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## UNIVERSITIES AND THE GLOBAL MARKETPLACE

National Academy of Engineering

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Irvine, California  
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I want to begin my discussion of universities and the global marketplace by taking a glance backward, to a time very different from our own. Forty-five years ago, as the world struggled to rise from the ashes of World War II, the United States was the dominant force in the world. Most of Europe and the Soviet Union were in ruins. Japan, physically devastated, was an occupied nation. China was torn by civil war. The economies of the East and the West had been crippled by a war of unprecedented destruction, which had also rent the social and political fabric of their societies.

By contrast, the United States emerged from the war physically unscathed, and confident of its preeminent economic, political, and military power. American policy influenced every facet of world affairs and, in particular, the world's economy. American goods and American resourcefulness set the standards for world trade. For example, the United States accounted for approximately 40 percent of world Gross National Product at the end of World War II.

Today, however, the winds of change are blowing hard and reshaping the economic, political, and social dimensions of our world:

- Ideological commitments that have locked in Communist governments for decades are giving way to greater political openness, economic development, and the use of technology, all of which are essential to the prosperity and personal freedom people throughout the world are seeking. From Poland to China, the movement toward democratization and greater economic freedom is gaining momentum--albeit, as in the case of China, unevenly.
- The past decade has seen the emergence of the Pacific Rim as a potent force in the world's economy and the world's affairs. The rise of Japan and of the newly industrialized states of Asia has especially challenged our assumptions about American dominance of the global marketplace. Our postwar share of world GNP has shrunk from 40 percent in 1945 to 22 percent today. The economic integration of Western Europe in 1992 will be another major force influencing America's economic position in world markets. And one can only speculate about the impact on the world's economy of the changes now taking place in Eastern Europe and the USSR.

- Today the East and West are struggling less with each other than they are in common struggling with what the Arab philosopher Hichem Djait (Hee-CHEM Jah-EET) has called the forces of "modernity"--the technological revolution, modern science, and the industrialization of labor--forces that should not be confused with Western civilization, as is often the case. These forces are changing the world not just at the margin but at the core. And one of the most striking qualities of this change is its international character. For example, the discrete national markets with which we have long been familiar define less and less the world's economic order. It is becoming increasingly difficult to buy American, to illustrate the point, even if one sets out aggressively to do so. Production of a car can involve workers in four or five countries before the final product rolls off the assembly line in the U.S.
- Moreover, ideas blow across political boundaries, even into the most insulated of nations and societies, disquieting, troubling, indeed in some instances overturning even the most ideological and inflexible of established orders. Even the role and place of the military in this equation are coming under intense scrutiny. All of these forces--economic, political, ideological, religious, social, and cultural--are interrelated and global in their significance and effect.

Who will the leading nations be in this dramatically altered economic and political environment? According to investor Felix Rohatyn:

At a time when both superpowers have implicitly recognized the irrelevance of nuclear weapons (except as a deterrent), the real power in the world is coming to consist of surplus capital combined with national self-discipline, advanced technology and superior education. The leading nations of tomorrow, by those standards, are likely to be Japan and post-1992 Europe. The United States, once the unquestioned leader of the West, falls short in every one of these categories.<sup>1</sup>

Surplus capital, national self-discipline, advanced technology, and superior education--an agenda for the future we would do well to heed. The United States has both advantages and disadvantages as it struggles to define its role and place in this changing scene.

The list of our problems will sound familiar: There is a growing gap between the rich and the poor in this country, and an ominous growth in the underclass--the unemployable poor caught in the vicious cycle of drugs, alienation, and the fragmentation of the family, especially in our inner cities.

The past few decades have brought an erosion of our sense of community and of the place and significance of local government, with a simultaneous gravitation of power and control to state and Federal governments. Ironically, at the same time our Federal government displays an incapacity--or is it an unwillingness?--to make tough decisions that appears to border on paralysis. One example is the Gramm-Rudman-Hollings bill, which by automating the budget process takes budget decisions out of the hands of those elected to make them.

We have a school system in deep trouble and chronically underfunded universities; predictions of a shortage of scientists and engineers in the coming critical decades; a decline in the attractiveness of the teaching profession at all levels. These are symptoms of a human resources problem of formidable dimensions, a subject I will return to in a moment.

And there is a certain malaise within the body politic attributable partly to the problems just mentioned and partly to the knowledge that our nation is no longer the dominant player on the world scene, but is increasingly but one of several countries capable of influencing the course of nations.

On the other hand, we have some striking advantages as well. The nation possesses remarkably stable political, social, and economic systems; and if you wonder about that, just consider conditions in Africa, the Middle East, and Latin

America, by way of example. And despite some very real problems, we have a society that not only adapts to change but actually encourages it. Our openness to new ways of doing things is a tremendous advantage in a world characterized by constant technological change, as is the nation's willingness to accept new talent and fresh ideas from throughout the world.

American universities are the finest in the world. The vigor of our basic research enterprise is truly remarkable, and its democratic and open spirit helps assure that the best flourish. Americans continue to capture most of the Nobel Prizes year after year, surely an indication that we are doing something right--or at least that we did so within the lifetime of the recipients!

I also count among our advantages the creativity and productivity of American business. Much is made these days of the short-term focus of American companies--too much, in my opinion. That view fails to take into account the extent to which American companies have recognized their problems and restructured during the 1980s; in many respects business has been more energetic in responding to change than either universities or government.

These are some of the reasons why foreign investors, including the Japanese, are anxious to invest in the United States. Dollar-denominated assets are valued because they are the currency of a society with an enormous capacity for

adaptability, hard work, creativity, an open attitude toward and a positive response to change.

This is the context in which I wish to discuss how universities can contribute to the national interest in an age of global technology.

The first contribution is one that only universities can make--the education and training of the scientists and engineers on which our ability to compete in a scientifically driven and technologically based economy depends. As this audience knows all too well, real concerns exist about the prospect of significant shortages of scientists, mathematicians, and engineers in the coming decades. These shortages will have a consequential and negative impact on the capacity of government, industry, and universities to meet their responsibilities. Richard C. Atkinson, Chancellor of the University of California's San Diego campus and current president of the American Association for the Advancement of Science, estimates that if corrective actions are not taken, "by the early years of the next century the annual supply of Ph.D.s [in the natural sciences and engineering] available to the nation's workforce will be about 10,500 versus a demand for about 18,000 "--which means there will be an estimated shortfall of about 7500 a year.<sup>2</sup> The gap between supply and demand should begin to show up in about five years.



As you will also know, this potential shortage is complicated by several factors. One is the demographic outlook. By the year 2000, only 15 percent of new labor force entrants will be white males, compared with 47 percent in 1987. Minorities will constitute 29 percent of new entrants during the same period, twice their current share. We will need to work hard on attracting more young people into science and engineering, therefore, and especially more women and minorities.

Another factor is our growing dependence on foreign-born students to fill our graduate programs and faculty positions, as well as to help meet the needs of industry and government. Currently about 30 percent of the Ph.D.s in the physical sciences are going to foreign citizens; 50 percent of mathematics doctorates; and 60 percent of engineering doctorates. Over half of U.S. assistant professors in engineering under the age of 35 are foreign citizens. As a result, some questions have been raised about the number of foreign students in our graduate and professional programs, and whether limits should be placed on foreign student enrollment.

I take exception to this concern. Our concern should not be that some of the world's brightest young people choose to study here, but that they will be less likely to stay than they have been in the past, because the economies of their

countries will be growing in the years ahead, along with their opportunities at home.

Rather, our policy should be to increase the number of Americans opting for advanced study in these vital disciplines. One way, of course, is through better financial support in the form of fellowships and other assistance for graduate students, as this nation has so effectively provided before. Chancellor Atkinson has proposed the establishment of a National Fellowship Program for Graduate Students similar to the post-Sputnik Federal programs that would provide fellowships of \$25,000 a year for four years of graduate study. He estimates that at least 3,000 new fellowships a year would be needed, just to address the shortfall in the national sciences and engineering; the estimated cost of such a program would be about \$300 million a year--a modest investment, given the richness of the potential return. Director Bloch has taken an important and helpful step in requiring that one criterion for National Science Foundation research funding must be the extent to which the proposed project contributes to the development and education of our human resources.

But even if we manage to produce sufficient numbers of scientists and engineers in the future, it will not be enough to ensure our ability to compete in a world that is being transformed by technology. The human resource question is much broader than that. According to one estimate by the American Society for

Training and Development, "productivity losses caused by poorly educated workers, together with the price of remedial training, cost business about \$25 billion a year."<sup>3</sup> Moreover, the Department of Labor has warned of a growing disparity between the skills of young people entering the workplace and the jobs of the future. Many of those jobs will demand a greater ability to read, write, reason, and compute than ever before. It is both ironic and frightening that this disparity is occurring at the very time many American schools are finding it difficult to graduate students who have mastered the most basic academic skills.

I heard recently about a survey of foreign executives, employed by multinational companies, who live in the United States. These executives were asked what they saw as the greatest asset enjoyed by the United States and its greatest liability. The greatest asset, most of them agreed, is the American university; the greatest liability is the American school. J.J. Servan-Schreiber, a distinguished French observer of the American scene, agrees. The "real danger to America," he said recently, is "not the Red Army, not the developing nations and their masses, but the internal disintegration of the education of youth prior to the university." <sup>4</sup>

We cannot compete successfully in the global marketplace with world-class scientists and engineers, and well-educated and experienced CEOs, if the companies they head are staffed by employees who cannot read or compute well

enough to follow basic safety instructions. Nor can we sustain indefinitely the lustre of the American research university if it rests on the foundation of a crumbling school system. In short, it is principally upon the quality of our human resources, not our natural resources or current technological advantages, that our economic competitiveness and national security will ultimately depend. And the question extends well beyond just scientific or technical fields. For example, our schools of business and schools of law should be training their students to function more effectively in the global marketplace--especially in the dynamic and emerging Pacific Rim--every bit as much as our schools of engineering should. Unless we address the whole question of developing our immense human resources in a more coherent and committed fashion than we have demonstrated so far, what we do in other areas will not matter very much in the long run.

Second, a competitive technological infrastructure demands efficient and flexible ways of translating new knowledge into processes and products. I wish simply to make a few comments on this topic from my perspective as head of a major research university.

Government, universities, and industry need to be careful about defining "technology transfer" too narrowly and concentrating on short-term cooperation to the exclusion of longer-term endeavors. At present, our collaborative

relationships with industry tend to be concentrated in specific projects, with few long-term cooperative programs. We should be pursuing short-term projects, but not to the exclusion of longer-term needs and interests of the country. I am concerned that more attention is not being devoted to where we will be in a particular disciplinary research area five or ten or more years down the road, and especially in those emerging areas that hold out the promise of new industries.

Biotechnology, for example, has created one of the few markets in which the United States has not been overtaken by the Japanese. That is because the first major breakthroughs in biotechnology took place in the United States in the mid-70s--at UC San Francisco and Stanford University, in fact--and we have protected that early edge with world-class research. This example also makes the point that basic research is one of the best investments we can make in our future competitiveness--not our competitiveness today or tomorrow, but for some years hence. As Nobel Laureate Glenn Seaborg has pointed out, applied research is nothing more than basic research with a time lag.

One example of what I have in mind is the Human Genome Project, the ambitious and exciting attempt to map the intricate architecture of the human genome. It is a cooperative endeavor involving industry, the Department of Energy, the National Institutes of Health, and the University of California,

including the three laboratories UC manages for the Federal government at Berkeley, Los Alamos, and Livermore. Many other American universities are involved as well, among them Stanford, Caltech, the University of Michigan, Yale, Harvard, and MIT. It is a multidisciplinary effort that will draw on physics, engineering, and computer science as well as on the life sciences. The first five years of the project are devoted to the task of developing the analytical and computational resources essential to sorting through and organizing the mountain of information that will flow from research into the human genome. Along the way, however, scientists expect useful information to emerge as research unfolds; indeed some applications already have.

What makes this project unusual is, first, that it combines the most basic and the most applied of goals. Its principal aim is enlarging our understanding of the most fundamental constituents of our physical life, but there is also every expectation that in the process we will find information vital to the cure of disease and advance of medical knowledge.

Second, this project has industrial sponsors even though no specific product is contemplated; industry is simply betting that what we learn from the Human Genome Project will someday yield profitable results. And they are probably right--in fact the Project is expected to revolutionize the practice of medicine as we discover more about genetically linked diseases.

Finally, it is both long-term and international. It is hoped that the task of sequencing the human genome will be achievable by the year 2000, a much longer horizon than that contemplated by most industry/university projects. Other countries are participating along with the U.S., among them Japan, Britain, France, Spain, Italy, and the USSR.

We need to be doing more of this kind of long-term, cooperative, precompetitive research. Our question of a project shouldn't just be "Will it yield a new product?" but also "Will it yield a new industry ten or fifteen years down the road?"

The large and growing cost of basic research in many disciplines has outpaced the ability of any one company or university--or even any one nation--to pay for all the promising areas that merit exploration. In addition, Federal funding of university research facilities has dropped, in real terms, by 95 percent over the past 20 years. This means that international cooperation in research, like the international collaboration that marks the Human Genome Project, is likely to become more common in the years ahead. This prospect, in turn, has generated some tough questions: In an era of fierce international competition for markets, can we afford to allow other countries to tap into American-generated technology? Should we restrict foreign support of research taking place on

American campuses? An equally compelling question is: "Can we afford not to?"

Universities, of course, have an obligation to insist on cooperative agreements that explicitly recognize that they are open centers of learning, not proprietary research institutes. The University of California at Irvine, for example, has entered into an agreement with the Hitachi Chemical Research Center, a California subsidiary of Hitachi Chemical Ltd. of Japan. Under the terms of the agreement, Hitachi will construct a \$15 million state-of-the-art biotechnical research facility adjacent to the campus's College of Medicine. Hitachi will occupy two floors of the building, and the ground floor will be used for research and office space by UC Irvine, under a 40-year lease. At the end of the 40 years, the building will become the property of UC Irvine.

There are advantages for both in this arrangement. UC Irvine will gain space that is urgently needed on this growing campus. Hitachi garners the advantage of working in close proximity with University scientists exploring the frontiers of biomedical discovery--and UC scientists will have a window on Japanese biomedical research they would otherwise not have had. But the agreement also provides that the University owns all patents which are derived from University research or from the use of University resources, including any research supported by Hitachi at UCI. This allows us to protect the right to open publication and to ensure the integrity of our basic research mission.



After all, knowledge knows no political boundaries. Scholars are members of an international community of learning that stretches back to the Middle Ages and, like the itinerant professors of the medieval period, today's scientists and scholars travel the world freely--as does the knowledge they discover. Thus, the focus of our concern should not be on creating artificial barriers (they won't work anyway) but on fostering cooperation between universities and their sponsors that helps add to our fund of knowledge and its productive use. Our nation stands to gain the most from this open arrangement.

Third and finally, universities, as well as our schools, have an important responsibility in helping people put the issue of risk into perspective. Our society seems to take the attitude that no risk is acceptable, that we should live in a hazard-free world, and that government should guarantee it. Life isn't that simple. There are real social and economic consequences to be faced when we reject emerging technologies out of hand because they pose some unanswered questions or involve some degree of risk--nuclear power or genetic engineering, for example. Or imagine what the world would be like today if Henry Ford had been required to file an environmental impact report before the Model T could go into production! In general, we are doing a poor job of educating the public about these matters compared with other nations, which all by itself constitutes a significant risk to our national welfare.

In 1983 I chaired the National Commission on Excellence in Education, whose report, A Nation at Risk, helped spark an educational reform movement in the United States. In closing, I quote from the report:

The risk is not only that the Japanese make automobiles more efficiently than Americans and have government subsidies for development and export. It is not just that the South Koreans recently built the world's most efficient steel mill, or that American machine tools, once the pride of the world, are being displaced by German products. It is also that these developments signify a redistribution of trained capability throughout the globe.

Knowledge, learning, information, and skilled intelligence are the new raw materials of international commerce and are today spreading throughout the world as vigorously as miracle drugs, synthetic fertilizers, and blue jeans did earlier.<sup>5</sup>

I have been encouraged since 1983 by the growing level of awareness and concern on the part of the American people about this issue; and despite the problems we face, I remain optimistic. The U.S. still leads in the world in many fields--supercomputers, telecommunications, computer-aided design, agriculture, biotechnology, and pharmaceuticals, for example--and I am confident that we can

make the most of the truly astonishing creativity, energy, and talent available in this country, especially if business, government, and universities make a determined effort to do so together.

If we succeed, one reason will be the efforts of organizations like the National Academy of Engineering, which for 25 years has encouraged the highest standards of performance in the engineering profession. I am delighted to offer warmest congratulations on that anniversary and honored to participate in this important conference.

1. Felix Rohatyn, "America's Economic Dependence," Foreign Affairs, 68, 1, 1989.
2. Richard C. Atkinson, "Supply and Demand for Science and Engineering Ph.D.s: A National Crisis in the Making," Remarks to the Regents of the University of California, February 16, 1989.
3. "A Shallow Labor Pool Spurs Business to Act to Bolster Education," Wall Street Journal, September 28, 1987.
4. "J. J. Servan-Schreiber Views a New American Challenge," Challenges, 2, 9, Council on Competitiveness, July 1989.
5. National Commission on Excellence in Education, A Nation at Risk: The Imperative for Educational Reform (Washington, D.C.: U.S. Government Printing Office, 1983).