

Current And Historic Trends In Physics And Related Fields

Roman Czujko

*American Institute of Physics, Statistical Research Center
College Park, MD 20740*

Abstract. This talk provides a statistical overview of the supply side in physics and related fields. Data on current and historic trends are presented in selected fields at both the bachelor's and PhD levels. Several of the major factors driving enrollment patterns in higher education are discussed. This paper concludes with an examination of issues related to both supply and demand. The AIP Statistical Research Center has been collecting data on enrollments and degrees in physics for 40 years and they are the source for the physics data presented. The sources for the data on related fields are the National Science Foundation in the case of PhD data and the U.S. Department of Education for bachelor's level data. Finally, this paper includes data on the size of the bachelor's degree classes of 1999 and 2000. These data were not available when the talk was presented.

BACHELOR'S DEGREES

In 2001, about 1.2 million bachelor's degrees were awarded across all fields in the U.S. (see Figure 1)[3]. After nearly a decade of declining undergraduate majors, the number of physics bachelor's awarded has increased in each of the last two years to just over 4,100 for the class of 2001 [2]. However, physics is a comparatively small field. Of every 1,000 bachelor's degrees awarded in the U.S., only 3.4 are in physics.

Physics lost market share during the late 1980's and most of the 1990's. By way of example, in 1985, 5.4 out of every 1,000 bachelor's degrees awarded in the U.S. were in physics. One of the reasons why fewer students were majoring in physics is that the academic environment for undergraduates has become very competitive. Even though the number of people earning bachelor's degrees increased during the last 15 years, their options increased even faster. In other words, today's students have far more majors to choose from than did students 10 or 15 years ago.

Thus, it is no longer possible for departments to sit back and expect the best students to come to them. In order for a department to survive, let alone thrive, it must become proactive in recruiting potential majors and in developing both activities and programs that keep those majors through to the bachelor's degree.

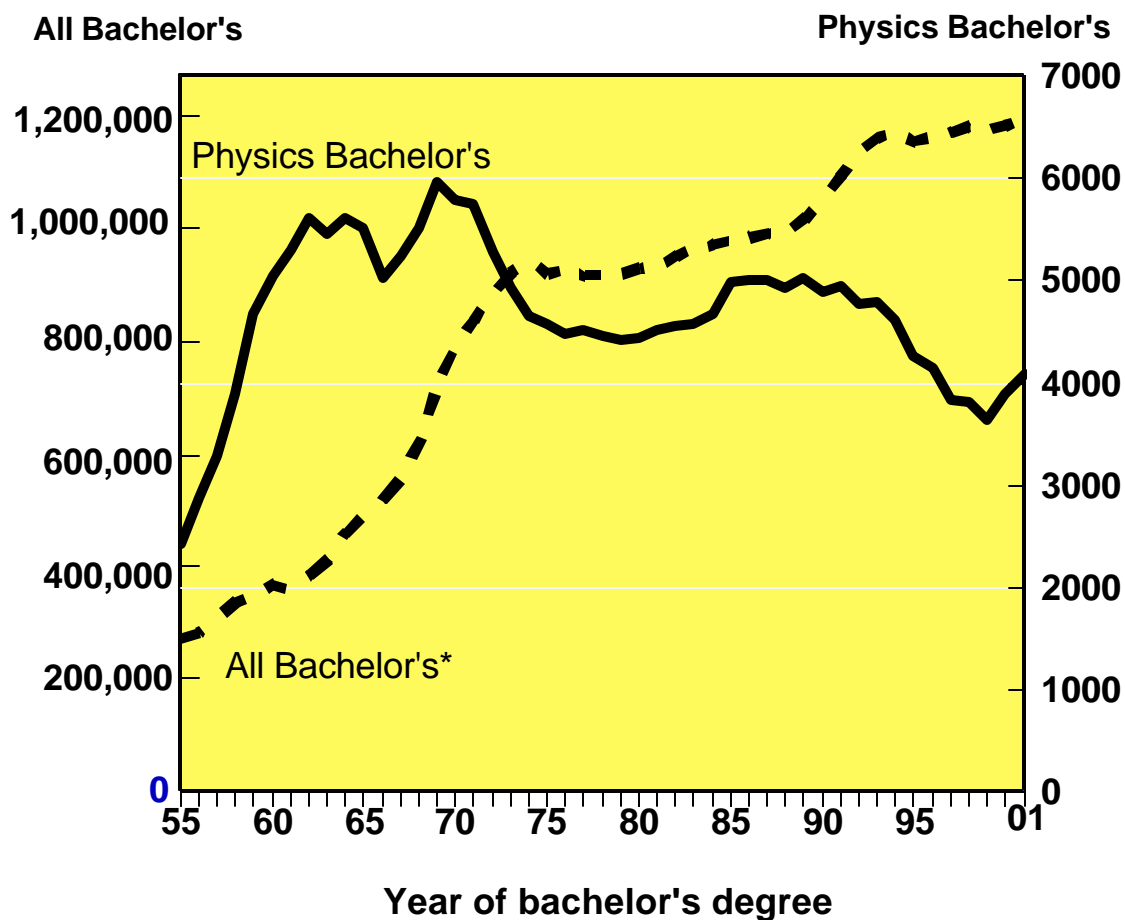


FIGURE 1. Physics bachelor's and total bachelor's produced in the U.S., 1955 to 2001 [2] [3].

The trends depicted in Figure 1 are not unique to physics. The decade of the 1990's was very volatile in terms of undergraduate education for many fields. Figure 2 illustrates the bachelor's degree production in selected fields from 1985 through 2000. Each of these fields portrays a different pattern. Many calculus-based fields, such as physics, engineering, and mathematics, lost majors during the decade of the 1990's. In fact, the engineering bachelor's class of 1998 was the smallest in 17 years [1].

Chemistry reversed the decline in their bachelor's degree production before 1995. In part, this was due to an increased emphasis on biochemistry within the undergraduate chemistry curriculum and, in part, it was because chemistry discovered opportunities in the pharmaceutical industry.

The number of students earning bachelor's degrees in computer science also went through a large cycle. The bachelor's class of 1996 was the smallest in 14 years and the dot com boom of the late 1990's had a dramatic effect on enrollments in computer science departments. In fact, the number of bachelor's degrees awarded in computer science has increased by nearly 8,000 in just the last two academic years.

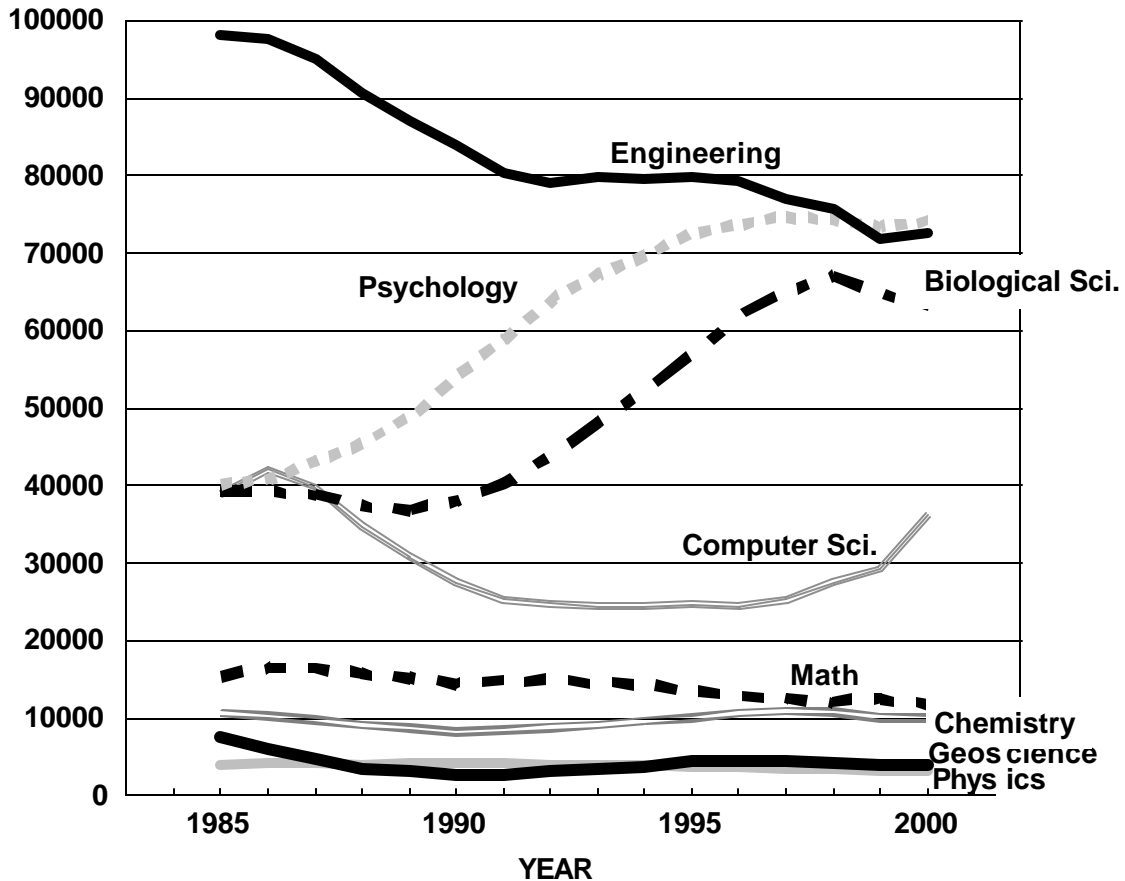


FIGURE 2. Total number of bachelor's degrees granted by discipline, 1985 to 2000 [1].

At the bachelor's level, the two fastest growing fields during the 1990's were biology and psychology [1]. Among the things that these fields have in common are the obvious connection to improving human life and women students. By way of example, 75% of psychology majors are women [3].

Thus, the decisions that women undergraduates make are, to a significant degree, driving higher education. In 1998, about 55% of all bachelor's degrees awarded in the U.S. were earned by women. The U.S. Department of Education projects that this trend will continue to grow and that women will represent 58% of the bachelor's class of 2010 [3].

Women have gradually increased their representation among physics and engineering bachelor's, but at levels far below the overall trends. The physics bachelor's class of 1999 was 21% women, the first time that it had ever passed 20%. The physics class of 2001 was 22% women [2].

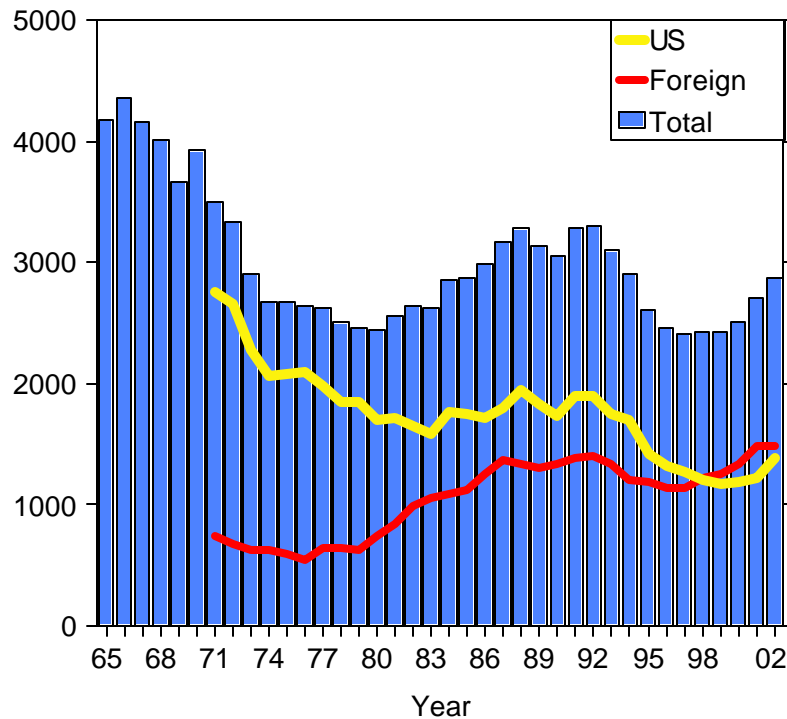


FIGURE 3. First-year US and foreign graduate physics students, 1965 to 2002.¹[2]

FIRST-YEAR GRADUATE STUDENT ENROLLMENTS

This discussion will focus exclusively on physics as it is among the few fields that regularly collect data on first-year graduate students. Figure 3 illustrates the cyclical pattern of graduate student enrollments over the last 38 years. The height of the bars illustrates the number of students admitted into physics graduate programs each year.

The two lines superimposed across the bars reflect the number of U.S. citizens and the number of foreign citizens entering graduate study in physics. The number of foreign citizens in graduate physics programs increased dramatically during the 1980's and 1990's. Over the last few years, enrollments increased among both US citizens and foreign citizens.

PHYSICS PHD DEGREES

Figure 4 depicts the number of physics PhDs awarded in the U.S. each year from 1900 through 2001. You don't have to be a physicist to recognize that this is a system under stress. Similarly, you don't have to be a social scientist to recognize that there is more going on in this graph than simply a reflection of the growing and waning interest in physics.

¹ A change in wording on the 2001 questionnaire resulted in more accurate data on first-year graduate students. This change was responsible for 3% of the reported 8% increase in total first-year students between 2000 and 2001.

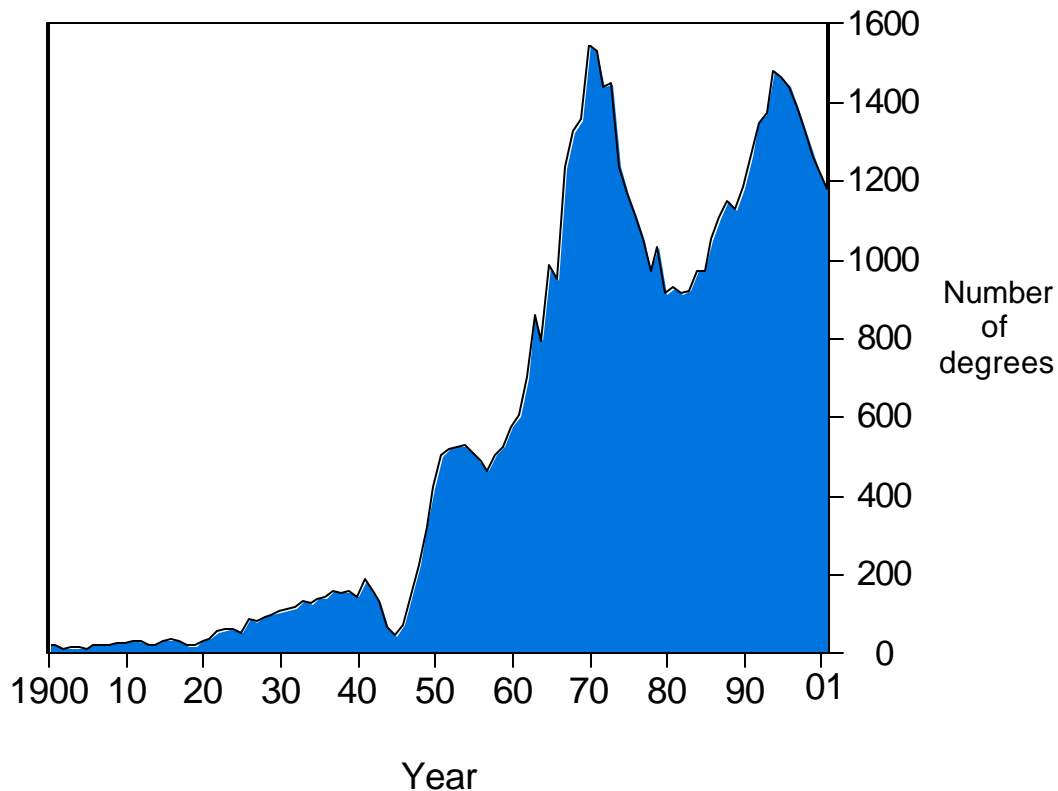


FIGURE 4. Number of Physics PhDs conferred in the US, 1900 to 2001 [2].

Economic and political events in both national and international arenas affect the number of physics PhDs awarded in the U.S. Physics PhD production plummeted during World War II and after the international recessions of 1970 and 1990. Conversely, physics PhD production increased after Sputnik was launched and again after President Kennedy announced the race to the moon.

After the People's Republic of China opened its doors to the West, many Chinese students came to the U.S. to attend graduate programs in physics and related fields. These Chinese students contributed significantly to the increase in physics PhD production during the 1980's. Similarly, after the Soviet Union dissolved in 1990-91, many of their students came to the U.S. to attend graduate programs. If not for the students from the Former Soviet Union, the decline in physics PhD production during the second half of the 1990's would have been more severe.

The number of physics PhDs awarded has been declining since 1994 at a rate of nearly 4% per year. Based on first-year student enrollment trends during the 1990's, we expect that physics PhD production will continue to decline until the PhD class of 2003. The number of U.S. citizens earning physics PhDs, however, is expected to decline until the class of 2005, at which point fewer U.S. citizens will have earned physics PhDs than in any year since 1965.

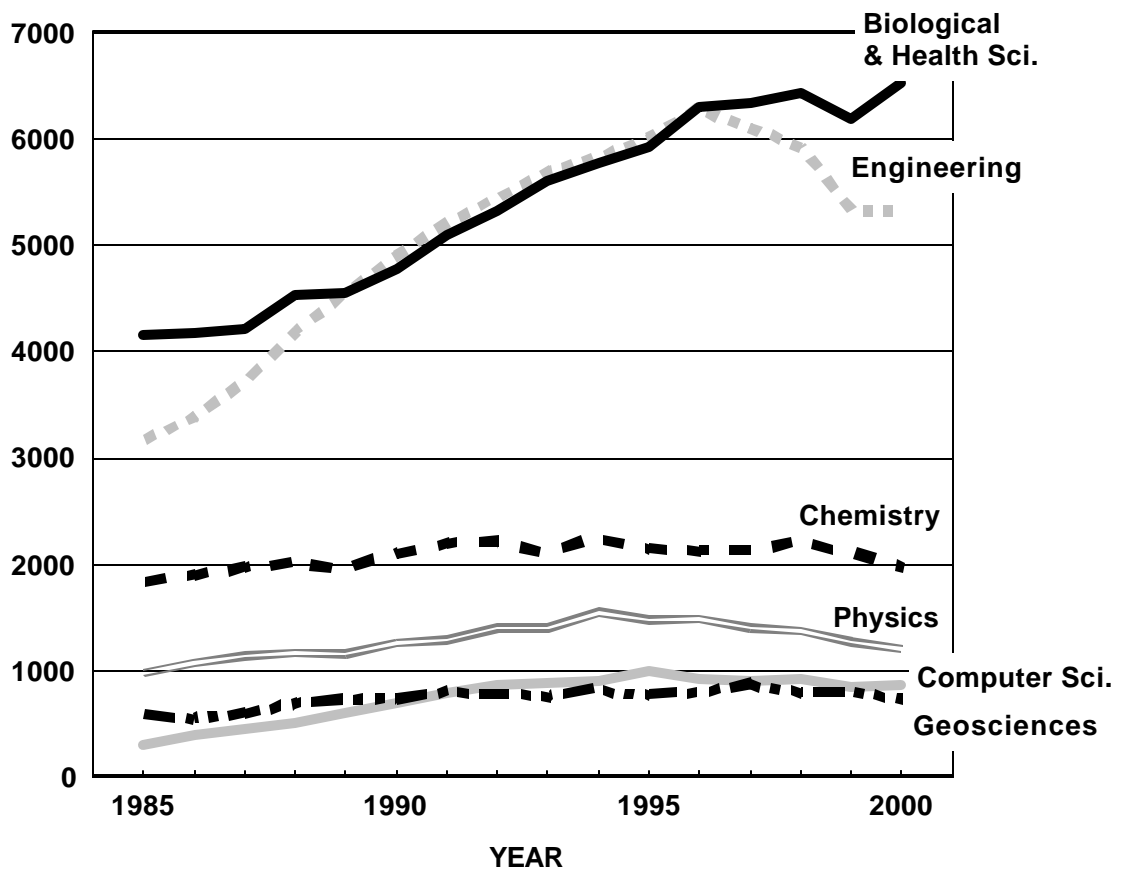


FIGURE 5. Total number of PhDs granted by discipline, 1985 to 2000 [1].

PhD Degrees in Selected Fields

Graduate education in the U.S. is arguably the best in the world and over 40,000 PhDs are awarded each year in the U.S. [3]. Figure 5 illustrates the annual production of PhDs in selected fields from 1985 through 2000. In each case, the number of PhDs awarded in 2000 was greater than in 1985. The growth in the life sciences and in engineering is especially noteworthy.

While the pattern of change during those 15 years varies by field, the annual PhD production in most of the fields displayed in this graph has either stabilized or declined during the last 4 or 5 years. The total number of new PhD's awarded in engineering has dropped by nearly 1,000 during the last part of the 1990's.

Since many of the issues discussed at this conference have a national defense component, citizenship is an important consideration. Figure 6 depicts the number of U.S. citizens earning PhDs in the same set of selected fields from 1985 though 2000. More U.S. citizens earn PhDs in each field in 2000 than in 1985 and, once again, the pattern of change during the intervening 15 years varies by field.

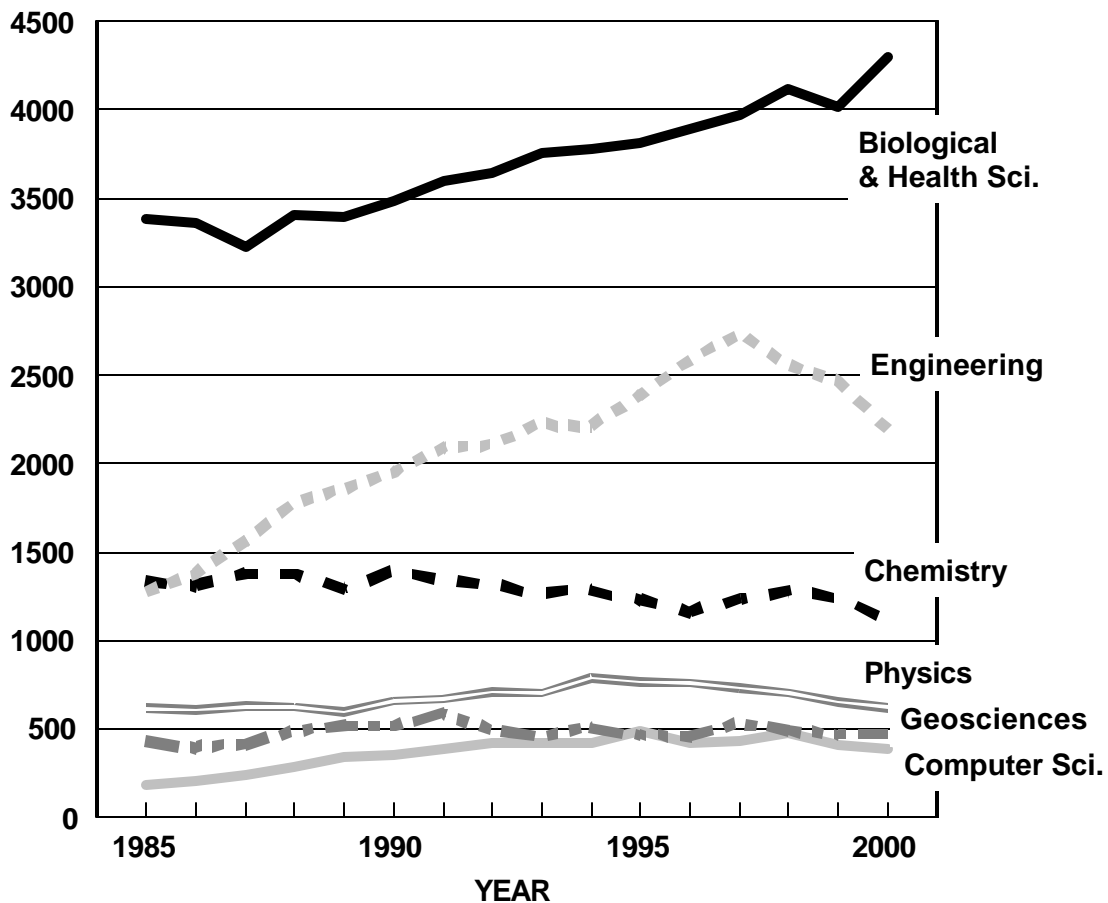


FIGURE 6. Number of PhDs awarded by discipline, US citizens only, 1985 to 2000 [1].

As indicated in Figure 5, engineering and life sciences overlap in total PhD production during the late 1980's and early 1990's. However, when citizenship is taken in account, thousands fewer U.S. citizens earn PhDs in engineering each year than do U.S. citizens in the life sciences. This discrepancy is because nearly two-thirds of life science PhDs are U.S. citizens whereas fewer than half (about 45%) of engineering PhDs are U.S. citizens [3].

Figures 7 and 8 depict the number of PhDs earned by U.S. citizens in subfields that are directly related to the issues discussed at this conference. Obviously, these graphs reflect small numbers. In order to factor out some of the random noise in the system, we have presented the data as two-year averages. Once again, in each case a greater number of U.S. citizens earned PhDs in each of these subfields in 1999 than did a decade earlier. However, in most cases, the peak in PhD production was during the mid 1990's with a drop off in the most recent years for the number of U.S. citizens earning degrees [1].

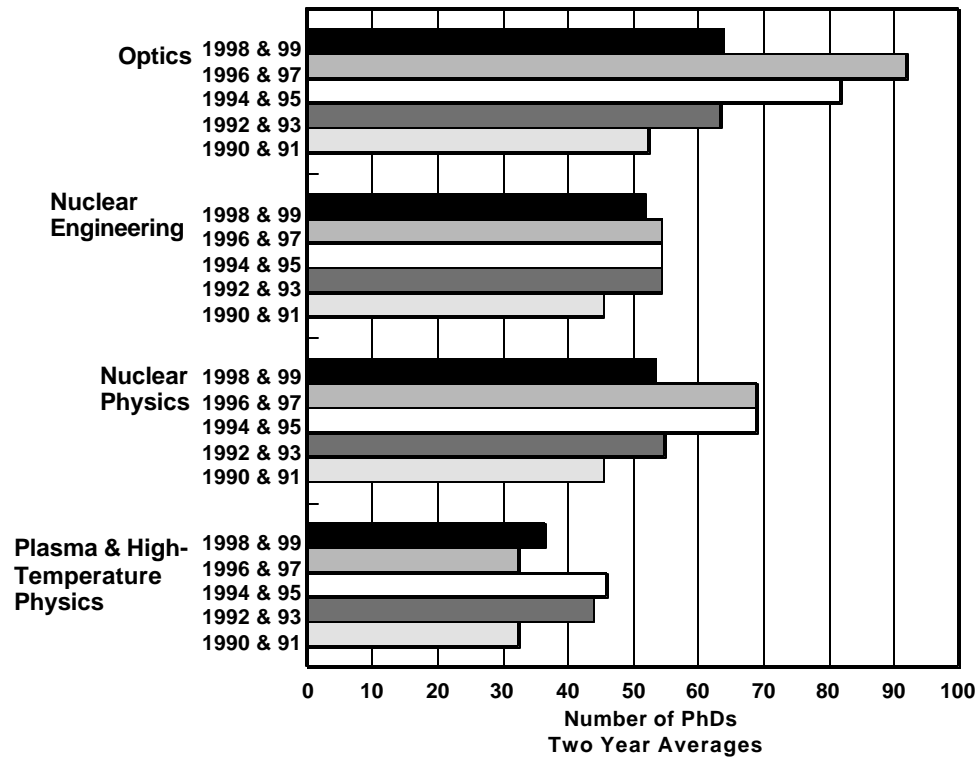


FIGURE 7. Number of PhDs granted by specific subfield, U.S. citizens only, 1990 to 1999 [1].

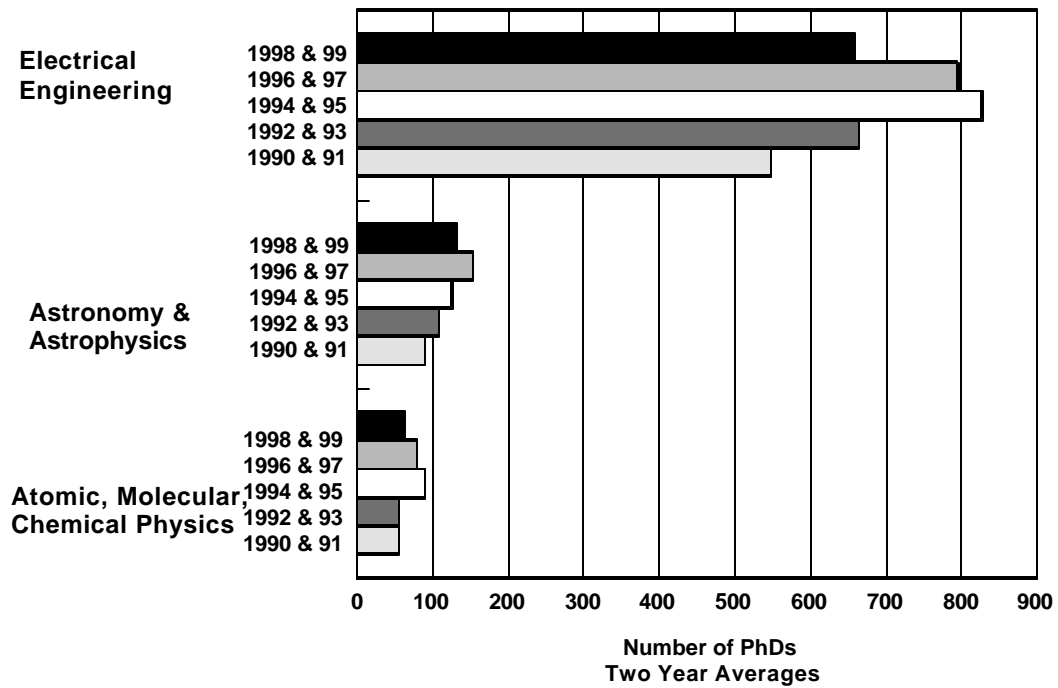


FIGURE 8. Number of PhDs granted by specific subfield, U.S. citizens only, 1990 to 1999 [1].

During this conference, there has been considerable concern expressed about the need for greater numbers of people trained in areas of direct relevance to our national security at the same time that we are seeing declining numbers of U.S. citizens pursuing degrees in these fields. The prospect of dramatically increasing the number of degrees awarded in selected fields can seem daunting. However, these are comparatively small fields in light of the total number of PhDs awarded each year. By way of example, to double the number of degrees awarded in nuclear engineering would mean changing the intended fields of study of less than 2% of the U.S. citizens who are likely to earn PhDs.

CONCLUDING REMARKS

The data presented in this paper have focused on the supply side, that is, on degree production in relevant fields over time. Equally important are issues related to the demand side and, in particular, the issue of whether we are facing a shortage. To increase the number of people in any field, in the author's opinion, involves three basic themes: encouragement, opportunity and resources.

To increase the number of people who may choose a particular field of study, we must encourage students, that is, heighten their awareness of the importance, relevance and excitement of the field. However, we must also provide them with the opportunities both to pursue advanced education in the field and to find meaningful, productive and challenging employment in the field. Such opportunities require resources and, in this case, the word resources has a dollar sign in front of and behind it.

Increasing research support of faculty has the inevitable effect of increasing the number of graduate students who are trained in a particular discipline. While this is necessary for increasing the supply, it is not sufficient. It is equally important to earmark the resources that will assure employment opportunities for these students after they graduate. To put money into supply without thought to the demand leads to the dissatisfaction and disillusionment of the students that you encouraged and trained. The latter can result in negative repercussions and a decrease in supply in the long run. In other words, demand is not simply a data issue, it is a policy issue.

REFERENCES

1. NSF (National Science Foundation) WebCASPAR Database System, <<http://caspar.nsf.gov/>> March 2002.
2. Nicholson, S., and Mulvey, P. J., *Roster of Physics Departments with Enrollment and Degree Data, 2000*. College Park, MD: American Institute of Physics, 2001.
3. Snyder, T. D., and Hoffman, C. M. *Digest of Education Statistics, 2000*, Washington, DC: U.S. Department of Education. National Center for Education Statistics, 2001.