Chapter 2

Demographic Trends: Undergraduate and Graduate Education

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Chapter 2

Demographic Trends: Undergraduate and Graduate Education

THE CHANGING COMPOSITION OF THE UNDERGRADUATE POPULATION

Significant changes in the size, composition, and career interests of the undergraduate population have characterized the past quarter century of American higher education. Demographic and other trends indicate that similar changes, although not as rapid or extreme, will also mark the next 20 to 30 years. Since the baccalaureate is the entry-level degree to a scientific or engineering career, the composition of the undergraduate population can be expected to have a significant effect on the size and make-up of the science and engineering work force. This section will examine the changing demographic and career patterns of the undergraduate population and discuss the implications of the trends for the size and quality of the scientific and engineering work force.

The explosion in higher education that took place in the 1960s saw undergraduate enrollments increase by 120 percent, from 3.3 million in 1960 to 7.4 million in 1970.[1] This sizable change was caused only in part by demographics. The number of 18 to 24 year olds, who constituted about 70 percent of the college population,[2] also increased over the decade, but at a substantially lower rate of about 54 percent.[3] Close to half of the increase in enrollment in the 1960s was caused by an increase in the rate at which high school graduates chose to participate in higher education. In 1960 only 23.7 percent of the 18 to 24 year olds that graduated from high school were enrolled in college: by 1970 that ratio had increased to 32.7 percent, where it remains today.[4]

In the 1970s, undergraduate enrollments increased by 47 percent (from 7.4 million in 1970 to 10.9 million in 1983),[5] but the population of 18 to 24 *year* olds only increased 22 percent. Most of the new college students were adults 25 years and older who doubled their participation in higher education as a whole (including graduate school) in that period. More than 70 percent of the new over-25 group were adult women, whose enrollment in higher education more than *tripled* between 1970 and 1983.[6] The overall share of women in higher education increased from 41.2 percent in 1970 to 51.7 percent in 1983.[7] Blacks increased from 6.9 percent of the higher education population in 1970 to 10.6 percent in 1978, but then fell back to 9.6 percent in 1982. Hispanics increased from 2.0 to 4.4 percent between 1970 and 1982; Asian Americans from 1.0 to 2.7 percent.[8]

In sum, from 1960 to 1983, the number of undergraduates increased by a factor of 3.3, from 3.3 to 10.9 million. About 60 percent of that change was due to demographics: a 1.9-fold increase in the number of 18 to 24 year olds. The remainder was caused by an increase in the rate at which high school graduates, especially adult women and minorities, chose to participate in higher education. These enrollment trends tended to favor public over private institutions and 2-year colleges over 4-year colleges. Enrollments in public institutions increased by a factor of 4.2 (from 2.3 to 9.7 million) in the 23-year period; enrollments in 2-year colleges increased more than sevenfold (from 650,000 to 4.7 million).[9]

[1] *Statistical Abstract, 2982-1983* (Washington, DC: U.S. Department of Commerce, Bureau of the Census, 1984), p. 159, corrected to include unclassified pre-baccalaureates; and *The Condition of Education* (Washington, DC: National Center for Education Statistics, 1985), p. 98.

[2] *The Condition of Education* (Washington, DC: National Center for Education Statistics, 1984), p. 72.

[3] *Projections of the Population* (Washington, DC: U.S. Department of Commerce, Bureau of the Census, 1984), p. 7.

[4] *Statistical Abstract (Washington,* DC: U.S. Department of Commerce, Bureau of the Census, 1985), p. 149.

[5] *Condition of Education*, op. cit., 1985, p. 79.

[6] Ibid,

[7] Ibid., table 2.4, p. 94.

[8] *Statistical Abstract*, op. cit., 1985, p. 152.

[9] *Statistical Abstract, 1982-83*, op. cit., p. 159, corrected to include non-degree credit students; and *Condition of Education*, op. cit., 1985, p. 79.

BACCALAUREATES

The doubling in the enrollment of undergraduates in the 1960s was accompanied by a doubling in the number of bachelor's degrees awarded in the course of the decade. In 1960, 395,000 students received B.A.s and B.S.s from the Nation's colleges and universities; by 1970 that number had increased by 112 percent to 840,000.[10]

The 1970s saw a very different pattern. Although the number of undergraduates increased by 47 percent between 1970 and 1983, the number of baccalaureates only increased by 16 percent (from 840,000 to 970,000).[11] The number of awards below the bachelor's degree granted in occupational curricula (business and commerce technologies, data processing technologies, health services and paramedical technologies, mechanical, engineering, and electronic technologies) increased 160 percent (from 154,000 to 400,000).[12] Thus baccalaureates decreased from 84.5 to 70.4 percent of the total undergraduate degrees awarded in the 1971-82 time frame.

The trend toward occupationally oriented degrees is mirrored by the changing mix of fields within the baccalaureate in the 1970s. As figure 2-1 shows, the number of bachelor's degrees in job-related fields, especially business and management, increased dramatically in the 1970s, while arts and sciences degrees declined substantially.[13] According to the National Center for Education Statistics (NCES):[14]

[10] *Statistical Abstract, 1979* (Washington, DC: U.S. Department of Commerce, Bureau of the Census, 1979) p. 168; Condition *of Education,* op. cit., 1985, p. 90.

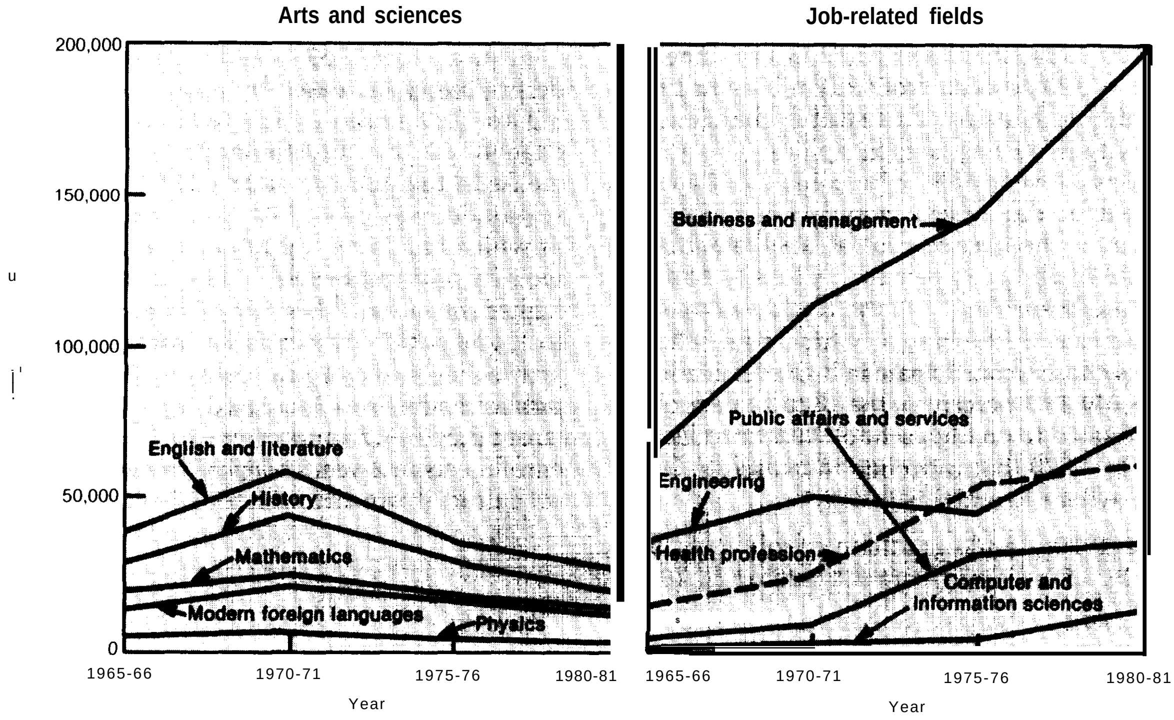
[11] *Condition of Education,* op. cit., 1985, p. 90.

[12] Sue E. Berryman, "The Adjustment of Youth and Educational Institutions to Technologically-Generated Changes in Skill Requirements," prepared for the National Commission for Employment Policy, May 1985, pp. 30 and 31.

[13] *Digest of Education Statistics,* 1983-1984 (Washington, DC: National Center for Education Statistics, December 1983), p. 119.

[14] Ibid., p. 118.

Figure 2-l.—Bachelor's Degrees Conferred in Selected Fields: United States, 1965-66 to 1980-81



SOURCE U S Department of Education, National Center for Education Statistics, *Digest of Education Statistics, 1983-84,* p 119

In **1965-66** degrees in English and literature, history, mathematics, modern foreign languages, and physics constituted **20.4** percent of all bachelor's degrees conferred . . . . by 1980-81 they had declined to 7.4 percent of the total . . . .

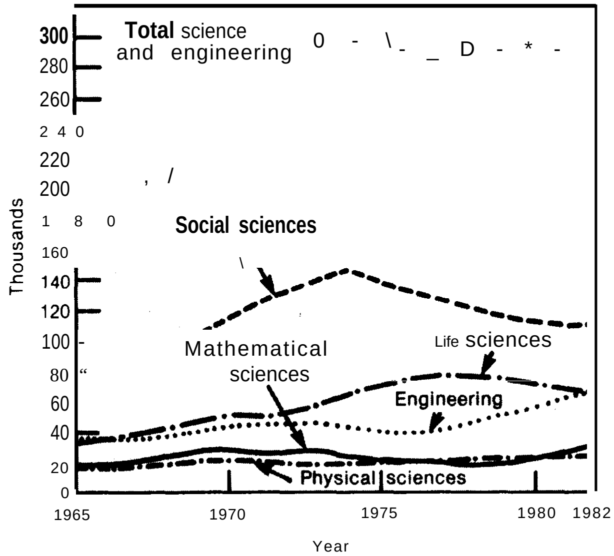
In 1965-66 degrees in business and management, engineering, the health professions, public affairs and services, and computer and information sciences comprised **22.6** percent of the total bachelor's degrees conferred . . . . in 1980-81 [they were] 41.8 percent . . . .

At least one occupationally oriented field has not participated in the general rise in recent years. Bachelor's degrees in education . . . peaked at **194,000** in 1972-73 and subsequently declined by 44.3 percent to 108,000 in 1980-81. There has been an annual decrease in public school enrollments for a decade, and this has adversely affected the demand for new elementary and secondary school teachers.

At first glance it appears that science and engineering fields have been immune from these striking changes in undergraduate career preferences. According to the National Science Foundation (NSF), science and engineering fields represented approximately 30 percent of the bachelor's and first professional degrees awarded every year from 1952 to 1982. In no year have they exceeded 32 percent or fallen short of 28 percent. (Unfortunately, the NSF tables and charts include first professional degrees, such as the M. D., D.D.S. D.V.M, and J. D., with bachelor's degrees, so the numbers are not strictly comparable to those presented above.) The total number of science and engineering bachelor's degrees and first professional degrees has remained within the 280,000 to 305,000 range since 1972.

This apparent constancy, however, masks some striking changes taking place within and between fields (see figure 2-2). From 1960 to 1974 the percentage of total B.A. s and first professional degrees awarded in the physical sciences and engineering fell from 4.1 and 9.6 percent, respectively,

Figure 2.2.— Bachelor's and First-Professional Degrees in Science and Engineering



SOURCE National Science Foundation. *Science and Technology Resources*, NSF 85-305, 1985 p 73

to 2.1 and 4.3 percent. That decline was accompanied by an increase in the percentage of degrees awarded in the social sciences from 8.0 to 14.4 percent. Between 1974 and 1982 the trend reversed itself, and engineering degrees increased from 4.3 to 6.5 percent of the total, while social science degrees fell from 14.4 to 10.9 percent. "

Science and engineering baccalaureates, therefore, appear to follow the same trends as total baccalaureates; increasing with total college enrollments through the 1960s and then going up only very gradually in the 1970s and early 1980s. Individual fields, however, follow changes in undergraduate interests, such as the shift from the natural sciences to the social sciences in the 1960s and from academic subjects to job-oriented subjects in the 1970s. **It is a combination of demographic forces and career and educational choices** (strongly influenced by **market considerations) that determines the number of bachelor's degrees that will be produced in a science or engineering field in a given year.**

Science and Engineering Personnel: A National Overview, NSF 85-302 (Washington, DC: National Science Foundation, 1985), p. 154.

Ibid.

FUTURE TRENDS: DEMOGRAPHICS

According to demographer Harold Hodgkinson, three major demographic trends will affect colleges and universities over the next quarter century. The first is the already cited decline in the population of 18 to 24 year olds:[17]

> Higher education can look forward to a general decrease in the size of high school graduating classes for 16 years, followed by increased numbers of high school graduates beginning in 1998. . . .

Most recent Census Bureau projections (Middle Series) indicate that the number of 18 to 24 year olds will decline from 30.4 million in 1982 to 23.3 million in 1996, a 23.4-percent decrease .18 This is the group that participates at the highest rate in higher education. As can be seen from table 2-1, for every 100 members of the 18- to 21-year-old population there are 27 full-time equivalent (FTE) students in higher education, (The number of "full-time equivalent students" is equal to the number of full-time students plus one-third the number of part-time students,) The ratio for 22 to 24 year olds is 11.5, and the ratios for all other age groups are much lower. [19]

Using the ratios in table 2-1 and the Census Bureau Middle Series projections of the population by age group,[20] it is relatively straightforward to construct a table of potential FTE enrollments in higher education for the rest of the century (and even to the year 2020, if one is willing to accept population projections based on births that have not occurred yet). Figure 2-3 shows a continued decline in FTE enrollments through 1996, with the minimum in that year at 85 percent of the peak in 1981. Enrollments then increase through the first decade of the 21st century, with a new peak occurring in 2010 about 15 percent above the 1996 minimum. 2]

These projections are based on a model developed by Carol Herring and Allen Sanderson that assumes existing patterns of enrollment in higher education among different age groups will continue for the next quarter century. Other assumptions could produce strikingly different results. For example, the number of 25 to 34 year olds in undergraduate education increased by nearly 70 percent in the decade 1972-82, as compared to an increase of only 23 percent in the number of 18 to 24 year olds. If this older group, which will remain relatively constant in population over the next decade, continues to increase its rate of participation in undergraduate education, it could partially offset the decline in 18 to 24 year old en-

"Harold Hodgkinson, "College Students in the 1990's: A Demographic Portrait, " *The Education Digest*, November 1983, pp. 28-31.

[18] *Projections of the Population*, op. cit., pp. 38 and 65.

[19] Carol Herring and Allen R. Sanderson, *Doctorate Employment: Supply and Demand Considerations, 1981-2000* (Princeton, NJ: Princeton University, 1981), p. 8.

[20] *F'rejections of the Population*, op. cit., pp. 30-81.

[21] FTEs through 2000 calculated by Herring and Sander-son, op. cit., FTEs, 2000-20 calculated by Eugene Frankel.

Table 2.1.— Full-Time Equivalent Enrollments

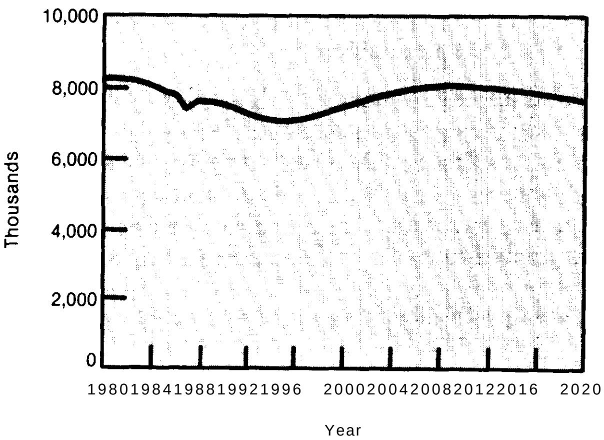
	As a percentage of the total population			
Age group	1968a	1973a	1978a	1980-2000b
17	7.1 "/0	6.70/o	5,80/o	6.00/0
18-21	28.0	28.0	26.0	27.0
22-24	9.7	11.2	11.4	11.5
25-29	4.0	5.0	5.0	5.0
30-34	1.9	2.5	3.0	3.0
35-59	0.4	0.6	0.8	0.8

[a] Actual

[b] Assumed based on current trends

SOURCE Carol P Herring and Allen R Sanderson. "Doctoral Employment Supply and Demand Considerations, 1981.2000, " Princeton University April 1981, p 8

Figure 2-3.— Projected Full-Time Equivalent Students in Higher Education



SOURCE Carol P Herring and Allen R Sanderson. Doctoral Employment Supply and Demand Considerations, 1981-2000, Princeton University, April 1981 p 8: and Office of Technology Assessment rollments.[22] specifically, if one assumes that ‘he percent enrollments in higher education of 30 to 34 year olds and 35 to 59 year olds will continue to increase at the rates they increased between 1968 and 1978 (0.1 and 0.04 percent per year), it would generate an additional 1 million full-time equivalents in 1996. The decline of 15 percent in FTEs between 1981 and 1996 would become a much less problematic decrease of only 2.4 percent.

Herring and Sanderson argue against these more optimistic assumptions :[23]

> There are those who . . . argue that the growth in "non-traditional" enrollments will more than compensate for the loss of the traditional population base in higher education. We disagree . . . . The recent increase [in non-traditional enrollments] has been due in large measure to women going back to school, and at the present time they make up about half of the enrolled students. Therefore, the impact of this catching up phenomenon—in which women were making up for missed educational opportunities—is expected to level off . . . . Part of the increase in older students can also be traced to the effects of the Vietnam War and the GI Bill. These effects, too, have undoubtedly run their course, and most veterans who are going to return to school on the GI Bill have done so by now.

The NCES projection of enrollments in higher education for 1993 is consistent with Herring and Sanderson's results. It projects a drop in FTE enrollments of 12.3 percent between 1983 and 1993.[24] Herring and Sanderson also project a drop of 12.3 percent. It is worth noting that in the NCES projections the fraction of enrollments that are part time increases from 42.9 percent in 1983 to 48.3 percent in 1993.

The second major trend noted by Hodgkinson is the increasing proportion of the college age population that will be made up of racial *or* ethnic minorities: 25

> The major decline in births after the baby boom was almost completely a Caucasian phenomenon. Birthrates for minorities stayed even during those years, resulting in an increased percentage of births coming from minorities . . . . The conclusion for higher education is inescapable: American public schools are now very heavily enrolled with minority students, large numbers of whom will be college eligible . . . . Out of sheer self-interest, it behooves the higher education community to do everything to make sure that the largest possible number of minority students do well in publIic school . . . . By 1990, minorities of all ages will constitute 20 to 25 percent of our total population, while their percentage among youth cohorts will be over 30 percent. In some states, minorities will be over 45 percent of the state birth cohorts.

Public school enrollments in 1980 presage these trends. Of the 46 million students enrolled in the Nation's public elementary and secondary schools in 1980, 26.7 percent were minority. of the largest minority groups, blacks represented 16.1 percent of enrollments, Hispanics, 8.0 percent.[26] Seven States and the District of Columbia had minority student populations in excess of 35 percent; 11 others exceeded 25 percent (see figure 2-4),[27] In addition, 23 of the 25 largest city school systems in the Nation had a majority minority population in 1980.[28]

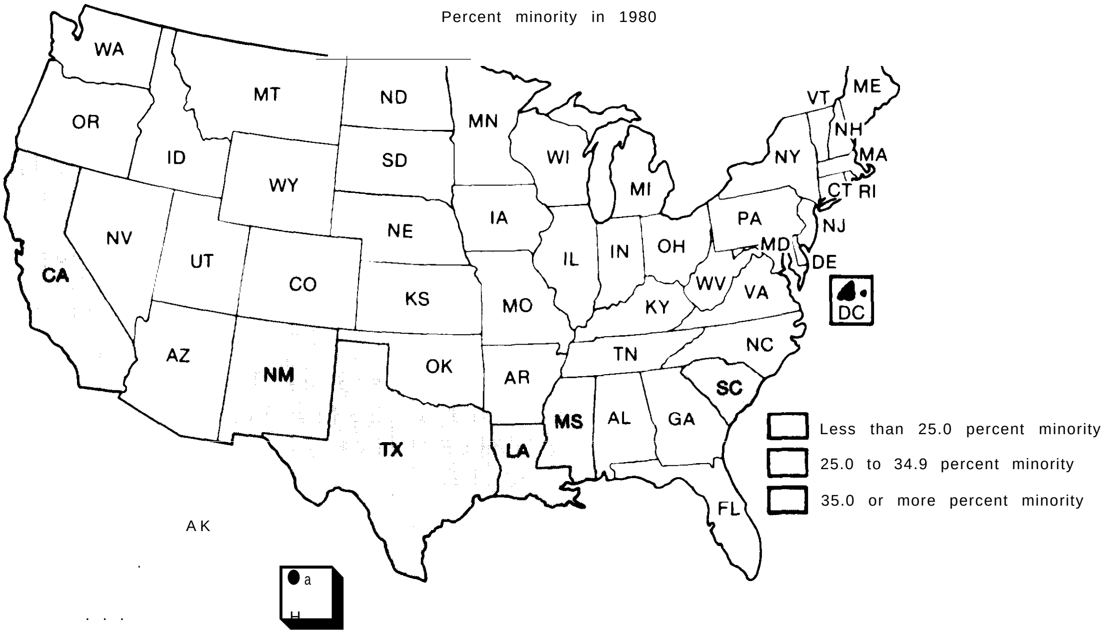
The report of a 1983 forum on "The Demographics of Changing Ethnic Populations and Their Implications for Elementary-Secondary and Post-secondary Educational Policy" concludes that :[29]

> Based on the demographic data . . . it seems clear that much greater attention will have to be paid to the needs of minority young people, and to the development of programs that are more responsive to their backgrounds and interests, for facilities and equipment to sustain these programs, and for teachers specificall y trained to teach particular populations. . . . More research is needed into how young people of different backgrounds learn, and existing research should be mined and adapted for practical application to local conditions.

"*Digest of Educational Statistics, 1983-1984,* op. cit., p. 98.
"Herring and Sanderson, op. cit., p. 6.
"*The Condition of Education*, op. cit., 1985, pp. 96 and 100.
[25]Hodgkinson, Op. cit., P. 29"

‘**The Condition of Education*, op. cit., 1985, p. 18.
[27]1 bid., pp. 18 and 19.
[28]Ian McNett, "Demographic Imperatives: Implications for Educational Policy, " Report of the June 8, 1983, Forum on "The Demographics of Changing Ethnic Populations and Their Impl icat ions for Elementary-Secondary and Postsecondary Educational Policy, " p. 10.
[29]1 bid., p. 20.

Figure 2-4.—Minority Enrollment As Percent of Public Elementary/Secondary School Enrollment, by State



SOURCE National Center for Educallon Statistics, *The Condition of Education, 1984 Edition*, p 19

A third trend noted by Hodgkinson and others is the striking variation in population growth from region to region. As can be seen from figure 2-5,[30] the number of high school graduates is expected to decrease between 1981 and 2000 in the North, East, South, and Central sections of the country, while increasing in the West, Far West, and Southwest. Moreover, some of the increases (in Wyoming, Nevada, Utah, Texas, and Alaska) will be as large as 48 to 76 percent, while some of the decreases (in Michigan, Massachusetts, New Hampshire, Rhode Island, Delaware, and District of Columbia) will be as great as 30 to 51 percent .[31]

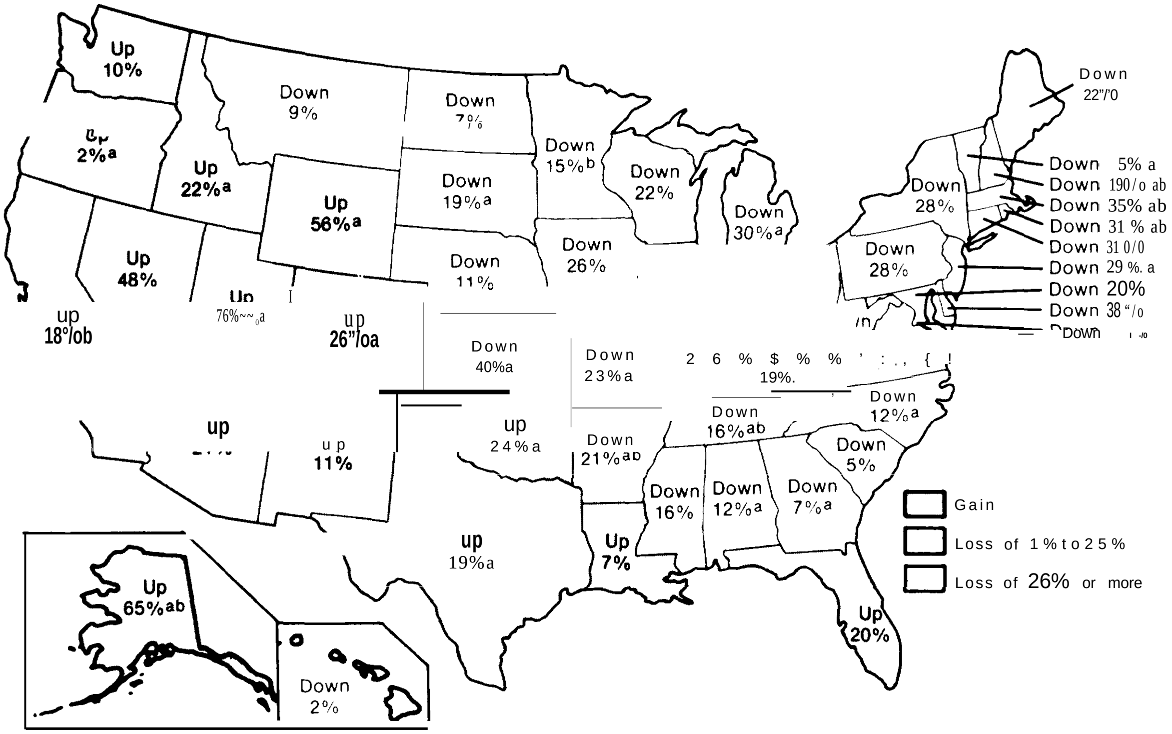
[30]Harold L. Hodgkinson, "Demographics and the Economy: Understanding a Changing Marketplace, " The *Admissions Strategist*, January 1985, pp. 1-6.
[31]Hodgkinson, op. cit., 1983, p. 29.

Thus [according to Hodgkinson] we are faced for the first time with a "two nation" perspective on educational policy—trying to get more educational facilities and services for youth in the Sun Belt, and continuing to cut back on these same services in the Frost Belt. It is hard to imagine how a single federal policy on educational assistance can be equitable in both "nations. " Further, since we can expect that institutions of higher education in the Sun Belt will begin to show gains in undergraduate student populations, while the Frost Belt institutions can look forward to at least a decade of decline in enrollments, it will be very difficult to present the "needs" of higher education to the U.S. Congress by 1990.

IMPLICATIONS FOR SCIENCE AND ENGINEERING PERSONNEL AND EDUCATION POLICY

The implications of these trends for science and engineering education appear to be the following: As the number of college graduates available for science and engineering careers decreases, it will become increasingly important to ensure that all potential resources are utilized to the fullest ex-

Figure 2-5.—Projected Changes in Graduates, by State, 1981-2000



aProjections include graduates of public high schools only All other State protections include public and nonpublic high school graduates
bProjections are for 1998-99

SOURCES. Western Interstate Commission for Higher Education. and Harold L Hodkinson, "Demographics and the Economy Understanding a Changing Marketplace, " *The Admission Strategist*, January 1985, p 3

tent possible, and that no qualified candidates for science and engineering education are discouraged by problems related to gender, race, or ethnic background. Hence, policies to promote equality of opportunity for women and minorities will take on increasing relevance to science and engineering "manpower" policy.

Blacks and Hispanics may be of special concern. They tend to participate in higher education at half the rate of their white counterparts, and tend to select quantitative fields as majors once in college or graduate school at one-half (for blacks) to three-fourths (for Hispanics) the rate of the white student population,[32] As the fraction of the college age population increases, programs to promote equality of access to science and engineering careers for minority groups may have to be expanded in order to prevent a decline in the number of science and engineering degrees awarded. These programs will be discussed in greater detail in chapter 5.

It is not possible to judge unequivocally the effects of a drop of 15 percent in the number of science and engineering baccalaureates on the Nation's scientific and technical efforts. NSF data displayed in table 2-2 show that only 43 percent of the science and engineering baccalaureates in 1980 and 1981 were employed in a science or engineering field in 1982.[33] Of the remaining science and engineering baccalaureates, 28 percent found work outside science and engineering altogether, 21 percent went *on* to graduate school in science

[32] Sue E. Berryman, *Who Will Do Science* (New York: The Rockefeller Foundation, 1983), pp. 18-21.

[33] *National Patterns of Science and Technology, 1984*, NSF 84-311 (Washington, DC: National Science Foundation, 1984), p. 24.

Table 2-2.—Transition of 1980 and 1981 Science/Engineering (S/E) Graduates From School to Work in 1982 (percent)

Degree level/field	Total	Employed			Full-time graduate students	Not employed	
		Total	In S/E	Outside S/E		Seeking employment	Outside labor force
Bachelor's degrees:							
All S/E	100	71	43	28	21	5	4
Physical sciences[a]	100	53	41	12	40	4	3
Mathematics	100	80	57	23	13	4	4
Computer specialties	100	94	85	9	3	2	1
Engineering	100	89	78	10	7	3	2
Life sciences	100	58	34	24	33	5	5
Social sciences[b]	100	68	21	46	22	6	5
Master's degrees:							
All S/E	100	74	55	19	21	3	2
Physical sciences[a]	100	65	47	18	29	3	3
Mathematics	100	77	56	21	17	3	3
Computer specialties	100	88	76	12	10	1	1
Engineering	100	82	72	11	14	2	2
Life sciences	100	65	47	17	31	2	3
Social sciences[b]	100	68	34	34	24	6	3

[a]Includes environmental sciences
[b]Includes psychology

SOURCE National Science Foundation, *National Patterns of Science and Technology Resources,* NSF 84.311. p 24

and engineering and other fields and another 5 percent were still seeking employment. Thus, it appears that the Nation is currently producing more science and engineering baccalaureates than are absolutely required by the science and engineering work force.

This finding clearly does not hold true for engineering and computer science, which showed employment rates in science and engineering of about 80 percent. However, engineering and computer sciences illustrate another important feature of the science and engineering marketplace: the extreme responsiveness of undergraduates to market signals and career opportunities. Undergraduate enrollments in both computer science and engineering have increased dramatically in the last 8 years in response to excellent job opportunities for baccalaureates in those fields, as discussed in chapter 1. If other scientific fields were to require greater numbers of technically trained baccalaureates, market signals alone would attract an increasing supply of undergraduates to them. As Sue Berry man has found:[34]

> Overall, the data on the levels and fields of completed degrees suggest that youth respond to oversupplies by earning fewer degrees in oversupplied fields. If they enter an oversupplied field, they increase the amount of education they obtain—presumably to increase their competitiveness in a loose labor market. They respond to shortages or more liberal employment opportunities by increasing their educational investments in these fields at the lower degree levels and reducing them at the higher degree levels—presumably because they are in a seller's market.

[34]Sue E. Berryman, "The Adjustment of Youth and Educational Institutions to Technologically-Generated Changes in Skill Requiremerits, " op. cit., p. v.

GRADUATE EDUCATION

Graduate school is the principal training ground for a research career. Here the student gains the advanced knowledge and techniques that are the tools of the research trade, and forms the professional contacts that shape a research career. A great deal of detailed information about science and engineering graduate education is available from the National Science Foundation, the National Academy of Sciences, the Institute of Medicine, and the science and engineering professional societies. Science and engineering graduate students are classified by field, degree, source of support, type of institution, sex, racial and ethnic group, and citizenship. Ph.D. scientists are probably the most thoroughly surveyed and well-documented citizens in the United States. This section summarizes the principal trends in graduate education, focusing on the doctoral degree as the entry level to a research career.

Graduate enrollments have followed a pattern similar to that of undergraduates in the past quarter century, dramatically increasing in the 1960s and then rising more modestly in the 1970s and early 1980s. However, the relationship to larger demographic trends is far more tenuous than in the undergraduate case. From 1960 to 1970 graduate enrollments nearly tripled, rising from 360,000 to over a million, while at the same time, the population of 22 to 34 year olds increased by only 18 percent.[35] From 1970 to 1982, by contrast, the number of graduate students increased only modestly, by 30 percent, while the overall population of 22 to 34 year olds rose more than 55 percent.[36] (See below.) Thus there appears to be no direct relationship between graduate enrollments and the graduate school age population.

Science and engineering have followed overall graduate enrollment trends quite closely. From 1960 to 1970 the number of full-time graduate science and engineering students enrolled in U.S. institutions increased 150 percent, from about 78,000 to 188,000.[37] By 1982 that number had reached 264,000, a further increase of 40 percent .38 (An additional 150,000 science and engineering graduate students were enrolled part time, bringing the total to 414,000.[39]) Enrollment growth was greatest in the social sciences and the life sciences over the full 23-year period, as can be seen from figure 2-6, and weakest in engineering, physical science, and especially mathematics and computer science. 40

The number of doctorate degrees awarded annually in all fields tripled in the decade of the 1960s, reaching a peak in 1973 at 33,755. It has subsequently declined to a level of 31,000 per year, where it has remained since 1978 (see above and figure 2-7).[4'] The number of science *and engineering* Ph.D. s grew slightly less rapidly, by a factor of 2.85 between 1960 and 1970. It reached a peak at 19,009 in 1972 and has subsequently declined to a nearly constant level of 17,500 to 18,000 per year in the 1980s, '2 The share of total doctorates awarded in science or engineering decreased from 65 percent in the early 1960s to 55 percent by the late 1970s.[43]

"*Statistical Abstract, 1982-83,* op. cit., pp. 25 and 159.

"*Condition of Education,* op. cit., 1985, p. 79; *Projections of the Population,* op. cit., p. 38.

[37]Susan Fallows, "Federal Support for Graduate Education in the Sciences and Engineering," background paper prepared for the Ad Hoc Committee on Government-University Relationships in Support of Science, National Academy of Sciences, 1983, p. 10.

[38]*Academic Science Engineering: Graduate Enrollment and Support, Fall 1982,* NSF 85-300 (Washington, DC: National Science Foundation, 1985), p. 20.

[39]Ibid.

[40]Fallows, op. cit. , p, 12"

"I bid., pp. 31 and 32; *Science and Engineering Personnel: A National Overview',* op. cit., p. 156, gives slightly different numbers for total Ph. D.s: 9,733 in 1960; 29,498 in 1970.

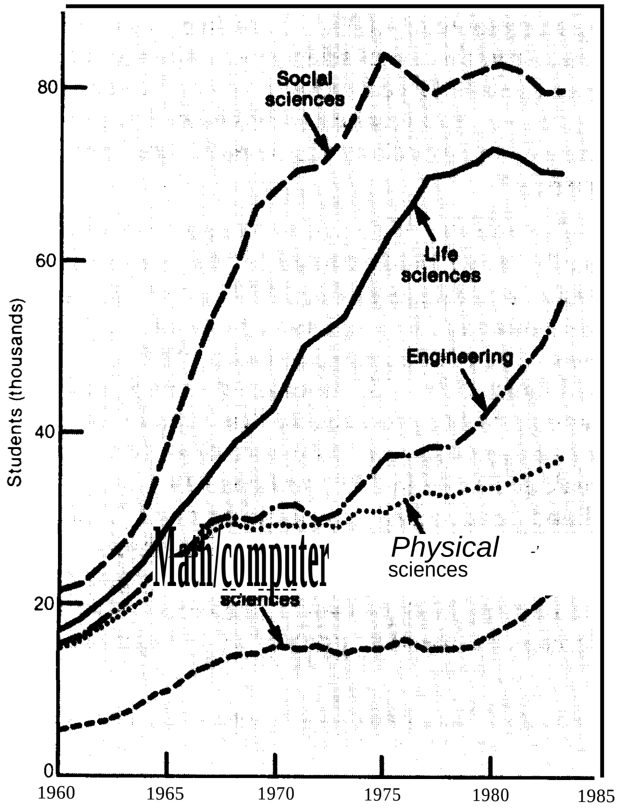
[42]Fallows, op. cit., p. 31.; *Science and Engineering Personnel: A National Overview,* op. cit., again gives different numbers, 6,263 science and engineering Ph .D. s in 1960 and 17,743 in 1970. This is due to a difference in classification of life science and social science fields between the National Science Foundation and the National Academy of Sciences.

[43]*Science and Engineering Personnel: A National Overview,* op. cit., p. 156.

Graduate Population, Enrollments, Ph.D.s

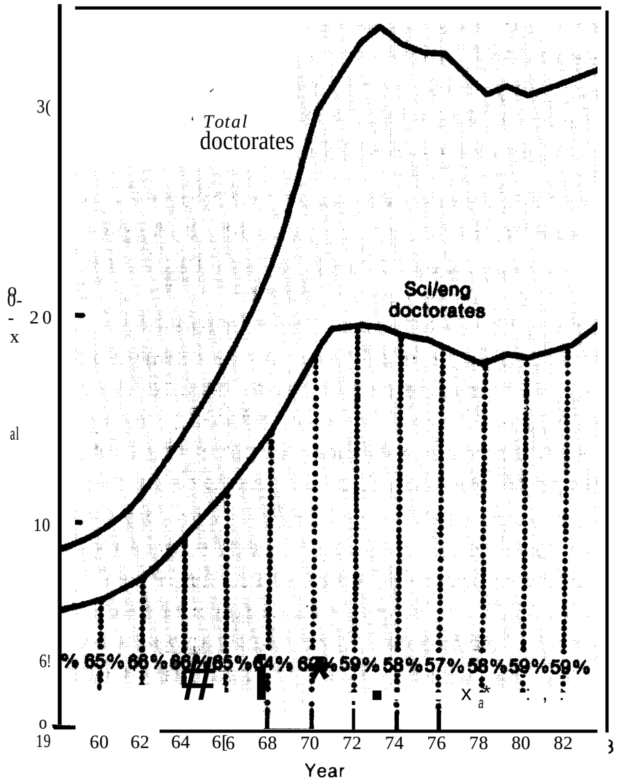
	1960		1970		1983
population of 22 to 34 year olds. ... , ...	29,250,000		34,500,000		53,600,000
(percent change)		(+18 perdent}		(+55 percent)	
Total graduate enrollment , ...	356,000		1,031,000		1,339,090
(percent change)		(+200 percent)		(+30 percent)	
S/E full-time enrollment , ... ,	’8		187,843		263,800
(percent change)		(+l50 percent)		(+ 40 percenO	
Ph.D.s per year, all fields..	9,132		29,479		31,190
(percent change)		(+223 percent)	‘	(+6 percent)	
S/E Ph.D.s per year	6,263		17,743		17,924
(percent change)		(+183 percent)		(+1 percent)	

Figure 2-6.—Full-Time Graduate Enrollments in Science/Engineering at U.S. Institutions, by Field and by Year, 1960-83



SOURCE Susan Fallows, *Federal Support for Graduate Education in the Sciences and Engineering* (Washington, DC National Academy of Sciences, 1983) p 12

Figure 2-7.—Number of Doctorates Awarded by U.S. Institutions, by Field and by Year, 1958-83



SOURCES Susan Fallows, *Federal Support for Graduate Education in the Sciences and Engineering* (Washington DC National Academy of Sciences 1983) p 12 and National Research Council *Doctoral Recipients from United States Universities Summary Report 1983* p 5

The number of Ph.D.s awarded annually grew at roughly the same rate in all science and engineering fields during the 1960s, as can be seen from figure 2-8. In the early 1970s, however, the paths of the different disciplines began to diverge. The number of doctorates awarded annually in engineering, and the mathematical and physical sciences decreased by 30 percent between 1971 and 1978, dropping from 4,500 to 3,200 per year in the physical sciences, from 3,500 to 2,400 in engineering and from 1,300 to 960 in mathematics and computer science. Meanwhile, the number of life science Ph. D.s remained constant at about 4,4oo per year, while the number of social science Ph. D.s increased from 5,000 to 6,000 per year.[44] Since 1978 the number of doctorates awarded each year in the various science and engineering fields has remained relatively constant, with modest increases taking place in engineering and the life sciences.

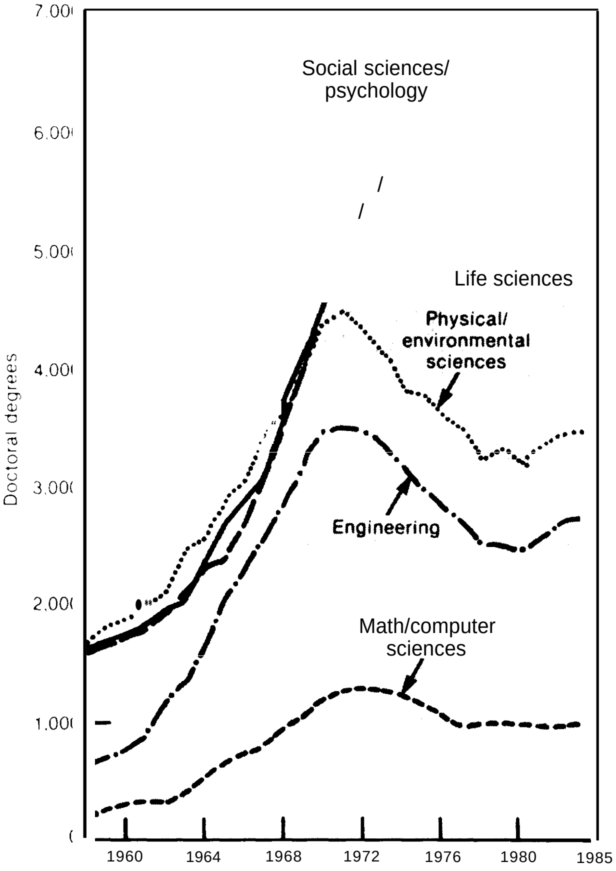
The changes in graduate enrollments and annual doctorates awarded in the different science and engineering fields are related to broader changes in the composition of the graduate school population since 1970. Women and foreign nationals have dramatically increased their shares of both enrollments and doctorates over the past 15 years, with the effects varying from field to field. According to educational consultant Robert Snyder:[45]

> It is important to note that graduate science and engineering enrollments would have remained

[44] Fallows, op. cit., p. 33.

[45] R. C. Snyder, "Some Indicators of the Condition of Graduate Education in Science and Engineering," paper presented at The Brookings Institution, Nov. 15, 1984, typescript, pp. 4-5.

Figure 2-8.— Doctorate Degrees in Science and Engineering by Field and by Year, 1958-83



SOURCES Susan Fallows *Federal Support for Graduate Education in the Sciences and Engineering* (Washington, DC National Academy of Sciences 1983} p 12, National Research Council *Doctoral Recipients From United States Universities, Summary Report,* 1983 p 5, and National Science Foundation *Science and Technology Resources.* NSF 85305 January 1985 pp 63-65

flat, were it not for the marked increases in female and foreign enrollments. With respect to gender differences, female full-time enrollment in doctoral institutions rose 53 percent in the 1975-**1982** time period, compared to level enrollment for men. While sharp percentage increases occurred in engineering, environmental and computer sciences, these increases were built upon a meager base. Therefore, as of 1982, women comprised only 11 percent of ful1-time engineering students, *20* percent in physical/environmental sciences and **25** percent in mathematical/computer sciences. The greatest impact of female enrollment increases has been in the biological sciences (**4o** percent women) and psychology/social sciences (**46** percent women). In fact, *male* full-time enrollment in the **1975-82** period declined 14 percent in the biological sciences and 17 percent in psychology /social sciences compared to *female* increases of **38** and **35** percent, respectively, in the same period. Thus female enrollments were wholly responsible for positive enrollment trends in these two broad fields.

In [the "EMP" sciences], enrollment increases have been due significantly to surging enrollments of foreign students. In engineering, foreign full-time enrollments rose at an average annual rate of **8.4** percent from 1975 to 1982, reaching almost 21,000 students or 43 percent of total full-time students in this broad field. This compares to an annual increase among U.S. citizens of only 1.6 percent, An even larger discrepancy was in mathematics/computer sciences. Here, foreign enrollments increased at a rate of 12.7 percent per year, to a **36** percent share of full-time enrollments, compared to a 0.5 percent per year increase for U.S. citizens. One encouraging note is that in 1981-82, the most recent year for which data are available, U.S. enrollments in both these broad fields rose at much higher rates than previously.

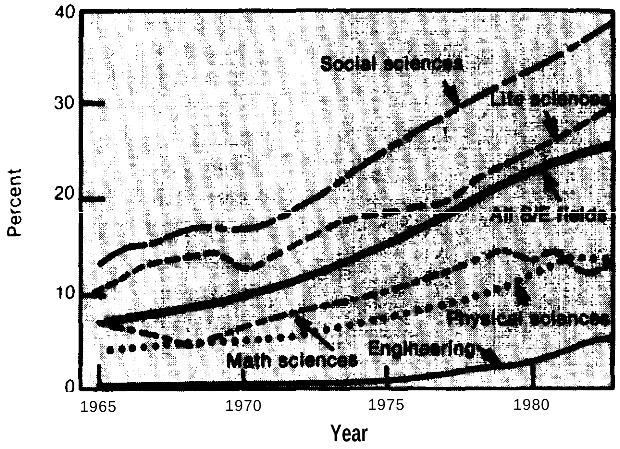
With respect to minority participation in graduate science and engineering education, the picture in recent years is not encouraging. While extended trend data are not available, recent NSF data show very low rates of participation. For all fields, blacks comprise only 2.5 percent and Hispanics 2.1 percent of full-time science and engineering enrollments in 1982.

Data on doctoral degree production confirm these trends. Figure 2-9 shows the dramatic increases in percentage of Ph. D.s awarded to women in all fields between 1965 and 1983.[46] Table 2-3 shows the dramatic increase in the percentage of science and engineering doctoral recipients who were foreign nationals on temporary visas between 1970 and 1983 in physics/astronomy, chemistry, mathematics, and engineering. The first two fields increased by more than a factor of 2; the last two by a factor of 3.[47]

[46] *Opportunities in Science and Engineering* (Washington, DC: Scientific Manpower Commission, 1984), p. 8.

[47] *Professional Women and Minorities* (Washington, DC: Scientific Manpower Commission, August 1~841, p. 32,

Figure 2.9.— Percent of S/E Ph.D.s Earned by Women



SOURCE Scientific Manpower Commission, *Opportunities in Science and Engineering,* Washington, DC, 1984, p. 8.

Table 2-3.—Percent of S/E Doctoral Recipients Who Were Foreign Nationals on Temporary Visas, Selected Years

Field	1962	1966	1970	1974	1980	1983
Physics/astronomy	13.70/0	12.20/0	11 .3'%	17.2°\o	19.2°\o	24.60/o
Chemistry	9.7	11.1	7.9	10.2	15.4	16.1
Earth/environmental science	9.2	12.9	13.9	16.1	12.7	16.6
Mathematics	16.8	12.6	10.9	18.5	18.7	29.8
Economics	17.2	20.1	17.2	22.0	25.0	25.9
Political science	19.1	13,0	9.3	10.8	11.9	13.9
Engineering	17.9	16.7	13.7	22.4	34.3	42.1
Biological science	14.4	14.3	10.5	10.5	7.8	8.6
Medical science	14.6	18.6	16.6	9.4	11.3	13.7
Agricultural science	23.8	30.4	25.3	33.2	32.6	31,2
Total S/E	15.2%	15.30/0	12.50/o	16.70/o	18.80/0	15.5%

SOURCE Scientific Manpower Commission, *Professional Women and Minorities.* Washington, DC, 1984, p 32

FEDERAL SUPPORT FOR GRADUATE EDUCATION IN SCIENCE AND ENGINEERING

The pattern of graduate enrollment and Ph.D. production in science and engineering in the 1960-7.s era is also related to the changing nature and level of Federal support for graduate education in those fields. Since World War II, the Federal Government has utilized a variety of mechanisms to support graduate students and further the goal of enhancing the Nation's resources of highly trained scientists and engineers. Fellowships and traineeships are the direct forms of support for graduate students that have been most frequently used to target areas of perceived personnel need. Research grants and institutional support have also provided essential, though indirect, means of supporting graduate education.

Fellowships are tuition/stipend mechanisms that are awarded directly to students through national competition. Award is made principally on the basis of merit, the intent being to attract the best students available into a particular field or problem area. Fellowships are portable in the sense that the awardee is free to enroll in any qualified institution to which he/she can gain admittance.

Federal traineeship programs (sometimes called "training grants"), in contrast to fellowships, are blocks of student tuition/stipend awards that are made to departments or institutions on a multi-year basis. Traineeships focus on the training program, not the student. Departments typically apply for training grants in national competition, and awards are made by peer review so that high quality standards are met. Because of the multiyear block nature of training grants, they are well suited to target personnel at social problem solving areas as well as broad fields of science. The National Institutes of Health (NIH) training grants, historically the largest of these programs, have been used for both purposes.

Federal research grants are an important vehicle for training and support of graduate students through the research assistantship (RA). Since research training is generally acquired through an apprenticeship with a faculty member, the RA aids in this mentoring process, while providing a source of financial support for the student. However, since the primary purpose of the RA is to assist in the production of research, the number of RAs awarded is often not explicitly related to national personnel and training requirements.

A final source of Federal support for graduate education is the institutional grant, such as the general science support grant, facilities and equipment support, and the science development grant. Most of these forms of assistance do not support graduate students directly, but undergird the research and education environment.

Prior to 1958, the primary source of Federal assistance to graduate education in science and engineering was the research assistantship. According to education consultant Robert Snyder, "a survey of graduate student support in 1954 by NSF indicated that 10 percent of all graduate students received Federal stipend support (6,751), of which 86 percent came in the form of research assistantships, " By 1969, the situation had changed dramatically: 36 percent of all graduate science and engineering students (51,620) were supported by the Federal Government, and 56 percent of those supported held either a fellowship or a traineeship. Table 2-4 illustrates those changes.[48]

The impetus for this change was the launching of Sputnik by the Soviet Union in October 1957. The following year Congress passed the National Defense Education Act (NDEA, Public Law 85-864) which "marked the inception of large-scale Federal graduate education support ."[49] The Title IV fellowship program of NDEA grew to support more than 15,000 graduate students at a budget of $86 million in 1968, with support being provided in many academic fields, including the heretofore excluded humanities.[50] In addition, NDEA also "provided subsidies to educational institutions to create low interest loans for needy students in all disciplines . . . . [which] would be

[48] Robert G. Snyder, "Federal Support of Graduate Education in the Natural Sciences: An Inquiry Into the Social Impact of Public Policy, " doctoral dissertation, Syracuse University, June 1981, pp. 103 and 110; appendix tables 6 and 9, pp. 264 and 267.
[49] Ibid., p. 108.
[50] Ibid.

Table 2-4.—Distribution of Primary Sources of Support for Full-Time Science and Engineering Graduate Students in Doctorate-Granting Departments, Selected Years

Source of support	1954	1966	1969	1974	1979	1983
Number of graduate students:						
All sources	67,136	118,273	141,199	195,915	223,409	243,646
Federal Government	6,751	44,612	51,620	48,016	52,871	47,402
institution/State	16,958	42,343	50,471	75,411	82,813	96,188
Self	39,000	19,571	26,307	56,085	67,686	75,641
Other	4,427	11,747	12,801	16,403	20,039	24,415
Percent distribution:						
All sources	100.0	100.0	100.0	100.0	100.0	100.0
Federal Government	10.1	37.7	36.6	24.5	23.7	19.5
institution/State	25.3	35.8	35.7	38.5	37.1	39.5
Self	58.1	16.6	18.6	28.6	30.3	31.0
Other	6.6	9.9	9.1	8.4	9.0	10.0

NOTE Except for 1979 and 1983 absolute numbers in this table should be used with caution for trend analysis because they are derived from somewhat incompatible sources 1954 data include part-time students thereby overrepresenting self-support

SOURCES National Science Foundation *Graduate Student Enrollment and Support in American Universities and Colleges 1954* National Science Foundation *Graduate Student Supped and Manpower Resources in Graduate Science Education* fall 1966 and fall 1969 National Science Foundation, *Academic Science Graduate Enrollment and Supper/ Fall 1978* and National Science Foundation *Academic Science/Engineering Graduate Enrollment and Support Fall 1983* forgiven for students who later went into teaching careers. "[51]

In the years following the passage of NDEA, the President's Science Advisory Committee issued a series of reports calling for increased support for science and engineering education. These reports —Education *for the Age of Science* (1959); *Scientific Progress, the Universities and the Federal Government* (the "Seaborg report, " 1960), and *Meeting Manpower Needs in Science and Technology* (the "Gilliland report, " 1962)— "articulated the national need for greater numbers of scientists and engineers . . ., and for stronger Federal support for the training of manpower for basic research and for university level teaching. "[52] They were followed by a set of significant actions:

1. The NSF fellowship program, begun in 1952, was expanded from about 500 to 2,500 per year.
2. An NSF traineeship program was begun in 1962, and awarded 5,000 traineeships a year to 200 institutions by the late 1960s.
3. NIH predoctoral support programs expanded from 55 traineeships in 1958 to 7,696 traineeships and 1,527 fellowships in 1970.
4. The National Aeronautics and Space Administration (NASA) instituted a traineeship program in 1962 for engineers, mathematicians and physical scientists.
5. The Atomic Energy Commission (AEC) expanded its fellowship program and instituted a new traineeship program (1965) in nuclear science and engineering.

All told, the number of science and engineering graduate students supported by Federal predoctoral fellowships and traineeships increased from 5,000 in 1961 to 34,100 in the peak year of 1969.[53] (See figure 2-10.) At the same time Federal research and development (R&D) support to universities expanded fourfold, from $40s million in 1960 to $1.595 billion in current dollars in 1969.[54] As a result, the number of federally supported research assistantships increased to more than 19,600 in 1969.[55]

In addition to direct stipends for graduate study and research, two new programs in the mid-1960s broadened the scope of Federal support for graduate education. These were the Guaranteed Student Loan and College Work Study programs authorized by the Higher Education Act of 1965 (Public Law 89-329). The work study program "enabled graduate departments and researchers to hire low income students at a small fraction of the costs of the students' wages through Federal wage subsidies. " The loan program was directed at low-income graduate and undergraduate students in all fields "as part of a larger shift in Federal policy towards aiding disadvantaged socioeconomic groups. "[56] By 1969 more than 70,000 students were receiving guaranteed student loans; 17,000 were enrolled in college work-study programs and 27,400 held NDEA loans. An additional 91,464 graduate and professional school students (the numbers are not available for graduate students alone) were supported by veterans benefits.[57] It should be noted, however, that the average level of support per student from these programs was less than $1,000 per year, as compared to more than $5,500 per year, tuition plus stipend, from the NDEA Title IV fellowship program.

Thus, between 1960 and 1969 Federal support for graduate education in science and engineering expanded dramatically, as part of an overall Federal emphasis on post-secondary education. Other forces were at work as well during this period. Increasing State support for higher education, and especially the expansion of many State university systems in this era, created an increasing demand for new faculty to instruct the growing numbers of undergraduates. And increasing undergraduate enrollments created significant additional demands for teaching assistants, thereby providing much additional graduate student support. By 1969, over 50,000 full-time science and engineering graduate students were receiving their primary source of support from institutional and State sources, nearly as many as received Federal

[51] Fallows, op. cit., p. 5.

[52] Ibid.

[53] Snyder, op. cit., 1981, p. 109 and appendix table 7, p. 265.

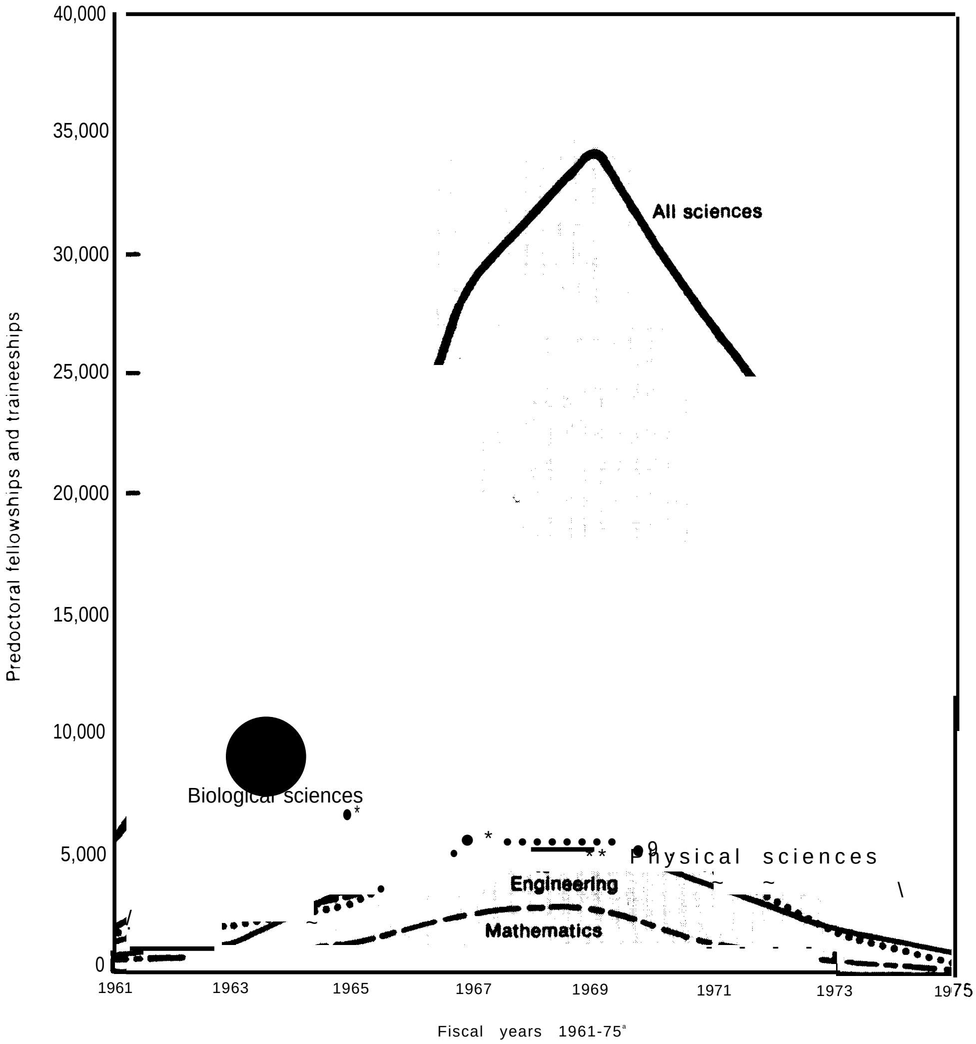
[54] Fallows, op. cit., p. 404,

[55] Snyder, op. cit., 1981, p. 267, The number 19,646 given in appendix table 9 of Snyder's dissertation represents those full-time graduate science students who indicated research assistants ips as their "primary type of support. " There may be other RA recipients that relied on other sources for "primary support" and are therefore not Included in the total in Snyder's table,

[56] Fallows, op. cit., p. 6.

[57] Snyder, op. cit., 1981, appendix table 11, p. 269 and appendix table 12, p. 270.

Figure 2-10.— Federal Predoctoral Fellowships and Traineeships by Field. Fiscal Years 1961 -75[a]



[a]Data include NIH training grant trainees in the biological sciences but not in other fields, data do not include NIMH trainees
[b]Estimate

SOURCES For all fields except biological sciences — FY 1961-1969 data, FICE (1970), FY 1970-1975 data, FICE (unpublished) For biological sciences–FICE (1970, unpublished) and NAS,NIH trainee file, and NIH (1978) Robert G Snyder, *The Effectiveness of Federal Graduate Education Policy [for] Scientific Personnel*, report to Off Ice of Technology Assessment June 1985, table 2

assistance (see table 2-4). Of those students, 33,000 held teaching assistantships.[58]

With undergraduate enrollments in both public and private institutions increasing dramatically, as we have seen above, the labor market for doctoral personnel was booming in the 1960s. The 260,000 new junior faculty hired during the decade exceeded the number of doctorates awarded between 1960 and 1969—170,000—by 53 percent.[59] This situation boosted the salaries of doctorate recipients relative to other occupations, thereby providing added inducement for more

[58]*"Graduate Student Support and Manpower Resources In Graduate Science Education,* NSF 70-40 (Washington, DC: National Science Foundation, 1969), p. 50.

[59]Allan Cartter, *Ph.D.s and the Academic Labor Market* (New York: McGraw-Hill, 1976), p. 123.

people to enter doctoral study .[60] (Faculty salaries rose 50 percent faster than those of all other workers during the 1960s, according to Richard Freeman.[61])

Thus, a complex array of interconnecting variables—Federal, State, and private sector—appear to have combined to produce the surge of graduate enrollments and doctoral production in the 1960s. In addition, the Vietnam War led many male college graduates to enroll in graduate school and remain there through receipt of a degree.

The year 1969 turned out to be a watershed for Federal support of graduate education in science and engineering. A combination of political, economic, and social factors, and a growing Federal awareness that demand for doctoral scientists and engineers was not keeping up with supply, led to severe cutbacks in Federal fellowship and traineeship support. The number of U.S. Government supported fellows and trainees declined from 36,000 in 1969 to 10,800 in 1975. The NDEA Title IV fellowship program was phased out in 1973. NSF traineeships, NIH fellowships, NASA traineeships, and AEC fellowships and traineeships were all eliminated in the early 1970s. All that remained by 1979 were 4,800 NIH traineeships, approximately 1,500 Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) traineeships and fellowships, and 1,500 NSF merit fellowships.[62]

Federal R&D expenditures at universities, which had increased by a factor of 4 in current dollars, and a factor of 3 in constant dollars, between 1960 and 1968, stopped growing. In 1974 the level of Federal R&D support to universities was only 25 percent above its total 6 years earlier in current dollars, and 7.2 percent less in constant dollars.[63] The number of federally supported research assistantships decreased by about 10 percent between 1969 and 1974.

The effects of changing levels of Federal support on the supply of new science and engineering Ph.D.s is seen most dramatically by comparing the experience of different science and engineering fields during the contraction period, 1968-75. Figure 2-10 and table 2-5 show the dramatic drop in the number of Federal fellowships and traineeships awarded in engineering, mathematics, and the physical sciences between 1968 and 1975. The number of awards dropped from 3,000 to 200 in mathematics; from 6,000 to 600 in the physical sciences, and from 5,500 to 700 in engineering.[64] The total number of full-time stu-

[60] *The Demand for New Faculty in Science and Engineering* (Washington, DC: National Research Council, 1980), p. 117.

[61] Richard Freeman, *The* Market for College-Trained Manpower (Cambridge, MA: Harvard University Press, 1971), pp. 77-80.

[62] Snyder, op. cit., 1981, pp. 122 and 123.

[63] Fallows, op. cit., p. 4.

[64] Snyder, op. cit., 1981, appendix table 7, p. 265.

Table 2-5.—Federal Predoctoral Fellowships and Traineeships by Field, Fiscal Years 1961.75[a]

Fiscal year	All sciences	Mathematics	Physical sciences	Engineering	Biological sciences	Social sciences
1961	5,445	629	1,273	638	1,782	1,123
1962	9,245	852	1,684	860	3,911	1,938
1963	11,224	899	1,955	1,050	4,940	2,380
1964	12,757	1,024	2,461	1,402	5,337	2,533
1965	16,683	1,211	2,974	3,092	6,329	3,077
1966	21,929	1,824	4,353	4,190	7,536	4,026
1967	28,895	2,598	5,424	4,784	9,250	6,839
1968	33,901	3,024	5,960	5,507	10,161	9,249
1969	34,100	2,734	5,776	5,058	10,882	9,650
1970	30,646	2,006	4,459	4,323	11,182	8,676
1971	26,694	1,073	4,071	3,540	9,669	8,341
1972	23,579	776	3,212	2,953	8,851	7,787
1973	19,335	447	1,893	1,938	8,114	6,943
1974	13,084	343	1,183	1,225	6,111	4,222
1975	10,787	208	592	715	6,098[b]	3,174

[a]Data include NIH training grant trainees In the biological sciences but not in other fields data do not Include NIMH trainees
[b]Estimate

SOURCES For all fields except biological sciences–FY1961-69 data, FICE (1970), FY 1970-75 data FICE (unpublished) For biological sciences–FICE (1970, unpublished) and NAS NIH trainee file. and NIH (1978) Robert G. Snyder, *The Effectiveness of Federal Graduate Education Policy [for] Scientific Personnel*, report to OTA, June 1985, table 2 dents in doctorate granting departments supported by the Federal Government in engineering, mathematics, and physical science decreased by 18, 57, and 33 percent, respectively, between 1969 and 1974 as can be seen in table 2-6.[65] Figure 2-8 shows the substantial decline in Ph. D.s awarded in engineering, mathematics, and the physical sciences that occurred in the period 1972-78.[66] It should be noted that those three fields were also affected by a decline in Federal research funds awarded to universities of 20 percent in constant dollars between 1968 and 1974.[67]

By contrast, Federal fellowships and traineeships declined, but not nearly so precipitously, in the biological and social sciences—from 11,000 to 6,000 in the former, and from 9,700 to 4,200 in the latter. Moreover, as table 2-6 shows, the total number of full-time graduate students supported by the Federal Government, including RAs and other forms of support, actually increased by 45 percent in the life sciences and remained constant in the social sciences in the period 1969-74. In addition, Federal funding of research at universities and colleges in the life and social sciences remained at the same level, in constant dollars, throughout the 1968-74 period, as opposed to the decline in engineering and the mathematical and physical sciences reported above. It is not surprising, therefore, to find that the number of Ph. D.s in the life and social sciences did not decrease in the 1970s.

The apparent correspondence between decreases in Federal educational support in particular fields and decreases in the numbers of doctoral degrees awarded several years later does not, of course, prove causality. The numbers do, however, suggest that there may be a relationship between these two variables.

From 1974 to 1980 the Federal share of support for full-time science and engineering graduate students in doctorate granting institutions remained relatively constant at about to 23 to 25 percent of the total. Since 1980 it has declined to less than 20 percent.[68] Figure 2-11 presents the percentage shares of Federal support for science and engineering graduate students as a whole and by field. Note the sizable variation from field to field, with mathematics and the social sciences at 11 percent Federal support, and engineering, physical and environmental sciences, and life sciences at 20 to .30 percent.

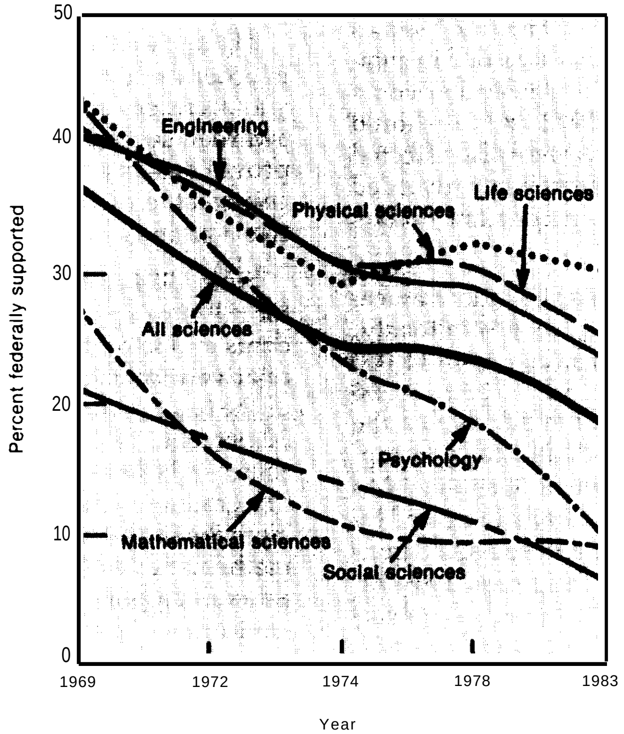
[65] Ibid., appendix table 10, p. 268.
[66] Fallows, op. cit., p. 33.
[67] Snyder, op. cit., 1981, p. 262.
[68] Ibid., appendix table 10, p. 268; and *Academic Science Engineering: Graduate Enrollment and Support, Fall 1982,* op. cit., pp. 112-113.

Table 2-6.— Full-Time Graduate Students in Doctorate-Granting Institutions Supported by the Federal Government by Broad Field, Selected Years

Total full-time enrollment/ number federally supported	1969	1972	1974	1978	1983
All sciences	141,199	149,937	195,915	217,588	243,646
Federal	51,620	45,029	48,016	51,373	47,402
Engineering	30,820	30,908	33,691	37,129	53,553
Federal	12,334	11,246	10,164	10,625	11,924
Physical sciences	30,175	27,544	29,649	31,375	35,904
Federal	13,187	9,687	8,868	10,123	10,886
Mathematical sciences	11,727	11,909	13,423	13,706	19,581
Federal	3,223	1,908	1,393	1,307	1,794
Life sciences	27,588	34,083	54,800	65,097	65,185
Federal	11,513	12,037	16,757	19,659	17,221
Psychology	11,918	14,282	18,728	20,677	21,327
Federal	5,127	4,691	4,404	3,943	1,982
Social sciences	28,971	31!211	45,624	49,604	48,096
Federal	6,236	5,460	6,430	5,716	3,595

SOURCES Robert G Snyder *Federal Support of Graduate Education in the Natural Sciences*, doctoral dissertation Syracuse University, June 1981 app table 10 p 268 and National Science Foundation *Academic Science/Engineering Graduate Enrollment and Support Fall 1983* NSF 85300, table CI 4, pp 112113

Figure 2-1 1.—Full-Time Graduate Students in Doctorate-Granting Institutions Supported by the Federal Government by Broad Field, Selected Years



SOURCES Robert G Snyder, *Federal Support 01 Graduate Education in the Natural Sciences.* Doctoral Dissertation, Syracuse University, June 1981 appendi x table 10, p 268, and NSF, *Academic Science/Engineering Graduate Enrollment and Support, Fall 1983.* N S F *85-300,* table C14 pp 112-113

THE FUTURE

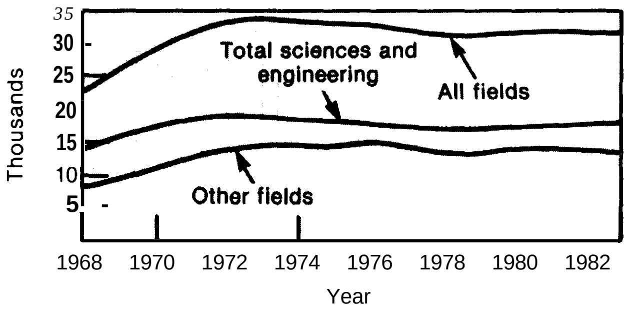
The exact interplay of the various factors that will determine graduate enrollments and Ph.D. production in the sciences and engineering over the next 20 years is difficult to predict. It was shown above that three factors appear to influence the numbers of Ph. D.s awarded in science and engineering fields: Federal support for graduate education, State and institutional support, and demand for new doctorates. Federal support for graduate education in the sciences and engineering may rise modestly in the next decade if the funding of research grants to universities, and hence research assistantships, continues to increase. Fellowship and traineeship support will probably remain constant. State and institutional support will probably decline due to declining enrollments, with the declines being greatest in the Northeast, Middle Atlantic, and Midwestern States. However, it is also possible that science and engineering enrollments will not experience the overall declines of the rest of the higher education system and that States will continue to provide extra support for science and engineering research at their State universities as part of their efforts to develop high-technology industries for economic growth. In that case, State and institutional support may not decline at all.

As for demand, we shall see in chapter 3 that the academic demand for new science and engineering faculty is likely to be very weak over the next decade and very strong from 1995 to 2010. Industrial demand for new science and engineering Ph. D.s, by contrast, has been growing at 7.8 percent per year over the past decade and will, if it continues to grow at present rates, compensate for the decline in academic demand between 1985 and 1995. After that, if industrial demand continues to grow, there will be stiff competition between industry and academia for new scientific and engineering doctoral degree recipients in the 1995-2010 time frame. That competition will be discussed in chapter 3.

In the near-term, what is remarkable is the overall flatness of the recent trend lines, since 1978 (see figures 2-12 and 2-13),[69] for total doctorates, for doctorates in science and engineering, and for full-time graduate enrollments in science and engineering. The only exception has been engineering graduate school enrollment, which has in-

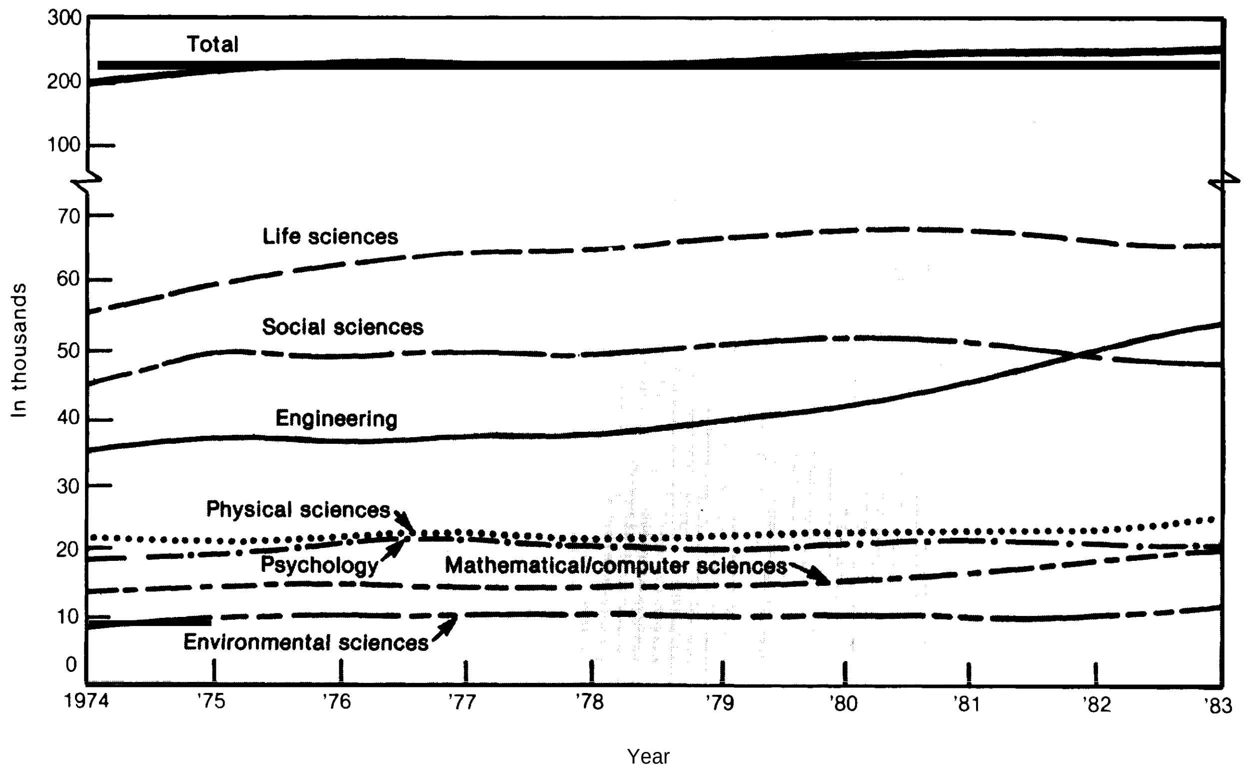
[69] *Science and Technology Resources,* NSF 85-305 (Washington, DC: National Science Foundation, January 1985), pp. 75 and 77.

Figure 2-12.— Doctorates Awarded



SOURCE: National Science Foundation, *Science and Technology Resources,* NSF 85-305, January 1985, p 77

Figure 2-13.—Full-Time Graduate Enrollment by Area of Science/Engineering[a]



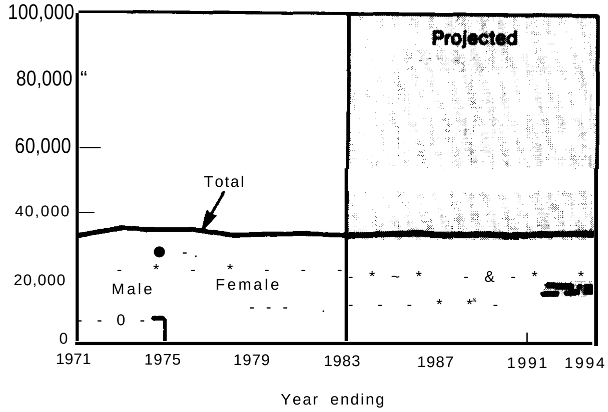
[a] In doctorate.granting institutions prior to 1974, data were collected from a selected group of departments rather than from the universe
[b] Includes support from State and local governments.

SOURCE: National Science Foundation, *Science and Technology Resources,* NSF 85-305, January 1985, pp 53-65.

creased dramatically, primarily at the master's level. A reasonable assumption for the next decade, which is that of the Scientific Manpower Commission and the National Center for Education Statistics (see figure 2-14),[70] is that there will be a continuation of current enrollment and Ph.D. production levels. Engineering is likely to continue to increase its share and the social sciences to decrease theirs, due to market forces. Women, whose attainment of science and engineering Ph.D.s has grown at a rate of 6.8 percent per year since 1973, are likely to increase their share of doctorates in these fields, while that of men will probably continue to decline. Foreign nationals will undoubtedly continue to be strongly represented among science and engineering Ph. D.s.

The working assumption for this document is that near-term graduate enrollments will remain constant and Ph.D. production will remain within about 10 percent of its current level. In the longer run, the strong market for science and engineering Ph. D.s that should occur at the turn of the century could lead to an increase in the number of annual doctorates awarded in those fields as students are attracted into them by career opportunities. This development will be discussed in chapter 3 when we examine the future demand for science and engineering doctoral degree holders.

Figure 2-14.—Trends in Doctor's Degrees Conferred, by Sex of Recipient



SOURCE U S Department of Education, National Center for Education Statistics, *Condition of Education,* ?985, p 129

[70] *The Technological Marketplace* (Washington, DC: Scientific Manpower Commission, May 1985), p. 11: and *Condition of Education, 1985,* op. cit., pp. 128-129.