POLICY
INFORMATION
REPORT

Meeting the Need

for Scientists, Engineers, and an Educated Citizenry in a Technological Society

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CONTENTS

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Foreword

My experience in corporate settings has taught me that the first step to solving a complex problem is to understand the system in which it operates. I believe that Paul Barton's report does this for a critical social and economic issue facing our country — the increasing need for graduate-level scientists and engineers and the need to reverse the low participation rates within these fields by persons of color. But, as this report makes abundantly clear, failure to address this challenge is not only an issue of advancing opportunities for persons of color, it is also an issue associated with sustaining a desired stream of qualified scientists and engineers. Failure to expand the number of qualified individuals seeking advanced degrees in these sectors also jeopardizes the future economic success of this country. The inability to attract scientists and engineers from our entire population is problematic given the strong demand for scientists and engineers, our changing demographics, and the extraordinary turnover we can expect in these employment sectors as baby boomers retire.

Barton incorporates numerous critical information sets to help us better comprehend this significant issue. From the demographers, we learn that we are facing an increasingly diverse population. From the labor economists, we understand that the number of jobs in these technical areas will continue to rise at a rapid rate, though we also learn that the number of individuals pursuing advanced degrees in these fields is falling. And from the educational research community, we find that the achievement level in mathematics and science at all ages, together with more general literacy skills, is woefully inadequate to repopulate and sustain a well-qualified and diverse science and engineering workforce.

Just as this report clarifies that the challenge is not an issue only *for persons of color*, it also makes clear that this is not just a *graduate education* issue, either. While there are certainly steps that the graduate community can, and must, take to improve the situation, the larger story is that we must focus our efforts on improving the success of students from the beginning of their educational career. To expand the pool of those who will become our future scientists and engineers, we must create opportunities for young people to attain levels of academic competence that will allow them to succeed in mathematics and science majors in college and subsequently succeed at the graduate level. To accomplish this will require a concerted and collaborative effort by corporate, governmental, and educational communities.

I firmly believe that the information presented in Barton's report will serve as the basis for ETS and others to better understand the systems that underlie access to graduate study. This understanding will help ETS and its partners create an infrastructure that will increase access. I also believe that the report provides ETS with the focal points needed to direct its partnerships with corporations and the educational community to maximize the possibilities from existing activities, and to design and implement novel approaches to facilitate entry into graduate study.

This report serves as a reaffirmation of my values and the values of ETS, especially with respect to our desire to work with corporate, educational, and other partners to meet the shared goal of increased access. What is truly hopeful is that this report presents several clear pathways to help our nation reach a desired outcome — creating and implementing supportive systems to facilitate entry into graduate study for science and engineering majors.

Kurt M. Landgraf
President
Educational Testing Service

Executive Summary

Extensive and growing concern about the underachievement of U.S. students in science and mathematics — particularly after the fourth grade — has several interrelated dimensions:

- The general need for an educated citizenry in an increasingly technological society and economy;
- The adequacy of the pool of well-educated young people from which we can draw a sufficient supply of highly skilled workers, scientists, and engineers, a need interrelated with the large disparities in academic achievement in the student population generally; and
- The inequality among racial and ethnic groups in achievement in science and mathematics and their underrepresentation in science and engineering professions.

Our unfortunate plight is conveyed by the title of a just-issued ETS report, *The Twin Challenges of Mediocrity and Inequality: Literacy in the U.S. from an International Perspective*.[1] This report highlights the mediocre literacy skills of U.S. adults compared to those in other countries and shows that as a nation we are among the world's leaders in the degree of inequality between our best and worst performers. A triple challenge would include the underrepresentation of minorities among our high-achieving students and in graduate schools that produce our scientists and engineers.

Mounting evidence has spurred business organizations into activity on a number of fronts, with warnings becoming increasingly shrill. A recent newsletter issued by the National Alliance of Business was headlined "Skilled Workforce Shortage Could Cripple U.S. Economy."

Capability in mathematics and science is obviously critical to pursuing science and engineering professions. Yet, international studies show that U.S. students lose ground in science and mathematics achievement, compared to those in other developed countries, after the fourth grade. And while this country made some gains in mathematics achievement over the last decade, only about one in five twelfth grade students are considered to be "proficient" by the National Assessment of Educational Progress (NAEP); furthermore, science achievement actually slipped in the 1990s. In terms of inequality, just 3 percent of Black students and 4 percent of Hispanic students reach the proficient level in mathematics by the twelfth grade.

What does all of this portend for the adequacy of the pool of talent from which we can draw our scientists and engineers, and for increasing the representation of minorities in these professions? To answer these questions, it is necessary to assess a number of factors that are involved.

- The projections of the U.S. Bureau of Labor Statistics indicate that science and engineering occupations will grow over the next decade, in some cases much more rapidly than the economy generally. The fastest-growing occupation of all will be computer specialists, at 69 percent from 2000 to 2010. Other occupations will grow at below-average rates, but in some cases, declining output of graduate schools will necessitate filling many vacancies in the next ten years.
- Enrollment in graduate schools that prepare people for most engineering, mathematics, and physical science occupations has followed a downward trend.

1 Andrew Sum, Irwin Kirsch, and Robert Taggart, *The Twin Challenges of Mediocrity and Inequality: Literacy in the U.S. from an International Perspective*, Policy Information Report, Policy Information Center and the Center for Global Assessment, Educational Testing Service, February 2002.

- While there has been recent growth in the number of master's and doctorate degrees awarded, the award of bachelor's degrees in the decade 1987-88 to 1997-98 has been down by:

    - 14 percent in engineering;
    - 22 percent in computer science; and
    - 26 percent in mathematics.

  In these subject areas, fewer students will be in the pipeline to get graduate degrees. The population of 20- to 21-year-olds was stable from 1988 to 1998, so population change does not account for these large declines. For example, over the same time period, there was a 9 percent increase in the number of bachelor's degrees awarded in the physical sciences.

- As the baby boomer scientists and engineers retire, they will have to be replaced. To borrow a vivid description of demographers, the bulging baby boom pig will complete its journey through the labor force python in the next 10 to 15 years.

- While the number of 18- to 24-year-olds will grow by 3 million by 2010 and offer possibilities of a fresh supply of scientists and engineers from our colleges and graduate schools, there is one striking fact about that population increase: only 3 in 10 will be White. (Among all 18- to 24-year-olds, the percentage of those who are White will decline from 66 to 62 percent). White students currently represent a disproportionately large share of degree recipients.

- Blacks, Hispanics, and American Indians — who are currently underrepresented in college and graduate school programs — will constitute almost 60 percent of the population increase over the next decade. And as pointed out above, only 3 or 4 percent of high school seniors from these subgroups currently reach the "proficient" level in mathematics. While the growth in the proportion of these minorities in the 18- to 24-year-old population is not dramatic, it does point toward need for greater effort to improve their educational achievement.

Together these facts make it clear that meeting our nation's future economic needs will not be possible without improving the math and science achievement of underrepresented minorities. This report documents the extent to which minorities are represented in science and engineering occupations. Although they are still underrepresented, the fact that their proportions have been advancing provides hope that further efforts, appropriate to the scale of the need, will meet with further progress. This report hopes to inform efforts in six crucial areas.

- *Starting Early*. Equalizing achievement for White and minority students will mean starting early — although progress can still be made at later points of intervention. Early childhood education beginning at age three can help level the playing field. The recommendations in the just-released report *Preschool for All: Investing in a Productive and Just Society*, by the Committee for Economic Development, make the case.[2]

- *Better Teaching*. Improvement in the quality of teaching in science and mathematics will be essential. We can get guidance here from the recent report of The National Commission on Mathematics and Science Teaching for the 21st Century, chaired by John Glenn. The report, *Before It's Too Late*, lays out a comprehensive plan.[3]

- *Raising Minority Achievement at the Top*. The focus has been on improving the academic skills of the

2 Committee for Economic Development, *Preschool for All: Investing in a Productive and Just Society*, Statement of the Research and Policy Committee, 2002.

3 *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century,* September 2000.

lowest performers and equalizing the average performance of White and minority students. Yet, average achievement will not produce scientists and engineers, and the 3 or 4 percent of minority students now reaching the proficient level on the NAEP assessment will not move us toward equality of representation in science and engineering occupations. The National Task Force on Minority Achievement, created by the College Board, provides a different and more appropriate focus in its report, *Reaching the Top*.[4]

- *Identifying the Sources of Low Achievement*. The joint study by the National Center for Education Statistics and the National Science Foundation, *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement*,[5] provides a useful starting point for understanding and addressing the sources of low performance.

- *Assistance*. High-achieving minorities from lower income families need help of a variety of kinds to make good choices and navigate the transition from high school to college. Financial aid is an important factor. In high school, guidance and counseling is very weak and has generally been ignored in the education reform movement.

- *Persistence*. Getting into and beginning college is not enough; there has to be persistence to graduation. We can obtain guidance here from two sources:

  - The study of 5,500 high-ability minority students, titled *Persistence in Science of High-Ability Minority Students*, by Educational Testing Service.[6]

  - The U.S. Department of Education study, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment*.[7] The highest predictor of persistence to college graduation was taking a rigorous curriculum in high school.

Meeting the need for better science and mathematics instruction, for an adequate supply of scientists and engineers over the next 10 to 20 years, and for more equality in the preparation and representation of minority populations in these professions are all interconnected. And while this report focuses on the science and engineering jobs essential to the economy, improving elementary and secondary education in science and mathematics would also address two other matters: the broader need for a skilled workforce generally, and the adequate preparation of students — particularly minority students who are underrepresented in higher skilled and higher paying occupations — to succeed in postsecondary education.

It isn't just tomorrow's innovative engineers and scientists who will drive our economy, but a larger cadre of well-educated workers in an array of fields that require quantitative and scientific knowledge. And beyond both a sufficient supply of scientists and engineers, and a large cadre of skilled workers, is the need to have a generally educated citizenry in a vibrant and democratic society. The task ahead is as daunting as it is necessary.

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4 The College Board, *Reaching the Top*, Report of the National Task Force on Minority High Achievement, 1999.

5 Samuel S. Peng, DeeAnn Wright, and Susan T. Hill, *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement*, U.S. Department of Education, National Center for Education Statistics, February 1995.

6 Thomas Hilton, et al. *Persistence in Science of High-Ability Minority Students*, RR-89-28, Educational Testing Service, May 1989.

7 Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment*, U.S. Department of Education, June 1999.

Introduction

Many sources have told us that the United States has a real problem in the level of science and mathematics achievement among our students. This was a considerable concern over a dozen years ago when President George H. Bush and the nation's governors established education goals, later ratified by the U.S. Congress. One of these goals was that American students would be first in the world in science and mathematics achievement by the year 2000, although many people in the math/science community thought this goal was unrealistic on that time scale. Some progress was made in mathematics, but none in science. And international studies have shown that the U.S. is far from reaching this ambitious goal.

This report concerns the state of science and math achievement generally. It is more specifically concerned, though, with the lower average achievement of minority students, and even more specifically with the relatively small proportion of minority students who score in the top reaches of science and math achievement. Advanced achievement is the foundation from which this nation builds the next generation of highly skilled workers in an increasingly technological economy. And it is the foundation from which we produce scientists, engineers, and technology experts whose roles are so critical to our economic progress and our position in the global economy.

The data and analyses available suggest that meeting the need for highly skilled workers over the next decade and beyond will be problematic unless focused efforts are made to improve achievement, particularly among underrepresented minorities. The demographics are such that these minorities will constitute the great majority of the increase in population of 18- to 24-year-olds between now and 2010; almost 60 percent of the three million increase in this age group will be Black, Hispanic, or American Indian.

Improving the math and science achievement of minority students is only the first step, however. It will be necessary to increase the number of students obtaining undergraduate and graduate degrees in science, mathematics, and engineering. While demand is projected to remain strong in the occupations that require postsecondary degrees in these areas, enrollments and degrees in many of these occupational areas have declined over the last decade or are not growing. The gap between the supply and demand for such workers is likely to grow far bigger as the baby boomers — now at the peak of their capabilities and contributions — approach retirement.

The following sections of this report examine supply and demand projections for various occupations, the barriers to meeting emerging shortages, and the status of minority representation in science and engineering — as well as high achievement in elementary and high school, the prospects for progress, and the extensive work to be done. One objective of this report is to provide a comprehensive but brief assessment of these matters. Another aim is to provide more detailed information for those with a more specific interest; accordingly, an appendix includes extensive statistics on supply and demand for scientists and engineers, and on progress in minority representation in these professions.

A Looming Shortage?

On many fronts, the business community has sounded the alarm about shortages of educated workers. Many employers and business leaders point to American students' weak achievement in math and science and predict devastating results for the supply of scientists, engineers, and other workers in our increasingly technological society and economy. For example, a recent issue of the newsletter of the National Alliance of Business (NAB), *Work America*, carries the headline "Skilled Workforce Shortage Could Cripple U.S. Economy." The story begins this way:

> *The focus of our education systems — K-12 and postsecondary — is seriously out of line with the constantly increasing demands of tomorrow's world. The changing fields, functions and advances in technology demand people with better preparation in mathematics and science in particular and in a wide variety of other skills in general.*

The concern is so great that NAB is leading a business coalition to do something about raising math and science achievement, both in the K-12 period and in postsecondary education. NAB is seeking to develop a "blueprint for action" that will help companies leverage their investment in math and science education in smarter and more effective ways.

Supply

If the need for scientists and engineers is indeed growing, the enrollment statistics in our graduate schools are far from encouraging. In a few cases, small increases have been made, but the predominant trend in graduate school enrollments in engineering, mathematics, and the physical sciences has recently been downward.[8]

- From 1990 to 1997, total graduate engineering enrollments increased, then declined from 107,625 to 101,008. (The peak occurred in 1992, at 118,035.) The largest declines, in percentage terms, were in aerospace (22 percent), engineering science (19 percent), mining (20 percent), and nuclear (32 percent). There was a large increase in biomedical engineering at 33 percent.

- The peak graduate enrollment in the physical sciences also fell, from 35,348 in 1992 to 31,108 in 1997. The largest decline since 1990 was in physics (19 percent). Enrollments in astronomy and chemistry also declined.

- Graduate enrollment in mathematical sciences also peaked in 1992 at 20,355, then fell each year, down to 16,759 in 1997.

- In computer sciences, graduate enrollments rose by 5 percent from 1990 to 1997, to 36,010, just under the 1992 level.

- Graduate enrollments in earth, atmospheric and ocean sciences rose 5 percent from 1990 to 1997, but were down in 1997 from their peak in 1994.

Coming off earlier gains in graduate school enrollments, the actual number of degrees at the doctorate level climbed substantially from 1987-88 to 1997-98, doubling in computer and information science, and rising 43 percent in engineering, 58 percent in mathematics, and 20 percent in the physical sciences.

Modest growth occurred at the master's degree level in computer and information science (22 percent) and in engineering (15 percent). However, the number of master's degrees awarded in mathematics and the physical sciences and science technologies slid by 6 percent over this decade.

What is worrisome about the future trend in advanced degrees is the downward trend in bachelor's degrees, except in the physical sciences (see Figure 1).

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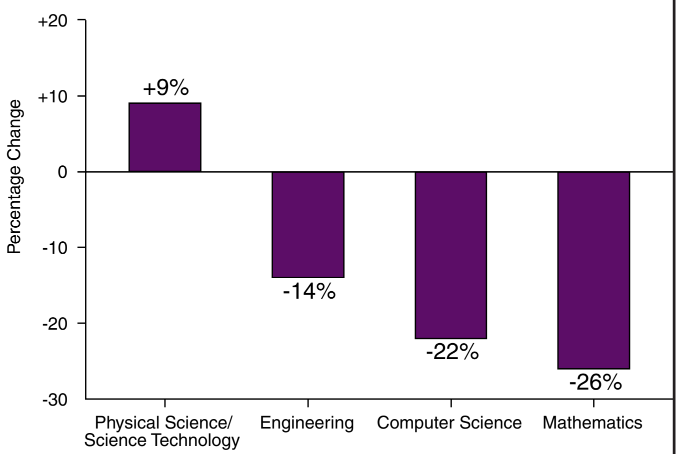
8 National Science Foundation, *Survey of Graduate Students and Postdoctorates in Science and Engineering Fall 1997*, cited in National Center for Education Statistics, *The Digest of Education Statistics*, 2000. In this report we focus on mathematics and the physical sciences, although some tables include data on the life sciences.

Figure 1: Percentage Change in Bachelor's Degrees Conferred, 1987-1988 to 1997-1998



Source: National Center for Education Statistics, Digest of Education Statistics, 2000.

In the decade 1987-88 to 1997-98, bachelor's degrees in engineering, computer and information science, and mathematics were down 14 percent, 22 percent, and 26 percent, respectively. This occurred even though there was no change in the size of the population of 20- to 21-year-olds from 1988 to 1998.[9] Furthermore, after the mid-1980s, the percent of high school graduates enrolling in college the fall after they graduated, and the percent of 18- to 24-year-olds enrolled in college, increased. This smaller pool from which master's and doctorate students are drawn portends a decline in degrees at those levels, unless there is a dramatic increase in the percentage of bachelor's degree recipients who go on to graduate school and complete it.

Demand

Projections of demand for scientists and engineers by the U.S. Bureau of Labor Statistics show continued growth in employment in engineering and science occupations from 2000 to 2010 (see Table 1).

Employment growth is expected to be particularly strong in the computer specialist fields, with a projected 69 percent increase in average employment growth. This contrasts with the decline of 22 percent in bachelor's degrees awarded in the computer sciences from 1987-88 to 1997-98; however, a great many workers in the computer science fields do not come from undergraduate computer science programs, but from other education paths such as electrical engineering, math, and business.[10] A whopping 2.3 million job openings will need to be filled in the coming decade if employment is to reach the level of demand projected. (Projections for individual occupations are provided in the Appendix.)

Projecting both supply and demand is a difficult business and involves assessing the changes occurring in the economy and in manufacturing and production processes, as well as the direction and speed of technological change. The supply as well as demand for qualified workers has to be projected. In doing so, one must account for the historical role of immigration in meeting supply shortcomings, the use of work visas, and the increasing number of foreign graduate students we educate and who plan to stay in the U.S. Below are the summary assessments of the Bureau of Labor Statistics of the "Job Outlook" for the period 2000-2010.[11]

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9 This age group declined somewhat toward the middle of the decade and recovered by the end of it. There was a decline in the 22- to 24-year-old population.

10 See Peter Freeman and William Aspray, *The Supply of Information Technology Workers in the United States*, Computer Research Association, 1999.

11 These are abstracted from the *BLS Occupational Outlook Handbook*. More details can be found in the appendix.

Table 1: Projections of Employment and Job Openings, 2000-2010

Occupations	Average Employment 2000	Average Employment 2010	Percent Change	Total Job Openings 2000-2010
Total, All Occupations	**145,594,000**	**167,754,000**	**+15**	**57,932,000**
All Engineers	1,465,000	1,603,000	+9	452,000
Computer Specialists	2,903,000	4,894,000	+69	2,259,000
Mathematical Scientists	89,000	95,000	+6	26,000
Physical Scientists	239,000	283,000	+18	124,000

Source: Daniel E. Hecker, "Employment Outlook: 2000-10," *Monthly Labor Review*, November 2001, pp. 65-66.

Outlook

- *Engineers* - Overall engineering employment is expected to increase more slowly than the average for all occupations. However, job opportunities in engineering overall are expected to be good through 2010 because the number of engineering degrees granted is not expected to increase significantly over the 2000-2010 period.

- *Computer Software Engineers* - Computer software engineers are projected to be the fastest-growing occupation from 2000 to 2010. Very rapid growth in the computer and data processing services industry, which employs the greatest number of computer software engineers, should result in very favorable opportunities for those with the required skills.

- *Systems Analysts, Computer Scientists, and Database Administrators* - Systems analysts, computer scientists, and database administrators are expected to be among the fastest-growing occupations through 2010. Employment of these computer specialists is expected to increase much faster than the average for all occupations as organizations continue to adopt and integrate increasingly sophisticated technologies. The expansion of employment in this area will be driven by very rapid growth in computer and data processing services, which is projected to be the fastest-growing industry in the U.S. economy.

- *Physicists and Astronomers* - Historically, many physicists and astronomers have been employed on research projects, often defense-related. Because defense expenditures are expected to increase over the next decade, employment of physicists and astronomers is projected to grow about as fast as the average for all occupations through the year 2010. The larger source of job openings, however, will be the need to replace physicists and astronomers who retire.

- *Atmospheric Scientists* - Employment of atmospheric scientists is projected to increase about as fast as the average for all occupations through 2010, but prospective atmospheric scientists may face competition if the numbers of degrees awarded in atmospheric science and meteorology remain near current levels.

- *Chemists and Materials Scientists* - Employment of chemists is expected to grow about as fast as the average for all occupations through 2010. Job growth will be concentrated in drug manufacturing and in research, development, and testing service firms.

- *Mathematicians* - Employment of mathematicians is expected to decline through 2010 because very few jobs with the title mathematician are available. However, master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as engineering or computer science, should have good job opportunities.

While there is variation among the fields, it is clear that employers are justifiably concerned about the adequacy of the future supply of personnel in these fields that require extensive education and training.

In addition to these data on trends in enrollments and degrees, it would also be helpful to track the completion rates for those who enroll, at all levels, in the education pipeline. Unfortunately, this is not possible with the data available. An extended discussion of persistence to the degree is provided later in this report.

Will the Need Be Met?

The supply and demand for such a highly educated and trained workforce is a dynamic interaction, with success depending on a myriad of factors. No doubt many needed adjustments will occur as a result of the interplay of information, choices, and markets. The question is whether these adjustments will be adequate to meet the need.

According to the *Occupational Outlook Handbook*, produced regularly by the Bureau of Labor Statistics, opportunities are good to excellent in the highly respected and well-paid science and engineering occupations; they are a safe investment of time and money. And counselors, parents, and students generally get this message, even though the information systems available to help high school students make career choices are not at all perfect. Nevertheless, we do go through periods of under-response and over-response, and of shortages, balances, and surpluses in the supply-demand cycles. The fact that employers fear shortages, and strong employer organizations are gearing up to increase supply, shows that the adjustment gears are beginning to turn.

While market forces are at work, we should not assume matters will take care of themselves. It is crucial to understand the large facts and emerging trends that pose barriers to any "natural" adjustments.

One barrier is the well-recognized weaknesses in the preparation of elementary and secondary students in science and mathematics; the performance of U.S. students compared with those in other developed countries has caused consternation. Although the results of the comparisons are quite favorable at the fourth grade, U.S. students begin slipping behind after that level. There were encouraging signs of progress in mathematics in the 1990s, as measured by NAEP, but science performance failed to improve.

The generally accepted fact of under-performance in math and science constrains expansion in the proportion of high school graduates who can successfully prepare for the science and engineering professions. Science and engineering may wean some high-achieving students away from pursuit of other professions, but the proportion of those well enough prepared will establish limits. The fact is that science and engineering are at the top of the list in terms of demanding academic preparation. For example, we know that the prose and quantitative literacy requirements for engineers are 341 and 353 on a 0 to 500 scale, respectively, compared to the average requirement for all professional occupations of 332 and 328.[12]

The constraint of low to middling achievement in academic subject matter will likely yield only to sustained and intensive effort. Improving achievement is now in the spotlight, largely through what has become a standards and testing movement, and will not be detailed here.[13] Suffice it to say that higher academic achievement for more students will be critical to enlarging the pool from which colleges and graduate schools can draw.

The Baby Boom Retires. The huge presence of the baby boomers at the various stages of aging has transformed both the educational system and the labor market. In the next decade and a half — as demographers have sometimes put it — the baby boom pig will largely complete its journey through the labor force python. The babies born in the first year after World War II turned age 55 in 2000. Accordingly, the large cohort of baby boomer scientists and engineers, with all of

12 Paul E. Barton, *What Jobs Require: Literacy, Education, and Training, 1940 to 2006,* Policy Information Center, Educational Testing Service, January 2000. To provide some perspective on how these scores compare, the average quantitative scores for persons with four or more years of college is 307 and for persons with just a high school education, 270.

13 This author has argued that we must go far beyond these efforts; see Paul E. Barton, *Facing the Hard Facts in Education Reform*, Policy Information Perspective, Policy Information Center, Educational Testing Service, July 2001.

its accumulated knowledge and experience, will soon be retiring.

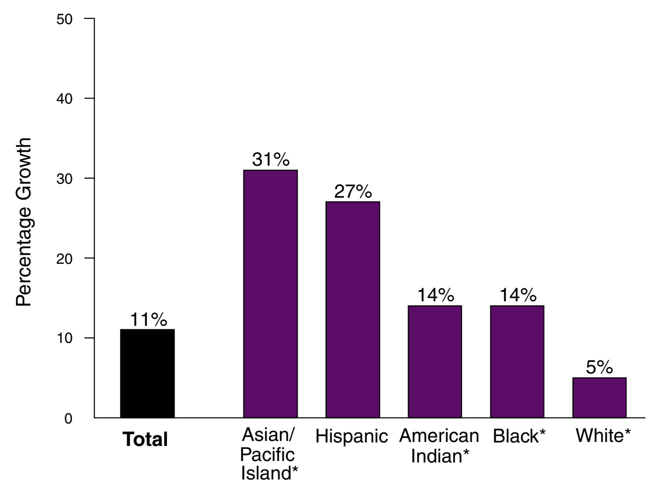
The baby boomers represent a very large number of experienced professionals, and the effects of their impending retirement on the labor market will be considerable. In 1990, there were 11.6 million 55- to 64-year-olds in the labor force; and by 2010, that number is expected to be 21.2 million — about double the number in 1990. These numbers will rapidly diminish after 2010.

The year 2010 may seem distant, but in fact the time span is not very long when you consider how long it takes to turn a graduating high school senior into a scientist or engineer with a master's or a doctoral degree. Additionally, many students now take from five to six years to achieve a bachelor's degree, and the time to get a degree in graduate studies has been lengthening. And if you need more high school seniors qualified to enter these fields, how many more years do you have to reach back? Clearly, the time for action is now.

The More Rapid Growth of Minorities. As the baby boomers retire, where are the young people who will go to college and graduate school to be prepared to take their place? In 2001, there were 27.2 million 18- to 24-year-olds. By 2010, we can expect an increase of 11 percent, or 3 million, bringing the total to 30.2 million. There will be, however, a very big difference in the racial and ethnic composition of these young adults than was the case when the baby boomers flooded the colleges in the 1960s. In the next ten years, the minority population will grow more rapidly than will the majority.

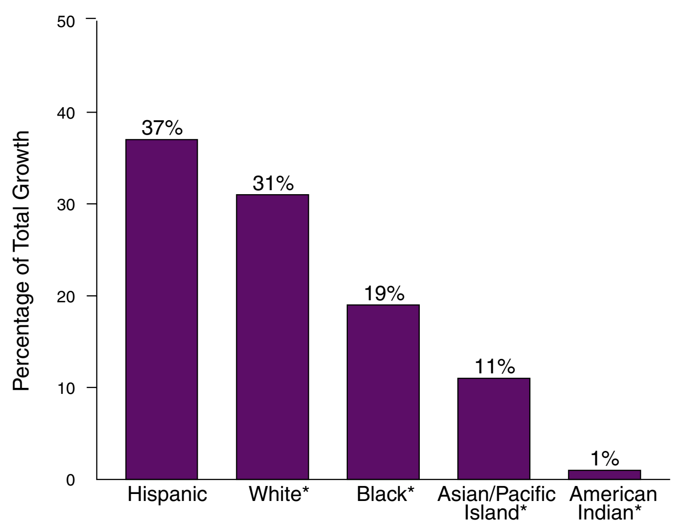
In Figure 2 we can see the difference in the growth rates. While White young adults aged 18 to 24 are expected to increase by just 5 percent from 2001 to 2010, this contrasts with a 14 percent increase among Blacks and American Indians, a 27 percent increase among Hispanics, and a 31 percent increase among Asian and Pacific Islanders (who are overrepresented

Figure 2: Population Growth of 18- to 24-Year-Olds, 2001 to 2010, by Racial/Ethnic Group



*Non-Hispanic
Source: U.S. Census Bureau. http://www.census.gov/population/projections/nation/summary

Figure 3: Percentage of Total Growth of 18- to 24-Year-Olds Among Racial/Ethnic Groups, 2001 to 2010



*Non-Hispanic
Source: U.S. Census Bureau. http://www.census.gov/population/projections/nation/summary

relative to their numbers in obtaining degrees in science and engineering).

If we look at the composition of this net growth for the decade (3 million 18- to 24-year-olds), the contrasts are considerably more striking (see Figure 3). *Of the growth in 18- to 24-year-olds, just 3 in 10 will be White*. Thirty-seven percent will be Hispanic, 19 percent Black, 11 percent Asian and Pacific Islander, and 1 percent American Indian. By 2010, 62 percent of the total population will be White, compared with 66 percent in 2001.

What are the implications of these population trends? In order to replace the retirees and meet the projected demand for skilled workers, we must increase the number of minority students who complete college and graduate degrees (although their proportions have been rising). From the standpoint of equity, this will be a laudable undertaking. But it will also become a necessity to meet the needs of the economy.[14]

Asian Americans will likely continue to get degrees in science and engineering in greater proportions than the population as a whole. But what about Black and Hispanic individuals, underrepresented populations that together will grow by over a fifth by the year 2010, and constitute 57 percent of the net increase? We must prepare these underrepresented minorities to: a) qualify to pursue a science and engineering profession; b) enter college and graduate; and c) pursue and complete a graduate degree in science and engineering. We now examine trends in these areas.

14 A report readers may want to consult is *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, by the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, September 2000.

Minorities in Science and Engineering Education and Its Prerequisites

Before the question of what to do and how to do it, there is the question of where we are now and what progress we are making. Has there been any significant rise in the proportion of underrepresented minorities who are qualified to enter college to study science and engineering, and who get the necessary degrees to enter these professions? We will start with the award of degrees and work back to the pre-college education period, where the platform is built.

Degrees of Progress. Over the past decade, clear progress has been made in raising the proportion of degrees going to people from underrepresented minority populations, a fact that provides encouragement for the success of greater efforts in the decade ahead.

The increased representation of minority group students was most pronounced in the award of bachelor's degrees in science and engineering (see Table 2). Degree awards to underrepresented minorities rose from 9.7 percent of the total in 1990 to 14.7 percent of the total in 1998 — a gain of over 50 percent in the proportion. Over the same time period, the gain for master's degrees was from 5.0 to 8.2 percent, and for doctorate degrees from 3.9 to 5.5 percent.

Underrepresentation grows at each degree level. In 2001, these minority groups constituted about three in ten of the population in their twenties. This proportion is more than five times as high as the proportion getting doctorate degrees. Nevertheless, minority representation is growing.

In the general population, the growth in college degrees is greater among women than among men, as it is among minorities. And the proportion of minority women of all women getting degrees in science and engineering is greater than for men. For example, in the award of bachelor's degrees, underrepresented minority women accounted for 17.5 percent of all degrees awarded to women, compared to 12 percent awarded to men (see the complete table in the appendix).

Graduating from High School. To the extent that we do not get our youth through high school with a diploma, we limit the pool from which we can obtain scientists and engineers. The U.S. is not doing well in this regard, and the situation has been obscured by the official statistics available. These statistics include people who earn a GED degree as well as those who

Table 2: Science and Engineering Degrees Awarded to Underrepresented Minorities as a Percent of Total Degrees in These Fields

	Bachelor's Degrees		Master's Degrees		Doctorate Degrees	
	1990	1998	1990	1998	1990	1998
Total	**9.7**	**14.7**	**5.0**	**8.2**	**3.9**	**5.5**
Black Non-Hispanic	5.3	7.6	2.6	4.3	1.6	2.4
Hispanic	4.0	6.5	2.2	3.5	2.0	2.8
American Indian/Alaskan Native	0.4	0.6	0.3	0.4	0.2	0.4

Source: Susan T. Hill, *Science and Engineering Degrees by Race/Ethnicity of Recipients: 1990-1998*, National Science Foundation, June 2001.

receive a diploma at the end of four years of high school. By this combined measure, the graduation rate is in the high 80s, and has been increasing. But estimates not including the GED show a graduation rate of about seven in ten, down from about three out of four a few years ago. The GED is a valuable program, but for a very high proportion of those who receive it, it does not likely constitute a measure of achievement sufficient to enter the demanding professions of science and engineering.[15]

While the overall high school graduation rate is around 70 percent, it varies by race and ethnicity. The most comprehensive information available is from a study by Jay P. Greene.[16] His estimates are by state and by race and ethnicity. Greene uses state data on eighth grade enrollment for 1993 and regular high school diplomas awarded for 1998, with some adjustment for distortion due to the possibility of students moving into and out of the area.

The state with the lowest overall high school graduation rate was Georgia at 57 percent, and the highest was Iowa at 93 percent; 25 states had rates in the 70s. The rates for Black youth range from a low of 40 percent in Wisconsin to a high of 71 percent in West Virginia (rates could not be calculated for 13 states). The Hispanic rate ranged from a low of 32 percent in Georgia to 82 percent in Montana (rates could not be calculated for 13 states). Among White youth, the low was 61 percent in Georgia and the high was 95 percent in Iowa (data were not available for 10 states).

Among city school districts, Cleveland, Ohio, was estimated to have graduated 28 percent of its students, with Memphis next at 42 percent.[17] Fairfax County, Virginia, had the highest graduation rate, at 87 percent.

Over the last quarter century, the nation's high school graduation rate, excluding the GED, has been stable at between 70 and 75 percent, and is now at the low end of the range. Nothing about the overall graduation rate, or the rates for Black and Hispanic youth, offer any reason for optimism about the future. In the last quarter century, national and local dropout prevention campaigns have come and gone. On the average, at least, they have been of no avail. High achievement standards loom high on the national agenda; higher completion rates do not.

A Limited Reservoir to Recruit From. If we need to attract new youth into science and engineering professions, do we have enough young people coming out of our schools to guide toward the colleges and graduate schools that produce them? The question is particularly relevant to efforts to greatly increase the representation of minorities in science and engineering occupations.

Raising achievement has been high in the priorities of presidents and governors for the last two decades. The 1980s saw incremental success in that we narrowed some achievement gaps between majority and minority populations; however, we have not held on to all the ground we gained. And while we have raised average achievement scores in mathematics, science achievement has been flat.

As measured by NAEP, the fourth and eighth graders in all ethnic and racial subgroups made gains in

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15 However, the GED has very recently been changed substantially, and the test is more demanding; in the future, more preparation will be required to obtain the GED.

16 Jay P. Greene, *High School Graduation Rates in the United States*, Manhattan Institute for Policy Research, prepared for the Black Alliance for Educational Options, November 2001.

17 Completely accounting for migration of students between the eighth grade and graduation age would be very challenging in making these estimates.

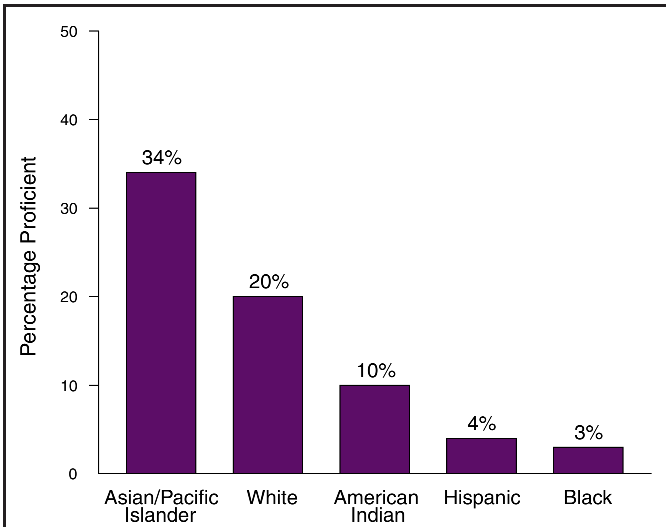
average mathematics achievement in the 1990s. Twelfth graders also gained in mathematics from 1990 to 2000. The distribution of scores is very wide, however, and "average" scores are not good enough to enter science and engineering education. We need to know more specifically how students are doing in the upper reaches of the NAEP achievement scale. We will look at this for mathematics, a way of judging qualifications for science and engineering education.

NAEP classifies students according to three achievement levels reached on the assessment: "Basic," "Proficient," and "Advanced." Based on the NAEP description of what students at the Advanced level should know and be able to do, one might argue that this is the level of achievement needed by students leaving high school and entering science and engineering education. But in America, that would be dreaming, even after a decade and a half of real effort to set standards and raise math achievement. Only 2 or 3 percent of White twelfth graders reach the Advanced level, and minority students (except Asian and Pacific Islanders) are so few that NAEP does not report a percentage.

To be more realistic, we drop down a level to Proficient. NAEP gives this description of what twelfth-grade students at this level should know and be able to do:

> *Twelfth-grade students performing at the* Proficient *level should consistently integrate mathematical concepts and procedures into the solutions of more complex problems in the five NAEP content strands.*
>
> *Twelfth-graders performing at the* Proficient *level should demonstrate an understanding of algebraic, statistical, and geometric and spatial reasoning. They should be able to perform algebraic operations involving polynomials; justify geometric relationships; and judge and defend the reasonableness of answers as applied to real-world situations. These students should be able to analyze and interpret data in tabular and graphic form; understand and use elements of the function concept in symbolic, graphical, and tabular form; and make conjectures, defend ideas, and give supporting examples.*[18]

Figure 4: Percentage of Twelfth Graders at or above the Proficient Level in NAEP Mathematics, 2000



Source: James S. Braswell, et al., *The Nation's Report Card: Mathematics 2000*, U.S. Department of Education, National Center for Education Statistics, August 2001.

In the 1990s, there was a statistically significant gain in the percent of White twelfth graders who scored at or above the Proficient level, but no such gains for other groups. (There were some gains during the decade at the fourth and eighth grade levels.)

In 2000, 20 percent of White twelfth graders and 34 percent of Asian and Pacific Islanders students scored at or above the Proficient level on the NAEP mathematics assessment. In contrast, just 3 percent of Black students, 4 percent of Hispanic students, and 10 percent of American Indian students scored at or above that level (see Figure 4).

18 The NAEP levels are set by the National Assessment Governing Board. James S. Braswell, et al., *The Nation's Report Card: Mathematics 2000*, U.S. Department of Education, National Center for Education Statistics, August 2001.

There is no way to determine just what mathematics score on a NAEP test is necessary to successfully pursue majors in college leading to entry into science and engineering professions. It is not likely to be much lower than the Proficient level on NAEP. We do know that over the last 25 years or so, about a fourth of 25- to 29-year-olds have attained a bachelor's degree, somewhat above the percentage of White students who scored at or above the Proficient level on NAEP. Of course, most college majors do not require this level of mathematics. We can be sure that the small percentages of Black and Hispanic twelfth graders at the Proficient level represent a formidable barrier to raising the representation of these minorities in science and engineering, absent very concerted and sustained national effort.

Prospects for Progress

This report has been about the outlook for supply and demand for science and engineering occupations, the state of preparation of students to pursue these occupations in colleges and graduate schools, the relative preparation of minority youth, and the extent to which minorities are making headway in increasing their representation in these professions. In order to look at the position and prospects for minorities, we have to look at the total situation in these professions, for prospects would be bleak if we were facing surpluses in these occupations at a time when we were trying to expand minority representation.

In order to look at the needs of science and engineering generally, we have to be concerned with the adequacy of academic preparation generally, as well as of underrepresented minorities. The U.S. has well-recognized weaknesses in turning out a high proportion of high-achieving students in math and science; these are simply magnified when we look at the preparation of minorities in math and science — the critical prerequisites for successful pursuit of degrees in science and engineering.

We find a very high rate of under-preparation of minorities, and it is also the case that large percentages of these ill-prepared minority students are going to schools where most all of the students are well below par in achievement. Many minorities are in schools where the entire student body is under-performing, so there is an intertwining of measures needed to bring minority student achievement up to the level of the majority, and measures needed to raise achievement in under-performing schools generally.

Further, the measures that are receiving priority in the standards-based education reform movement are intended both to raise achievement overall and to reduce gaps between majority and minority student populations.[19] And when we look at where we are going to get more scientists and engineers from our population growth, we run into the stark fact that the minorities are the majority; that among 18- to 24-year-olds, Whites will constitute only 31 percent of the net growth in that population up to 2010, and 62 percent of that total population group. There is thus no clear demarcation between a discussion of the needs in the science and engineering arena in general, and a discussion of the needs of increasing minority representation in specific.

Starting Early. The medical profession and the Surgeon General have established that cigarette smoking causes lung cancer, and warn us not to start. But we are also told that if we have been smoking, no matter how long, we improve our chances if we stop. Likewise, in the area of increasing achievement in mathematics and science, our best chances will come from greatly expanded *early* childhood development and education. This will provide more equal starting points, which is critical if we are to: a) reduce the inequities of achievement in the K-12 period of education, and b) enlarge the pool of high school graduates who are prepared to pursue careers in science and engineering.

The National Assessment of Educational Progress has well established that the achievement disparities found among racial-ethnic groups in the twelfth grade are also found in the eighth and fourth grades. These disparities do not just spring up from nowhere; they are already there when young children enter school, and even earlier, as a result of the different life experiences in the early years.[20] In fact, a longitudinal study currently being carried out by the National Center for

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19 However, we have made no progress in reducing gaps between achievement of the majority and minorities in the period of emphasis on standards-based reform. For one account, see Paul E. Barton, *Raising Achievement and Reducing Gaps: Reporting Progress Toward Goals for Academic Achievement in Mathematics*, a report to the National Education Goals Panel, January 2002.

20 Richard J. Coley, *An Uneven Start: Indicators of Inequality in School Readiness*, Policy Information Report, Policy Information Center, Educational Testing Service, March 2002.

Education Statistics provides clear evidence that disparities in cognitive development are present when children begin kindergarten.[21]

Clearly, we can do things later that will reduce inequality of achievement in grade school and high school. But these measures will be less effective, and the gains smaller and likely more expensive, the longer we delay. The case for an early start is not only being made by professionals in the field of early childhood development. Early intervention is recognized as critical to all goals for educational achievement, and for the economy and nation as a whole. The prestigious Committee for Economic Development, a business organization, released a report in February 2002 entitled *Preschool for All: Investing in a Productive and Just Society*. It had this to say:

> *For too long, the United States has paid lip service to the importance of preschool opportunities that prepare children for school without undertaking the level of investment needed to turn promise into reality. Just as we have long seen elementary and secondary education for all as a societal responsibility, we must now undertake to extend educational opportunity to all children age 3 and up.*[22]

Improving Mathematics and Science Instruction and Curriculum. The quality of teaching in mathematics and science has recently been put under the microscope by the National Commission on Mathematics and Science Teaching for the 21st Century, chaired by John Glenn. The Commission was composed of 25 leaders from the fields of government, business, and education. The urgency of the situation is conveyed by the title, *Before It's Too Late*. Its perspective is this:

> *First, at the daybreak of this new century and millennium, the Commission is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but how well we educate them in mathematics and science specifically . . .*
>
> *Second, it is abundantly clear from the evidence already at hand that we are not doing the job that we should do — or can do — in teaching and use of ideas from these fields. Our children are falling behind; they are simply not "world class learners" when it comes to mathematics and science . . .*
>
> *Third, after an extensive, in-depth review of what is happening in our classrooms, the Commission has concluded that the most powerful instrument for change, and therefore the place to begin, lies at the very core of education — with teaching itself . . .*
>
> *Fourth, we believe that committing ourselves to reach three specific goals can go far in bringing about the basic changes we need. These goals go directly to issues of quality, quantity, and an enabling work environment for teachers of mathematics and science . . . Specifically, we offer suggestions on how to:*

- *Establish an ongoing system to improve the quality of mathematics and science teaching in grades K-12;*
- *Increase significantly the number of mathematics and science teachers and improve the quality of their preparation; and*
- *Improve the working environment and make the teaching profession more attractive for K-12 mathematics and science teachers.*[23]

21 For early findings and a description of the survey, see Jerry West, Kristin Denton, and Elvira Geronimo-Hausken, *America's Kindergartners*, National Center for Education Statistics, 2000.

22 Committee for Economic Development, *Preschool for All: Investing in a Productive and Just Society*, a Statement of the Research and Policy Committee, 2002.

23 *Before It's Too Late: A Report to the Nation from The National Commission on Mathematics and Science Teaching for the 21st Century*, September 2000.

The Commission provides a thorough assessment of the state of mathematics and science teaching and a comprehensive set of measures to improve it. Strengthening instruction is critical to getting more students at the top level of achievement needed to enter science and engineering, and critical to reducing the wide disparity by race and ethnicity that now exists at the Proficient level of performance on the NAEP math and science assessments.

We note a very recent and promising development in the Southern Regional Education Board's High Schools That Work Consortium involving 26 states and over 1,100 high schools. The consortium is launching a "Pre-Engineering Course of Study" that begins in the middle grades and extends through high school. The goal is to "increase the number and quality of engineers and engineering technologists by providing:

- A fully developed curriculum for high schools;

- A middle grades technology curriculum;

- Extensive training for teachers;

- Training for school counselors;

- Access to affordable equipment; and

- College-level certification and course credit."[24]

High Minority Achievement. Many analyses and proposals have dealt generally with the gap between majority and minority achievement. Typically they point to the difference in average scores, or to the much higher incidence of low scores on standardized tests. The specific focus of this report is increasing the proportion of high scorers. We have pointed out that this proportion among Black and Hispanic students lags far behind White students (who lag behind Asian American students). However, not long ago, the shortage of high achievers was dealt with in depth by the National Task Force on Minority High Achievement appointed by the College Board. After over two years of work, it issued a report titled *Reaching the Top*. Its concern about high achievement differed from earlier efforts that addressed the gap in general. The report stated the task force's goal this way:

> *The National Task Force on Minority High Achievement was convened by the College Board to address a relatively neglected aspect of the situation: the reality that far too few Black, Hispanic and Native American students are reaching the highest levels of achievement. The Task Force also has been asked to address a related issue: the fact that large disparities in achievement exist between students from these groups and White and Asian American students at essentially all socio-economic levels. Until many more underrepresented minority students from disadvantaged, middle class, and upper class circumstances are very successful educationally, it will be virtually impossible to integrate our society's institutions completely, especially at leadership levels. Without such progress, the United States also will continue to be unable to draw on the full range of talents in our population during an era when the values of an educated citizenry have never been greater.*[25]

The roots of unequal achievement are deep in the American economy and society. But it is not just a problem of getting achievement up to some minimum (the way we approached it in the 1970s). It is also getting a higher portion up to a maximum. A new and comprehensive analysis of literacy in America, from an international perspective, carried the title *The Twin Challenges of Mediocrity and Inequality*.

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24 This will be carried out by SREB through a partnership with Project Lead the Way, Inc. See *HSTW Presents a Pre-engineering Program of Study*, Southern Regional Education Board, Atlanta, or visit these websites: www.sreb.org and www.pltw.org.

25 The College Board, *Reaching the Top*, Report of the National Task Force on Minority High Achievement, 1999.

After establishing the extent of inequality and mediocrity in adult literacy in the U.S., the authors warn:

> *The continued high levels of inequality in literacy, math, and science knowledge among elementary and secondary students, young adults, and the entire adult population of the U.S. do not bode well for the future outlook on inequality in the schools, the economy, the labor market, and our social and civic life. If we fail to reduce the degree of inequality in literacy skills over the coming decade, then the cognitive demands for access to most high-skilled, high-wage jobs in the U.S. labor markets and for actual participation in civic and political life will create a bifurcated distribution of economic and political rewards in the future.*[26]

We can add that we will be unlikely to meet the expanding need for scientists and engineers with this degree of mediocrity in achievement, nor will we be successful in further raising the proportion of minority group members in these professions.

Sources of Inequality and Mediocrity. It is probably impossible to use the tools of social science research to unravel all the determinants of educational achievement, although sufficient brainpower, unlimited access to all the relevant data, and adequate resources for analyzing it, might get us reasonably close. The undertaking seems as monumental as the project to map the human genome. Even if we succeeded, in the end we would be left with a voluminous list of factors and conditions found to be "associated" (correlated) with academic achievement; actual "causes" would remain elusive.

We do know that a large set of school factors, student characteristic factors, family and resource factors, and community factors is involved in academic achievement. Various research efforts have tackled pieces of this mystery, using data sets often designed for other purposes; some light filters through the clouded windows. We will not attempt a synthesis here. But one fairly recent study by the staff of the National Center for Education Statistics is particularly relevant to the topic of this report and is quite comprehensive.

This study and report was a collaborative effort between the National Center for Education Statistics of the U.S. Department of Education and the Division of Science Resource Studies of the National Science Foundation. It uses several databases, the most important of which is the National Longitudinal Study of eighth graders and the first follow-up study when they were tenth graders. The report, *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement*,[27] used the conceptual framework shown in Figure 5 and derived from a synthesis of previous research.

The analysis involved 39 variables clustered in accordance with the above framework. The principal findings were as follows:

- The underrepresentation of Blacks, Hispanics, and American Indians in science and mathematics-related fields "reflects in large part the outcomes of their education at all levels."
- All racial-ethnic groups of students were found to "have equally positive attitudes toward science and learning in school, and they have similar aspirations for science and mathematics-related careers."

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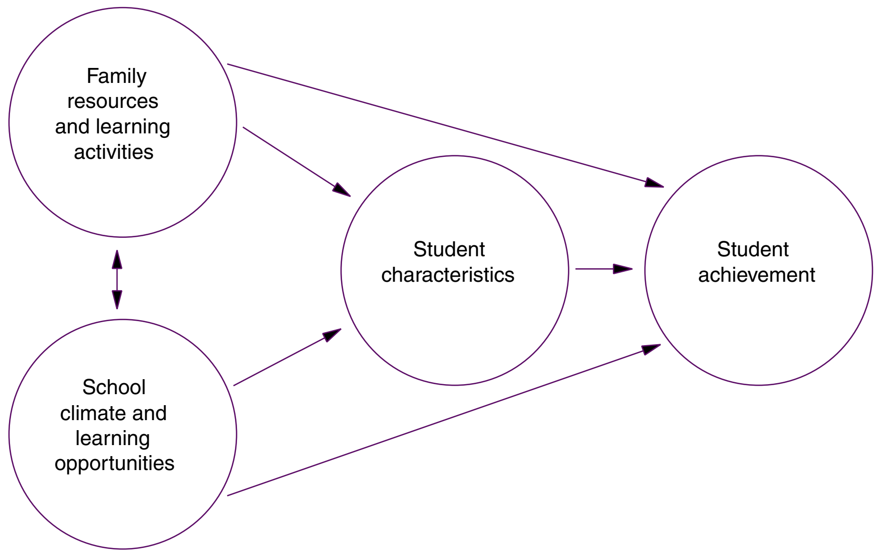
26 Andrew Sum, Irwin Kirsch, and Robert Taggart, *The Twin Challenges of Mediocrity and Inequality: Literacy in the U.S. from an International Perspective*, Policy Information Report, Policy Information Center and the Center for Global Assessment, Educational Testing Service, February 2002.

27 Samuel S. Peng, DeeAnn Wright, and Susan T. Hill, *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement*, U.S. Department of Education, National Center for Education Statistics, February 1995.

Figure 5: Conceptual Framework for Studying Science and Mathematics Education



Source: Samuel S. Peng, DeeAnn Wright, and Susan T. Hill, *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement*," National Center for Education Statistics, February 1995.

- As many minority students grew older, however, interest waned as they fell behind in science and mathematics.

- The following factors were found to be associated with lower achievement in science and mathematics:

  a. **Socioeconomic status and home support for learning**. "A larger percentage of these minority students come from families in poverty, and their parents are more likely to have low educational levels and to be unemployed. Thus, they are less likely to have learning materials and educational activities at home and to participate in educational activities outside of school. Their parents are less likely to provide adequate mentoring or role models for science and mathematics learning and also are less likely to have high educational expectations for them.

  b. **School characteristics**. "A larger percentage of these minority students attend disadvantaged schools where the overall academic and supporting environments are less conducive to learning. Their schools have lower achievement scores and more discipline and safety problems. Their schools also do not or cannot place as much emphasis on learning and grade completion as other schools. Students in these environments are less likely to have a strong peer group or community support to encourage them to work hard in school.

  c. **Level of school involvement**. "A larger percentage of the minority students suffer from the lack of persistent effort and active involvement in school. They are perceived more often by teachers as being inattentive and frequently disruptive in class. They are also more likely to fail to complete homework and to perform below their ability.

  d. **Type of high school program**. "A larger percentage of these minority students reported that

> they were in a low track achievement group and non-college preparatory high school programs. Consequently, they have received less rigorous academic training and have failed to obtain enough preparation, competence, or motivation to take more high level courses that prepare them for science and mathematics-related fields.

According to the study's authors, "each of the(se) home, school, and individual factors separately accounts for a small proportion of the achievement differences between these minority students and white and Asian students, based on the results of regression analyses. However, when these variables are considered jointly, their relationship with achievement differences is higher, i.e., the achievement differences are 45 percent less than if the students have the same value on all selected variables in the study." In other words, numerous factors are associated with differences in science and mathematics achievement, and all together, they explain less than half of the achievement differences. But the 45 percent that is associated with achievement is higher than typically found in such studies, and not to be dismissed lightly.

A Matter of Assistance and Persistence. Even for those high-school students who reach a level of achievement that qualifies them to enter college with the goal of pursuing a science or math degree, a number of hurdles remain. They need the counseling and support that will help them realize they can go to college and succeed. And they need help with all of the associated tasks that need to be done — finding the right college, taking admissions tests, filing applications, obtaining recommendations, and completing financial aid forms. The ratio of counselors to students in high schools is pitifully low, and this vital element has largely been ignored over the last two decades of education reform.

Not only will counseling and guidance be in short supply for this assistance, but many disadvantaged students lack the help at home and from relatives that is readily available to students with higher income parents who themselves are college graduates. For those who seek to increase college attendance among those qualified to go, this is a situation not to be ignored. Beyond increasing the ratio of guidance counselors to students, the need for guidance and counseling support could be met with supplementation from volunteers and from staff loaned by the personnel offices of concerned corporations.

The financial barriers to higher education have received considerable attention. Since the 1970s, federal and state financial aid programs have emerged and become critical to increased college attendance among minority students who are not in the upper brackets of family income.

A program of financial support at the graduate level has been operating now for over 25 years in the private sector, the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM). GEM consists of more than 150 corporate and university partners. Its efforts have resulted in more than 2,100 African Americans, American Indians, Latinos and Latinas, and Puerto Ricans graduating with a GEM Fellowship and internship experience.

An adequate supply of candidates for graduate study, of course, requires an adequate supply of college students in science, mathematics, and engineering who persisted and completed four years (or more) and received their degrees. However, a high proportion of those who enter college in all fields fall by the wayside. It is especially important for science and engineering that we help insure that high-ability minority students persevere to a degree.

In 1989, Educational Testing Service completed a large research project on the subject of persistence, undertaken at the request of the National Science Foundation's Committee on Equal Opportunities in Science and Engineering. The goal was to determine why some high-ability minority students persist and some do not. High ability was defined as achieving SAT mathematical scores of 550 or above; the sample was a total of 5,000 underrepresented minority students. The findings were as follows:

- High-ability minority students persisted to an unusually high degree. The non-persistent mostly transferred to other fields; few were dropouts.

- In general, what seemed to distinguish the persisters most from the balance of the sample was: 1) their finding the study of math, science, or engineering at the college level enjoyable, interesting, or rewarding; and 2) their personal commitment to mathematics, science, and engineering as a career. Taken together, these results point to the critical importance of the educational climate of undergraduate schools, and especially the quality of instruction in first year math and science courses.

- "At the high school level, what distinguished the persisters most from the other groups was their greater participation in math and science clubs, in honors courses and advanced placement courses in math and science, and in science activities."

  "College-based minority recruitment/enrichment programs also made a difference."

  "The persisters reported that scientists and engineers they knew or knew about or met in summer jobs and part-time work, especially minority scientists and engineers, influenced them more than parents, friends, and teachers did, although these figures were still important . . . high priority should be given to programs that provide promising minority students with opportunities for part-time and summer work in science and engineering."

- When other factors are controlled, "Ethnicity per se contributed little to the prediction" of persistence.[28]

These findings relate to those students already enrolled in college. Another key question is, what kind of students graduating from high school actually persist in college? An answer to that question will tell us a lot about how to improve the high school experience for minority — and all — students showing an interest in science and mathematics, as well as how to identify candidates for college who are likely to complete their degrees.

A very important and recent research study has found that the intensity of the high school curriculum is the most important factor in predicting whether a minority student will successfully complete college and receive a bachelor's degree. This finding emerges from an extensive analysis of "High School and Beyond" Longitudinal Survey data, including student transcripts, carried out at the U.S. Department of Education.[29] The rigor of the high school courses taken is a better predictor of completion to degree than either test scores or GPA/class rank, as seen in Table 3.

Examining courses taken is important in identifying minority students with the best chance to succeed. Taking rigorous courses may help make up somewhat for lower standardized test scores. Of course, schools that offer more rigorous courses may also often be schools that have better student support systems in place.

Clifford Adelman, the study's author, summed up the results as follows: "If we are genuinely interested in improving the degree completion rates of minority students, which of these indicators would we rather

28 Thomas L. Hilton et al., *Persistence in Science of High-Ability Minority Students*, RR-89-28, Educational Testing Service, May 1989.

29 Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment*, U.S. Department of Education, June 1999.

Table 3: Percent Completing to Bachelor's Degree*

Highest 40% on Scale	White	Black	Latino	Asian
Rigorous Curriculum	86	73	79	89
Test Scores**	81	67	67	95
GPA/Class Rank	79	59	57	85

*Among students who entered 4-year colleges directly from on-time high school graduation.
** Scores on tests given as part of the Longitudinal Study, not on SAT or ACT tests.

use? The answer, as they say, is a 'no-brainer': the only field on which we can exercise change. A test score is a snapshot of performance on a Saturday morning. Secondary school grades — and the relative standing that they produce in 'classes' where the student body may be constantly changing — carry as much reliability as a pair of dice.[30] But the intensity and quality of curriculum is a cumulative investment of years of effort — in schools, teachers, and students, and provides momentum into higher education and beyond. It obviously pays off."

* * * *

Together these facts and research findings can help inform and guide efforts to find ways and means of raising the preparation of students generally — especially minority students — who are prepared to pursue college and graduate degrees and ultimately careers in science and engineering. This review covers a long time period, from the cradle to the degree. The earlier the effort is made, the more likely the success will be. But improvement can be made at any stage we begin.

30 R. Elliott and A.C. Strenta, "Effects of Improving the Reliability of the GPA on Prediction Generally and on Comparative Predictions for Gender and Race Particularly," *Journal of Educational Measurement, 25* (4), pp. 333-347 (as cited in Adelman, 1999).

Appendix

Engineer Occupations Projections to 2010

Computer and Math Occupations Projections to 2010

Life and Physical Scientists Occupations Projections to 2010

Job Outlook for Engineers

Job Outlook for Computer Software Engineers

Job Outlook for Systems Analysts, Computer Scientists, and Database Administrators

Job Outlook for Physicists and Astronomers

Job Outlook for Atmospheric Scientists

Job Outlook for Chemists and Materials Scientists

Job Outlook for Mathematicians

Percentage Distribution of Bachelor's Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

Percentage Distribution of Master's Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

Percentage Distribution of Doctorate Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

Engineer Occupations Projections to 2010

Employment in engineering occupations will grow by 138,000, or 9 percent, from 2000 to 2010, with 432,000 total job openings to fill. While growth in some specialities will be modest, three will grow by 25 percent or more.

Growth in Engineering Occupations*

(Numbers in Thousands)

	2000	2010	Growth		Total Job Openings** 2000-2010
			Number	Percent	
All Engineers	**1,465**	**1,603**	**138**	**9**	**432**
Aerospace Engineers	50	57	7	14	22
Agricultural Engineers	2	3	0	15	1
Biomedical Engineers	7	9	2	31	4
Chemical Engineers	33	34	1	4	7
Civil Engineers	232	256	24	10	60
Computer Hardware Engineers	60	75	15	25	23
Electrical and Electronic Engineers	288	319	31	11	84
Environmental Engineers	52	66	14	26	24
Industrial Engineers	198	210	12	6	45
Marine Engineers and Naval Architects	5	5	0	2	1
Materials Engineers	33	35	2	5	9
Mechanical Engineers	221	251	29	13	94
Mining and Geological Engineers, including Mine Safety	6	6	0	-1	1
Nuclear Engineers	14	14	0	2	3
Petroleum Engineers	9	8	-1	-7	2
All Other Engineers	253	254	1	0	51

*Daniel E. Hecker, "Employment Outlook: 2000-10," *Monthly Labor Review*, November 2001, page 65.
**Job openings due to growth in the economy and the net replacement needs resulting from workers who leave the labor force or transfer to other occupations.

Computer and Math Occupations Projections to 2010

Employment in Computer Specialist occupations will grow by almost 2 million — almost 70 percent — from 2000 to 2010, with 2.26 million total job openings to fill; some specialties will almost double. Mathematical Science occupations will experience no or modest growth, although Operations Research Analysts will increase by 8 percent.

Growth in Computer and Mathematical Occupations*

(Numbers in Thousands)

	2000	2010	Growth		Total Job Openings** 2000-2010
			Number	Percent	
Computer Specialist Occupations	**2,903**	**4,894**	**1,991**	**69**	**2,259**
Computer Programmers	585	680	95	16	217
Computer Scientists and Systems Analysts	459	729	269	59	309
Computer Software Engineers	697	1,361	664	95	711
Computer Support Specialists	506	996	490	97	512
Database Administrators	106	176	70	66	74
Network and Computer Systems Administrators	229	416	187	82	197
Network Systems and Data Communications Analysts	119	211	92	78	97
All Other Computer Specialists	203	326	123	61	141
Mathematical Science Occupations	**89**	**95**	**5**	**6**	**26**
Actuaries	14	15	1	5	3
Mathematicians	4	4	0	-2	0
Operations Research Analysts	47	51	4	8	19
Statisticians	19	20	0	2	3
Miscellaneous	5	5	0	3	1

*Daniel E. Hecker, "Employment Outlook: 2000-10,"*Monthly Labor Review*, November 2001, page 65.
**Job openings due to growth in the economy and the net replacement needs resulting from workers who leave the labor force or transfer to other occupations.

Life and Physical Scientists Occupations Projections to 2010

Employment in Life and Physical Sciences will grow by 77,000 — almost a fifth — from 2000 to 2010, with 217,000 job openings to fill. The percentage increase will be the same for both Life and Physical Scientists. The highest growth rate will be among Medical Scientists. The largest number of job openings will be among Environmental and Geo-Scientists.

Growth in Life and Physical Scientists Projections*
(Numbers in Thousands)

	2000	2010	Growth		Total Job Openings**
			Number	Percent	2000-2010
Life Scientists	**184**	**218**	**33**	**18**	**93**
Agricultural and Food Scientists	17	19	2	9	7
Biological Scientists	73	88	15	21	42
Conservation Scientists and Foresters	29	31	2	8	12
Conservation Scientists	16	18	1	8	7
Foresters	12	13	1	7	5
Medical Scientists	37	47	10	27	18
All Other Scientists	28	33	4	16	15
Physical Scientists	**239**	**283**	**44**	**18**	**124**
Astronomers and Physicists	10	11	1	11	4
Atmospheric and Space Scientists	7	8	1	17	3
Chemical and Materials Scientists	92	110	18	19	47
Chemists	84	100	16	19	43
Materials Scientists	8	9	2	20	4
Environmental Scientists and Geo-Scientists	97	118	21	22	52
All Other Physical Scientists	33	36	3	9	17

*Daniel E. Hecker, "Employment Outlook: 2000-10,"*Monthly Labor Review*, November 2001, page 66.
**Job openings due to growth in the economy and the net replacement needs resulting from workers who leave the labor force or transfer to other occupations.

JOB OUTLOOK FOR ENGINEERS

- **Overall engineering employment is expected to increase more slowly than the average for all occupations. However, overall job opportunities in engineering are expected to be good through 2010 because the number of engineering degrees granted is not expected to increase significantly over the 2000-10 period**. Projected employment growth and, thus, job opportunities vary by specialty, ranging from a decline in employment of mining and geological engineers to faster-than-average growth among environmental engineers. Competitive pressures and advancing technology will force companies to improve and update product designs and to optimize their manufacturing processes. Employers will rely on engineers to further increase productivity, as investment in plant and equipment increases to expand output of goods and services. New computer and communications systems have improved the design process, enabling engineers to produce and analyze various product designs much more rapidly than in the past and to collaborate on designs with other engineers throughout the world. Despite these widespread applications, computer technology is not expected to limit employment opportunities. Finally, additional engineers will be needed to improve or build new roads, bridges, water and pollution control systems, and other public facilities.

- The number of bachelor's degrees awarded in engineering began declining in 1987 and has remained at about the same level through much of the 1990s. The total number of graduates from engineering programs is not expected to increase significantly over the projection period.

- Although only a relatively small proportion of engineers leaves the profession each year, many job openings will arise from replacement needs. A greater proportion of replacement openings is created by engineers who transfer to management, sales, or other professional occupations than by those who leave the labor force.

- Most industries are less likely to lay off engineers than other workers. Many engineers work on long-term research and development projects or in other activities that continue even during economic slowdowns. In industries such as electronics and aerospace, however, large cutbacks in defense expenditures and government research and development funds, as well as the trend toward contracting out engineering work to engineering services firms, have resulted in significant layoffs for engineers.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR COMPUTER SOFTWARE ENGINEERS

- **Computer software engineers are projected to be the fastest-growing occupation from 2000 to 2010**. Very rapid employment growth in the computer and data processing services industry, which employs the greatest numbers of computer software engineers, should result in very favorable opportunities for those college graduates with at least a bachelor's degree in computer engineering or computer science and practical experience working with computers. Employers will continue to seek computer professionals with strong programming, systems analysis, interpersonal, and business skills.

- Employment of computer software engineers is expected to increase much faster than the average for all occupations as businesses and other organizations continue to adopt and integrate new technologies and seek to maximize the efficiency of their computer systems. Competition among businesses will continue to create an incentive for increasingly sophisticated technological innovations, and organizations will need more computer software engineers to implement these new technological changes. In addition to employment growth, many job openings will result annually from the need to replace workers who move into managerial positions, transfer to other occupations, or leave the labor force.

- Demand for computer software engineers will increase as computer networking continues to grow. For example, the expanding integration of Internet technologies and the explosive growth in electronic commerce — doing business on the Internet — have resulted in rising demand for computer software engineers who can develop Internet, Intranet, and other web applications. Likewise, expanding electronic data processing systems in business, telecommunications, government, and other settings continue to become more sophisticated and complex. Growing numbers of systems software engineers will be needed to implement, safeguard, and update systems and resolve problems. Consulting opportunities for computer software engineers also should continue to grow as businesses increasingly need help to manage, update, and customize their increasingly complex computer systems.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003,* U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR SYSTEMS ANALYSTS, COMPUTER SCIENTISTS, AND DATABASE ADMINISTRATORS

- **Systems analysts, computer scientists, and database administrators are expected to be among the fastest-growing occupations through 2010. Employment of these computer specialists is expected to increase much faster than the average for all occupations as organizations continue to adopt and integrate increasingly sophisticated technologies**. Growth will be driven by very rapid growth in computer and data processing services, which is projected to be the fastest-growing industry in the U.S. economy. In addition, many job openings will arise annually from the need to replace workers who move into managerial positions or other occupations or who leave the labor force.

- The demand for networking to facilitate the sharing of information, the expansion of client/server environments, and the need for computer specialists to use their knowledge and skills in a problem-solving capacity will be major factors in the rising demand for systems analysts, computer scientists, and database administrators. Moreover, falling prices of computer hardware and software should continue to induce more businesses to expand computerized operations and integrate new technologies. In order to maintain a competitive edge and operate more efficiently, firms will continue to demand computer specialists who are knowledgeable about the latest technologies and are able to apply them to meet the needs of businesses.

- Increasingly, more sophisticated and complex technology is being implemented across all organizations, which should fuel the demand for other computer occupations. There is a growing demand for systems analysts to allow firms to maximize their efficiency by using available technology. The explosive growth in electronic commerce — doing business on the Internet — and the continuing need to build and maintain databases that store critical information on customers, inventory, and projects is fueling demand for database administrators familiar with the latest technology.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR PHYSICISTS AND ASTRONOMERS

- **Historically, many physicists and astronomers have been employed on research projects — often defense-related. Because defense expenditures are expected to increase over the next decade, employment of physicists and astronomers is projected to grow about as fast as the average for all occupations through the year 2010. The need to replace physicists and astronomers who retire will, however, account for most expected job openings**. The federal government funds numerous noncommercial research facilities. The Federally Funded Research and Development Centers (FFRDCs), whose missions include a significant physics component, are largely funded by the Department of Energy (DOE) or the Department of Defense (DOD), and their research and development (R&D) budgets did not keep pace with inflation during much of the 1990s. However, federal budgets have recently increased for physics-related research at these centers, as well as other agencies such as NASA. If R&D funding continues to grow at these agencies, job opportunities for physicists and astronomers, especially those dependent on federal research grants, should be better than they have been in many years.

- Although research and development budgets in private industry will continue to grow, many research laboratories in private industry are expected to continue to reduce basic research, which includes much physics research, in favor of applied or manufacturing research and product and software development. Nevertheless, many persons with a physics background continue to be in demand in the areas of information technology, semiconductor technology, and other applied sciences. This trend is expected to continue; however, many of these positions will be under job titles such as computer software engineer, computer programmer, engineer, and systems developer, rather than physicist.

- For several years, the number of doctorates granted in physics has been much greater than the number of openings for physicists, resulting in keen competition, particularly for research positions in colleges and universities and in research and development centers. Competitive conditions are beginning to ease, because the number of doctorate degrees awarded has been dropping, following recent declines in enrollment in graduate physics programs.

- Opportunities may be more numerous for those with a master's degree, particularly graduates from programs preparing students for applied research and development, product design, and manufacturing positions in industry. Many of these positions, however, will have titles other than physicist, such as engineer or computer scientist.

- Persons with only a bachelor's degree in physics or astronomy are not qualified to enter most physicist or astronomer research jobs but may qualify for a wide range of positions in engineering technician, mathematics, and computer- and environment-related occupations.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR ATMOSPHERIC SCIENTISTS

- **Employment of atmospheric scientists is projected to increase about as fast as the average for all occupations through 2010, but prospective atmospheric scientists may face competition if the number of degrees awarded in atmospheric science and meteorology remains near current levels**. The National Weather service (NWS) has completed an extensive modernization of its weather forecasting equipment and finished all hiring of meteorologists needed to staff the upgraded stations. The NWS has no plans to increase the number of weather stations or the number of meteorologists in existing stations for many years. Employment of meteorologists in other federal agencies is expected to decline slightly as efforts to reduce the federal government workforce continue.

- On the other hand, job opportunities for atmospheric scientists in private industry are expected to be better than in the federal government over the 2000-10 period. As research leads to continuing improvements in weather forecasting, demand should grow for private weather consulting firms to provide more detailed information than has formerly been available, especially to weather-sensitive industries. Farmers, commodity investors, radio and television stations, and utilities, transportation, and construction firms can greatly benefit from additional weather information more closely targeted to their needs than the general information provided by the National Weather Service. Additionally, research on seasonal and other long-range forecasting is yielding positive results, which should spur demand for more atmospheric scientists to interpret these forecasts and advise weather-sensitive industries. However, because many customers for private weather services are in industries sensitive to fluctuations in the economy, the sales and growth of private weather services depend on the health of the economy.

- There will continue to be demand for atmospheric scientists to analyze and monitor the dispersion of pollutants into the air to ensure compliance with federal environmental regulations outlined in the Clean Air Act of 1990, but employment increases are expected to be small.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR CHEMISTS AND MATERIALS SCIENTISTS

- **Employment of chemists is expected to grow about as fast as the average for all occupations through 2010. Job growth will be concentrated in drug manufacturing and in research, development, and testing services firms**. The chemical industry, the major employer of chemists, should face continued demand for goods such as new and better pharmaceuticals and personal care products, as well as for more specialty chemicals designed to address specific problems or applications. To meet these demands, chemical firms will continue to devote money to research and development — through in-house teams or outside contractors — spurring employment growth of chemists. Strong demand is expected for chemists with a master's or Ph.D. degree.

- Within the chemical industry, job opportunities are expected to be most plentiful in pharmaceutical and biotechnology firms. Biotechnological research, including studies of human genes, continues to offer possibilities for the development of new drugs and products to combat illnesses and diseases which have previously been unresponsive to treatments derived by traditional chemical processes. Stronger competition among drug companies and an aging population are contributing to the need for innovative and improved drugs discovered through scientific research. Chemical firms that develop and manufacture personal products such as toiletries and cosmetics must continually innovate and develop new and better products to remain competitive.

- In most of the remaining segments of the chemical industry, employment growth is expected to decline as companies downsize and turn to outside contractors to provided specialized services. As a result, research and testing firms will experience healthy growth. To control costs, some chemical companies, including drug manufacturers, are increasingly turning to these firms to perform specialized research and other work formerly done by in-house chemists. Despite downsizing, some job openings will result from the need to replace chemists who retire or otherwise leave the labor force. Quality control will continue to be an important issue in the chemical and other industries that use chemicals in their manufacturing processes. Chemists also will be needed to develop and improve the technologies and processes used to produce chemicals for all purposes, and to monitor and measure air and water pollutants to ensure compliance with local, state, and federal environmental regulations.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

JOB OUTLOOK FOR MATHEMATICIANS

- **Employment of mathematicians is expected to decline through 2010 because very few jobs with the title mathematician are available. However, master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as engineering or computer science, should have good job opportunities**. However, many of the workers have job titles that reflect their occupation, rather than the title mathematician.

- Advancements in technology usually lead to expanding applications of mathematics, and more workers with knowledge of mathematics will be required in the future. However, jobs in industry and government often require advanced knowledge of related scientific disciplines in addition to mathematics. The most common fields in which mathematicians study and find work are computer science and software development, physics, engineering, and operations research. More mathematicians also are becoming involved in financial analysis. Mathematicians must compete for jobs, however, with people who have degrees in these other disciplines. The most successful jobseekers will be able to apply mathematical theory to real-world problems, and possess good communication, teamwork, and computer skills.

- Private industry jobs require at least a master's degree in mathematics or in one of the related fields. Bachelor's degree holders in mathematics usually are not qualified for most jobs, and many seek advanced degrees in mathematics or a related discipline. However, bachelor's degree holders who meet state certification requirements may become primary or secondary school mathematics teachers.

Source: Extracted from the *Occupational Outlook Handbook, 2002-2003*, U.S. Bureau of Labor Statistics, downloaded 12/26/01.

Percentage Distribution of Bachelor's Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

Underrepresented minorities have increased their proportion among those who receive bachelor's degrees in science and engineering, from 9.7 percent in 1990 to 14.7 percent in 1998.

	Total		Men		Women	
	1990	**1998**	**1990**	**1998**	**1990**	**1998**
Total	100	100	100	100	100	100
U.S. Citizens and Permanent Residents,						
Total	96.4	96.4	95.5	95.6	97.7	97.3
White Non-Hispanics	78.1	70.6	78.9	72.0	77.2	69.1
Asians	5.6	8.4	5.8	8.7	5.4	8.1
Underrepresented Minorities, Total	9.7	14.7	8.0	12.2	12.0	17.5
Black Non-Hispanics	5.3	7.6	3.9	5.7	7.1	9.7
Hispanics	4.0	6.5	3.7	5.9	4.4	7.1
American Indians/Alaskan Natives	0.4	0.6	0.3	0.6	0.4	0.7
Unknown Race/Ethnicity	3.0	2.7	2.9	2.7	3.1	2.7
Nonresident Aliens*	3.6	3.6	4.5	4.4	2.3	2.7

Source: Susan T. Hill, *Science and Engineering Degrees by Race/Ethnicity of Recipients: 1990-1998*, National Science Foundation, Table 1, June 2001.
* Nonresident aliens include foreign citizens on temporary visas only. No racial/ethnic data are are collected for this group.

Percentage Distribution of Master's Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

Underrepresented minorities increased their proportion of master's degree recipients from 1990 to 1998, from 5 percent to 8.2 percent.

	Total		Men		Women	
	1990	**1998**	**1990**	**1998**	**1990**	**1998**
Total	100	100	100	100	100	100
U.S. Citizens and Permanent Residents,						
Total	77.4	75.4	73.8	71.2	84.7	81.8
White Non-Hispanics	61.5	56.3	58.3	53.7	68.1	60.1
Asians	5.6	7.1	5.8	7.1	5.3	7.1
Underrepresented Minorities, Total	5.0	8.2	4.1	6.5	6.8	10.8
Black Non-Hispanics	2.6	4.3	2.0	3.2	3.8	6.0
Hispanics	2.2	3.5	2.0	3.1	2.6	4.2
American Indians/Alaskan Natives	0.3	0.4	0.2	0.3	0.4	0.5
Unknown Race/Ethnicity	5.2	3.8	5.5	3.8	4.6	3.9
Nonresident Aliens*	22.6	24.6	26.2	28.8	15.3	18.2

Source: Susan T. Hill, *Science and Engineering Degrees by Race/Ethnicity of Recipients: 1990-1998* National Science Foundation, Table 2, June 2001.
* Nonresident aliens include foreign citizens on temporary visas only. No racial/ethnic data are are collected for this group.

Percentage Distribution of Doctorate Degrees in Science and Engineering by Race/Ethnicity and Sex, 1990-1998

While underrepresented minorities have increased as a proportion of doctorate receipients (from 3.9 percent in 1990 to 5.5 percent in 1998), the percentages remain very small, lower than for master's degrees, and very much lower than for bachelor's degrees.

	Total		Men		Women	
	1990	1998	1990	1998	1990	1998
Total	100	100	100	100	100	100
U.S. Citizens and Permanent Residents,						
Total	67.2	66.9	61.7	62.1	81.4	76.7
White Non-Hispanics	56.7	51.4	52.4	47.8	71.0	58.7
Asians	4.4	7.9	4.6	7.7	4.0	8.2
Underrepresented Minorities, Total	3.9	5.5	3.3	4.4	5.4	7.7
Black Non-Hispanics	1.6	2.4	1.4	1.7	2.3	3.7
Hispanics	2.0	2.8	1.8	2.4	2.8	3.5
American Indians/Alaskan Natives	0.2	0.4	0.2	0.3	0.3	0.4
Unknown Race/Ethnicity	1.3	2.2	1.4	2.2	1.0	2.1
Nonresident Aliens*	28.7	28.5	33.9	33.7	15.4	18.7
Citizen’s ID Unknown	4.1	4.6	4.4	4.2	3.2	4.6

Source: Susan T. Hill, *Science and Engineering Degrees by Race/Ethnicity of Recipients: 1990-1998* National Science Foundation, Table 3, June 2001.

* Nonresident aliens include foreign citizens on temporary visas only. No racial/ethnic data are are collected for this group.

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