctoral degree is now working as an assistant professor in the Chemistry Department. Another student from Puerto Rico who is working on her doctorate in environmental engineering plans to return home and teach.

The university has also witnessed an increase from 5 to 30 in the number of graduate students in the civil environmental engineering program over the last 10 years. The department cannot accept additional students and is, in fact, turning down four out of five applicants. The department is becoming highly selective, targeting only the best students.

National Science Foundation funding has had other significant impacts on New Mexico State University. The largest portion of the funds is dedicated to student and faculty support (two new environmental engineering faculty have been hired), to supplies and chemicals, and to overhead. Additionally, since receiving the original seed money

from NSF in 1986, the university has developed an excellent reputation for research in pollution control.

University expertise in environmental research has also led to ties with other national research organizations. For example, in 1989 the university entered into a funding agreement with the U.S. Department of Energy (DOE) to create a Waste Education and Research Consortium. This consortium includes the three major universities in New Mexico—New Mexico State University, the University of New Mexico, and New Mexico Institute of Mining and Technology. Sandia and Los Alamos National Laboratories are also part of the consortium, along with the DOE's Waste Isolation Pilot Project. DOE wants to mitigate the impact of energy production, especially fossil fuels and oil spills. Texaco, Inc., has become interested in the university's work and provides funding toward the project. NSF has proven to be the catalyst for funding from these other sources.

NSF funds have been instrumental in obtaining other funds. Every dollar New Mexico State University receives from an external resource is matched by the state and the Federal Government, thus tripling its financial resources for minority undergraduates. The funds help pay undergraduate minority students who work on research projects.

New Mexico state-provided funds are used to buy equipment such as a gas chromatograph, a mass spectrometer, a high-performance liquid chromatograph, a total organic carbon analyzer, and an atomic adsorption spectrophotometer.

RIMI participants are proud of their accomplishments. At least nine articles have appeared in professional publications, and it has become routine for students to make presentations at national and international chemistry and civil engineering conferences.

The grant has laid the foundation for a great future at New Mexico State University. Participants are hopeful about developing important new technologies that will aid in the removal of environmental pollutants. Dr. Cadena believes the use of natural minerals modified by organic compounds to remove pollutants from water will be commonly used in five years. And, if current environmental trends continue, the university's environmental engineering budget may double in the next five years. More important, the grant provides an opportunity to educate people to solve major local and global concerns.

North Carolina Agricultural and Technical State University Improvement of Cell Plasma Membrane Research Capabilities in Biology

At North Carolina Agricultural and Technical (A&T) State University, Dr. David W. Aldridge, professor of biology, focuses on instilling in his students a sense of pride in what they do. "Interacting with students takes time," said Dr. Aldridge. "It takes time to give them good habits. They have to believe in the importance of what they're doing, whether it's washing dishes or reading oxygen uptake."

Even Dr. Aldridge's undergraduate and high school students are assigned small experiments to perform. Though the level of work is not necessarily publishable, the students perform every stage of the experiments themselves, from laying out experimental designs and collecting the data to crunching numbers for statistics.

Most minority students receiving graduate science degrees at A&T come from predominantly black institutions. "Many of our students have little science background. We're kind of an initiation for them," said Dr. Aldridge. "A&T has a good track record in getting students up and out in the sciences." Of the 18 students who earned A&T science degrees this year, 9 are enrolled in graduate school in the sciences and 4 are enrolled in medical school. One has been accepted at MIT.

More A&T undergraduates than master's students enter Ph.D. programs, partly because salaries drop off above the master's degree level. Of A&T students who have received bachelor of science (B.S.) or master of science (M.S.) degrees, Dr. Aldridge is aware of nine who are still involved in science.

"The university can be a safe haven for becoming an adult," said Dr. Aldridge. "We teach students to deal with stress, paperwork, and difficult supervisors. It boils down to giving students pride in what they do."

Dr. Aldridge has trained nine graduate students. A&T's RIMI grant has provided stipends for six. In 1992, three students earned master's degrees in biology. Two of the three were from Dr. Aldridge's lab. One has continued in environmental science at the University of Southern Florida. The other is employed with the Federal Government.

In the summer, Dr. Aldridge opens his lab to high school students who seek research experience and science exposure. Many are good students who have

been "turned off to science in high school, but have their interest sparked again," Dr. Aldridge said.

"The hands-on laboratory experience is a turn-on for students. The things we teach in class come alive in the lab," he said. Recently he received a card from a former high school student who had planned to major in business, but who is now finishing her second semester in chemistry. "We help our students make decisions about what they want to do."

Without NSF funding, it would have been difficult for A&T students to gain modern research experience. "Training students takes money," said Dr. Aldridge. Because graduate schools prefer applicants with research experience, the opportunities provided by NSF funding make A&T students more competitive.

NSF support for a RIMI grant in 1983 financed Dr. Aldridge's initial equipment purchases to set up his laboratory. The same funding also helped keep his lab going during the 1980s, when the university had little money.

Dr. Aldridge and Dr. Thomas L. Jordan received $30,000 in matching funds from the university for the 1989 RIMI award. At the time, A&T had no doctoral program. However, the University of North Carolina System Board of Governors has authorized A&T to offer a Ph.D. in engineering beginning in 1993.

The grant made possible research in cell biology. A professor in the Biology Department, Dr. Aldridge is studying how fresh-water mollusks adapt to changes in temperature to maintain a constant level of fluidity. Since materials are more liquid at higher temperatures, changes in fatty acids can alter the natural change in viscosity of cellular fluid by changing the composition of the phospholipids that make up the major part of cell membranes. Essentially, an increase in saturated fatty acids can "harden" the cell membrane to make it less permeable in higher temperatures. Dr. Aldridge's research indicated changes in the relative percentages of the various fatty acids with changes in temperature and a small change in cholesterol. The researchers hope to develop assay techniques to differentiate fatty acids and changes in cell membrane composition. Dr. Jordan is studying changes in plasma membrane lipids during the growth cycle of bacteria.

NSF is one of a few sources of funding for Dr. Aldridge's research area. Though the National Institutes of Health (NIH) also funds environmentally related research, their major focus is humans, not invertebrates.

NSF funding has helped A&T to attract faculty they could not otherwise afford. Day-to-day university operations have become easier as well. A&T now has an Office of Research Administration, and the NSF grant supports clerical staff and assistantships that enable students to participate in the research.

Equipment purchased with the RIMI grant is shared between departments. When the Chemistry Department needs a gas chromatograph, it uses the one purchased by the Biology Department. When Dr. Aldridge needs a scanning spectrophotometer, he uses the one in the Chemistry Department. "It is hard to demarcate where one program starts and another ends," said Dr. Aldridge.

This equipment also allowed the department to perform research on zebra mussels in the Great Lakes under a grant from the Army Corps of Engineers. The equipment needed included the gas chromatograph, respirometers, specific ion meters (especially for the ammonia ion, to measure nitrogen excretion), spectrophotometer, and computers.

Dr. Aldridge hopes that some of his RIMI-sponsored research using gas chromatography to analyze cell composition will apply to the Army Corps of Engineers grant as well. In that work, he will study how environmental stresses affect invertebrates. Though invertebrates are difficult to kill, they do show stress that lowers their reproductive capabilities. Dr. Aldridge's work may enable the Army Corps of Engineers to evaluate environmental stress in a given organism.

The Army Corps of Engineers grant involves research on a "nuisance" mollusk the Army is trying to eliminate. (Dr. Aldridge thinks they will just have to live with it.) However, the same research also could be applied to measure environmental stress on endangered fresh-water species the Corps is tasked with protecting. Examples include a fresh-water snail species in the Pleurocerid family and species in the Unionid family of large mussels.

Knowledge is not always used in the way originally intended. Whatever fields of endeavor Dr. Aldridge's students finally select, they will be able to apply a standard of excellence to whatever they do.

St. Mary's University
Near-Threshold Excitation of Molecules by Electron Impact

"The most significant thing about this project for me is giving the students who are interested in research the opportunity to follow their curiosity—

especially those students who really have the potential, but not the environment to do the research," said Dr. Mehran Abdolsalami, assistant professor of electrical engineering at St. Mary's University. "With this project, I can provide all the equipment necessary for our research, even though we are a small university. I did not have that luxury as an undergraduate."

Dr. Abdolsalami has been studying techniques for near-threshold electron scattering of molecules, an important problem in quantum collision theory. He is applying a method for electron scattering called the First-Order Non-Degenerate Adiabatic (FONDA) theory. He wants to implement exact exchange in the FONDA theory and apply this technique to a more complex molecule, the nitrogen molecule.

Of the two current methods, one breaks down as threshold excitation is approached; the other is applicable only to the simplest molecules, like hydrogen, because the process is too complex for today's computers. If Dr. Abdolsalami can apply this technique to enable the study of nitrogen molecule collisions with sufficiently high accuracy and a methodology that is manageable on today's computers, it should have wide applicability.

The nitrogen molecule is used in industry to excite the carbon dioxide laser molecules to generate a carbon dioxide laser beam. Experimentalists are looking for the kind of information Dr. Abdolsalami's results could provide about the transition of the nitrogen molecule from one state to another.

Earlier, St. Mary's lacked computing equipment sufficient for high-level research. It was the National Science Foundation grant that gave Dr. Abdolsalami the computing capability he needed. The award of a RIMI grant in October of 1990 enabled him to purchase faster computers, including four Sun workstations. "Now students and project consultants can spend time on the computer and complete the research without interruption," he said. "We have as much time as we can use on these computers because they're dedicated to the project." The last of the three phases of his project will require fast computers. Dr. Abdolsalami hopes to use NSF funding to purchase Sparc Station 10, which is three times faster than Sparc Station 2, the computer now being used in the project.

Dr. Abdolsalami reports that the research is progressing very well. He initially faced some unanticipated networking problems and delays on equipment, but those have been resolved.

On the other hand, he did not anticipate the work needed to orient the students to the research process. NSF funding supports two undergraduate students and one graduate student in his lab. Two of the three students, one undergraduate and one graduate, are Hispanic.

Initially, the students treated small research projects more as homework than as independent work. If, for example, a student had an assigned project and wrote a computer code that did not work, the student brought the code back to Dr. Abdolsalami for help. "It took me four or five months to teach them that what they are doing now is different from a course project. They've learned to use their intuition and their judgment and come up with their own solutions."

The students have changed in other ways as well. Dr. Abdolsalami has one graduate student who has decided to pursue a Ph.D. in his current area of research with Dr. Abdolsalami. "Another one of my students, before he became involved in this project, was sure he didn't want to go to graduate school. Now that he has had a taste of research, he is headed for graduate school.

"In research, once you give the students responsibility, they like it. It excites them a lot. That's my experience.

"One major result of the NSF grant has been to prepare these students to go on to other research institutions, should they decide to continue in research," Dr. Abdolsalami said.

Tuskegee University Center for Computational Epidemiology

At the Center for Computational Epidemiology at Tuskegee University School of Veterinary Medicine, Dr. Tsegaye Habtemariam is creating a new branch of science. "Computational science is the third branch of science," said Dr. Habtemariam. "Classical science includes two branches: theoretical science and experimental or empirical science. In experimental science you conduct experiments in the laboratory or in the field and observe and generate data. In theoretical science, the understanding revolves around a theory that explains behavior. Computer modeling provides a new arena of computer-based scientific experimentation." Within the branch of computational science, Dr. Habtemariam is working on computational epidemiology or the use of computers for research.

Taking advantage of advances in information management and computer modeling, Dr.

Habtemariam is developing a new approach to conducting research by integrating computer modeling and expert systems as a means of generating experimental data. "Instead of gathering data in the field and using the computer to analyze it, we are using the computer to recreate the whole experimental medium," said Dr. Habtemariam. "The computer serves as the field or laboratory.

"You can define populations on the level of ecosystems of cells, molecular epidemiology; as populations of data; or in the highest levels of ecosystems, people or even global systems," explains Dr. Habtemariam. Information about growth and death of populations under various conditions can be programmed into the computer to model an ecosystem. Different parameters can be used to define the systems, and different variables can be introduced into the system to discover what effect is created. The computer can process decades of evolution in hours.

Dr. Habtemariam is working on the basic science for advancing methods of computer modeling. "The object is to develop methods of computational modeling and apply them to specific problems like health," he said. For developing the Center's methodology, Dr. Habtemariam is using the population dynamics of trypanosoma, a parasite that is a significant world problem.

Extensive qualitative and quantitative data have been collected on trypanosoma, which is important for the methodology that Dr. Habtemariam hopes to develop. "Quantitative modeling emphasizes numbers, but the majority of biological data is qualitative description, which is the domain of expert systems," he said. "The two methods are generally used separately, but if we can combine the two, we will be able to advance problem-solving and decision-support models."

Over the past four years, the Center has instituted several projects, many of which contribute to multidisciplinary databases. Current projects include the development and application of the Problem-Oriented Epidemiologic Approach (POEA) methodology to expand knowledge of schistosomiasis and trypanosomiasis and the development of expert system modules to help select and implement control strategies in biomedical areas.

Center accomplishments include two demonstrations at the World Conference on the Environment in Rio de Janeiro this year. Project staff have published over 74 papers in eight different journals and proceedings. In addition, 70 presentations have been made at both national and international conferences in England; Antwerp, Belgium; the International Center in Insect Physiology and Ecology in Kenya; Addis Ababa University in Ethiopia; and the University of Glasgow, Scotland.

All of this would not have been possible without National Science Foundation support. "The initial Center and even the concept of the computational epidemiology center came from the original NSF grant," said Dr. Habtemariam. The first NSF grant in 1986 bought a VAX 11750 and enhanced the computing capability of the university. In 1988, RIMI grant funds were used to purchase a Mac 2 FX workstation. Although the grant is fairly small for setting up computational research, Tuskegee was able to leverage the NSF support into a major National Institutes of Health (NIH) grant and a grant from Digital Equipment Corporation (DEC) for networking fiber optic thin-wire ethernet.

Because of the NSF-supported facilities, the Center also received a grant from the U. S. Department of Health and Human Services to create a Center of Excellence for the medical education of minorities. This medical information center has a biomedical information system with a research component and an education component for minority students. The education component is funded by the U. S. Department of Education.

The Center also has received support from Apple; Symbolics, Inc.; and the Dodge Foundation and would like to obtain more support from private foundations. The Center further extends its capabilities through collaboration. For example, the Center has written a joint proposal with a nearby university to combine its expertise in video disk technology with Tuskegee's expertise in computational modeling.

The Center has become a campus resource. Faculty from other departments train in computational methodology in the lab during the summer. In addition, "Faculty come to us to develop joint proposals," said Dr. Habtemariam. Within the School of Medicine, faculty use the information system for biomedical information. International visiting scientists are also attracted to the Center's work. "All major visitors on campus come to visit the Center," said Dr. Habtemariam. During the summer of 1992, the Center hosted a Fulbright Fellow and a Fogerty International Fellow, among others.

The Center also serves as a resource for students, and Dr. Habtemariam has been amazed at the

richness of the scientific disciplines brought together in this program. The NSF grant supports 17 minority graduate students in epidemiology, engineering, and biology. Three students have been awarded master's degrees in epidemiology. The Center is training 30 undergraduates and is reaching out to high school students to bring them into the laboratory in the summer. "These minority students have the opportunity for exposure to new science that would not have been available without support from NSF," said Dr. Habtemariam.

"The Center in computational epidemiology is now beginning to hold its own in the international scientific community and to influence research all over the world," said Dr. Habtemariam. The Center is pioneering methodologies and training future researchers to solve international health problems. NSF was the key to initiating this international program.

University of Puerto Rico at Rio Piedras and Mayaguez The Algebraic and Combinatorial Computing Group

The Algebraic and Combinatorial Computing Group at the University of Puerto Rico (UPR) at Rio Piedras and Mayaguez has surged forward in research with support from NSF. Since 1984, the Rio Piedras Mathematics Department has moved from having the lowest number of publications per researcher at the Rio Piedras campus to having the second highest number in all science departments at UPR. In addition, Mathematics Department funding increased twentyfold, from $100,000 for the ten years 1974 to 1984 to nearly $2 million for the five years 1985 to 1990.

Impetus for increasing the output and quality of the research and learning facilities was provided by the Mathematics Department's focus on computer modeling and simulations. "Modeling and simulation are extremely important to Puerto Rico's future because science is becoming computational," said Dr. Oscar Moreno, principal investigator in the Algebraic and Combinatorial Computing Group.

"NSF was the funding cornerstone," said Dr. Moreno. "The RIMI grant was instrumental in getting us going." With a 1986 grant from NSF, the Gauss Research Laboratory at Rio Piedras acquired a state-of-the-art FX/8 Alliant minisupercomputer. With the Alliant, the computing group organized a local area network (LAN) among local researchers. In 1988, with additional support from NSF, the group connected the Alliant through NSFNET to the network of supercomputers at NSF. "These links are important, since they allow our researchers to communicate with mainland computers," said Dr. Moreno.

The last objective of the RIMI proposal is a cooperative effort between the Rio Piedras and Mayaguez campuses to offer a doctorate in computational mathematics. The program will be carried out with the cooperation of local and national industry and assistance from national research institutions. Dr. Moreno feels the expanded graduate program will continue to upgrade the level of research, enabling UPR to train faculty and professionals to serve the needs of research and industry.

The computing group's work in applied computational mathematics is aimed at developing the high-performance computing capability for the island of Puerto Rico. Researchers have been collaborating with Cornell University in symbolic computation and linear analysis. The main thrust of their research is the development of computational techniques involving communications science, symbolic computation, and modeling. "Traditionally, mathematics is used to influence applied research," said Dr. Moreno. "But using applied math, you impact the real world."

Their work in computation has also influenced the world of mathematics.Techniques developed for applied math are being applied back to theoretical mathematics to expand previous results. For example, the 30-year-old Theorem of Ax, which posits a number of solutions to a multiple-variable polynomial, has been improved. New computation techniques substituting values for variables have increased the number of solutions.

Over the last five years, the computing group has established cooperative links with some of the mainland's top research institutions: the University of California at Berkeley, Cornell University, IBM Watson Research Laboratory, AT&T Bell Laboratories, and Bellcore.

UPR is also working with the City University of New York, Rutgers, Michigan, and Ohio State Universities, the Universities of Southern California and Minnesota, and the Technical University of Denmark. Notable scientists from other institutions visit as researchers. UPR has collaborative agreements with the Communications Science Institute of the University of Southern California, the Mathematical Sciences Institute of Cornell

University, and the Institute for Problems of Information Transmission Center in Moscow.

UPR's outreach program focuses on the identification, encouragement, and training of students interested in the sciences. Precollege, college, and graduate students are recruited through the university's Resource Center.

Many students proceed from UPR to mainland universities. In the last three years, UPR has awarded 33 master's degrees. Eleven students continued on to Ph.D. programs at institutions including the University of California at Berkeley, Cornell University, Ohio State University, and Arizona State University.

One high school junior came to work in the computing group laboratory during the summer of 1989. On his own he traveled long distances two or three times a week during the year. "He came from a poor family, but was very disciplined," said Dr. Moreno. "I was very impressed with his interest." With Dr. Moreno's recommendation, the student won an internship at Lawrence Livermore Laboratory and continued his studies at a mainland university.

The expanded computation and modeling capabilities available to the computing group offer UPR students a resource that otherwise would not be available. Through the support received for this project, the mathematics communities in Puerto Rico and on the mainland have gained colleagues and trained students, and UPR students are preparing themselves to contribute to the advancement of computational mathematics.

University of Texas at El Paso
The System AG-S-SE: Phase Relations, Electrical and Optical Properties, and Application

The University of Texas at El Paso (UTEP), which serves a substantial number of underrepresented minority students, received National Science Foundation funds in 1990 to establish an interdisciplinary RIMI project in material science.

In its first year, the RIMI research group synthesized 30 compounds in the system Ag_2S—Ag_2Se (silver-sulfer-selenium compounds) and examined them on an optical microscope, electron microprobe, and x-ray powder diffractometer. These and other tests provided information on changes in lattice spacing associated with solid solutions, the electrical conductivity of the compounds, and the deposition of the materials as thin films. Fabrication of the silver-sulfur-selenium compounds as thin films is a prerequisite to potential applications in microelectronics and optoelectronics.

Three professors, five Mexican-American students, and one staff member on the RIMI project work on the overall silver-sulfur-selenium project. During those times when the compounds must cook for a month and cool slowly before investigators can try another mixture, students participate in other projects that use the skills, techniques, and equipment from their RIMI research. These spin-offs include measurement of surface area in corals, lead in soils, and minerals in oil-well core.

Two research articles, four abstracts, and four project-related presentations have evolved from the research on silver-sulphur-selenium systems. In each case, RIMI students were co-publishers.

For Dr. Nicholas E. Pingitore, Jr., professor in the Department of Geological Sciences and co-principal investigator along with Dr. J.J. Robillard of the Department of Physics, life is no longer calm and relaxed since receiving the RIMI grant. "I have never worked harder," said Dr. Pingitore. "Most of the minority students in our group have a limited background in research and they lack experience with laboratory equipment. Nevertheless, the principal investigators must do top flight science, along with mentoring and even some social work. El Paso is a poor community that doesn't have many resources; our students face hardships to get to the university. We must help them on the next step to careers in science. This is incredibly hard work but very rewarding."

Six Mexican-American students were enrolled in the project in 1990 and five in 1991. Undergraduate majors include the geological sciences, physics, electrical engineering, and chemistry; graduate students are geological science majors.

The influence of the grant on the students has been wonderful. "It is tough to be a minority student in El Paso," said Dr. Pingitore. "Some students feel lost when they first come to the university. They have never viewed science as something exciting...as something that involves teamwork...and as something that involves pride in what one is doing." Participation in the RIMI grant has changed that perception. Even the simple reality of wearing a laboratory coat has fostered a sense of professionalism, and working side by side with professors and graduate students makes undergraduate students feel special and able to see science as a career, something they could do. The five minority students on the project have gained

self-confidence and a real sense that they can be scientists.

The "recruitment window" is a part of that experience. The Department of Geological Sciences recently moved to a renovated building where the main laboratory, which houses the project, has windows that run the full length of the room. The windows are adjacent to a main, well-traveled university corridor. This permits other students to observe the equipment and activities in the lab, thus making the research visible to a larger segment of the university community, as well as to summer students from local junior and senior high schools. UTEP students have gained a sense of pride in their work and enjoy the opportunity to demonstrate their research skills.

The project has produced other benefits. Dr. Pingitore received strong support from the university in the form of a matching grant. The matching funds were close to the NSF grant amount and included $75,000 for x-ray equipment. The equipment not only benefits the RIMI research but also will be useful for other projects and will bring UTEP closer to a state-of-the-art capability in materials research. The NSF funds take pressure off the technical assistants to obtain outside jobs and increase the overall number of students the university can support. The grant also encourages interaction among departments, bringing geological sciences, physics, and chemistry professors together to work on the RIMI project. For example, Dr. Leigh C. Porter, a chemistry professor, works cooperatively with a minority chemistry student to provide electrical measurements for the RIMI project.

Applications for project findings abound. As a direct result of the initial research findings, Professors Pingitore and Porter have submitted a grant proposal to fund development of the silver-sulfur-selenium compounds as solid-state thermal bulk switches and nanoswitches. Their compounds may be appropriate for microwave sensors or as a temperature sensor on bottles of food, wine, or medicine to indicate if the product has been exposed to temperatures above appropriate levels. The compound is a "designer material," a solid solution with a continuous range of compositions, making it possible to change the properties of the material with the composition.

The RIMI project also is collaborating with Sandia Laboratories. Sandia Laboratories has a strong commitment to UTEP and is allowing RIMI investigators to use its high-temperature x-ray diffraction equipment during the summer. The experience gives students an opportunity to work at a large laboratory and to observe many scientists at work. Students gain self-confidence from these summer trips and positive reinforcement for their chosen profession.

Teamwork...student self-confidence...hands-on research; these components contribute to the success of this RIMI project, clearly seen through UTEP's "recruitment window" of opportunity.

Wayne State University Nutrient Homostasis: Coordination of Response Patterns by the Nucleus Tractus Solitarius

Dr. Robin A. Barraco, professor of physiology, has been researching basic brainstem mechanisms for regulating bodily functions since 1985 when he received his first RIMI grant from the National Science Foundation.

"When you breathe and your blood pumps, you move around nutrients," Dr. Barraco said. While studying how the brain regulates blood pressure, he found that the most active area was a small area of the lower brain, right above the spinal cord, called the nucleus tractus solitarius (NTS). That finding opened a whole new area of research.

It was NSF's emphasis on basic research that allowed Dr. Barraco to explore this unexplored area of the brain and discover its relation to other functions in the body. The RIMI grant was the first funding Dr. Barraco received to determine the implications of his research.

"You go to NSF when you want to explore a new horizon or a basic mechanism. NSF is the one agency for unique, cutting-edge research," Dr. Barraco said. Three major agencies fund research similar to that of Dr. Barraco: the National Institutes of Health (NIH); the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA); and NSF. However, NSF is the only agency that funds basic research not related to disease. The others fund clinical, disease-related research that is targeted at mental health, drug abuse, cancer, heart disease, or other health disorders. "For the really innovative work, NSF is the place," he said.

The basic research Dr. Barraco performed under the NSF grant has provided the foundation for related research funded by NIH and ADAMHA. "Once you have completed the basic research, there are different directions you can explore that are more appropriate to other agencies," he said.

Brain research itself is a young discipline. The first professional organization in neuroscience, the Society for Neurosciences, was established in 1969, two years before Dr. Barraco graduated. In 1985, the lower part of the brain was mostly discounted in neurological work because it was related to the more primitive functions of the vertebrate brain. Taste and smell are projected there, and the development of this part of the brain represented the first time vertebrates connected those senses with visceral sensations, like nausea. One of the strongest types of learning is taste aversion—for example, using Mercurochrome to stop thumb sucking. The development of the NTS, therefore, represents an evolutionary advance for vertebrates.

The NTS is a central integrating area for all visceral information. Everything inside the body, including all of the organs, transmits signals to this part of the brain. The regulation of such things as sweating and heart rate is part of the autonomic nervous system. The NTS regulates blood sugar level, peristaltic movement, release of hormones (peptides including insulin for digestion) in the gut, respiration, and blood pressure.

"No one really understands how the brain senses and regulates activities like the level of hormones and the metabolic needs of tissues through blood flow changes," said Dr. Barraco. It turns out that NTS plays a major role in doing all this.

"The brain function that dignifies the real meaning of life is the one that senses what your internal feelings are," he said. "And now we know that this is located way down there just above the spinal cord." Dr. Barraco discovered in mapping the NTS that this small area in the medulla has pathways that network to all the higher brain areas associated with an individual's emotions and thoughts.

Dr. Barraco is also looking at another area of the brain that is connected with the NTS, called the nucleus accumbens, which is associated with emotional expression. "This area of the brain is a hot area for research right now. It is the major reinforcement area of the brain," he said. "If you stimulate this area with an electrode, you can get any behavior you want. This is the area where drug addiction takes place. When this area is activated, it releases neurotransmitters that transmit great pleasure. It is in charge of your reward drive, and it is all connected through the NTS."

According to Dr. Barraco, his study of NTS provides an entirely different way of looking at consciousness and brain function, perhaps forming the basis for a whole new strategy in the study of mental illness and consciousness, performance, brain function, and memory.

At the time Dr. Barraco received his degree, only half a dozen neurotransmitters were charted. "Now we know the brain has a vast chemical vocabulary of at least 500 substances including neuromodulators. Every known neurological substance we know is found in the NTS. The NTS can communicate with every major area of the brain, something that even the higher brain doesn't do," he said.

"In America the great tradition in brain science formerly belonged to psychologists and their research on memory. Brain research is a discipline only a quarter of a century old," Dr. Barraco said.

The understanding that a complex vocabulary of communication substances exists in the brain—such as endorphins that activate during long-distance runs—is a relatively new finding. In fact, the number of known substances that the brain uses for communication has jumped from in the twenties to the hundreds in the last five or six years, Dr. Barraco explained.

Dr. Barraco is currently editing a first-of-its kind book on the NTS, with contributions from international scientists who are also investigating this area of the brain. The book is a direct result of research spurred by Dr. Barraco's second RIMI grant. Dr. Barraco also has written a histological atlas of the NTS portion of the rat brain, thereby creating the first reference work on the subject to stimulate future research.

With his first RIMI grant, Dr. Barraco established his laboratory, with subsequent funding directed toward the creation of advanced microinjection techniques. This high-tech procedure was developed under NSF funding at Wayne State University by Dr. Richard Campbell. Dr. Campbell was one of the few African Americans in the nation to earn a doctorate in neuroscience.

Using RIMI program support that began in 1985, Wayne State University has established powerful and sophisticated surgical, neurophysiological, and neuropharmacological methods for examining brainstem regulatory functions. These methods now serve as an important resource in the university community for faculty research collaboration and student training. Many university staff have been trained in microinjection and surgical techniques.

Since 1989, with the aid of two RIMI grants, Wayne State has graduated two Ph.D. students, one of whom is a minority; two master's students, one of whom is a minority; and four baccalaureate students,

all of whom are minorities. Students in the laboratory complete an apprenticeship and are matched by interest with faculty mentors. Dr. Barraco works with five faculty members. The RIMI program provides for the funding of one graduate student and one postdoctoral student.

Dr. Barraco has trained eight Ph.D.s who are now teaching around the country, as well as three graduate students. "I not only teach my students how to think and reason in science, but also share with them my feelings on ethics and morality in science," he said.

For over two decades, Dr. Barraco has had a strong commitment to minority student education. He serves as the Program Director of the ADAMHA Minority Access to Research Careers (MARC) program, an honors undergraduate training program at Wayne State University. "So I'm growing students at the undergraduate level in brain research," he said. He places students with faculty around the university who are performing brain research and uses ADAMHA funds to provide stipends of $6,700 per year plus full tuition for selected students.

Another important part of Dr. Barraco's life is developing a network of people concerned with the education of underrepresented minorities and women from high schools and colleges, as well as graduate and postgraduate students and faculty members.

"I see it as a national security issue," he said. "The largest pool of human power in the next century will come from women and minorities. We have to train women and minority scientists for careers in science and engineering to provide the scientists for the next century. It's imperative."

Minority Research Centers of Excellence

The Minority Research Centers of Excellence (MRCE) program seeks to increase the number of minorities in science and engineering by making substantial resources available to upgrade the capabilities of the strongest and most research-productive minority institutions. This funding provides increased opportunities for minority faculty and students to engage in research, and supports the initial phase of establishing the Centers. The program also enables these institutions to use their resources and research to increase the effectiveness of related science and engineering activities for other institutions in their regions.

The MRCE program was initiated in 1987 to encourage institutions that have previously received funding through Research Improvement in Minority Institutions (RIMI) and Minority Research Initiation (MRI) program grants. Criteria for selection include the institution's ability to attract teams of experts and proof of progress in establishing a research infrastructure with other institutions.

Universities are required to have a 50 percent minority student population with graduate programs in science and engineering. Awards provide up to $1 million for up to five years. The National Science Foundation's (NSF) Centers of Excellence model has been replicated by several other government-funded science programs.

All of the Minority Research Centers of Excellence are featured in this publication because meeting the requirements to establish an MRCE indicates that the institution has proved itself as a model program.

Figure 9 illustrates the number of students participating in the MRCE program and the number of research papers produced from 1987 to 1991. **MRCE student participants increased from approximately 50 in 1987 to more than 300 in 1991. Concurrently, publications in refereed journals by faculty increased from approximately 10 to more than 200 in the same time period.** Figure 10 shows the geographic distribution of the eight MRCEs.

Figure 9:

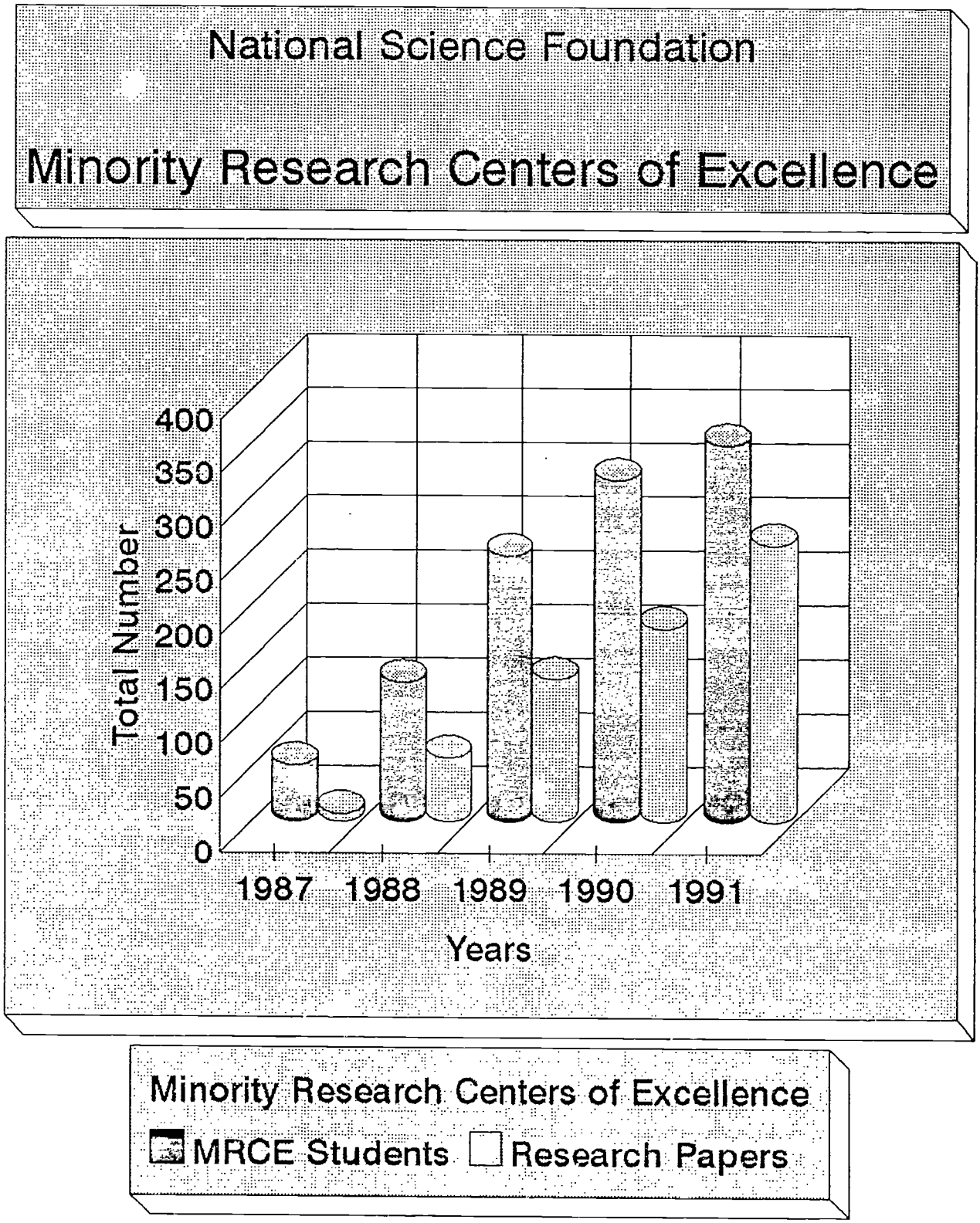
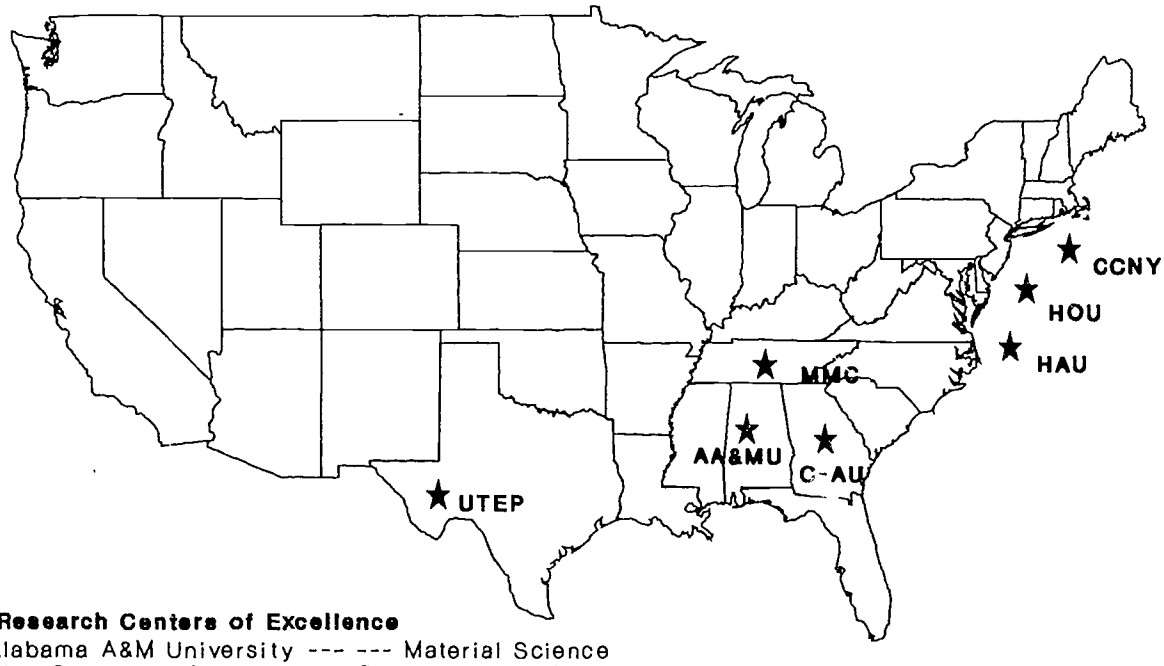

National Science Foundation
Minority Research Centers of Excellence
Total Number
400
350
300
250
200
150
100
50
0
1987
1988
1989
1990
1991
Years
Minority Research Centers of Excellence
MRCE Students
Research Papers

Figure 10:

Geographic Distribution
of
Research Centers of Excellence



Minority Research Centers of Excellence

AAMU - Alabama A&M University --- --- Material Science
CCNY - City College of New York -- Chemistry and Engineering
CAU - Clark Atlanta University --- Physics and Mathematics
HAU - Hampton University --- High Energy and Nuclear Physics
HOU - Howard University --- --- Material Science
MMC - Meharry Medical College --- Cell and Molecular Biology
UPR - University of Puerto Rico --- --- Interdisciplinary
UTEP - University of Texas at El paso --- Chemistry and Eng.

Alabama Agricultural and Mechanical University

Scientists at the Alabama Agricultural and Mechanical University (AAMU) Minority Research Center of Excellence (MRCE) for the study of Nonlinear Optics and Optical Materials have taken the high road in their investigation...all the way into outer space. Since AAMU was awarded an MRCE grant in 1988, it has increased the number of its laboratories from four to twelve.

Investigators at AAMU are performing research in quantum optics and in the preparation of crystal materials for optical and electronic systems. Studies include the growth of bulk crystals of semiconductors and optically active materials from solution. These crystals have been characterized and growth models have been developed, to advance the state of crystal research and further their application to products that enhance our daily lives.

Four of the dozen laboratories at the Center are dedicated to growing various types of crystals, with the remaining eight engaged in optics and laser research. The crystal materials used in the optics of laser systems are now finding wide application in manufacturing and biomedical fields.

Accomplishments by the faculty in the area of crystal growth include a collaboration with the University of Wisconsin at Madison and the University of Alabama at Huntsville in the growth of superconducting crystals. The results of this joint research were carried in the *Journal of Crystal Growth.*

In certain experiments, it is fair to say that the Center's research is out of this world! That is certainly the case when you consider the exciting work carried aboard U.S. space shuttle missions. In one experiment in January 1992, a solution growth of triglycine sulfate (TGS) crystal was flown aboard the International Microgravity Laboratory (IML-1) into Earth orbit on board the STS-42 space shuttle mission.

X-ray inspection of crystals manufactured in space indicate better homogeneity and fewer defects than their Earth-made counterparts. Infrared detectors are sensitive to thermal conditions. These crystals, therefore, are useful in detecting forest fires from space—an important commercial application for AAMU's research. The AAMU crystal work may also be applied to maintaining strict temperature controls on the International Space Station Freedom, scheduled to be circling Earth at decade's end.

Dr. Ravindri Lal developed a new process for growing TGS crystals in space, which greatly increased the quality of the crystal compared with crystals grown on Earth. Data accumulated from the shuttle research mission are helping scientists to understand how fluids behave in the low-gravity environment of outer space.

Alabama's MRCE has established novel collaborations between the Center and industry. "The participation of industry is very critical," said Dr. Lal.

Accomplishments by the faculty in the area of crystal growth include collaborations with the University of Wisconsin at Madison, the University of Alabama at Huntsville, and the University of Alabama in Tuscaloosa in the growth of superconducting and mixed organic crystals. The result of this joint research was carried in the pages of the *Journal of Crystal Growth* and *Journal of Applied Physics*.

The faculty members have perfected certain photorefractive crystals grown by Czochralski technique. Using this method, Center scientists have been able to grow industrial-quality barium titanate and bismuth silicon oxide crystals. Barium titanate is difficult to buy commercially, with very limited sources for obtaining the crystal material. A small crystal of five cubic millimeters costs about $4,000, and a nine or ten cubic millimeter crystal costs about $10,000. Striving for perfection in the quality of these crystals means a number of trial tests are needed. "Perfection in the crystals is one of the main characteristics that we attempt," said Dr. Venkateswarlu, Associate Director for Research. Both of these crystals are very useful in signal processing and for optical phase conjugation in lasers.

The Center has a strong partnership with Hughes Electro-Optics Data and the System Group, which is also working in optical crystals. The Center and Hughes have signed a Memorandum of Understanding research agreement that involves an exchange of students, faculty, and Hughes experts. In addition, Hughes recruits students for summer research experiences. "It also has resulted in some valuable research equipment transferred from the corporation to AAMU," said Dr. Jeanette Jones, Executive Director of the Center and Vice President of Research and Development.

"This is a benefit that not only helps the department of physics, but benefits the whole university. As a result of the work that we're doing in physics, which was enhanced by the NSF funding, we have experienced a great deal of benefit

throughout the university. It has been a catalyst for us."

"A primary example of the collaboration we are establishing is our arrangement with NASA's Marshall Space Flight Center's (MSFC) Space Science Laboratory," said Dr. Alton Williams, the Center's Assistant Director for Research.

Sheila Nash Stevenson, a graduate student at the Center, is being supported by MSFC in her dissertation research. She is an MSFC employee and was awarded $100,000 by MSFC for equipment support.

The Center also collaborates with EDO/Barnes Engineering Division of Connecticut, a leading supplier of infrared detectors. Fabricating detectors requires multimillion dollar establishments, which are not available in Alabama at the moment. AAMU also has alliances with several other groups including AT&T Bell Labs, Litton Airtron, Lawrence Livermore National Laboratory, and Oak Ridge National Laboratory. Joint activities with these groups have strengthened the new Ph.D. program in Nonlinear Optics and Optical Materials. The first two Ph.D. students graduated in May 1991.

NSF funding has enabled the university to expand the number of graduate students from 14 to 42 and to increase its physics faculty from 9 to 22. In addition, the number of minority students in the program has grown from 6 to 18. NSF funding also enabled the university to augment and focus its research agenda in materials science. Much of the Center's funding now received from collaborative efforts with the U.S. Air Force, U.S. Army, Department of Energy, National Aeronautics and Space Administration (NASA), and others is a result of the initial support provided by NSF through RIMI and the MRCE Center.

The Center is also working to increase the number of minority students in the science pipeline through an outreach program for 4th and 5th grade students. One two-week outreach program emphasizes science, chemistry, biology, physics, math, English, computer science, and career exploration. The Center also supports a similar five-week program for students in grades 9-12. In addition, a six-week research apprenticeship program for grades 10-12 and college freshmen and sophomores has been established. In this program, students are assigned mentors and are tasked to work on a research project over the summer months.

"Since starting, we have served about 585 students," said Dr. Jerry Shipman, Associate Director for Center Outreach. "Our follow-up on these students has revealed that 100 percent graduated from high school and 96 percent attended college: 50 percent majored in scientific disciplines, 34 percent are undecided, and the remainder selected nonscientific areas."

Students who graduated from AAMU are well prepared for science careers. One student recently received a postdoctoral fellowship from the National Research Council and is now working for NASA's Marshall Space Flight Center. "One of the distinctive things about students who graduate from AAMU and have worked in the department is that they learn how to write research grants," said Dr. Jeanette Jones. For example, the very first physics Ph.D. student from AAMU submitted a proposal to NASA that resulted in a $1.5 million grant for five years.

"I think there are very few institutions who have graduates that are capable, in their first year out of school, of writing a proposal to attract funding at that level," said Dr. Jones.

City College of New York

"Our biggest accomplishment is the first rate science we do here. We're exploring the same problems as majority institutions, doing some of the same level of work as places like Berkeley," said Dr. Daniel L. Akins, Director of the Center for Analysis of Structures and Interfaces (CASI) at the City College of New York (CCNY).

The way Dr. Akins sees it, the MRCE offers an opportunity to show that minorities can make a contribution to the nation, and CASI's students are trying to win as a team. Everyone contributes.

The aim of the MRCE program at CCNY is not so much to develop a few stars as to move a broad number of students through the process. "In a few years we plan to have all of them making a contribution," said Dr. Akins. "Their success is a group success. They meet and share experiences and try to help each other out. They network and bring perspectives to each other."

CCNY has a long history of helping newcomers contribute to the American scene, beginning with immigrants, and the New York City area provides a unique group of students to the university as well. Dr. Akins feels CCNY's student population represents the wave of the future, a melting pot of nationalities—40 percent African American, 30 percent Hispanic, 13 percent Asian, and 17 percent others. "We're extracting the best talents from this population," Dr. Akins proudly said.

In addition to being Director of the MRCE, Dr. Akins is Chairman of the National Alliance of Research Centers of Excellence (NARCE), an organization in which students meet annually to share problems and knowledge gained from research experiences. "We represent a unique capability," said Dr. Akins. At first, he was surprised at the great desire and enormous range of skills evidenced in the students. "There is a pool of talent there to be tapped, but ways to tap into that talent are limited," he said. Major universities would have to do something special to reach out to minorities and they are not necessarily able or willing to do this. "We are trying to develop pathways for individuals to develop themselves."

In 1991, CCNY graduated two minority Ph.D.s in chemical and electrical engineering. In 1992, CCNY expects to graduate 14 students in scientific disciplines from laser physics to applied engineering. "Those students would not be in the pipeline if not for the Center," said Dr. Akins. "Only three or four might have planned to do Ph.D. work. The rest would not have thought about getting a Ph.D. in science because of barriers in terms of family or money. The Center has made it doable" through the research stipends provided, Dr. Akins stressed.

CCNY's undergraduate program, supported under CASI, is even more ambitious than its graduate program. In the former, there are 20 undergraduates "rubbing shoulders" with researchers who can "stand shoulder to shoulder with any faculty in the country," said Dr. Akins.

The students also receive support outside the classroom. CCNY has been very successful at placing students in industrial laboratories over the summer. For example, in 1991 students received industrial internships at the Motorola, Bell Communications Research, Sony, Hughes, and Timken corporations.

The numbers of participants can be attributed, in part, to the Center's outreach efforts. The philosophy is simple: talk to people and spread the word about the Center. Center staff regularly speak to local high schools and often meet with the parents of students on campus.

The MRCE project has also made a difference to the university in many ways. As the largest funded program at CCNY, it was a management challenge Dr. Akins couldn't refuse. At first he found a prevailing view that minorities could not handle such a large undertaking.

"That was unacceptable to me," said Dr. Akins. "I've accepted challenges all my life, and I wanted to show that it could be done." A competitive individual, he likes taking on things that others call impossible. Operating the MRCE "in a competent, efficient manner is a feat," said Dr. Akins. He showed it could be done, and his success has resulted in other minorities assuming the reins in other programs on campus.

One of the advantages of the National Science Foundation's MRCE program is the flexibility afforded by Center-level funding. One thing the Center can do is respond quickly to new opportunities. Through seed money, the Center can support a project that has not been formally approved for funding. Subprojects can be managed because of the flexibility. "We take advantage of that kind of discovery activity to develop new proposals," said Dr. Akins. It allows the researcher to pursue some ideas or investigate trails that might open up new research arenas.

Dr. Akins is conducting one of the major projects at CASI. His research group is studying sensitized processes at semiconductor interfaces using laser scattering techniques or spectroscopy. Research could ultimately lead to new film techniques that may increase the speed at which information can travel in composite integrated circuits.

"We're breaking new ground every day," said Dr. Akins. With original research, "every step is unknown. Sometimes you find solid results; other times you step on quicksand."

Dr. Akins said three new spectroscopy techniques have been integrated into his research program. They are Fourier Transform Raman (FT-Raman), coherent anti-Strokes Raman scattering (CARS), and picosecond Raman spectroscopies. FT-Raman is used for observing vibrational modes of aggregated cyanide dyes and other important molecules. The new techniques for characterizing systems allow researchers to see details they could not see before. It is hoped that CARS spectroscopy will enhance signal intensities. Picosecond Raman spectroscopy allows measurements of electron-transfer rates at semiconductor interfaces.

Clark Atlanta University

Do science and soccer have something in common? Dr. Alfred Msezane and Dr. Carlos Handy of Clark Atlanta University's Minority Research Center of Excellence believe that some of the same principles used to coach soccer will stimulate and excite students about science by converting athletic competitiveness into intellectual competitiveness. They contend that seeing their names in print and

knowing that scientific research can open doors will inspire students to pursue research careers.

The co-directors of the MRCE have coached soccer teams together. They took disadvantaged youth, taught them the game, brought cohesion to their teamwork, honed their competitiveness, and made them winners.

Dr. Msezane stresses the importance of countering students' fear of failure: "Students need to be allowed to make errors. When you experiment in physics, if you fail, you try again."

Over the years, Dr. Msezane and Dr. Handy have been able to share their expertise in physics with minority students through the assistance of NSF's RIMI grants as well as funding from the U.S. Department of Energy and the Office of Naval Research. The MRCE grant has permitted them to expand their program to encompass more students in their "environment of excellence."

Their MRCE—the Center for Theoretical Studies of Physical Systems—is consolidating and expanding research capabilities in physics. Research at the Center is conducted through dynamic interdisciplinary research clusters in (1) atomic and molecular theory, (2) quantum few/many body problems, and (3) mathematical physics/applied mathematics. The clusters will strengthen and expand ties with several national and international scientific institutions.

Led by principal investigators or group leaders, each cluster involves researchers who are members of other clusters as well as visiting scientists, research associates, graduate and undergraduate students, and high school students.

The MRCE program sponsored two parallel outreach programs involving 48 students in the summer of 1992. The first is an "open door" program involving Atlanta area students from grades 8-12. In 1992, the Center's inaugural year, 34 high school students participated in the open-door program, and most were highly motivated, reports Dr. Msezane. The Center exposes them to college-level experiments in physics and the rudiments of calculus. While many students are uncertain about their future careers, a number of the participants are considering a career in the sciences as a result of their involvement in Center programs.

A key ingredient of the Center's success is that calculus is taught not only from the chalkboard, but also by involving students in hands-on experiments using computers. This permits students to see that research and calculus have immediate and practical applications.

The second parallel component of the program is the High School Summer Research Apprentice's Program. In 1992, 15 students, primarily women, were selected to participate. This program has proven extraordinarily successful. Matched with mentors, participants work on challenging research projects. They are introduced to the whole spectrum of computer physics. Utilizing computers with advanced software, students study mathematics, atomic and molecular properties, quantum mechanics, computer graphics, condensed matter, and atmospheric physics.

In the future, Dr. Msezane and Dr. Handy plan to introduce students to supercomputers such as the Cray and parallel processors. The co-directors explain: "They are an integral part of Physical Science research. Comprehensive workshops will permit students to advance their knowledge of such computers and assist them in understanding the potential of a research career."

NSF funding for the Center has also assisted Dr. Msezane and Dr. Handy in leveraging funds from other sources. Additional support for the program has come from the Office of Naval Research, the U. S. Department of Energy, IBM, and Digital Equipment Corporation. Since most of the grant funds are utilized to support students, the Center seeks additional assistance from the private sector to implement innovative programs. For example, a Mobile Physics Demonstration Laboratory is planned that will visit local schools for several days, allowing students to view a panorama of exciting experiments that cannot be duplicated easily by public schools.

The Center also plans to identify experiments that can be placed within area schools for extended periods of time. Clark Atlanta University professors will visit the schools to offer guidance. Both projects, however, require a truck that can house and transport the experiments. Local private sector support is being sought.

Unlike other grants and contracts that require traditional methods, the NSF grant allows Center staff to experiment with innovative approaches to problems in science education. This freedom makes winners of students and schools, permits healthy competition, motivates students, and frees scientists to generate and implement ideas. The co-directors' enthusiasm for scientific research and the teaching of students is evident: "Problems excite us, and we love competition."

Clark Atlanta University is expanding its faculty with talented researchers from throughout the country and other continents. For example, Dr.

Romain Murenzi, a wavelet analysis expert, and Dr. Xiao-Qian Wang, a superb researcher in density functional theory/molecular dynamics, will join the Center in the fall. Dr. Murenzi, originally from Ruanda, is currently at Saclay, France, while Dr. Wang, a native of China, is at the University of Minnesota.

Through the MRCE grant, the Center has built a sophisticated computing facility at Clark Atlanta University. The computers were acquired through support from IBM, Digital Equipment Corporation, and the Pittsburgh Supercomputer Facility. The MRCE co-sponsored a workshop on the Clark Atlanta campus in April 1992 entitled "Electron-Ion Collisions." The U. S. Department of Energy's Lawrence Livermore Laboratory co-sponsored the event. Support also came from IBM, Digital Equipment Corporation, the Office of Naval Research, and other branches of the Department of Energy. Approximately 40 researchers from the United States and Europe participated in the workshop.

"One of the main goals of the MRCE is to create an environment of excellence where students are encouraged to pursue scientific challenges and be competitive with the best in their field," explained Dr. Handy. To this end, a Chautauqua Course in Applied Mathematics was held in March for Center students and professors. Georgia Institute of Technology professors and a professor from the University of Texas at Arlington participated as speakers.

The External Advisory Board members of the MRCE come from such institutions as The American Physical Society, The American Association of Physics Teachers, Stanford University, Georgia Institute of Technology, Jet Propulsion Laboratory, Harvard-Smithsonian Center for Astrophysics, Massachusetts Institute of Technology, Battelle Pacific Northwest Laboratories, The University of Waterloo, and Los Alamos National Laboratory. These members will strongly enhance coupling and interaction of the Center with major research universities and national/international laboratories and impact the training of students in the physical and mathematical sciences.

From supercomputer workshops to a laboratory on wheels, the various Clark Atlanta University MRCE programs herald a great future in attracting minority students to science and engineering.

Hampton University

The Minority Research Centers of Excellence Nuclear/High Energy Physics Research Center of Excellence (NuHEP) at Hampton University is the first program of its quality in nuclear and high-energy physics at a Historically Black University. Beginning in September 1992, Hampton will be the first minority institution in Virginia to offer a doctoral program in physics.

Hampton is taking advantage of a collaboration with a high-energy and nuclear physics facility near the campus to enhance the capabilities of its physics department. For the past nine years, Hampton has taken part in the development of the Continuous Electron Beam Accelerator Facility (CEBAF) operated for the U. S. Department of Energy (DOE) by the Southeastern Universities Research Association (SURA).

Dr. Warren W. Buck is Director of the MRCE and Interim Chairman for the Department of Physics. He sees the accelerator as an opportunity to augment important work in physics by the department and its faculty. More than eight years ago, Dr. Buck began his Hampton career teaching courses related to physics and began building a relationship of mutual support between administrators and researchers.

Hampton's faculty hold joint research positions at CEBAF and collaborate with many other universities. Close collaborations are maintained with Morehouse College, Virginia State University, Jackson State University, The College of William and Mary, Michigan State University, Yale University, University of Houston, North Carolina Agricultural and Technical State University, and Old Dominion University. Over the next two years, Hampton will be refurbishing and managing a 60-ton spectrometer that will be used in CEBAF experiments. Technicians and engineers will be required to maintain the spectrometer.

The CEBAF facility provides opportunities to conduct experimental and theoretical physics research. Experimental work is focused on developing new detectors and specialized measuring instruments. Hampton has been approved for experiments in hypernuclear physics and spectroscopy, which will get underway in the next two years. Theoretical work includes relativistic models of mesons and electromagnetic structure using quantum electrodynamics (QED) and quantum chromodynamics (QCD).

"We have African American students involved in world-class science through the MRCE," said Dr.

Buck. Of the 27 graduate students in the department, 30 percent are African American and 20 percent are women. In the undergraduate population, 100 percent of the students are African American. Through the physics department's collaboration with CEBAF, "we can introduce students to forefront type physics that traditionally has not involved a large percentage of the minority community," he said. "It is opening up research physics to minorities and the rest of the world, making highways to success that people can walk on."

Dr. Buck finds that his students are in great demand. The forecast for January 1993 is that all available students will be recruited for summer internships. In spring 1992, the Massachusetts Institute of Technology (MIT) approached NuHEP about a possible collaboration. Additionally, one Hampton-area university is prepared to provide full tuition for physics students, provided they teach upon completing their degree.

Like many of the other MRCE directors, Dr. Buck enjoys taking on pioneering projects. "There are always many problems when you are doing something new that people have not seen before." From his experience sailing the Atlantic for three years, he knows what it is like to go up against a hurricane "Other problems are small by comparison," he explains. Following his sailing epoch, he charted a new course for himself by teaching physics. "I wanted to build something that cannot be torn down very easily."

Dr. Buck publishes in the *Physics Review*, which is one of the top refereed journals in his field. He collaborates with colleagues at many other physics facilities and has earned the Outstanding Service Award from the User's Group of CEBAF. Among numerous awards, he received an Honorary Superior Accomplishment Award from the National Aeronautics and Space Administration NASA/ Langley Research Center for his significant contributions to the development of practical shield designs for countering radiation on human space flights.

As a new challenge, Dr. Buck is conveying to others a sense of mission. One area in which he is applying this philosophy is the outreach program. "What we want to do is expose students to physics and get them excited about the science," he said. He established the Undergraduate Institute in Physics (UnIPhy) summer program, with support from the U. S. Department of Energy to pay for student research at national laboratories. In addition to giving opportunities at laboratories, the program provides students from schools without physics courses the opportunity to spend a semester at Hampton to supplement their studies.

Dr. Buck would like to reach students from elementary school through graduate school. Recently, the Center hired an outreach liaison to develop a precollege component that initially will consist of elementary school activities. Also, the liaison will identify other science education efforts in the community. "For example, there are numerous programs for middle school students in the Hampton area. So we want to find out what they're doing, and to avoid competition. We want to make the community stronger," said Dr. Buck. "That's the idea. Because if we compete with each other, we're lost. So our goal is to try to work together and to work together continuously."

Howard University

Sophisticated aircraft avionics and jet turbine engine control electronics that operate at high temperatures are some of the applications for the electronic materials on the research agenda of Howard University's Materials Science Research Center of Excellence (MSRCE).

According to Dr. Michael Spencer, Director of the Center, only a few people in the nation are studying many of the materials now under analysis at the university. "In materials work, we are often trying to find out basic things about how to grow materials and what properties these materials have," said Dr. Spencer. Casting an eye toward how the research will be applied, the Center Director senses a bright future. "The applications of our work will be exploited maybe 5 or 10 years down the road," he said.

The Center has been able to fabricate new kinds of electronic materials for and create demonstration devices of material systems previously unavailable. Compound semiconductors made of gallium arsenide, straight-layer super lattices of indium arsenide, and gallium arsenic are among the materials being analyzed. To predict the performance of these materials, the Center uses computer simulation technology.

Dr. Spencer was a Minority Research Initiative (MRI) grant recipient in 1981 and a Presidential Young Investigator awardee in 1985. In 1987 he became the Director of the MSRCE. He is quick to point out that the MRI grant facilitated the strong research programs now under way. Following that

award, Spencer won a Research Improvement in Minority Institutions grant. "In some ways the MRCE was almost the next logical step," he said. "As you continue to grow in research, and your group begins to grow—and if you are an experimentalist—you have to begin to think about large funding. The Center-funding mode is really the only way to do it."

"One of the nicest things that can happen when you are trying to do research is to have stable funding for a given period of time," said Dr. Spencer. "The initial center-funding mode offers at least three years of funding and potentially five. With that kind of baseline stability, it becomes possible to do many things that are impossible without stable funding. One of the more attractive features of some of the NSF programs, like the Presidential Young Investigator program, is that it is a five-year funding program. It is an individual program and the levels of funding are nowhere near center levels but, nevertheless, the five years means that you can plan."

There are trade-offs, Dr. Spencer continued, with the move into large-scale funding. "The grant administration becomes more complicated. As you begin to do research with sophisticated equipment, the equipment then demands technician support as well as other administrative support, which are large dollar items. People are very costly. And with people you really don't want to be in the position of wondering where their money is going to come from every year," he said.

"If you are going into a research arena, you are changing direction from something else, in this case pure teaching," emphasized Dr. Spencer. The MSRCE's contribution to increasing minority participation in the sciences and engineering is a recognized benefit. The university clearly sees the value of maintaining the vitality of the Center, but there is always the fundamental problem of resource allocation. Any organization that is growing requires the allocation of more resources from the limited amount available at the university, Dr. Spencer stressed.

Between the RIMI grant and the MRCE grant, Howard University was able to purchase three "reactors," devices for furthering their materials research: a molecular beam epitaxial (MBE) reactor for gallium arsenide, a chemical vapor deposition (CVD) reactor for aluminum nitride, and a sublimation or bulk reactor for silicon carbonide. The CVD reactor was specifically designed for deposition of wideband gap silicon carbide. The MBE reactor was purchased under the previous RIMI grant for thin films, and the bulk reactor was acquired for bulk films. These were major devices directed at the wideband materials research. The MBE reactor has been used a great deal for putting down films at the atomic level. The atomic level is verified by these characterization techniques.

Dr. Spencer and his colleagues have worked hard to focus the research to ensure a synergy among projects. The Center is developing themes in its research work and in the work it does in collaboration with industry and other universities.

The Center has established a number of collaborations. The most important is a three-year research agreement with Digital Equipment Corporation (DEC) on integrated optical receivers that involves computer chip-to-chip communication. The collaboration was engineered by a former Howard student and has been helpful because it "allows you to get a real sense of what industry is focused on," said Dr. Spencer. In addition, DEC will donate, over the course of three years, $300,000 worth of equipment to the Center.

The Center also collaborated with the Naval Research Laboratory (NRL), growing films of gallium arsenide for NRL to characterize. Dr. Spencer reported that the research produced some unanticipated results. In the course of the work, researchers discovered a self-interstitial defect—a new kind of defect in semiconductor materials. The collaboration proved highly productive in terms of the number of research papers published.

"The most important thing our research provided is that it showed people what big research can look like at Howard. Once people could see our work in operation it was easy enough to duplicate the effort," said Dr. Spencer. Following the initial grant, the number of research applications in other departments at the university has increased.

The MSRCE was the first large research center that was not part of the medical school at Howard University. Dr. Spencer noted that the MSRCE grant helped provide the impetus for the university to establish the Office of Research Administration, which did not exist prior to the award.

Most recently, Howard University has developed close ties with the former Soviet Union. Through a cooperative exchange program, Howard University researchers and Russian scientists have collaborated on research involving wideband semiconductors.

The grant also pays stipends for 25 graduate student researchers. At Howard, the stipend pays for tuition plus about $800 per month. Graduate students receive training from laboratory technicians

in the use of the lab equipment necessary for the research. Each student has a faculty advisor to assist with thesis work. Undergraduates work on small projects in the laboratory for course credits.

The Center and the graduate students are highly visible in the community, receiving coverage in such magazines as *Ebony* and *Black Enterprise*.

The most impressive accomplishment of the Center, according to Dr. Spencer, was graduating ten students in science and engineering in the 1991-1992 academic year alone. Howard University conferred seven master's degrees and three doctoral degrees to MSRCE students—almost double the number in 1990-1991. "Some of these students have already chosen academic careers where they will be positively influencing others," said Dr. Spencer.

Meharry Medical College

National Science Foundation funding to establish the Minority Research Center of Excellence at Meharry Medical College in Nashville, Tennessee, has strengthened the institution's overall research structure. The funding has enabled the college to obtain significant research grants from other agencies, including the National Institutes of Health (NIH), Department of Defense, the Navy, and the Army, explained Dr. George C. Hill, Interim Dean, School of Graduate Studies and Research, as well as Program Director of the MRCE program.

According to Dr. Hill, the MRCE grant has accomplished two things. It has fostered interdisciplinary research, bringing together professors from various departments to communicate and carry out joint research. Meharry uses the MRCE funding to offer seed grants of $8,000 to $10,000, giving the faculty a chance to work together using limited funds. If the idea turns out to be a fertile area for research, they can then apply for a larger grant. Last year, ten applications for grants were submitted to government agencies from individuals who had received seed grants, and seven were funded. "Department collaborations are being fostered and the work is across disciplines," said Dr. Hill. "That's the exciting direction things are going."

Another benefit of the grant that never ceases to amaze Dr. Hill is how the funding attracts students to the program. "That's the exciting part," said Dr. Hill. Students from Historically Black Colleges work in the laboratories with stipends from the MRCE grant.

NSF has supported Meharry through a number of RIMI grants as well as the MRCE grant since Dr. Hill's arrival at Meharry in 1983. Within his first two years at Meharry, he was awarded a RIMI grant to perform the technology research applied to African trypanosomes. His research was directed toward applying the technology to the molecular biology of parasites, a subject that resulted in the publication of two technical papers authored by Dr Hill and his colleagues. As part of his NSF-funded work, Dr. Hill and his colleagues initiated a course on recombinant DNA technology designed for graduate students and faculty.

Following the award of Dr. Hill's grant, other departments at Meharry that offer graduate programs have been successful in obtaining a total of seven additional RIMI grants.

NSF support has permitted the Center to purchase three critical pieces of equipment: an oligonucleotide synthesizer, a peptide synthesizer, and a protein sequencer. This equipment is in an institutional Molecular Biology Core Facility but is available to all faculty, and it allows Meharry researchers to synthesize nucleotide sequences or sequence segments of DNA or protein. Students use the core facility for their research. The Center has 22 faculty members from different departments, the qualifying criteria being an expressed interest in membrane biology. In addition to the five graduate departments—Biomedical Sciences, Microbiology, Pharmacology, Physiology, and Biochemistry—professors at the Center also represent pediatrics and anatomy.

"The Center's interests are quite broad, with a focus on membrane biology, including cloning genes for membrane proteins, biochemical work looking at the structure of membranes and receptors, and the role of biological membranes in regulating cell function," said Dr. Hill. "One of our researchers, a physical biochemist, is studying synthetic membranes and looking in detail at how they function," he said. Dr. Hill is looking at the function of lipid bilayers and examining their biophysical properties.

The equipment Meharry has been able to purchase with MRCE funds is a valuable teaching tool for inquiring students, and it is particularly useful for students in Meharry's strong graduate training program. Currently, 60 students are in the graduate program which include M.D./Ph.D. and D.D.S./Ph.D programs. The MRCE grant supports five research stipends. Meharry's summer recombinant DNA technology course cost the Center

$6,000 and is one of the best training courses anywhere, according to Dr. Hill. "Over the summer months, faculty and students carry out projects involving the cloning and sequencing of genes. Students come to this institution for such training from majority institutions like Vanderbilt. That's the reverse of standard thinking," he proudly emphasized.

"The students make it all worthwhile," said Dr. Hill. "We measure our success in terms of the number of students that enter science careers," he said. In 1992, Meharry graduated eight students with biomedical sciences doctoral degrees, including five minority students. As Dean, Dr. Hill had the pleasure of handing some of his former students their diplomas. "That was so exciting," he said. "Working with students and motivating them is the raison d'etre."

Dr. Hill's interest in students extends to reaching out to them before they enter college. Earlier is better for motivating students, as far as he is concerned. "High school is really too late," he said. Dr. Hill and his staff enjoy interacting with students and visiting local schools, making good use of a specially prepared video by the MRCE on science careers. Participating faculty in the outreach effort also visit magnet high schools. Over the summer months, students from both high school and middle school work with faculty in the Center's laboratory. "Our outreach program has been evaluated as excellent and Mr. Fred Hamilton, Associate Project Director, is responsible for that," added Dr. Hill.

Opportunities for students after graduation are provided through collaborations with other universities and industry. One of those collaborations is with the Merck Foundation, a pharmaceutical company with strong ties to international health. Meharry has been receiving support from Merck for the last five years. In addition, students work at Merck during the summer. The relationship between Merck and Meharry has been of benefit to several students in furthering their involvement in innovative research, as well as providing them with important contacts and possible employment opportunities. In addition, the Historically Black Research Universities Foundation recently chose to support Meharry from among seven other Historically Black Research institutions.

As one of NSF's first two MRCEs to be established, Meharry Medical College stands as a model program in attracting students into science, engineering, and mathematics careers.

University of Puerto Rico at Mayaguez

The University of Puerto Rico (UPR) at Mayaguez has developed six components in its Center for Tropical Caribbean Research. The first is an outreach program. The other five are the study of tropical forests, natural hazards, natural products, terrestrial ecology, and the geology of the Caribbean.

"Our students are awakening," said Dr. Juan G. Gonzales, co-director of the university's Minority Research Center of Excellence (MRCE) program and Associate Dean of Academic Affairs. "We're getting students from the undergraduate programs involved in research. Our top students in science and engineering work with professors over the summer. That gives these students the incentive to develop themselves in a particular discipline—be it engineering, science or something else—and continue on to graduate school. We want to send more students into their professions with a Ph.D. degree. We're trying to stop leaks in the pipeline.

"A lot of major universities in the States are taking advantage of our good students. More and more of our high school students are being recruited by mainland universities. We like that. It shows that through our programs—summer camps, teacher training, student training, lectures—more students are well prepared to go to many universities. Yes, sometimes the mainland schools take our best students, but that's good. It is the contribution we make to the nation. We can't be egotistical.

"At the same time, our best professionals are being recruited by U.S. agencies. If you go to NASA, you'll find at least 250 of our engineers working there. Sometimes we call that a brain drain, but still, it means that we are training our students well. It means the support that we're getting from NSF is having a major positive impact on our population.

"The MRCE grant has done very good things for our students," said Dr. Gonzales. "Their research has become very professional." Students have been working with professors on the mitigation of natural disasters. They simulate natural disasters, such as hurricanes, and study ways to improve construction methods in disaster-prone regions. Their recommendations have been submitted to the island government for possible inclusion in building codes.

UPR has been working to raise the level of faculty research as well. About 12 years ago, the university reached a crossroads that led to more research. Since then, university chancellors have more aggressively championed science, mathematics, and engineering research. Before the MRCE project, UPR won

funding for NSF's Experimental Project to Stimulate Competitive Research (EPSCoR) program. UPR previously had received a grant in 1980 for the National Science Foundation's Resource Center for Science and Engineering (RCSE) at the San Juan campus; a branch of that program was established at Mayaguez.

"We're getting to the point where we can develop something bigger with a wider spectrum of action," said Dr. Gonzales. For example, many students are researching the development of natural products from marine algae and other marine organisms found in mangrove and coral reef systems. As a result of the natural products program, "a group of scientists are working together to develop research to examine problems in biotechnology," he said. "This is a good example of how a program looking into products obtained from the ocean now turns into a more sophisticated type of activity, in this case biotechnology."

"Our NSF-funded projects have encouraged interdisciplinary activity in engineering, science, mathematics," said Dr. Gonzales. "We're getting faculty from both San Juan and Mayaguez to work together. That creates a wider spectrum of thinking. We need chemists and engineers to help understand computer models, traditional biologists who work with different types of animals, and modern biologists who work with DNA and genetic engineering," he said. "It's a very interesting interaction of different disciplines."

UPR's increased focus on research has improved the quality of teaching as well. "The research adds a certain quality to classes," said Dr. Gonzales. "When teachers teach from their own information, rather than just lecturing from a textbook, they have more effervescence."

As with most of the staff, Dr. Gonzales adds teaching to his other duties as Assistant Director of the MRCE. He is also in charge of outreach. "I try to get involved with high school teachers and kids as part of the precollege component of our program. We want to get to the high schools, and even the elementary schools, to help students prepare better for college," he said.

UPR runs 7th- through 10th-grade summer camps with intensive mathematics, physics, chemistry, biology, English, and Spanish classes. "The idea is to give good students the tools to continue in research programs, be it here or in the U.S.," said Dr. Gonzales.

UPR's reputation is attracting an increasing number of applications from locations as diverse as Canada, Spain, South America, and Japan. Puerto Rico is a small island about 100 by 35 miles wide. What differentiates UPR's marine science program in the Center from mainland programs is Puerto Rico's tropical location. Mayaguez has the only Ph.D. program in marine sciences in Puerto Rico.

Puerto Rico also boasts one of the major tropical forests in the world, Yeunque Forest, in the eastern part of the island. Students in the Center's terrestrial ecology program use Yeunque as a hands-on research laboratory.

A few years ago, "we encountered a situation that turned out to be a pleasant surprise for our terrestrial ecology students," said Dr. Gonzales. The Center had a team of people studying many aspects of the forest from its natural development to its ability to recover from damage. "The pleasant and unpleasant event was Hurricane Hugo. Everything we wanted to do in the laboratory happened naturally. We didn't have to simulate a disaster because the hurricane destroyed much of the area. So now we're looking at how a forest recovers after a storm like Hugo. We simply took advantage of something that was unanticipated. We hadn't had a major hurricane in Puerto Rico for the last 60 years. This one provided a very good laboratory experience." Students measure how the amount of light on the Yeunque Forest floor changes over time. Now, as the forest grows back, there is more shade on the canopy organisms.

As a result of MRCE/NSF funding, UPR has intensified its relationships with both community and industry. UPR's Industrial Advisory Committee is one example. Puerto Rican industries concentrate more on manufacturing than on research and development. In the collaboration, the university borrows some of industry's highly trained personnel to teach, and in return, provides advisory assistance. According to Dr. Gonzales, the collaboration works because rather than asking industry for donations, the university participates in a true give-and-take relationship.

One example of the working relationship between industry and UPR involved complaints about industry releasing gases into the air. UPR scientists found traps in the gas pipelines that allowed gas to build up until it leaked into the atmosphere. Industrial engineers then found a way to address the problem.

"Because NSF funding has allowed us to improve ourselves as a university, we've become a partner in Puerto Rico's future," Dr. Gonzales said.

University of Texas at El Paso

In our high-tech world, materials science research plays a crucial role in keeping American industries competitive and on the cutting edge as the nation moves toward the 21st century. From automotive manufacturing to producing microelectronics, materials science research can strengthen products, improve their resistance to wear and tear, and further boost a product's capabilities.

The National Science Foundation-funded Materials Research Center of Excellence at the University of Texas at El Paso (UTEP) is developing a competitive, state-of-the-art research center in materials science. UTEP is having a profound effect on increasing the number of minorities and women choosing careers in materials science.

For a glimpse of what the demographics of universities in the Southwest may look like in the year 2000, talk to Dr. Rey Elizondo, UTEP's Dean of the College of Science. UTEP is the largest majority (60 percent) Hispanic university in the United States. When Dr. Elizondo first joined the faculty, he saw the potential to develop a model program for bringing minorities into mainstream academics.

Through NSF's support, the Center provides research stipends to many students. That makes a tremendous difference in a university where 65 percent of the students must work to pay for their education. "Rather than working in fast food restaurants to earn money, they can work at the Materials Research Center and learn at the same time," said Dr. Elizondo. Students are matched with faculty mentors based on mutual research interests and work 20 hours a week in the laboratory.

The accomplishments of the project are reflected in the quality and quantity of research by both students and faculty. In 1991, project faculty received 36 grants, published 93 research papers, made 93 presentations, and applied for one patent. This year, the project's researchers have applied for three additional patents. Forty-eight students participated in research, comprising thirty-six undergraduates, eleven graduates, and one postdoctoral student. Students were invited to make 26 presentations of their research at national meetings. At one meeting, a UTEP student was the only undergraduate to receive an award among sixty participants. Of benefit to faculty scientists, students coauthored 14 research papers with their colleagues. "People are constantly surprised that our undergraduates' research is of such high quality as to be accepted in refereed publications," said Dr. Elizondo.

It has been well documented that enrollments in science and engineering have been declining nationwide. But at UTEP, while overall enrollment at the university has increased 3 percent, science and engineering enrollment has increased by 6 percent. Dr. Elizondo attributes this increase to UTEP's summer science and engineering outreach programs with local public schools.

During the summer months, UTEP offers students in grades 7-11 a hands-on science and engineering learning experience. Students attending the Summer Science Institute are invited to solve problems in biology, chemistry, geology, math, and physics, while the Summer Engineering Institute introduces students to careers in engineering. In addition, the Summer Institute for Teachers helps math and science teachers develop innovative teaching materials. Throughout the school year, a special Weekend Program introduces junior high students to engineering and science through laboratory tours and demonstrations.

These outreach programs are a significant component of the project. Over 800 students participated in these activities in the summer of 1991. The results of these efforts have already begun to show. "We now have bachelor's students that were participants in the summer science and engineering institutes," according to Dr. Elizondo.

Dr. Elizondo believes the project serves as a useful model for successfully reaching minority students and developing their interest in science, engineering, and mathematics careers.

Perhaps the greatest achievement is UTEP's recent proposal to the state of Texas to offer a Ph.D. degree in materials science. Reaction from state officials in June 1992 was supportive, explains Dr. Elizondo. He is optimistic that UTEP will be recognized for doing Ph.D.-level research in materials science. "That could never have happened without NSF," says Dr. Elizondo.

NSF funds also supported Research Improvement in Minority Institutions (RIMI) projects that helped UTEP acquire an electron microprobe and a transmission scanning electron microscope. "These were essential if we were going to succeed as a state-of-the-art research center," said Dr. Elizondo. With NSF's funding, the university is developing a materials science focus, thereby attracting additional faculty following an investment in tenure-track positions in materials science research. In addition, the university has successfully matched NSF grant money to buy needed equipment.

Dr. Elizondo has been pleasantly surprised by "the willingness of the faculty and staff at all levels and in all departments of science and engineering—chemistry, physics, metallurgical and materials engineering—to work together to put forth a multidisciplinary Ph.D. proposal in materials science." The departments now meet once a month to discuss information, exchange ideas, and share problems and solutions.

UTEP has been successful in leveraging its NSF funding to generate support from other academic institutions, national laboratories, and industry.

UTEP has formed partnerships with five local industries that provide research funding for Center activities. For example, researchers are working with a small electronics company on thin television screen surfaces for a new type of television screen.

Another research team in the materials science laboratory successfully completed a technology transfer project with Imaging Science Technologies, Inc., of Charlottesville, Virginia. Partially funded under the Federal Small Business Innovative Research (SBIR) program, research in the MRCE laboratory led to new developments in photodichroism (the interaction of a substance with polarized light) that resulted in industrial production of long-wavelength infrared detection and imaging systems.

The Center's program to invite guest lecturers to campus recently led to the establishment of student internships. As a result of a visit from the director of materials science at IBM in New York, two project students will participate in research at this world-renowned facility this summer.

One type of partnership that Dr. Elizondo recommends other MRCEs might consider is collaboration with another NSF Science and Technology (S&T) Center. For example, at the invitation of the University of Texas at Austin (UTA), UTEP and its S&T Center worked out a strong partnership in which UTEP and UTA not only exchange students but also fund student research at both universities.

UTEP's partnerships with national laboratories also involve equal investments on both sides. Sandia Laboratory, for instance, has offered equipment on its inventory list that is not actively in use for permanent loan to UTEP faculty. The result of this partnership over the past two years has enabled UTEP to receive approximately $500,000 worth of equipment.

While Sandia hopes to employ some of the outstanding minority scientists graduating from UTEP's program, it also committed staff and resources beforehand. "Sandia has gone out of their way to think of ways to help our Center," said Dr. Elizondo.

Dr. Elizondo points out that many industrial and academic organizations have expressed an interest in collaborating with the Center because of its large number of minority science majors. However, he considers an ongoing relationship and a financial commitment to be necessary components of a real partnership.

Using the Center's state-of-the-art equipment, UTEP scientists are recognized at the national level. UTEP is one of only seven universities with an advanced electron microprobe. Its surface characterization laboratory uses electron spectroscopy in physics research. The materials analysis laboratory uses a state-of-the-art x-ray unit to determine the crystal structure of organic compounds, metals, semiconductors, and ceramics.

One research project that received considerable publicity is a contract with the Bank of Belgium for developing a new technology to prevent counterfeiting. The research focuses on the use of special materials to print currency and legal documents that would go blank if counterfeiters tried to duplicate them.

In chemistry, a multidisciplinary team is studying how altering the molecular structure of a compound might create new materials for aerospace engineering and biotechnology. Another team is exploring ways of slowing down or eliminating corrosion in metals. One application of this knowledge might be the reduction of wear in surgical implants. Another group of researchers is studying silicon transition metal materials. The results of this work may have implications for the electronics industry.

UTEP's Materials Research Center of Excellence has opened up research avenues that will help assure the competitiveness of the nation in the world market. UTEP also has proven to be an incubator for strengthening the ability of talented minority students to actively participate in the national research arena.

Appendix A – List of EHR Minority-Targeted Projects by Program

Comprehensive Regional Centers for Minorities (CRCM)

Participating Institutions and Program Directors

Dr. Jewell P. Cobb
Access Center
703 Administration Building
California State University
5151 State University Drive
Los Angeles, CA 90032

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Maricopa County Community College
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MSE Center, Room 604
2220 Victory Parkway
Cincinnati, OH 45206

Ms. Melva Ware/Dr. Harvest Collier
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8001 Natural Bridge Road
St. Louis, MO 63121

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308 Culbertson Hall
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Post Office Box 128
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University of Puerto Rico
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Alliances for Minority Participation (AMP)

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Birmingham, AL 35294

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Arizona State University
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Dr. Carl Erdman
Engineering Program Office
301 WERC Building
University of Texas Engineering Experimental Station
College Station, TX 77843-3126

Research Careers for Minority Scholars (RCMS)

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Appendix B - List of Other NSF Publications of Interest

Other NSF Publications of Interest

NSF Guide to Programs, available from the NSF Forms and Publications Unit, briefly describes Foundation activities. The following brochures, available from the NSF Forms and Publications Unit, describe Foundation-wide programs:

- NSF Minority Graduate Fellowships - Intended for ethnic minority groups, i.e. American Indians, Blacks, Hispanic, Native Alaskan (Eskimo or Aleut), or Native Pacific Islander (Polynesian or Micronesian). Program requirements are similar but not identical to those for the NSF Graduate Fellowship Program. Contact Fellowship Office at NRC on (202) 334-2872, and ask for Brochure NSF 90-62.
- Research in Undergraduate Institutions (RUI) provides support for faculty research at predominantly undergraduate institutions. Contact the relevant program office or the RUI Coordinator, Room 1225, NSF, phone (202) 357-7456. (NSF Publication 89-60)
- Research Opportunity Awards (ROA) allows science and engineering faculty in predominantly undergraduate institutions to participate in NSF-supported research at research institutions. Contact relevant program office or the ROA Coordinator, Room 1225, NSF, phone (202) 357-7456.
- NSF Faculty Awards for Women Scientists and Engineers (FAW) recognizes outstanding women faculty. Nominations are made by their institutions for faculty women who are not yet full professors. Contact the relevant NSF program office or the FAW Coordinator, phone (202) 357-7456. (NSF Publication 90-42)
- Visiting Professorships for Women (VPW) provides support for experienced women scientists or engineers to undertake advanced research and teaching at a host institution. Contact VPW Program Director, Room 1225, NSF, phone (202) 357-7734. (NSF Publication 89-37)
- Research Planning Grants (RPG) provide opportunities for women scientists and engineers who have not had prior independent Federal research support to develop competitive research proposals. Contact the relevant program office or the Coordinator for Women's Programs, Room 1225, NSF, phone (202) 357-7456. (NSF Publication 90-121)
- Career Advancement Awards (CAA) provide opportunities for women scientists and engineers to expand research capability and productivity. Contact the relevant program office or the Coordinator for Women's Programs, NSF, phone (202) 357-7456. (NSF Publication 90-121)
- Undergraduate Faculty Enhancement (UFE) offers opportunities for groups of faculty who teach undergraduates to learn about new techniques and developments in their fields. Contact UFE, Room 639, NSF, phone (202) 357-7051. (NSF Publication 90-112)
- Research Experiences for Undergraduates (REU) provides opportunities for undergraduate students to participate in research or related activities. Contact the relevant NSF disciplinary program office. (NSF Publication 90-79)
- Instrumentation and Laboratory Improvement (ILI) Program provides matching grants for the purchase of undergraduate instructional apparatus. Contact ILI, Room 639, NSF, phone (202) 357-7051. (NSF Publication 90-101)

Ordering by Electronic Mail

If you are a user of electronic mail and have access to either BITNET or Internet, you may prefer to order publications electronically. BITNET users should address requests to pubs@NSF. Internet users should send requests to pubs@nsf.gov. In your request, include the NSF publication number and title, number of copies, your name, and a complete mailing address. Publications will be mailed within two days of receipt of request.

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- Press releases
- NSF organization charts and phone books
- NSF vacancy announcements
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On-Line STIS. If you have a VT100 emulator and an Internet connection or a modem, you can log on to the on-line system. The on-line system features full-text search and retrieval software to help you locate the documents and award abstracts that are of interest to you. Once you locate a document, you can browse through it on-line or download it using the Kermit protocol or request that it be mailed to you.

Direct E-Mail. You can request that STIS E-mail you a weekly summary of all the new documents on STIS. You can also sign up to get the full text of all documents added to STIS.

WAIS. If your campus has access to the Wide Area Information Servers, you can use your local WAIS client to search and download NSF publications.

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Topic: index

You will receive a list of all the documents on STIS and instructions for retrieving them. Please note that all requests for electronic documents should be sent to **stisserv**, as shown above. Requests for *printed* publications should be sent to *pubs@nsf.gov* (Internet) or *pubs@NSF* (BITNET).

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Getting Started with the On-Line System

If you are on the Internet: *telnet stis.nsf.gov*. If you cannot connect, try *telnet 128.150.195.40*. At the login prompt, enter *public*.

If you are dialing in with a modem: Choose 1200, 2400, or 9600 baud, 7-E-1. Dial 202-357-0359 or 202-357-0360. When connected, press Enter. At the login prompt, enter *public*.

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Topic: stisdirm

You will receive instructions for this service.

Getting Started with WAIS

The NSF WAIS server is stis.nsf.gov (128.150.195.40). You can get the ".src" file from the "Directory of Servers" at quake.think.com.

For More Information

For additional assistance contact:

E-mail: *stis-request@nsf.gov* (Internet)
stis-req@NSF (BITNET)
Phone: 202-357-7555 (voice mail)
TDD: 202-357-7492

NSF 91-10 Revised 3/30/92

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