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"Partnerships, Progress, and Planning in the Educational Enterprise"

By

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To

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Good evening, ladies and gentlemen. I am delighted to join you this evening for this 6th National Conference of the Council on Undergraduate Research, and I am honored that you have invited me to give you my perspective on issues associated with your conference topic, "The Undergraduate Research Triangle, Academics, Industry, Government--Enriching Science through Partnership."

Actually, I have more than one perspective on partnerships in education to share with you this evening. As you may know, I was educated at one of the leading institutions in research (including partnered research), the Massachusetts Institute of Technology, where I earned both my Bachelor's Degree and my Ph.D, both in Physics. I have pursued my interest in Physics in a number of research positions in the private sector, including AT&T Bell Laboratories, where I initially became directly involved in the State of New Jersey's efforts to develop university industry government partnerships; as a founding member of New Jersey Commission on Science and Technology - created by Governor Thomas Kean in 1985.

Last year, in the space of a few weeks, I went from being a Professor of Physics at Rutgers University, to a member of the

U.S. Nuclear Regulatory Commission in May 1995, to Chairman of the NRC last July. My rapid transition from the laboratory and the campus, to developing policy guidance and providing management direction for one of the government's major science and technology-based regulatory bodies has provided me (1) an unusual vantage point for assessing the value and promise of the scientific enterprise, and (2) experience in all three legs of the research triangle - academia, industry, and government. All of these experiences, as well as my personal, lifelong devotion to science, prompt me to lend my support to the goals and objectives of the Council on Undergraduate Research. Like all of you, I believe strongly that hands-on research at the undergraduate and, of course, at the graduate level is an indispensable component of science education; that science is learned best by doing it; and that research is an essential function of science faculty at all institutions of higher learning, not just the large research universities that tend to dominate the national research agenda.

I am confident that everyone in this room would agree with these principles. But there can be, and frequently is, a gulf between concept and implementation in any field of endeavor, and the educational enterprise is no exception. Moreover, if we are to foster long-term interest and pursuit of careers in science and engineering, I believe that a program of sponsored undergraduate research should be a part of a comprehensive effort to promote science, engineering, and mathematics from the K-12 level to the graduate level. Consequently, I believe we need to take into account several factors: (1) how undergraduate research programs can be implemented in a manner that supports other partnership programs already in existence; (2) the wider social, political, and economic context in which the effort to promote undergraduate research is taking place; and (3) the potential problems that our experience with partnerships at the graduate level have revealed. In order to ensure that undergraduate research programs proceed in an ordered development as opposed to incremental growth from uncoordinated initiatives, I would in fact advocate some form of strategic planning, in both the narrow sense of establishing common understandings between the academic institutions and its chief partners and major constituencies in developing its undergraduate research program, and in the broader sense of outlining the intended future of the academic institution itself. I place a lot of emphasis on planning because I believe planning is necessary to ensure that our smaller educational institutions, with less resources available to them and therefore with less margin for error in investing in educational initiatives, are able to avoid unanticipated setbacks that they can ill afford; that academic institutions of all sizes are able to maintain their essential identity and character that industry\university partnerships may challenge; and that undergraduate research programs are successfully linked to other programmatic efforts to ensure maximum returns on investments in education for industry, government, educational institutions, and the public.

That the partnership approach to research can produce major headaches for academia was dramatically illustrated earlier this month by an incident that began almost a decade ago at a university in Florida and continues to plague both the university and its corporate partner in a jointly sponsored research project. As reported in a front page article in the June 7, 1996 edition of The Washington Post, under a headline that read "From University Lab to the Chain Gang," the story describes an undergraduate laboratory assistant, participating in a university-industry partnered project, who has claimed credit for a new and potentially lucrative way to cleanse human waste water, a discovery made while working on the project. This rancorous dispute over intellectual property rights, the Post indicates, is just one of many that are increasingly becoming acrimonious and vicious, "particularly at universities where money from the private sector, and the possible patents and royalties that may ensue, have replaced more traditional ways of funding and doing research."

Disputes over intellectual property rights and patents are problems that with careful planning and appropriate agreements can be avoided, or mitigated. Also significant and problematic for university-industry-government partnerships are changes in the national environment that have had a major impact on all of the research triangle members. Perhaps the most pervasive and disturbing change that those of us in government have perceived is an increasing public skepticism and doubt about the value and cost of scientific research, the products of new technology, and the scientific and engineering judgements that support decision-making in industry and government. The result has been dissatisfaction with traditional institutions like government, the public schools, and institutions of higher education, which are seen as being responsible for, or ineffective in dealing with, the new technological intrusions into everyday life.

This public perception of science and technology is at least in part driven by the changing nature of the American economy, which has shifted from an industrial to an information-base. Characterized by a dramatic increase in the rate of technological change, increased competitiveness, and the internationalization of the economy, the changing nature of the economy has meant loss of jobs and lowered individual expectations of continued prosperity. To many, the university-industry-government partnership in research that fueled the post World War II prosperity is perceived as failing to deliver on its long-term promise and potential.

Economic change and changing public perceptions have affected each member of the traditional research triangle profoundly. America's colleges and universities, still dependent on public and private support for their survival, find themselves caught between three apparently disparate pressures (1) to take a more active role in economic development through technology and knowledge transfer to industry to help U.S. industry compete more effectively in the international economy; (2) to find new sources of financial support to keep the costs of the educational enterprise from rising too precipitously; and (3) to restore to prominence the traditional academic functions of teaching over research.

Industry too has had to change drastically in response to economic change and globalization of competition. Industrial research laboratories, once a primary performer of basic scientific research and developer of pioneering technology, have been moving rapidly in the direction of activities that are more relevant to current product and process development. Industrial restructuring, deregulation, and global competition have placed corporate research under increasing financial scrutiny, and cost savings have been achieved by such traditional supporters of research as IBM and AT&T by substantially reducing or refocusing their research efforts. What this appears to mean is that in the future, many new technologies will be discovered in either university or government laboratories, and that industry may seek, through partnerships, research programs that contribute more directly to the immediate commercial advantage of the sponsoring firm.

As I am sure you know, the Federal government, the traditional primary financial backer of university research, has also been sharply affected by economic change. Cutbacks in Federal support for university research began as government cut back its commitments to military-oriented and basic research. As a result, growing disaffection occurred in academia as good research projects went unfunded and government turned more and more toward a policy favoring technological, as opposed to scientific, inquiry as well as more specialized research intended to support specific agency missions.

Despite these Federal cutbacks, the major Federal agency programs in support of university research remain active - NIH, NSF, and DOE are three of the largest non-military related Federal programs. Since many of you are familiar with the range of research support provided by these three agencies, I would like to illustrate the emphasis on specialized research interests using my own agency, the Nuclear Regulatory Commission, as an example.

By way of background, the Nuclear Regulatory Commission is an independent regulatory agency created by the Congress in 1975 to regulate the civilian uses of nuclear material. Specifically, the NRC is responsible for ensuring that activities associated with the operation of nuclear power plants and fuel cycle plants, and medical, industrial, and research applications of nuclear material, are carried out with adequate protection of public health and safety, the environment, and national security. The source of our authority to carry out this mission is contained in a series of legislative actions taken by the Congress since 1954, and we fulfill our responsibility by conducting a system of licensing and regulatory activities. At full complement, the NRC has five Commissioners nominated by the President and confirmed by the Senate; the President designates one of the Commissioners as Chairman. Since July 1995, I have been the Chairman of the NRC. In addition to our headquarters offices in Rockville, Maryland, the NRC maintains four regional and one field office as well as a technical training center.

Although it is only 21 years old, the NRC's roots go back to the World War II Manhattan Project and the Atomic Energy Commission (AEC), the Federal agency created in 1946 to control the technology of the atomic bomb and to explore potential further military uses for atomic energy. In 1974, the Congress decided to separate the AEC's promotional and developmental activities from its regulatory functions and established the NRC as a separate Federal regulatory agency, free from the responsibility to encourage the development of a nuclear industry and weapons technology, concentrating solely on the regulation of the civilian uses of nuclear material.

The NRC today is a small corner of the Federal Government where science and technology predominate, and where the issues being addressed go to the very heart of important national policy issues and are directly related to the protection of public health and safety and national security. For this reason, it is vitally important that NRC research programs provide a strong independent technical capability for our regulatory programs. Without this strong technical component, our decision making capability would be diminished and public safety could be compromised. It is this independent capability that has made the NRC preeminent in nuclear reactor regulation around the world.

NRC's research program focuses on a number of important areas like reactor core physics, thermal-hydraulics, materials, severe accidents, and risk assessment. We also participate in, and stay abreast of, international nuclear research programs. In addition, there are always emergent issues, such as the integrity of radiation embrittled reactor pressure vessels, the behavior of reactor fuel at higher burnups, and human/organizational factors in nuclear operations.

We are now in a period of change at the NRC. Even without external pressure to reduce costs, a new culture, which I refer to as risk-informed, performance-based regulation, is being adopted by the NRC. We are becoming less prescriptive and more performance-oriented in our regulatory posture in order to provide greater flexibility to licensees while maintaining adequate protection for the public. Cost-consciousness and cost-effectiveness pervade all of NRC's operations, including research.

NRC's research programs are being reexamined to ensure proper focus under this new paradigm. Research planning must consider the current and prospective level of plant safety, and there should be reasonable expectation that research projects and their results will be cost beneficial. Among the criteria to evaluate the merits of a research project are the likelihood that the results will improve the effectiveness of regulations, and minimize any undue burdens they impose. Some of the rules that the NRC developed conservatively in the 1960's and 1970's because of lack of information may now be modified as a result of improved knowledge that has been gained through investments in research over the past 20 years. Research in areas such as Probabilistic Risk Assessment has the potential to reveal vulnerabilities in nuclear technology and operations, or to illustrate unnecessary conservatisms. Future investments in research will be expected to continue this trend.

A portion of our research program is implemented through educational grants, which have provided an excellent vehicle for partnership between universities and the NRC. The NRC grants program was established to support educational institutions in the pursuit of state-of-the-art research related to nuclear issues. NRC grants have been awarded to colleges and universities covering a broad spectrum of nuclear-related topics, such as probabilistic risk assessment, human factors, thermal hydraulics, seismic assessment, and fracture mechanics. Depending on funding availability, NRC announces its grants program to the public, and based on the quality of proposals submitted, competitively awards approximately fifteen (15) grants annually. NRC grants generally have been awarded to university faculty, who have in turn employed both graduate and undergraduate students to assist in the research. NRC grants have contributed to the education of students in the nuclear field and, at the same time, provided benefits to the general public, nuclear and non-nuclear industries, and to the NRC.

NRC also awards competitive contracts to universities. Universities usually <u>compete</u> for NRC contracts, except where they are the sole source, perhaps as the result of the submission of an unsolicited proposal. University Principal Investigators frequently employ the services of graduate and undergraduate students to assist with the required research under these contracts. The unsolicited proposal process affords universities the opportunity to submit unique or innovative ideas to the NRC. These proposals are not in response to formal requests but rather are submitted on the initiative of the proposer. Since 1988, NRC has also used the Broad Agency Announcement (BAA) process, a special competitive program, to stimulate interest among universities in competing for NRC contracts. Under this process, NRC publicizes areas of mission-related research interest in the Commerce Business Daily and invites interested parties, including universities, to propose technical approaches and innovative ideas to satisfy those needs.

In addition, the Nuclear Regulatory Commission conducts a program to support Historically Black Colleges and Universities (HBCU's).

The NRC program provides opportunities for faculty and student participants from HBCUs to accomplish the following:

- Continue their education in the areas of their research participation.
- Enhance their professional development in science, mathematics, engineering, human factors and related areas.
- Become familiar with the research areas of NRC.
- Become available as scientists, engineers, and related professionals for future employment in fields related to NRC's mission.

NRC's HBCU program is accomplished through a Research Participation Program.

- Faculty activities include on-campus research. On-campus projects involve faculty/student teams in research and education activities during the academic year, generally preceded or followed by participation at a Federal facility during the summer.

- Graduate students are eligible to participate in research education and training at the national laboratory sites or other Federal facilities during the academic year or during the summer. Appointments are contingent upon the research activity contributing toward the student's degree. In addition, students may also participate with faculty members in on-campus research.

- Undergraduate students are eligible to participate in a summer research education and training effort. Students are appointed for an 8-10 week summer experience at a national laboratory or other Federal facility. Undergraduate students may also participate in on-campus research in faculty/student teams.

In fiscal year 1995, our HBCU faculty and student research participation program supported 26 faculty and students from 18 HBCUs and 10 states.

As my description of the NRC research program makes clear, Federal agency research other than NSF, NIH, and DOE, tends to be small in scale, highly specialized, and mission oriented.

Given the challenges that each of the partners in the research triangle seem to be experiencing, the question that needs to be asked is whether partnerships in undergraduate research are worth pursuing? I believe the answer to that question is "yes."

The one thing we do know about partnerships at all levels of the educational enterprise is that they tend to work, particularly from the standpoint of the university or school and its students. As you know, partnerships in research at the graduate level abound. One of the best known, the Ben Franklin Partnership in Pennsylvania, began in 1982 as part of a wide-scale effort in the 1980's to involve state governments in investing in university business partnerships. The product of intense planning by the Pennsylvania state planning board from 1977 through 1981, the project began with state-initiated studies of the Pennsylvania economy and meetings with industry, government, labor, and academic leaders, followed by testing the perceptions about the proposed partnership through further studies and solicitations of public comment.

The state considered several different approaches, according to Roger Tellefson of the Pennsylvania Department of Commerce, including 1) <u>Centers of Excellence</u> organized around a specific technical field for which an identified basic research center would be created, as has been accomplished in Microelectronics in North Carolina, biotechnology in Massachusetts and several different areas in Utah: 2) <u>information dissemination</u>, or knowledge transfer through computerized data retrieval systems and other technology transfer agents, as used in Ohio, Maryland, and Michigan: 3) <u>entrepreneurial education</u>, or encouragement of new startup companies through entrepreneurship programs at universities and small business development centers: and 4) <u>Advanced Technology Consortia</u>, in which higher education, industry, and government organizations combine to fund jointly research projects usually of an applied nature, as in Ohio and Michigan. Pennsylvania chose the consortia approach, establishing four advanced technology centers to engage in cooperative research and development projects. Institutions involved in the program include Lehigh University, the University of Pennsylvania, Drexel University, Temple University, University of Pittsburgh, Carnegie-Mellon, Penn State, and hundreds of private sector firms and other public and private institutions.

Ohio's Thomas Edison Program has three main thrusts: the Edison Seed Development Fund, which offered grants to be matched from private corporations for early stage research projects; the Edison Technology Centers, which focused on cooperative research; and the Edison Incubators, which are centers to provide an environment in which small, newly emergent companies can be nurtured during their formative years by the host university.

Of course, I am most familiar with partnership programs established in New Jersey, which were funded initially by $87 million provided from a 1984 bond issue. The New Jersey Commission on Science and Technology led the way in development of these programs, which include technology transfer, business development, human resources development, and information dissemination programs, as well as a dozen Advanced Technology Centers to conduct leading edge R&D at universities in partnership with private industry. Some of these centers work as cooperative programs in which industry members agree on a common research agenda; others work on a project basis with industrial sponsors interested in particular work; and others employ both methods at once.

All leverage the state investment in science and technology areas deemed important to the economy of New Jersey. All of these initiatives were named at building the requisite academic and business infrastructure for continued economic growth. I served as a member of the New Jersey Commission in Science and Technology for ten years, with a position on the Executive, Budget and Scientific Fields Committees. I represented AT&T Bell Laboratories at the time. Later, I became a professor at Rutgers, which is the sponsor for 7 of the 12 R&D centers. The heart of the program was always the Advanced Technology centers. Some centers were jointly sponsored by more than one university. For example, the Center for Advanced Biotechnology and Medicine, sponsored by Rutgers University and New Jersey's University of the Health Sciences, UMDNJ. This particular center receives Federal support from NIH and NSF, and has multiple corporate and foundation sponsors. The Center for Ceramic Research hosted by Rutgers, is supported by NSF, the Department of Commerce, NIST, and DOE, and has numerous industrial contributors.

The magnitude of the Advanced Technology Center program, and its concentration at Rutgers have provided the university ample graduate-level research opportunities. Fees paid to the centers pay salaries and tuition of student researchers. Some of these students are undergraduates, and Rutgers makes extensive use of NSF's capabilities for adding undergraduate research funds to existing contracts. This allows two undergraduate researchers to work on each NSF contract, so that each undergraduate can work for half a year with a graduate student. In effect, the centers provide Rutgers' students a window into a leading-edge research environment.

Other undergraduate research programs at Rutgers provide internships in the summer months to work at either the centers or at other research institutes as well as numerous specific research projects involving individual students working with faculty members. At the present time, Rutgers is negotiating with a software company in New Jersey to create 30 undergraduate internships directly with the company, a significant commitment on the part of the company and a sizeable project for Rutgers students.

Of all the Rutgers undergraduate research projects, the one I find most interesting and in many ways the most challenging is the Douglass Project for Rutgers Women in Math, Science, and Technology. Founded in 1986 by Douglass College, one of the four liberal arts undergraduate schools at Rutgers, the Douglass Project's goal is to encourage the persistence of women in math and science studies during their undergraduate years. Through a series of activities, the project brought women students together across the undergraduate colleges and across disciplines to inspire undergraduate women as they explore career, graduate, and professional school options.

The Douglass Project spans the gap between graduate and upper-level undergraduate research and activities under way at the K-12 level in New Jersey to improve science instruction. The project encompasses an outreach program, funded by the Merck Institute for Science Education, in which undergraduate volunteers lead hands-on science activities in public school classrooms and provide other assistance as needed and Project Super, a first year undergraduate program funded by the Alfred P. Sloan Foundation. Super is a year-long project that includes an initial five day residential summer program where students explore options in math and science and do hands-on experiments. During the year, Super students participate in group and faculty mentoring programs, and enroll in a credit-bearing course on the research process. In the following summer, selected students receive a stipend for a research-oriented internship.

The Douglass Project also includes pre-college programs. The Douglass Science Institute (DSI) Program series is a multi-year summer residential math and science enrichment program for high school women attending schools in nine New Jersey counties. Students begin the program as entering ninth graders and have the option of continuing their participation in the next three summers. The DSI program was implemented in 1993, when the first group of forty-six students started the program. Since then, a new group of entering 9th grade women has entered the program each summer. For the first time this year, the 12th grade participants will take part in an internship program, a four week research experience in July and August in a corporate or university laboratory. Students are expected to devote 20 hours per week to this internship program.

The Douglass Project, as well as the other programs in New Jersey and Pennsylvania that I have described, suggest the wide variety of partnerships that are available to the academic community to enhance undergraduate research and to foster careers in science. Depending on the location of your institution and the purpose for which you seek to pursue partnership agreements, there are several successful models to choose from. My own favorite is the Douglas Science Project because it occupies the critical space between pre-college instruction and the junior/senior undergraduate years, when students have already made up their minds on their future careers. The Douglass Project engages the interest of students at the critical freshman and sophomore years when students are most likely to abandon their plans for a science career and need the most support. Moreover, most of its features can be implemented anywhere, even in a small college community. This type of partnered project is especially effective, however, where existing K-12 research programs in science and math and reasonable opportunities for graduate and upper-level undergraduate research activities coexist on the same or at nearby campuses.

I think experience to date with partnerships reiterates the need for one other important step beyond the design of the undergraduate research program being developed -- the need for careful systematic planning. Even if you are in a state like Pennsylvania or New Jersey, where the state has invested years of planning into its partnership program, it is still, I believe, very important for colleges and universities to plan their participation in such programs to ensure that other partners understand your objectives which should always include, at least in part, the enhancement of the undergraduate experience.

Thank you for your attention. If you have any questions, I would be pleased to respond.