Enhancing Minority Participation in Horticultural Biotechnology Research—Tuskegee Univ. Experience

corporate sectors, is a multibillion dollar activity that is expected to grow stronger while adding hundreds of thousands of high-paying jobs to the U.S. economy. The agricultural sector, especially horticulture, constitutes a significant part of the biotechnology industry. The high economic importance of fruits, vegetables, ornamental plants, and cut flowers will ensure that horticultural biotechnology will continue to attract substantial investment in basic research and product development.

Clearly, continued success of the biotechnology industry depends on the availability of a trained pool of scientists and technicians, and a well-informed public. In addition to specialists in molecular biology, biochemistry, and tissue culture, there is an increasing need for biotechnology experts with diverse backgrounds: patent attorneys, public relations specialists, journalists, administrators, extension workers, ethicists, socioeconomic analysts, agribusiness managers, ecologists, and educators. The new workforce require-

ments will challenge our educational systems to restructure and be responsive to the changing demands.

Tuskegee Univ. (TU) is a private, yet state-related, land-grant institution and was founded in 1881 by Booker T. Washington, a visionary educator. TU has been foremost among institutions of higher learning in training African-American professionals in such areas as agriculture, forestry, veterinary medicine, and aerospace engineering. The university has a rich tradition of research and extension in horticulture. The legendary scientist, Dr. George Washington Carver, who worked at TU for 48 years until his death in 1943, developed more than 400 products of sweetpotato (*Ipomoea batatas* L. Lam.) and peanut (*Arachis hypogaea* L.). The Center for Plant Biotechnology Research at TU is located in historic Milbank Hall, which once housed Dr. Carver's laboratory. The primary mission of this center is to employ molecular and cellular genetic approaches to investigate and manipulate the genome of

The population structure in the United States has been undergoing a dynamic change over the past few decades. Ethnic minorities now constitute an increasing part of the population. Yet, the proportion of African-Americans, Hispanics, and Native Americans in scientific professions has not increased significantly, nor does it mirror the diversity in the population. Many colleges and employers cognizant of this inequity are making concerted efforts to redress this imbalance by recruiting more minorities and women. Social, economic, and moral reasons warrant a change toward greater inclusiveness and pluralism in education and hiring. Future horticultural scientists, practitioners, and educators will be drawn increasingly from the ethnic minority segments of the U.S. society. Land-grant universities have a major responsibility in recruiting, retaining, and training more minority students in horticultural and allied sciences than in the past.

Biotechnology, is already a dominant part of the research in life sciences in academic and

Received for publication 19 Sept. 1995. Accepted for publication 19 Oct. 1995. I thank several of my colleagues for editing the manuscript. Contribution no. 258 from the George Washington Carver Agricultural Experiment Station. Research was supported by grants from the U.S. Agency for International Development, U.S. Dept. of Agriculture, National Aeronautics and Space Administration, and National Science Foundation. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

¹Associate Professor.

Front cover (clockwise from top): Jacquelyn Jackson, an undergraduate student, will use various promoters to develop transgenic sweetpotato plants to study gene expression. Martis Watts, graduate student, is investigating the genetic diversity of peanut germplasm using DNA amplification fingerprinting. Scientists and students of the Center for Plant Biotechnology Research at Tuskegee Univ.

Fig. 1. John Rasheed Bennett, an undergraduate student, conducts research on developing an enhanced somatic embryogenesis system for sweetpotato.

crops to enhance their productivity. The focus is mainly on the improvement of sweetpotato, but research on peanut and cowpea (*Vigna unguiculata* L. Walp.) is also well underway. The National Aeronautics and Space Administration (NASA) has chosen sweetpotato and peanut as two of the eight crops to be grown in long-term space missions and is supporting research on these crops at TU. The biotechnology center at TU was among the first to develop transgenic sweetpotato plants, employ particle bombardment to deliver genes into this crop, and identify polymorphic DNA markers to study genetic diversity in sweetpotato and peanut. Plans are now underway for field-testing transgenic sweetpotato in 1996. The ongoing projects employ many novel techniques in gene cloning, vector construction, and DNA marker identification using innovative approaches, such as differential display polymerase chain reaction (PCR) and amplified fragment length polymorphism (AFLP). Research is aimed at the development of transgenic sweetpotato plants with resistance to disease, improved protein quality, herbicide tolerance, and the production of novel biopolymers and oral vaccines. In cowpea and peanut, the focus is on using DNA markers to analyze genomes and on genetic diversity studies on germplasm.

Currently, there are four postdoctoral and two visiting scientists, and seven graduate and five undergraduate students working in the center. In addition, during the summer, students from local high schools have the opportunity to work as research interns. College students work along with a senior scientist who serves as their mentor, and eventually students undertake independent research projects or work in teams. Students clearly perceive that their mentors have high expectations about their performance. For instance, John Rasheed Bennett, an undergraduate, is investigating somatic embryogenesis in sweetpotato and is testing a novel "cycling" approach to produce embryos rapidly and in higher frequencies (Fig. 1). Eventually, he hopes to study gene expression during somatic embryogenesis. Jacquelyn Jackson, another undergraduate student, is fusing various plant promoters to the jellyfish green-fluorescent protein coding sequence, and studying the tissue specificity of gene expression in sweetpotato. An attempt is made in the center

Historically Black Colleges and Universities

Historically black colleges and universities (HBCUs) are a group of 103 institutions that have traditionally catered to the higher educational needs of African-Americans. Among these, 17 institutions have a land-grant charter under the second Morrill Act of 1890. These are called 1890 institutions, and along with Tuskegee Univ., they have received the formula funding for food and agriculture research and extension from the USDA since 1977. Despite meager resources, HBCUs have played a significant role in educating African-Americans in the United States and have performed a remarkable job of training a disadvantaged section of the population. HBCUs constitute 12.7% of all institutions conducting research and development, but they received only $\approx 1\%$ of total federal funds awarded to academic research and development (Mixon et al., 1995). Yet, HBCUs have educated almost 40% of this country's African-American graduates. In 1991, nearly 60% of the African-American agricultural graduates were from HBCUs (National Science Foundation, 1994). Nearly 75% of all African-American PhD graduates and 85% of African-American physicians were educated at the undergraduate level at HBCUs. This notable achievement is striking considering that HBCUs enroll only 17% of African-American students nationwide. Part of the reason for the success of HBCUs in this effort is an environment that nurtures self-confidence, strong support and understanding by the faculty, and low student-faculty ratios (Allen, 1992; Murty and Roebuck, 1992).

to promote intellectual interaction and scientific thinking through weekly laboratory meetings, journal club presentations, and periodic reports. While TU does not yet have a PhD program, all graduate students who have completed their MS thesis research in our center have gone on to PhD programs, published their research findings in refereed journals, and presented papers at national meetings.

It is perhaps trite to say that it is critical to attract bright young people to science. We have consistently provided opportunities for minority undergraduates and high school students to pursue biotechnology research. Undergraduates also are encouraged to spend their summer at other institutions to broaden their horizons. Students from our center have interned at many elite institutions, such as Cold Spring Harbor Laboratory, Cornell Univ., Michigan State Univ., and the Univ. of California, Berkeley. Students bring back new knowledge and expertise from such internships. Students also are encouraged to become involved in dialogues on critical issues related to the application of science in society. Three of our undergraduate students (John Bennett, Jacquelyn Jackson, and Irvin Moody) have participated in meetings on science, technology, and society at Johns Hopkins and Stanford universities. These meetings were conducted by Student Pugwash, a national organization based in Washington, D.C.

Minority high school students are offered internships in the center during the summer to experience the excitement of biotechnology research. The implicit goal of this initiative is to lead students to consider a scientific career. Leela Rabon, science teacher at the local

Booker T. Washington High School (BTWHS) has spent one summer in our center learning molecular biology techniques and now uses many of these techniques in her classes. Her students routinely call on our scientists and students for assistance with their competitive science projects. I occasionally deliver guest lectures on biotechnology at BTWHS. Emmitt Jolly of BTWHS, who worked here during Summer 1991 and 1992 comparing DNA profiles of space-exposed and earth-based tomatoes, is now an undergraduate student majoring in biology at TU. During Summer 1994, Jolly interned at Univ. of California, San Francisco, and developed a paper based on his research in cancer genetics, which has been

published in the journal *Science*. Natalie Knight, currently a senior at BTWHS, compared various novel gel matrices for resolving PCR-amplified DNA, and her paper describing this research has been published in *Molecular Biotechnology*. Michael Thurman, a senior at Montgomery Catholic High School, is comparing various mutants of green-fluorescent protein as a candidate marker for noninvasive detection of in vivo gene expression in sweetpotato.

The laboratory training in biotechnology at TU for our undergraduate and graduate students is supplemented by two courses in molecular biology, one that I teach and one taught by Dr. Jiliang Chiu in the Biology Dept. Emphasis is placed on participatory and interactive learning through "hands-on" exercises, critical thinking, enhanced communication, group discussion, and decision making on critical issues related to biotechnology. All students enrolled in these courses are required to develop a research proposal in agricultural biotechnology and present it to the class as a seminar. The use of video programs, computer software, and satellite-downlink further enhances learning among students. The U.S. Dept. of Agriculture (USDA) has recently awarded me a grant to develop a multimedia center that will adopt innovative instructional technologies in teaching biotechnology and related subjects.

Since agricultural biotechnology has great relevance to developing countries, we have provided experiential training in genetic engineering for scientists and students from Ghana, Kenya, Swaziland, Tanzania, Zaire, Dominican Republic, India, and China. Soon scien-

Fig. 2. Number of BS (shaded bars) and MS (dark bars) degrees awarded in agriculture to African-Americans in the United States between 1977 and 1991. [Source: National Science Foundation (1994)]

Fig. 3. Number of PhD degrees awarded in agriculture (shaded bars) along with those awarded to African-Americans (dark bars) in the United States between 1983 and 1993. [Source: National Science Foundation (1994)]

tists from Nepal, Nigeria, and Brazil will join us.

Because of the small size of our institution (3500 students), we have actively sought scientists from other institutions to visit, present seminars, and interact with our scientists and students. Many notable plant molecular biologists, including Roger Beachy, George Bruening, Peter Day, Peter Greshoff, Kenneth Keegstra, and Virginia Walbot, have enriched us with their visits. Such visits, while showcasing scientific excellence to our students, also promote networking, which is critical to advancement in a scientific career. During 1991, we hosted a workshop funded by the National Science Foundation to promote research in plant molecular biology among faculty and students from historically black col-

leges and universities. A similar workshop on transgenic plants was conducted in Apr. 1996. It attracted more than 400 participants, including nearly 100 minority students. We also have been a downlink site for several video conferences in biotechnology. We collaborate with scientists from other institutions—Auburn Univ.; Louisiana State Univ.; Scripps Research Inst.; Boyce Thompson Inst. for Plant Research; Univ. of California, Davis; and USDA—Agricultural Research Service. We also interact or collaborate with corporate researchers from Abbott Laboratories, American Cyanamid, Demeter Biotechnologies, the Monsanto Co. and Pioneer Hi-Bred International. Increasing support from the corporate sector for training students in biotechnology is

critical to ensure a supply of trained personnel to the industry. Corporate scientists can enhance minority participation in biotechnology research by acting as mentors to students from local schools and colleges.

African-Americans and other minorities are woefully under-represented among the pool of degree holders in science, including agriculture (National Science Foundation, 1993) (Figs. 2 and 3). Although African-Americans constitute 13% of the U.S. population, in 1993 they represented only 3.2% of doctorates in all subjects and 1.1% of doctorates in agriculture (National Science Foundation, 1993, 1994) (Fig. 3). Alarming, the number of doctorates awarded to African-Americans is in decline, and this has strong ramifications in our ability to provide role models for younger generations. Minorities are an underdeveloped resource, and the agricultural schools clearly have a responsibility to increase their efforts in recruitment and training of minorities. Initiatives also are needed to promote counseling, guidance, and mentoring of minority students in horticulture. Recruitment efforts should extend to areas such as the inner cities and the rural south, where minorities predominate, and highlight the diversity of opportunities in a horticultural career. Mentoring is an informal system, but one that is crucial to career development in science (Wyche and Frierson, 1990). Institutions should actively promote protege-mentor relationships involving minority students. It may be useful to initiate a system of reward and recognition for those faculty who have successfully mentored minority students. It is incumbent on all of us to provide an environment that motivates and nurtures these students to ensure their professional development and to enable them to realize their potential.

Literature Cited

- Allen, W.R. 1992. The color of success: African-American college student outcomes at predominantly white and historically black public colleges and universities. *Harvard Educational Rev.* Spring 1992:26-44.
- Mixon, G.A., J.Q. Adams, T. Broome, B. Curry, B. Peters, K. Tollett, and H.D. Irvin. 1995. The historically black colleges and universities: A future in the balance. *Academe* Jan.-Feb. 1995:49-58.
- Murty, K.S. and J.R. Roebuck. 1992. The case for historically black colleges and universities. *J. Social Behavioral Sci.* 36:171-192.
- National Science Foundation. 1993. Selected data on science and engineering doctorate awards: 1993. NSF, 94-318. National Science Foundation, Arlington, Va.
- National Science Foundation. 1994. Science and engineering degrees, by race/ethnicity of recipients: 1977-91. NSF, 94-306. National Science Foundation, Arlington, Va.
- Wyche, J.H. and J.H.T. Frierson. 1990. Minorities at majority institutions. *Science* 249:989-991.

C.S. PRAKASH
Center for Plant Biotechnology Research
School of Agriculture and Home Economics
Tuskegee Univ.
Tuskegee, AL 36088-1641