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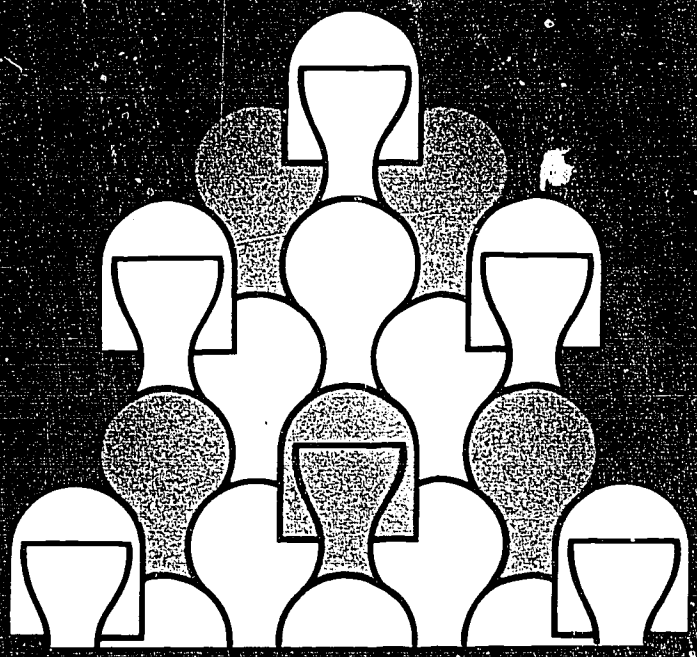
ABSTRACT

Designed as one means of drawing attention to the need for quality scientific and technical education for today's youth, this booklet examines recent trends in education and demography and discusses their implication in producing scientists and engineers for the future. Information is presented on: (1) the need for a scientific and technical workforce; (2) recent decline in degrees awarded in science/engineering fields in the United States; (3) demographic trends; (4) strategies for the present and future in increasing participation in science/engineering programs; and (5) need for science/engineering education. Eight graphs are included. (ML)

Human Talent for Competitiveness



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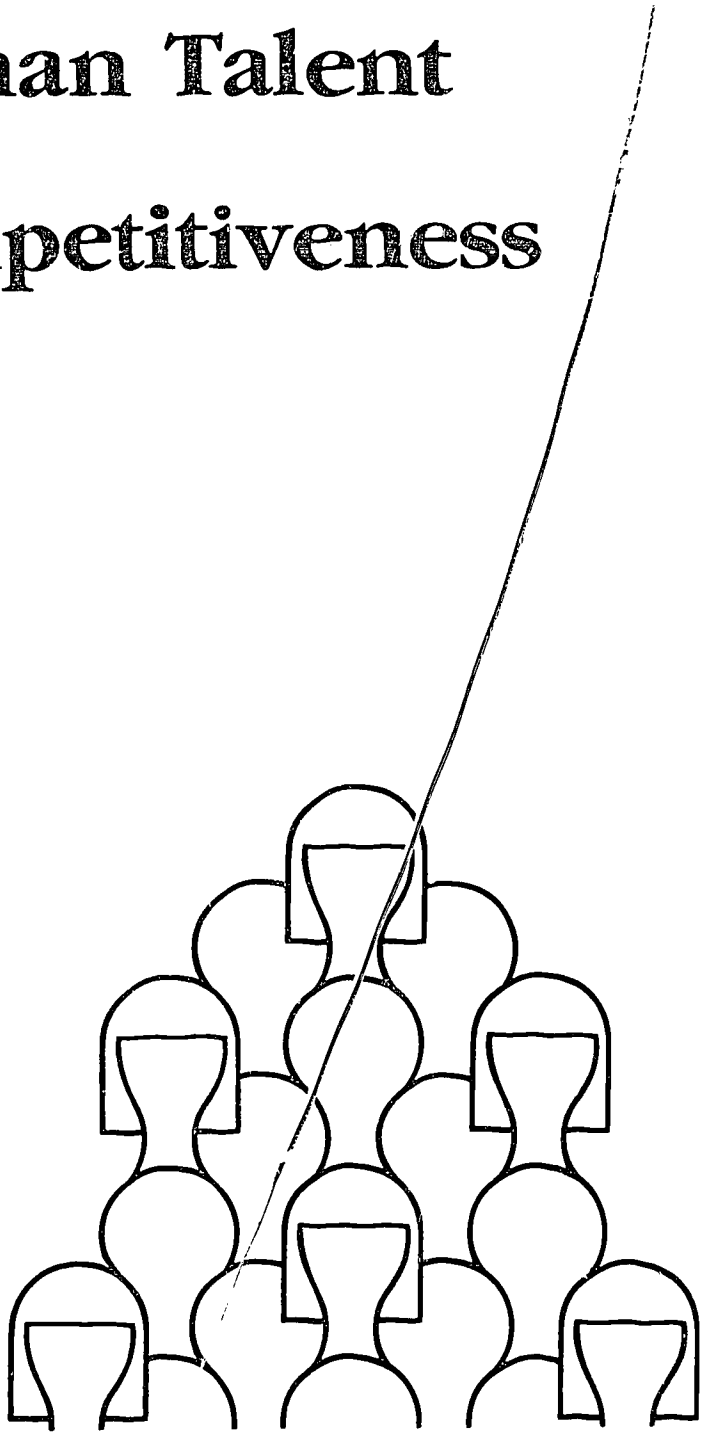

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PREFACE

The scientific and technical education of our young people is one of our most important national responsibilities. It is also a primary responsibility of the National Science Foundation, whose mission includes strengthening education in the sciences, mathematics, and engineering at all levels.

Much of the NSF focus in this area is at the graduate level, supporting students who will become Ph.D. scientists and engineers. But the Foundation also provides support for programs at the elementary, se[illegible]ary, and college level that help improve the quality of instruction in the sc[illegible]nd mathematics and make much needed equipment and instruction availa[illegible]nger students.

This booklet is intended as a means of drawing a[illegible] to a critical issue, one in which we all have a common stake and a shared responsibility. There is little room for complacency about our ability to meet our need for scientists and engineers in the future.

Erich Bloch
Director
National Science Foundation

HUMAN TALENT FOR COMPETITIVENESS

The future belongs to the young. But how prepared will our young people be for the challenges of an increasingly competitive, technologically based world? Will they be able to maintain our economic leadership and quality of life?

There was a time when the answers to these questions seemed obvious. For many years after the Second World War, our economic, scientific, and technological leadership was unchallenged. New knowledge and technological innovation have played a critical role in establishing our world preeminence in the economic arena.

The contribution of science and technology to our productivity continues to be important, but increased competition from other nations has made our position less secure. We no longer dominate the world market and our products must compete even in our domestic market with goods from abroad.

In recent years our balance of trade has become overwhelmingly negative and we are running deficits not only in traditional goods, but in high technology products as well. What were once key areas of economic strength, such as steel, automobile manufacture, and more recently, semiconductor and computer industries, are declining and eroding.

The implication is clear. As we face the future, we cannot take our past achievements for granted.

Today, an unprecedented explosion of knowledge marks the onset of a new era – an age of information and technology. Since *people* are the source of new knowledge, we will rely increasingly on a well educated and trained work force to maintain our competitive position in the world and our standard of living at home.

This booklet looks at recent trends in education and demography and discusses their implication for our ability to produce the scientists and engineers our Nation needs in the future.

The Need

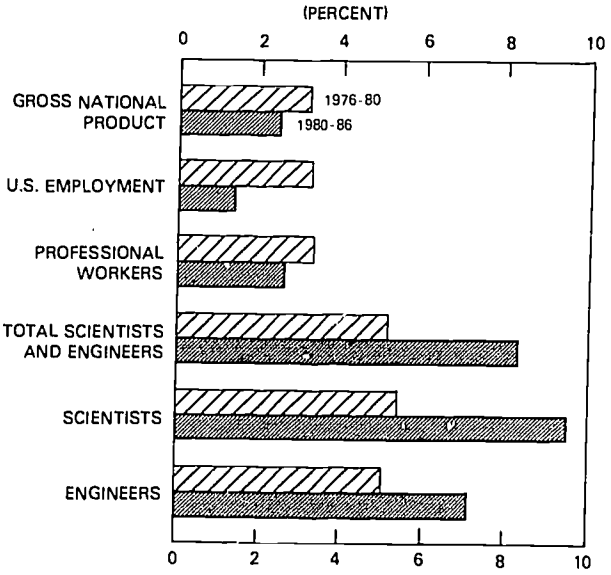
There is a close relationship between the quality of life we enjoy and the new knowledge that results from basic research. Close to half of all the productivity gains of the last decade are the result of innovation – the application of knowledge generated by our talented scientists and engineers.

In universities, they are the mentors of new generations of scientists and engineers. Increasingly, they are also the leaders, managers, and decision-makers in our modern technological society. The economy of tomorrow, even more than today, will require a population skilled in the sciences and mathematics.

The increased importance of this talent pool is reflected in employment trends (fig. 1). In the last decade, the employment of scientists and engineers increased three times faster than total U.S. employment and twice as fast as total professional employment.

FIG. 1

AVERAGE ANNUAL GROWTH IN SCIENCE AND ENGINEERING EMPLOYMENT AND OTHER MANPOWER AND ECONOMIC VARIABLES



SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

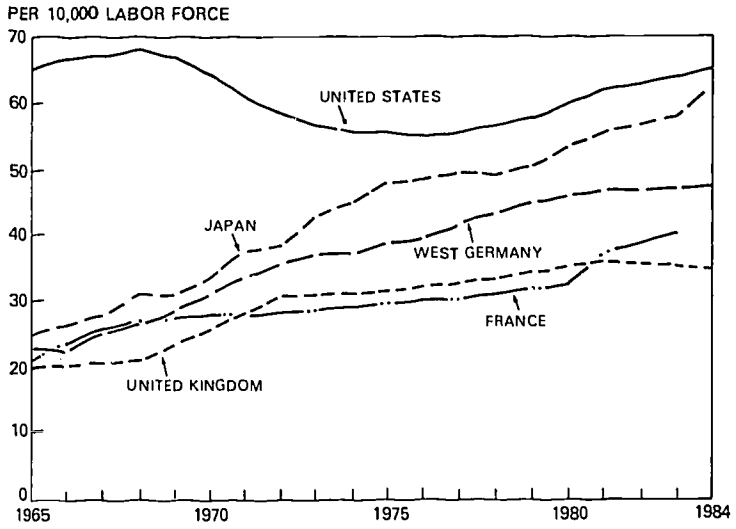
The number of industry-employed scientists and engineers engaged in research and development alone increased by almost 60% from 1973 to 1985. This is the biggest increase among all employment sectors and it attests to the increasing complexity of the products, processes, and tools associated with our economy.

Such increases in technical employment are not restricted to the United States. Other countries are also keenly aware that economic leadership depends on the availability and quality of science and engineering personnel. Our competitors are rapidly catching up with the United States in the proportion of their labor force devoted to research and development (fig. 2).

Japan, for example, has doubled its technical workforce in the last two decades. In 1982 it produced more engineers – in absolute numbers – with a population only half of the U.S. total. The developing nations are catching up as well and positioning themselves to be

FIG. 2

SCIENTISTS & ENGINEERS ENGAGED IN RESEARCH & DEVELOPMENT PER 10,000 LABOR FORCE POPULATION, BY COUNTRY



SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

more effective international competitors. India, for example, has increased its population of scientists and engineers tenfold in the last two decades.

Trends in Degree Production

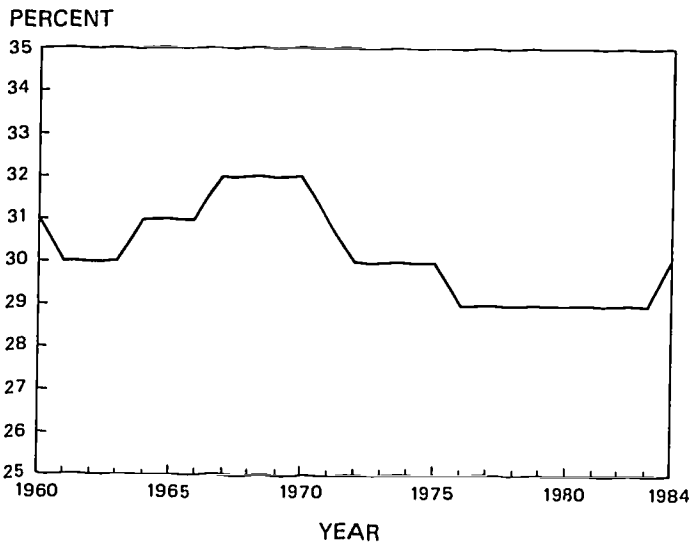
What do trends in degree production tell us about our ability to respond to present and anticipated need?

At the bachelor's degree level, between 1965 and 1985 there has been considerable fluctuation in all the science and engineering disciplines. But overall, the proportion of the U.S. graduating class majoring in the sciences and engineering is smaller today than it was in the 1970's (fig. 3).

The decline at the baccalaureate level is accentuated at higher degree levels. Science and engineering degrees currently constitute a smaller fraction of all higher edu-

FIG. 3

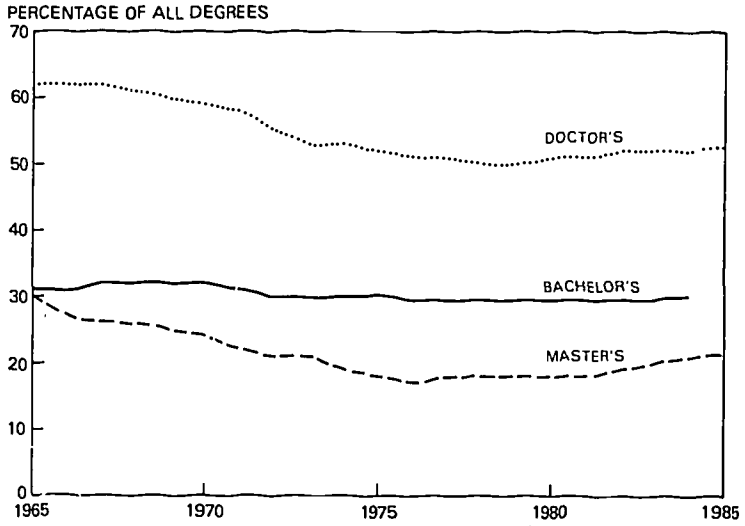
SCIENCE AND ENGINEERING BACHELOR'S DEGREES AS PERCENTAGE OF ALL DEGREES



SOURCES: NATIONAL SCIENCE FOUNDATION, SRS AND CENTER FOR EDUCATION STATISTICS

FIG. 4

PROPORTION OF ALL DEGREES AWARDED IN S/E FIELDS



SOURCES: NATIONAL SCIENCE FOUNDATION, SRS AND CENTER FOR EDUCATION STATISTICS

cation degrees awarded by the Nation's colleges and universities than they did in the 1960's (fig. 4). To make matters worse, college graduates have been less interested in going on for higher degrees (fig. 5).

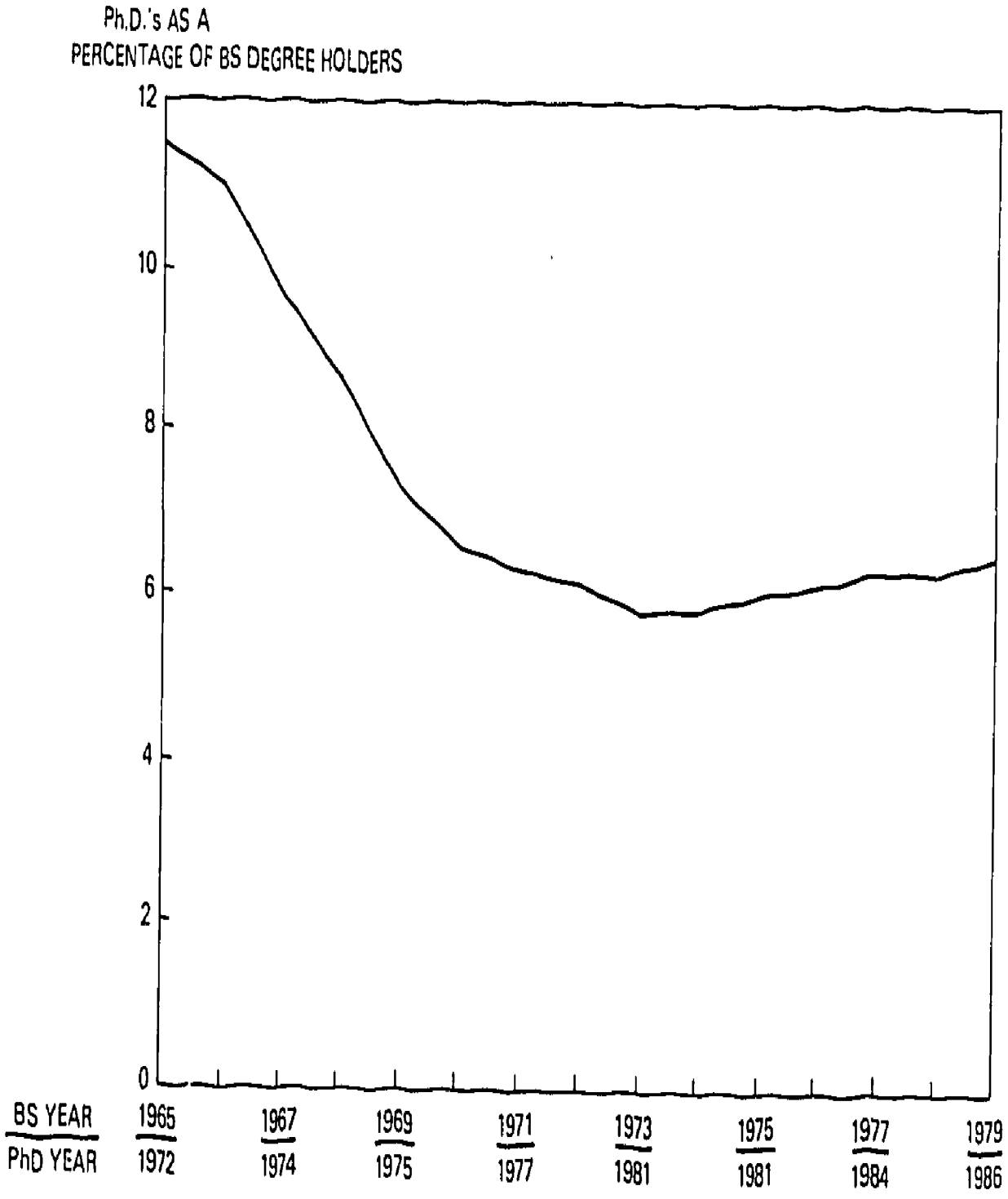
Recently, because of significant increases in the enrollment of women and foreign students, the rate at which baccalaureates go on for graduate work has stabilized. But with fewer Americans choosing the Ph.D. track in the sciences and engineering, we are increasingly dependent on foreign nationals in some of the most important specialties (fig. 6).

In recent years, more than half of our new engineering Ph.D.s have been foreign nationals, and there have been significant increases in the proportion of foreign citizens earning mathematics and physics doctorates. In fact, foreign students have accounted for nearly 85% of the growth in full time graduate enrollment in our doctorate granting institutions in the last decade.

We are fortunate to attract these talented people to our universities. Many foreign graduates of our educa-

FIG. 5

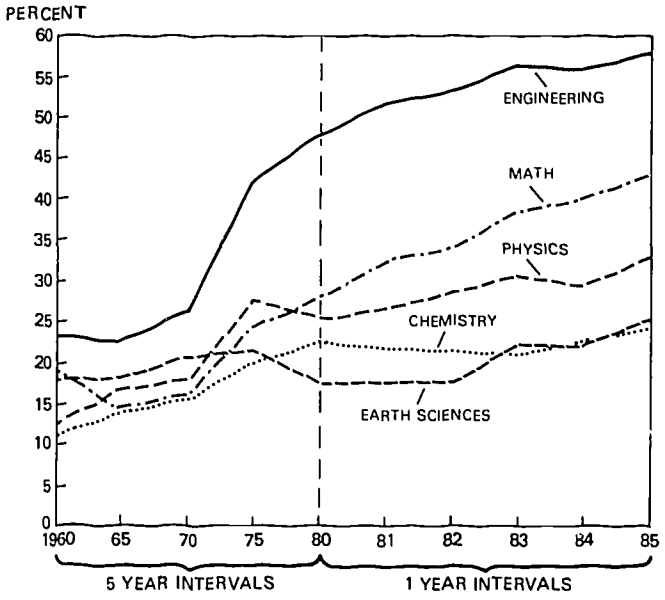
SCIENCE AND ENGINEERING BACCALAUREATES ATTAINING PH.D.'S SEVEN YEARS LATER



SOURCES: NATIONAL SCIENCE FOUNDATION, SRS AND CENTER FOR EDUCATION STATISTICS

FIG. 6

DOCTORAL DEGREES AWARDED TO FOREIGN STUDENTS AS A PERCENTAGE OF ALL DOCTORAL DEGREES FROM U.S. UNIVERSITIES, BY FIELD



SOURCES: NATIONAL SCIENCE FOUNDATION, SRS AND NATIONAL RESEARCH COUNCIL

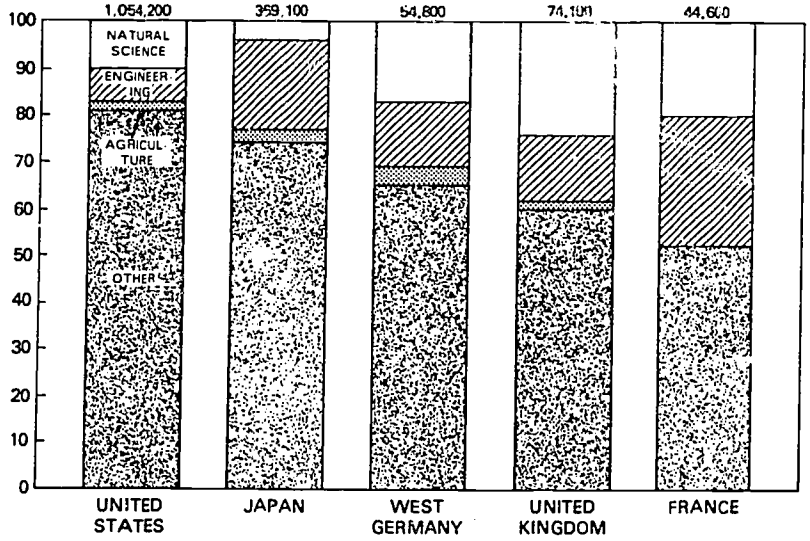
tional institutions remain in this country and make important contributions to research and education, and to our economy. Nevertheless, it is bad policy on our part to be dependent on an unpredictable resource and not to be able to meet more of our needs with American talent.

Compared to other industrialized nations, the United States awards the smallest proportion of first university degrees in the science and engineering fields (fig. 7). At the doctoral level, the United Kingdom and France have higher concentrations of degree recipients in the natural sciences than does the United States, and Japan awards a higher proportion of engineering degrees. These comparisons are important because the investment we make in human resources today fuels our factories and educational institutions tomorrow.

FIG. 7

INTERNATIONAL COMPARISONS: FIRST UNIVERSITY DEGREES BY FIELD

(PERCENT IN 1983)



SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

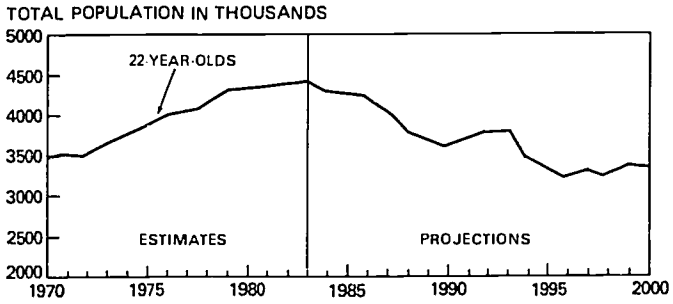
Demographics

Turning around these trends in degree and career selection is a large undertaking. Projected demographic trends will make the task of maintaining levels of degree production in the sciences and engineering even more difficult.

The number of 22-year-olds – the group from which bachelor's degree recipients are primarily drawn – has been dropping since 1983 and will continue to decline into the next century (fig. 8). This means that unless a greater *proportion* of the undergraduate population is attracted to the sciences and engineering than ever before, the *number* of future degrees in these fields will decline. Just to maintain present numbers, we may have to increase the attraction rate by as much as 50%.

FIG. 8

ESTIMATES OF 22-YEAR-OLDS IN THE U.S. POPULATION



SOURCE: BUREAU OF THE CENSUS

Resources to Meet the Need

How can we meet our anticipated need for scientists and engineers? Evidently, we must increase the rate at which undergraduates choose to major in these disciplines and the rate at which they decide to go on for graduate work in these fields. Again, changing demographics present us with a special challenge.

The time is past when white male graduates, even at increased rates of participation, might fill our needs. We must take advantage of *all* our resources, particularly women and underrepresented minorities.

The potential shortfall in science and engineering baccalaureates and in higher degrees could be alleviated if women increased their participation substantially from present levels. In fact, women enrolled for undergraduate study now outnumber men. They also earn one third of all Ph.D.s. However, despite the dramatic increases in the number of women in graduate programs, they earn only 16% of doctorates in the physical sciences, 15% in mathematics, and 6% in engineering. Furthermore, recent increases in the number of women in graduate and undergraduate scientific and technical programs, particularly in engineering, have begun to drop off.

Among minorities, the problem is even more serious. Today, Blacks and Hispanics represent about 20% of the total population but they account for less than 2% of

doctoral degrees in the physical sciences and engineering. By 2020, they will constitute one third of the population. An improvement in their rates of participation in undergraduate and graduate programs is therefore even more urgent.

Given the complex reasons for female and minority underrepresentation in the sciences and engineering, near-term changes will be difficult. But the development of human talent is a long-term process. That is why it is imperative that we deal with the situation now.

What Should We Do?

The data clearly paint a disturbing picture. How do we deal with it? No single action would be sufficient to solve this problem. It must be attacked at all levels and in all its elements.

That means we must begin where formal education starts, at the elementary school level. Several major reports, from the Department of Education, the National Science Board, the Carnegie Commission, and the National Governor's Association, have pointed to serious problems in primary and secondary education in this Nation, particularly in the sciences and mathematics.

The inferior performance of American students in mathematics, when compared to those of other nations, is just one aspect of a complex educational problem which includes an illiteracy rate of 10% and the failure of 25% of the population to complete high school. Unless our students acquire a proficiency in the sciences and mathematics in the early high school years and complete their schooling, it is difficult for them to pursue a career in engineering or the natural sciences.

We must face the problem of declining numbers among college students and increase the attraction rate to the sciences and engineering. That means targeting the elementary and secondary levels, with special attention to women and minorities. Strategies to achieve these ends must include many different elements, such as better prepared teachers and instructional materials, more fellowships, research opportunities for both teachers and students, and better equipped laboratories.

We must also remedy the rate at which minorities participate in science and engineering programs at the undergraduate level. Their rate is lower than that of non-minority students. Attracting minority students to

these programs is not enough. We must have programs to reduce drop-outs.

It also means improving the undergraduate curriculum. A recent report of the National Science Board points out that a deterioration of science, math, and engineering education at the undergraduate level is reflected by uninspired instruction, obsolete equipment, and outdated curricula.

Finally, our ability to attract people to the sciences and engineering is a function of the reward system. Today, there is a perception that law and business students are better off in their future careers than science and engineering majors. We must change this perception, and the reality behind it, if we want to compete successfully against other countries. With respect to attracting doctoral candidates to university research careers in particular, that means not only better faculty salaries, but also first class research opportunities and high quality instrumentation and facilities.

Conclusion

Our Nation's investment in science and engineering talent – and in research – pays enormous dividends to our society in the long run. It must be adequate to our needs and it must be protected against short term shifts that ignore the damage to our long term interest.

Science, mathematics, and computer literacy will increasingly become a requirement for almost all employment. The general competence of our population in these subjects will be an important element in determining our performance in the world arena. That requires basic preparation for all our children.

Science and engineering education also requires a commitment to nurturing our human talent through the higher levels of degree attainment. The training of scientists and engineers depends on a continuous and cumulative process of education. Disruptions in this process are costly and take precious years to overcome. This is a cost our Nation cannot afford.