Leaving

Science

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Occupational Exit from Scientific Careers

Anne E. Preston

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INTRODUCTION

With the reduction in the percentage of U.S.-born men choosing science and engineering majors over the last thirty years, national attention has turned to recruiting and retaining women and minorities in science. In the 1980s, pipeline issues were prominent as it became clear that the educational conduit through which career scientists must travel was leaking, especially at critical junctures. Research into these phenomena created a host of explanations behind the leakage and has been the impetus behind the implementation of a number of seemingly effective policy proposals. But as the educational system graduates a growing number of women and minorities with a strong scientific education, researchers need to understand that although the pipeline, as defined, ends when a scientific degree is earned, the problem of attrition continues. This book examines attrition from scientific careers for both men and women. This study estimates the rate of occupational exit from science during the period roughly between 1965 and 1995, identifies the differing factors behind exit for male and female scientists, and discusses the consequences for them of leaving science.

Over the last thirty-five years, high school students have become better prepared for careers in science and mathematics at the same time that the percentages of bachelor's degrees awarded in these fields have declined. Since the early 1980s, the average number of high school mathematics courses completed has increased from 2.6 to 3.4, and the average number of science courses completed has increased from 2.2 to 3.1 (U.S. Department of Education, National Center for Educational Statistics [NCES] 2002). The percentages of high school graduates taking calculus, physics, and chemistry have roughly doubled over the same period (National Science Board 2002). As the number of bachelor's degrees awarded has increased by almost 50 percent since 1970, the percentages of these degrees awarded in engineering, the physical sciences, and mathematics have declined. Only biological sciences and computer sciences have experienced relative increases, together increasing from 4.6 percent of all degrees in 1970 to 8 percent in 2000. In fact, the absolute number of mathematics and physical science degrees fell over the period. Similarly, although total Ph.D.s awarded have increased more than 50 percent during the same period, the percentage of doctoral degrees awarded in the natural sciences has declined from 40.6 percent to 32.9 percent and there were absolute declines in mathematics and physical science Ph.D.s (U.S. Department of Education 2002). Only computer science Ph.D.s have increased in relative terms.

This relative decline in science-oriented bachelor's and doctoral degrees over the last thirty years has been especially prominent for U.S.-born nonminority white men. These men are receiving absolutely fewer bachelor's and doctoral degrees than they did in 1976 (U.S. Department of Education 2002). These declines are especially evident in the natural sciences, where there has been a large influx of foreign students. For example, from 1992 to 2001, the absolute number of white male U.S. citizens earning a Ph.D. in the natural sciences or engineering declined by 13.6 percent (U.S. Department of Education 2002). Science policymakers have turned to women and minorities, who had traditionally been underrepresented in science and engineering, to fill the gap. Starting in the early 1980s, governmental organizations such as the National Science Foundation (NSF) and private organizations, including the Alfred P. Sloan Foundation, began financing research programs into the causes of underrepresentation and educational programs at the elementary, secondary, and collegiate level to attract and retain young women and minorities. Although failure to persist is still greater for women and minorities than for white men and certain fields are better at attracting and retaining women and minorities than others, if one judges these programs according to growth in degree recipients, they have been very effective. Since 1970, the percentage of natural science and engineering bachelor's degrees awarded to women has increased from 12 percent to 38 percent; smaller but still significant is the increase from 9.4 percent to 15.8 percent of the portion of Ph.D.s in these areas earned by women. The number of doctoral recipients who are American Indian, African American, or Hispanic has increased from 3.3 percent to 6.7 percent in engineering, from 2.9 percent to 8.1 percent in biological sciences, and from 2.3 percent to 6.3 percent in physical sciences. These same minorities currently make up more than 13 percent of the bachelor's degree recipients in the natural sciences and engineering (U.S. Department of Education 2002).

Although larger numbers of women and minorities are graduating from the science pipeline, little attention has been paid to survival in the workplace for science graduates, regardless of race or gender. But the numbers are striking. Data collected by the Bureau of the Census in the 1980s (Survey of Natural and Social Scientists and Engineers [SSE], 1982–1989) reveal that approximately 8.6 percent of men and 17.4 percent of women left natural science and engineering jobs between 1982 and 1989. In the study, which is the basis for this book and which follows the careers of men and women who graduated with science degrees from a large public university between 1965 and 1990, this two-to-one ratio persists. For science graduates with an average work experience of twelve and a half years, 31.5 percent of the women and 15.5 percent of the men who had started science careers were not employed in science at the time of the survey. The data from the more recent NSF surveys (Division of Science Resource Statistics 1999) allow examination of the younger cohorts of scientists whose degrees were received in the late 1980s through the mid-1990s. In 1999, focusing on individuals under the age of thirty whose highest degree was a B.S. and individuals under the age of thirty-four whose highest degree was either an M.S. or a science Ph.D., women were one and a half times as likely as men to have left science. The statistics are not wholly comparable to the earlier data, since we do not know if these exiting graduates ever entered science careers after the degree was earned, and these individuals are relatively young and inexperienced. Comparably constructed statistics from the public university data reveal that, over the period in which careers were analyzed, 1965 to 1995, female exit rates from science for all science graduates, not just those who start a scientific career, were roughly one and a half times as high as male exit rates five years into the career. Therefore, the more recent statistics show no improvements in retention. Furthermore, they show real problems when compared to attrition of social scientists; in 1999, women under the age of thirty-four with Ph.D.s in the social sciences were half as likely to engage in occupational exit (5.5 percent) as women in the same age cohort with Ph.D.s in the natural sciences and engineering (12.3 percent).

This book is an analysis of the phenomenon of occupational exit from science during the period from 1965 to 1995, giving at least partial answers to the following questions. Why do men and women who have invested extensive time and money on a rigorous science education leave the field? Are the factors contributing to exit related to predictors of success and failure within the field of science? Do these factors differ for men and women? What directions do men and women take after leaving science? What are the consequences, in terms of career and well being, for these leavers?

Exit from the scientific workplace is often wasteful and inefficient for the actors involved. Individuals who have used personal funds to finance a scientific education often turn to occupations for which their learned skills are not nearly as valuable. The social return on educational investments by the federal government is likely to fall, and employing institutions that lose scientific employees cannot benefit from their often extensive training investments.

A better understanding of exit from scientific careers should lead ultimately to changes in the science education process and in the scientific workplace: modifications that will reduce attrition both by improving the information flow to potential scientific workers and by making the scientific workplace more hospitable to career men and women. But such a body of knowledge is also likely to result in workplace enhancements that make science careers more attractive to high-performing educated men and women. Understanding exit is not only a good defense against attrition but also a valuable component of the strategy to increase the attraction and desirability of careers in science.

The primary data set used in the study was collected for the purpose of better understanding attrition of scientists. The 1,688 individuals studied all received either a bachelor's, master's, or Ph.D. degree in natural sciences or engineering from a public university in the northeast between 1965 and 1990. Work histories of these individuals give information on career choices and outcomes from the date of last science degree earned until the survey date, which was roughly 1994. As of that time, only 51 percent of the 1,688 were still working in science. In addition, 103 of the survey respondents—52 men and 51 women—were interviewed between 1994 and 1996 to understand more fully the causes and consequences of exit from scientific employment. The result is a blend of statistical and qualitative analyses of careers of men and women who have earned science degrees. Of those still working in science, some are stars in the scientific community, but most make up the bread-and-butter personnel of our scientific workforce. Their collective stories give a rich and detailed picture of the ultimate product of science education in the United States.

The book begins with a discussion of the period and the people studied, a chapter that describes trends in science and the workplace over the period, blending both statistics and impressions of interviewed scientists. It concludes with a more complete description of the data sets used in the analyses. Chapter 2 continues with a complete examination of the magnitude and character of exit, giving estimates of rates of attrition, identifying demographics of those most likely to leave, and pinpointing major reasons for exit. Chapters 3 through 6 explore the four major reasons for exit identified by interviewees: inadequate salary and opportunity, lack of mentoring, difficulties shouldering family- and career-related responsibilities, and a mismatch between the individual's interests and the requirements of the scientific profession. Chapters 7 and 8 discuss the two important issues in the scientific workplace that were identified as having indirect effects on exit: rapidly growing knowledge within science and perceived discriminatory treatment of women. Finally, chapter 9 discusses policy prescriptions.

CHAPTER 1

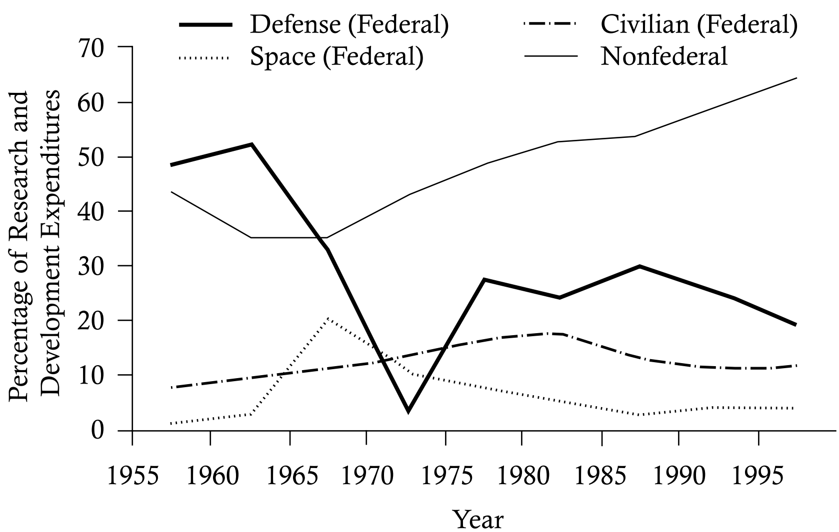
Science: The Period and the People

The scientific discovery process is always peeling away layers of an onion without ever knowing how many you have to peel before you find the core.

—Anonymous interviewee[1]

The focus of this study is the workplace experiences of men and women trained in the sciences between the mid-1960s and the mid-1990s. As a field of study and work, science has been influenced by four important changes over this period. First, and maybe most important, federal research funds, which made up two-thirds of research and development (R&D) spending at the beginning of the thirty-year period, fell to just over one-third of R&D funds by its end, as shown in figure 1.1. Second, fields of study that were most successful at attracting public attention, research funds, and new students changed dramatically during this period. Third, especially in the latter half of this period, there was an enormous influx of foreign-born scientists into Ph.D. programs and into the scientific workforce. Finally, women became a nontrivial and an increasing portion of the student body as well as the workforce in science. All of these changes had important effects on the workplace and careers of scientifically trained individuals.

Figure 1.1 *Federal and Nonfederal Research and Development Expenditures*

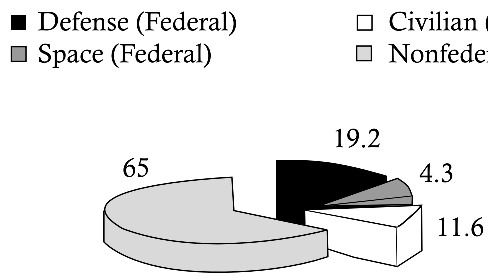


Source: Based on National Science Board 2002, table C-14.

Implications of the Changing Sources and Destinations of R&D Funding

Scientists interviewed agree that science, as a field, has lost some of the luster that it seemed to enjoy in the 1960s and 1970s. During that time, the United States was engaged in a race to explore the moon and in building a defense system to protect against threats of military action during the Cold War. Jacques Cousteau's undersea explorations were televised to adoring audiences. The environmental movement was born during the late 1960s, and this, along with the high prices and uncertain supplies of oil in the 1970s, turned the public's attention toward the possibility of alternative energy sources. Federal funding of R&D as a percentage of gross domestic product (GDP) peaked in 1964 at 1.93 percent. Approximately 65 percent of all R&D spending originated in the federal government, and over 80 percent of federal fund-

Figure 1.2 *Research and Development Expenditures 1995 (Percentages)*



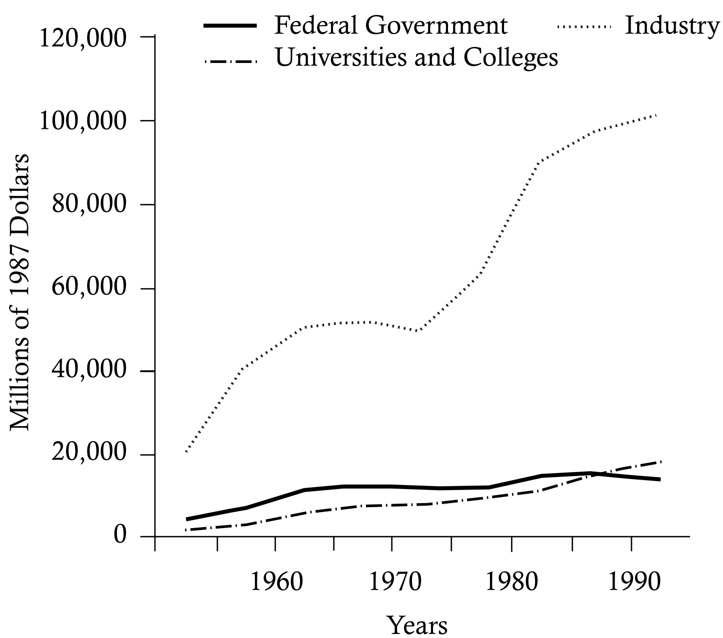
Source: Based on National Science Board 2002, table C-14.

ing of research and development was related to space exploration or defense development.

But during the 1980s and 1990s, public interest changed: the Berlin Wall fell, the fears of escalating oil prices diminished with increasingly stable supplies, the space race took a backseat to more pragmatic public issues, and concern for the environment waned. Federal funding for R&D, while increasing in absolute terms, fell to 0.89 percent of GDP, its lowest level since the mid-1950s. At the same time, nongovernment or private R&D funding, primarily financed by private corporations, increased disproportionately. Private funding, which made up little more than half of government funding in the 1960s, surpassed and nearly doubled government funding of R&D by 1994, as shown in figures 1.2 and 1.3. The federal government remained the spending leader only in basic research, the area that attracts the smallest amount of research funds. With this change in the source of R&D funds, the direction of scientific research has become increasingly dictated by market forces and by the ability to transfer knowledge to those technological advancements with a profitmaking potential.

The relatively slow growth in government funding of scientific research has had the greatest impact on careers of Ph.D. scientists as the traditional academic career path has become more difficult to realize and sustain. In the past, a scientist graduating from a university Ph.D.

Figure 1.3 Research and Development Performance by Sector



Source: Based on National Science Board 2002, table C-14.

program might possibly take on a two- to three-year postdoctoral position at another institution to get more research experience, land a junior academic position, and apply for grants to set up his or her own laboratory. Throughout his or her career, laboratory research would be funded by government grants from federal agencies such as the NSF, the National Institutes of Health (NIH), or the Department of Defense.

During the period from the mid-1960s to the mid-1990s, R&D funds received by colleges and universities more than tripled while the number of new Ph.D.s increased threefold. But with increasingly sophisticated and expensive equipment, competition for funds grew more intense. Labs were growing in size, and with more subordinates per grant-generating laboratory, the organizations were getting increasingly bottom heavy. Adams and associates (2003) show that between 1981 and 1999, authors per scientific paper increased from 2.8 to 4.4. New Ph.D.s were finding it harder to set up their own laboratories and increasingly took several consecutive postdoctoral positions before having the opportunity to settle into a permanent job. The proportion of new Ph.D.s who take on postdoctoral positions increased from 20 percent in 1970 to 39.4 percent in 1993. In 1993, 20 percent of life science Ph.D.s were still in a postdoctoral position four years after graduation. A young assistant professor in microbiology describes the situation: "the field of microbiology kind of grew like a cancer and one good lab gave rise to ten good post-docs who set up their own labs." After a while there was no money for new labs, but there was still demand for postdoctorals to run the existing laboratories. Graduates of Ph.D. programs moved from one laboratory to another until they got the "big break" (first authorship of a paper accepted in a high-impact journal) or they opted for another career path outside of academia. This academic career path has become especially unattractive for individuals with working spouses who may have problems finding jobs in the temporary locations of the postdoctoral appointments. Family responsibilities also take away from the "tunnel vision" and heavy time commitments that many scientists see as necessary in order to win the contest for grant money. Because women were more likely than men to have relatively immobile spouses and were less inclined to request compromises in either spouse's career or family life to accommodate job requirements, they were finding the academic career path increasingly inhospitable at the same time that equal opportunity law was opening more doors for them.

Doctoral Ph.D. students who did land permanent academic jobs found it progressively harder to survive in science careers as periodic grant renewals were no longer automatic. One Ph.D. in microbiology asserted that, during the period from the mid-1980s to the early 1990s, the percentage of grant applications being funded in her field fell from one-third to 5 percent. While this assertion may be an exaggeration, data on NIH grant-making shows that, by the mid-1990s, the success rates for both new and renewal grants were half the levels of the early 1980s. In addition, only a third of renewal grants were being funded

(Mandel 1995). A Ph.D. physicist at an Ivy League institution who began his career in the early 1970s with plentiful government funds was barely scraping by in the early 1990s. He explained, "It has a real impact on your overall productivity—because of the very large reductions [in funding] and in the people [funding agencies] we used to count on for support. So, in short, we can't help [but] be discouraged psychologically . . . you feel let down."

With R&D funds increasingly originating in private firms, industry grants and opportunities became more attractive to scientists. From 1973 to 1995, the percentage of the full-time doctoral labor force employed in the industrial sector increased from 24 percent to 35 percent (Long 2001). Because the emphasis in industry jobs is more on development and applied marketable research, they have been looked down on historically by academic scientists. As a Ph.D. chemist pointed out, one implicit measure of a professor's success is still "the number of his or her students that have gone on to become professors at big hot shot universities." He continued, "if you go off and do research at a federal laboratory or in industry, you've given in or given up." More recently there seems to be increased acceptance of jobs in industry, possibly because these workplaces are offering desirable perks, such as higher pay and more time for family life, that are not always available in academia.

Although the percentage of industry funds allocated across basic research, applied research, and development did not change, there was a real feeling by scientists that the character of research was changing. A Ph.D. in chemistry working for a successful pharmaceutical company explained:

> The pharmaceutical marketplace has changed more in the past decade [1985 to 1995] than it has ever changed before. . . . In order to be profitable in the pharmaceutical industry you have to approach research with a very different perspective than what you would have done ten years ago. The first question that is asked before committing money to a research program is "is the market there?"

He went on to describe a product that mimics the human growth hormone and that helps young children without natural growth hormones grow into normal, fully developed adults. Although the product is successful, he was confident that it would never have been developed in the environment of the 1990s because the small patient pool, children deficient in human growth hormone, guaranteed low profits. Even with the Orphan Drug Law passed in 1983, which allows firms that develop drugs for rare diseases both to have exclusive rights and to charge high mark-ups, the large pharmaceuticals have tended to stay away from these small markets. He conceded that, even in basic research, firm profits determine direction and focus.

Because science was the foundation of many government initiatives in the 1960s and early 1970s, the discipline was revered, and scientists were perceived as working for the public good. A Ph.D. physicist who grew up in the 1960s reading *Scientific American,* tried to describe the environment: "It was the time of the big space program in the sixties and there was a lot of interest in science in general in the country. . . . And a lot of technology came out of the space race—whole industries grew up from that." Another Ph.D. recipient in the mid-1970s recounted his experience in a NSF summer program for high school juniors in the early 1960s. Marveling at how active the government was in recruiting bright young people to science in the post-Sputnik period, he described a program in which sixty students from all over the country convened at a university campus for an eight-week program in chemistry, physics, and mathematics. He concluded, "I had never been around such smart people . . . and it was just glorious."

In stark contrast to the 1960s, the 1990s were a time when scientists felt neither well respected nor well rewarded. A professor of engineering recounted, "I never found any glamour in telling anyone that I was an engineer. It's much more satisfying and I get a much different response when I tell people that I'm a professor. There's not a lot of value placed on engineering in this society." A career engineer employed in industry had a similar concern: "When I go to a social gathering and they say 'What do you do?' I say 'Well, I'm an engineer.' 'Where?' they say, 'On the Long Island Railroad?' People have no idea what I'm talking about." A woman with a master's in biology lamented the differential respect afforded M.D.s and Ph.D. scientists: "Even the Ph.D. I worked for at the hospital was very envious of the M.D.s because we would be doing all the work . . . we would give them the data, and they would get all the glory." A biology graduate who worked in a laboratory before moving into business pointed out, "I don't think that our society puts enough value on research. Oh, if you find a cure you're wonderful, but [what about] the eight million other people [who] sweat and suffer?" She was disturbed that scientists put in tremendously long hours working on experiments that do not follow a time clock and get compensated by government grants with no overtime pay. Similarly, Ph.D. scientists have had to question the respect afforded them as they spend increasing number of years living on postdoctoral stipends.

The lack of financial reward was an ever-present concern for many of the scientists and engineers who saw research as driven by profit potential. As one engineer commented, "You know we're outside the flow of money in most businesses, we're usually an overhead and a necessary evil." Pay of scientists and engineers may have been low relative to other successful professionals such as lawyers and doctors. However, the scientists more often compared their own salaries to those of their managers. Many corporations have two different promotion and salary tracks: one for management and one for technical personnel. The opportunities and salaries of the technical personnel fall behind the management personnel before midcareer. A large majority of the male scientists left science for management and finance-related jobs with the hope of making more money.

The movement to market-driven R&D funding has occurred at the same time that changing national and world priorities have altered the focus of attention within science. As noted earlier, space exploration, political attention to defending against Cold War threats, developing alternative energy sources, and preserving the environment fueled the prominence of physics, astronomy, and geology in the 1960s and 1970s. By the early 1990s, these issues had receded in the public's consciousness. Over the same period there were remarkable changes in the biological sciences. The discovery of the chemical structure of DNA by Watson and Crick in 1953 created the field of molecular biology and propelled an explosion of basic research, which is having enormous impacts on contemporary medicine. Subsequent work on recombinant DNA paved the way for the biotech industry, which uses genetic engineering to create innovative products with wide ranges of uses. Meanwhile, computer technology exploded, allowing personal computers and the internet to change the structure of jobs in almost every field.

With a changing focus of public attention over the period, general funds for scientific research were reallocated toward these more popular fields, and students entering science were lured to these cutting-edge areas. During the period 1975 to 1995, the number of doctoral degrees awarded in physics increased by 20 percent, but the number of Ph.D.s awarded in math did not change. However, the number awarded in biological and agricultural sciences increased by 38 percent, and the number awarded in computer science increased a staggering 312 percent. As might be predicted by the increasing portion of R&D funds coming from industry, the number of doctoral degrees awarded in engineering also increased 89 percent (Long 2001).

Increasing Presence of Foreign-Born Students and Scientists

Since the late 1970s, there has been a marked increase in foreign-born science and engineering students and workers. Except for a period in the mid-1990s following the Tiananmen Massacre and the Chinese Student Protection Act, there was a steady increase in foreign-born students enrolling in master's and doctoral programs in the sciences and engineering. In 1999, foreign-born students made up 50 percent of all graduate students in engineering, mathematics, and computer science, an increase from roughly a third in the early 1980s. Across all scientific fields, one-third of all doctoral recipients were foreign born (National Science Board 2002). In 1980, foreign-born college graduates made up 11 percent of the scientific workforce; by 2000 this percentage had increased to 19 percent (National Science Board 2002). Sharon Levin and Paula Stephan (1999) find that in 1990 one in four doctoral scientists employed in the science and engineering workforce was foreign born, an increase from one in five ten years earlier. The impact of these foreign-born scientists on the labor market and on the workplace is bound to be significant. However, the focus of the present study is the exit of U.S.-born scientists. From the work histories and the interviews, the influx of foreign scientists seemed to have no direct impact on exit. However, if the influx of these scientists increased the supply of scientists looking for work relative to demand, there would have been downward pressure on earnings, a factor influencing exit. Also likely, the attrition of U.S.-born scientists and the increasing reluctance of domestic men, in particular, to follow a science career have made room for the influx of the foreign-born scientists into graduate programs and laboratories that were trying to grow at a faster rate than the domestic science workforce. While a correlation between influx and attrition may exist, the direction of causation is unclear.

Increasing Presence of Women in Science Degree Programs and in the Scientific Workplace

The thirty-year period from the 1960s to the 1990s was also a time of increasing education and employment opportunities for women, facilitated, at least partially, by public initiatives. The passage of Title VII of the Civil Rights Act in 1964 prohibited sex discrimination in employment, and in 1972, Title IX of the educational amendments of the Civil Rights Act barred sex discrimination in any educational program receiving federal assistance. Over this period, labor-force participation of women increased from 38 percent to 59 percent, the percentage of bachelor's and master's degrees awarded to women increased to more than 50 percent, and the previously stagnant female-to-male weekly earnings ratio rose from 0.63 to 0.75. The science field, which for all practical purposes was a "male" field in 1960, was not immune to the female demand for better and more inclusive education and employment opportunities. Women's entry into scientific fields was facilitated as well by the increasing public attention to and the growing research support of biology and life sciences, fields to which women were disproportionately drawn. Over the twenty-year period from 1975 to 1995, the percentage of bachelor's, master's, and doctoral degrees in science and engineering awarded to women all increased by roughly twelve percentage points.

With the increasing number of women in science, the character of the workplace changed. Prejudices, based on deep-rooted stereotypes that marked women as less capable in conducting science, have created gender conflicts. In the workplace, challenges of attracting women to science have broadened to challenges of retention. In a field in which occupational exit was already disproportionately high compared to other nonscience fields, women were twice as likely to leave scientific employment as men. Institutions were turning their attention to programs that alleviate the conflicts between family and work, which so often burden working women, and to policies that make science a more welcoming field to women in general.

DATA FOR THE STUDY

The remainder of this book studies careers of a group of scientifically trained individuals in an attempt to understand the character of occupational exit from science. Using statistical analysis and interview data, it explores a series of related questions: Who leaves science and who stays? What are the factors influencing attrition decisions? Are these factors different for different groups of scientists? Where do exiting scientists go, and what do they do? What are the consequences of exit and how do career paths of leavers and stayers diverge? What policy actions might improve retention and quality of life of science personnel?

The focus of the analysis is the career paths of men and women with science degrees, including life sciences, physical sciences, mathematics, and engineering. The career paths studied come from three complementary data sets. The first data set, the SSE, 1982 to 1989, was collected by the NSF and gives background data on exit for a national sample of working scientists. The survey, which asks questions concerning job, demographic, educational, and personal characteristics, was sent in 1982 to a stratified systematic sample of more than 100,000 1980 Census respondents. The full sample included a potential science sample of individuals who worked in a set of targeted science-related occupations and who had four or more years of college education, and a potential engineering sample of individuals who worked in occupations targeted as engineering and who had two or more years of college education. All respondents were resurveyed in 1984, 1986, and 1989. Only

69.7 percent of the initial respondents actually worked in science and engineering jobs and identified their occupation as in the natural sciences or engineering. These respondents contributed data on national patterns of exit from science. Table 1.1 outlines their general demographics.

The greatest differences between men and women in this sample are the discrepancies in age, marriage, and children. The men are older, more likely to be married, and more likely to have dependents. Because only a handful of women successfully entered the science and engineering professions before equal employment opportunity laws came into effect in the 1960s, the older cohorts in this national sample are almost exclusively male. Furthermore, engineering was slower in attracting women than even the natural sciences, so the female engineers in the sample are especially young. The difference in age of men and women most likely contributes to the difference in family characteristics. However, multivariate analysis of the data show that, after controlling for age, female engineers are 4 percent more likely not to have been married and 25 percent less likely to have had children than male engineers. Similarly, female natural scientists are 13 percent more likely to never have been married and 20 percent less likely to have had children than their male counterparts. Working women may choose not to marry or have children since the woman is the partner in the dual-career marriage most likely to shoulder the double responsibilities of family and outside employment. The biggest difference in the educational distributions across the sexes occurs for natural scientists seeking Ph.D.s, with the percentage of men earning Ph.D.s about ten points higher than the percentage of women. The percentage of both scientists and engineers who finish their education with a bachelor's degree is about six points higher for women than for men. Because the working engineer, in contrast to other scientists, needs only an associate's degree, educational cells do not sum to one for the engineering columns.

Although analysis of the national data set is particularly helpful in establishing national patterns of exit during a specified time period, the survey has several limitations. First, because it observes the scientific workforce at one point in time, there is a sample selection bias since the workforce includes only those individuals who identify their occupation as a science or engineering field and survived in the workforce un-

Table 1.1 Descriptive Statistics for National Sample of Employed Scientists and Engineers, 1982 (Standard Deviations in Parentheses)

	Natural Scientists		Engineers	
	Women	Men	Women	Men
Age in years	36.6	41.5*	32.3	42.8*
	(9.7)	(10.9)	(8.7)	(11.2)
Percentage never married	29.5	10.6*	31.1	9.2*
Percentage with children	33.4	54.0*	25.8	53.6*
Percentage with bachelor's degree	46.5	40.9*	63.0	57.7*
Percentage with master's degree	33.9	30.2*	19.7	21.8
Percentage with Ph.D.	18.9	28.2*	2.2	3.6*
Sample size	2913	8915	1839	24292

Source: Author's compilation.
*The male mean is significantly different from the female mean at the .01 level.

til the time of the survey. Many eligible workforce participants have already left the science and engineering workforce. Although all the individuals have a college degree, that degree is not necessarily in science or engineering, so it has attracted a group of individuals without formal training in science and engineering. Second, the survey observes each individual four times during the period between 1982 and 1988. These snapshots only give information on labor market and personal characteristics at the time of the observation without providing any information on the individual during the periods between surveys. Finally, information on each individual is limited by the scope of the survey.

In response to these limitations, the university database that contains in-depth information on careers of a set of relatively homogeneous individuals was developed. These data are the result of a work history survey sent to the population of active female alumnae and a random sample of active male alumni who received degrees in science, math, or engineering from a large public university in the northeast from the time of its establishment in the mid-1960s until 1991.[2] The survey asks questions with the goal of describing the complete educational, personal, and workforce histories of the respondents. It also collects information on factors affecting the respondents' career decisions. Of the 5,200 surveys mailed, roughly 400 were returned due to out-of-date addresses, and 1,688 were completed, for a response rate of 35 percent.[3] The survey is unique because it tracks each respondent's complete career progression since college graduation. Other researchers have successfully followed the careers of a set of scientists. For example, J. Scott Long and associates (Long 1978; Long, Allison, and McGinnis 1979; Long and McGinnis 1985) analyze career productivity and progression of male biochemists who earned Ph.D.s during a four-year period in the late 1950s and early 1960s. The present survey allows a more complete examination of attrition because it begins each observation at graduation from college, and it analyzes men and women in a host of different scientific fields. Extensive information is collected for each job. Every separation from the labor force and from a job is documented, and the explicit reasons for exit are identified. The individual's family history is also tracked to identify when in the career marriages, births, and divorces take place.

Demographic characteristics displayed in table 1.2 paint a different scientific portrait from the national sample largely because of the differing populations. Since this particular public university opened its doors in the 1960s, the university data set does not include the cohort of older, largely male scientists and engineers. Therefore, even though many of the characteristics are statistically different for men and women in the university sample, the magnitude of differences is smaller than in the national sample. On average, men are less than a year older than women; the difference in male and female labor-market experience is only slightly more than a year for respondents with a science degree but increases to three years for respondents with engineering degrees. Roughly the same proportion of men and women are married, however a larger percentage of men than women have children. For respondents with degrees in science, women are slightly less educated

Table 1.2 Characteristics of Respondents to University Survey, 1992 to 1994 (Standard Deviations Are in Parentheses)

	Natural Scientists		Engineers	
	Women	Men	Women	Men
Age in years	35.4	36.4*	33.5	34.8
	(7.2)	(6.6)	(7.6)	(6.5)
Experience in years	9.4	10.7*	7.1	10.3*
	(6.0)	(5.8)	(4.2)	(6.4)
Time at current job in years	5.8	6.6	4.8	6.1
	(5.0)	(5.1)	(3.4)	(5.6)
Percentage highest science degree: bachelor's	72.7	59.6	47.3	60.5*
Percentage highest science degree: master's	19.4	16.9	47.3	34.2*
Percentage highest science degree: Ph.D.	12.9	23.5*	4.8	5.2
Percentage never married	33.3	29.0	36.9	36.8
Percentage with children	47.5	54.2	42.2	49.1
Sample size	782	421	185	290

Source: Author's compilation.
*Female statistic is significantly different from the male statistic at the .01 level.

than men, with a higher percentage of women earning bachelor's and master's degrees and a higher percentage of men earning Ph.D.s; these findings are similar to those in the national sample. For engineers, there is a larger percentage of respondents with master's degrees in the present sample than in the national sample, possibly because the university has a large engineering master's program, and perhaps surprisingly, women are more likely than men to have earned master's degrees in engineering. The 1980s national data show that men in engineering were slightly more likely to earn master's degrees than women in engineering.

The third data set, containing information from interviews, was designed to understand more fully the factors behind occupational exit of men and women in the sciences. Twenty-six pairs of women from the original university sample were selected to participate in interviews concerning both their education and career experiences. In the original survey, respondents were asked if they would be willing to give an interview; 71 percent responded positively. From the willing respondents, the 52 women were initially selected to mirror the age, education, and family distribution of the respondents to the original survey.[4] The subsample was altered slightly after initial interviews revealed that career concerns varied by degree level, family status, and whether the woman was an engineer. The women in the interview sample, therefore, are slightly more likely to have Ph.D.s, to have studied engineering, and to be married with children than the full sample of women. Within each pair, the two women are similar in age, degree level, field of degree, and family circumstances. The difference between the two women in each pair is that one of the women has left science and one has stayed. The purpose of this pairing process is to help isolate the important factors behind exiting or continuing scientific careers that cannot be identified using standard statistical techniques. Twenty-six pairs of men were also identified and interviewed. The male pairs are matched to the female pairs so that individuals in the two pairs have the same age, family characteristics, level of degree, and subject of degree.[5] Because the occupational exit rate is lower for men than for women, it was not possible to have a stayer and a leaver in each pair. However, approximately 80 percent of the male pairs include both an individual still employed in the sciences and one who has left.

For the purposes of this book, the interview data are especially enlightening. In particular, the interviews identified the major topics to be explored. They also fill in the details, allowing us a deeper understanding of these topics than could have been obtained through statistical analysis. Finally, the interviews bring the topic of working in science to life, as the quotes give us a glimpse of the insights, concerns, humor, and general humanity of the scientists themselves.

CHAPTER 2

The Magnitude and Character of Exit

Exit from science is a slippery concept since "in science" and "out of science" are not easily defined terms. Science encompasses a large number of fields, and scientific skills are used in countless jobs. The boundaries separating "science" from "nonscience" jobs are porous and shifting as, over time, science and technology find their ways into and out of various activities in the workplace. Furthermore, the interfaces between science and management, science and medicine, and science and education are complex and heavily populated "no man's lands" in the attempt to define an "in" and "out" of science.

The definition of "in" and "out" of science that the National Science Foundation (NSF) uses in its surveys is used throughout the current study. Benefits of this definition are that it is easy to replicate and that estimates of attrition can be compared across data sets. In most cases, the scientist defines whether he or she is working in science; exit from science is self-reported. For example, in the 1989 post-Census survey, all employed individuals are asked "During the week of Feb. 5, 1989, were you working at (or temporarily absent from) a position related to the natural sciences, social sciences, or engineering?" to which the respondent can answer yes or no. In the master survey sent to the university scientists, a similar question is posed: "Is your current job related to natural sciences or engineering?" Letting the scientists decide for themselves whether their work is science related circumvents many issues. In particular, because current experts in the scientific field are best equipped to determine whether a job is science related at a particular point in time, respondents' own expertise is employed to help define exit from science.

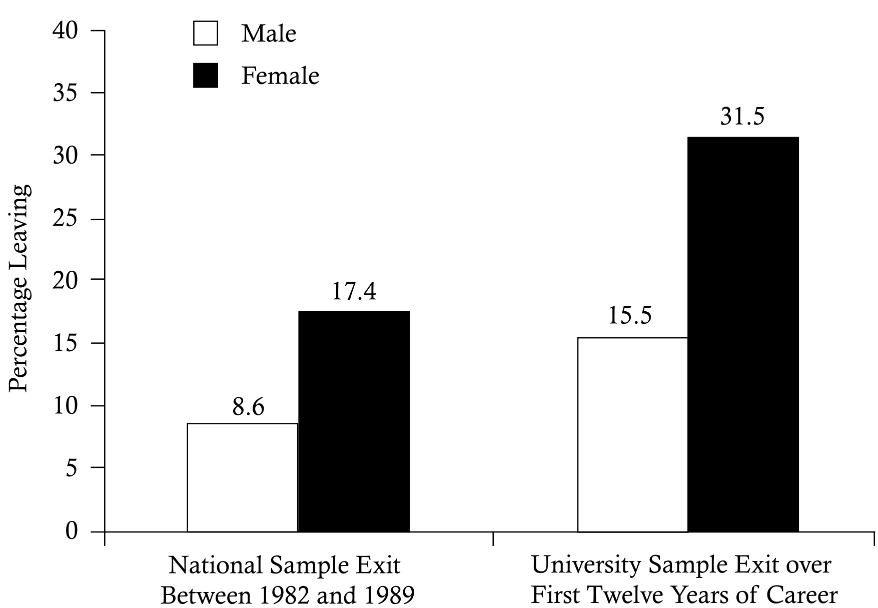
The self-reported responses are altered somewhat to deal with the interfaces with medicine and education. Following the lead of the NSF, medical doctors and other health professionals whose primary work activity is clinical diagnosis are not classified as working in science; medical doctors whose primary activity is research are working in science. For the purposes of the study and again as dictated by NSF, science educators at the junior college, secondary school and elementary school levels are not considered working in science, but science educators at the four-year college, university, or medical school levels are considered working in science.[1] Survey questions related to primary work activity and employing institution give information to make these alterations.

MAGNITUDE OF EXIT

Occupational exit or departure from a particular field is not the kind of labor-market statistics often reported. However, in 1987, a national survey sponsored by the Census Bureau posed the following question to persons employed in January 1986 and January 1987: "You told me that . . . is now working as. . . ." Then, "was . . . doing the same kind of work a year ago, in January 1986?" A negative answer to the question was interpreted as an occupational exit. According to the data, over the one-year period, 2.6 percent of engineers had exited engineering, a high rate of exit when compared to other professional occupations. In particular, 2.0 percent of college and university teachers, 0.6 percent of health-diagnosing professionals, 2.3 percent of health-assessment professionals, and 0.7 percent of lawyers and judges left their occupation during the same period (Markey and Parks 1989). These alternative occupations are possibly ones that require greater amounts of education, but still the difference in exit rates is startling. Engineers were four times as likely to engage in occupational exit as doctors and three and a half times as likely to exit their occupation as lawyers and judges. Compared to less well-paid occupations such as nursing and college teaching, engineers were still 15 percent to 30 percent more likely to leave their occupations. And as discussed later, scientists leave science to a greater extent than do engineers.

The NSF data was used to derive national estimates of exit from the scientific workforce. As noted earlier, the 1982 sample was originally selected from respondents to the 1980 Census who were in a set of targeted occupations and who had achieved a minimum level of education. Of those surveyed in 1982, only respondents who were employed, who answered yes to the question on employment in science or engineering, and whose stated occupation was in the natural sciences or engineering were tracked over time. This group was followed over the seven-year period to estimate exit rates. By 1989, 90.3 percent of the original respondents were still working in science.[2] The 9.7 percent who had left had either taken jobs unrelated to science, left the labor force, or become unemployed.[3] Even more striking is the fact that women left science at twice the rate as men: 17.4 percent, almost a fifth, of the scientifically employed women left science, and only 8.6 percent of the men left science (see figure 2.1). In the university data

Figure 2.1 *Percentage Leaving Science by Gender, National Sample and University Sample*

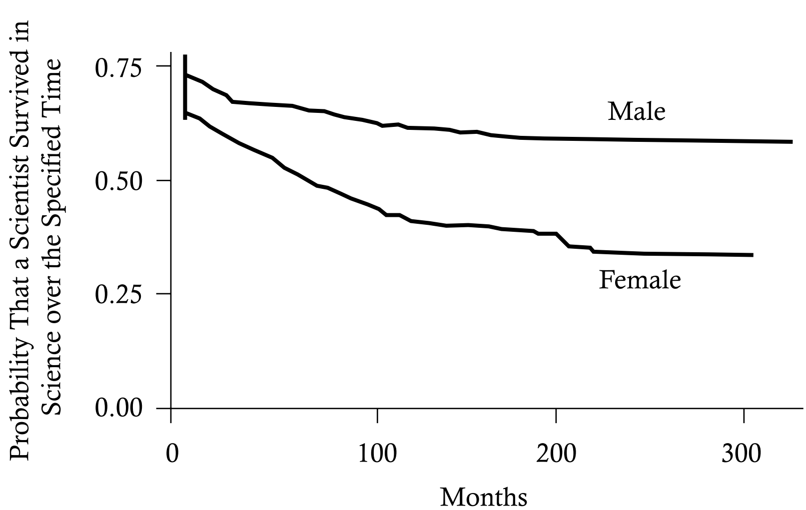


Source: Author's compilation.

set, this two-to-one ratio holds as well, even though the construction of the sample and the characteristics of the population are different. Of all the university-trained scientists who started a job in science, 15.5 percent of the men and 31.5 percent of the women had left scientific employment by the survey date, a period that averages twelve years across all respondents.

The university data set gives us a rare opportunity to examine exit from science by scientists because it allows us to follow these people's careers from the time they graduate from a university with their highest science degree. As expected, many of the scientifically educated college graduates never worked in science: 36.5 percent of the female graduates and 27.4 percent of the male graduates left science before they entered the labor market. Of those graduates who persisted in science, 16 percent of the women and 6 percent of the men had left science temporarily at one time or another, usually to spend some time out of the labor force.[4] Figure 2.2 gives the survival estimates of men and women in science for the university sample. The initial dropoff

Figure 2.2 Kaplan–Meier Survival Estimates, by Sex



Source: Author's compilation.

from 100 percent is the result of science graduates who immediately started work in nonscience jobs. The female survival curve is well below the male survival curve. Focusing on the ten-year (120 months) mark, roughly 37 percent of the women and 63 percent of the men remained working in science for ten years.

WHERE DO EXITING SCIENTISTS GO, AND WHAT DO THEY DO?

Scientifically trained personnel who leave science can take a variety of paths, directed by choices along the way. The first choice on leaving science is whether to continue to work outside of science or whether to leave employment altogether. If the individual decides to work outside of science, as the majority of leavers do, then he or she has a series of interrelated decisions to make. They include: whether to invest in further education for potentially better positioning in the nonscience labor market, what work activity to undertake, and in which industry to locate.

Exiting Employment Versus Finding a Nonscience Job

Both men and women are more likely to leave science for nonscience employment than to leave employment altogether. Depending on the individual, the route to nonscience employment may include a stint of time not working. Exiting employment is often a temporary situation that commonly ends for men when they find new jobs and for women as their young children grow up. Returning to science after an employment exit, however, becomes more difficult as time passes and skills become more obsolete. Temporary labor-force departure that was intended to end with reentry to science may in fact end with entry into a nonscience job and thus result in permanent exit from science.

Figure 2.3 plots percentage of the respondents to the initial sample who had exited by destination, where destination is nonemployment or work outside of science. For the purposes of the figure, destination is considered a static concept, identified for each worker at the point at which he or she was last observed. In the case of the national survey,

Figure 2.3 *Percentage Exiting by Destination*

Source: Author's compilation.

the last observation was 1989; in the case of the university survey, the last observation was the survey date, 1992 or 1994. Because women traditionally take on the role of caretaker of the family, they are much more likely than men to exit employment. In the national sample, 8.3 percent of the women working in science in 1982 were not working at any job by 1989, with about 45 percent of these women caring for family. However, 2.5 percent of the men were not working in any job by 1989, but only 5 of the more than 20,000 men were caring for family. These differences are reflected in the university sample as well, where 14 percent of the women and 3.7 percent of the men who started work in science were not working in any job at the time of the survey. Of the seven hundred men whose work histories were documented in the university sample, not one left the labor force to care for his family.

Women are also more likely than men to take on work outside of science. By the time the university survey was conducted, 18 percent of the women and 12.5 percent of the men who had once worked in science were currently working in a field outside of science. In the national sample, 6 percent of the men and 9 percent of the women who were working in science in 1982 had left for another field by 1989. Therefore, putting aside differences in nonemployment, women still are 50 percent more likely than men to leave science for work in nonscience fields.

Education Investment

Investments in further nonscience education are common for scientifically trained men and women who leave science. According to table 2.1 (columns three and four), which reports educational investments of the 1,700 men and women in the university sample, 59 percent of the men and 54 percent of the women who never worked in scientific careers earned advanced degrees outside of science.[5] An M.D. degree was the most sought-after advanced degree for scientifically trained

Table 2.1 *Nonscience Degrees Earned by Scientifically Trained Individuals Who Leave Science and Become Employed Outside of Science*

	Began Science Career		Never Began Science Career	
Percentage Earning	Male (n = 83)	Female (n = 203)	Male (n = 191)	Female (n = 353)
Master's degrees	13.6	15.1	10.3	22.6
Ph.D. degrees	1.5	0.9	0.0	2.7
M.B.A degrees	15.2	13.4	5.1	3.8
M.D. degrees	13.6	16.1	42.3	27.1
J.D. degrees	6.1	3.6	3.4	2.4
Total[a]	42.4	45.5	59.4	54.1

Source: Author's compilation.
[a]Some respondents earned more than one degree, so the individual rows add up to a sum that is greater than the total.

college graduates who did not take science jobs. Because completion of a set of science-oriented courses is a prerequisite for medical school, typically pre-med students majored in a science field. The big difference in type of degree by sex is in the area of medical degree and generic master's degrees. More than one and a half times as many men (42 percent) as women (27 percent) got degrees equivalent to an M.D., and more than twice as many women (23 percent) as men (10 percent) earned nonprofessional master's degrees, and a large number of these master's degrees were related to teaching. Furthermore, 86 percent of the degrees earned by men, as compared to 61 percent of the degrees earned by women, were in the high-paying professional fields of law, business, or medicine.

Investment in further nonscience education by male and female leavers who began careers in science (columns one and two) is surprisingly similar. Approximately 45 percent of these leavers invested in some type of postscience degree. In contrast with the men and women who never started a science degree, the medical degree was not the dominant degree sought. Approximately equal proportions of men and women leaving science work (15 percent) invested in M.B.A degrees, M.D. degrees, and in further master's degrees.

WHAT DO THEY DO, AND WHERE DO THEY DO IT?

Table 2.2 presents information on the four work activities and industries most frequently cited by scientists or engineers working outside of science and engineering. The data are separated by sex and by whether the scientifically educated respondents ever worked in science. As predicted by their educational investments, men who never worked in science were most likely to go into health-related work, with 32 percent having clinical diagnosis as their primary work activity and 13 percent having physician-related health services as their primary activity.[6] Women who never worked in science occupations were most likely to cite teaching and training as their primary work activity (33.9 percent), with clinical diagnosis identified second (21.6 percent) most frequently.

Men who left science after a spell of employment in science jobs were most likely to go into management, with substantially fewer go-

Table 2.2 Most Common Work Activities and Industries of Leavers (Percentages Are Given in Parentheses)

	Began Science Career		Never Began Science Career	
	Male (n = 83)	Female (n = 203)	Male (n = 191)	Female (n = 353)
Work activities				
Most common	Management (28.8)	Management (17.1)	Clinical diagnosis (32.4)	Teaching and training (33.9)
Second most common	Clinical diagnosis (10.6)	Clinical diagnosis (16.2)	Teaching and training (14.5)	Clinical diagnosis (21.6)
Third most common	Distribution and sales (9.1)	Teaching and training (13.5)	Management (13.3)	Physician-related health care (9.9)
Fourth most common	Teaching and training (7.6)	Computer applications (6.3)	Physician-related health care (12.7)	Management (9.6)
Industry				
Most common	Finance, insurance, and real estate (21.5)	Hospital or clinic (12.7)	Hospital or clinic (26.6)	Elementary and secondary school (24.0)
Second most common	Hospital or clinic (12.3)	Other health-related (11.8)	Other health-related (15.0)	Hospital or clinic (21.3)
Third most common	Other services (7.7)	Elementary and secondary school (10.9)	Elementary and secondary school (11.6)	Finance, insurance, and real estate (12.0)
Fourth most common	Elementary and secondary school (6.2)	Finance, insurance, and real estate (10.9)	Finance, insurance, and real estate (8.1)	Other health-related (10.0)

Source: Author's compilation.

ing into clinical diagnosis, distribution and sales, and teaching. For women who left science after working in science, clinical diagnosis and management were the most common work activities, but teaching and training were also prominent.

The industries that leavers entered mirrored the work activities that they took on, with hospitals or clinics, elementary or secondary schools, and finance, real estate, and insurance companies as the most frequently cited. However, for both men and women, the four most common work activities and four most common industries accounted for less than 50 percent of the locations of leavers. Focusing on these prominent industries and work activities, therefore, does not capture the variety of positions taken by leavers.

WHO LEAVES AND WHY?

This question is not an easy one to answer with the available data. Several methods are used for analysis. First, univariate and multivariate statistical analyses of the national and university data are conducted to determine workplace or worker characteristics that increase or decrease the probability of exit. Then, responses to the questions concerning reasons for exit in the work history survey are tabulated. Finally, the interviews of the paired men and women are examined to understand what employment or personal factor made one scientist choose to stay in science and one choose to leave.

Statistical Analyses

Statistical analyses of the probability of leaving science using the national and university data are helpful in identifying correlations between individual or work characteristics and the probability of leaving science. Group differences in probability of leaving are tested first by analyzing differences in proportions and then with multivariate hazard functions estimating the probability of leaving science, conditional on surviving a specified time period, as a function of educational, job, and personal attributes. The results of the analyses, which are consistent across both data sets, identify which scientists are more likely to leave, fueling hypotheses on what factors lead to exit and why.

Most noticeable is the effect that level of education and type of education have on the probability of exit. Exit rates vary by major of degree and by level of degree, most likely because of differences in the extent to which different educational degrees train recipients for a job or a career. In this context, the distinction between engineering degrees and science degrees is important. For example, a bachelor's degree in science is a broad-based degree that develops a body of knowledge and a way of thinking that can be helpful in a variety of careers. However, there are very few jobs, and even fewer careers, that use these skills explicitly. A chemistry major might use the skills learned in college as a laboratory technician at a pharmaceutical company, but most graduates interviewed perceived this type of a job as a "dead end." However, chemical knowledge may prove useful to a graduate hired in sales at a pharmaceutical company. But, as the worker develops his career in sales, the job will probably shift away from chemistry and move more toward sales. Alternatively, an engineering degree, regardless of level, is a narrower professional degree, one that prepares the graduate for a job and a career specifically in engineering. Of the graduates who never spent a day working in science, 90 percent were science majors, while only 10 percent studied engineering. Likewise, the exit rate of engineering majors was approximately half the exit rate of science majors. Finally, according to the university data, although women composed a much smaller percentage of the engineering workforce (7 percent in 1982) than the scientific workforce (25 percent in 1982), the ratio of female-to-male exit remained two-to-one in both subfields.

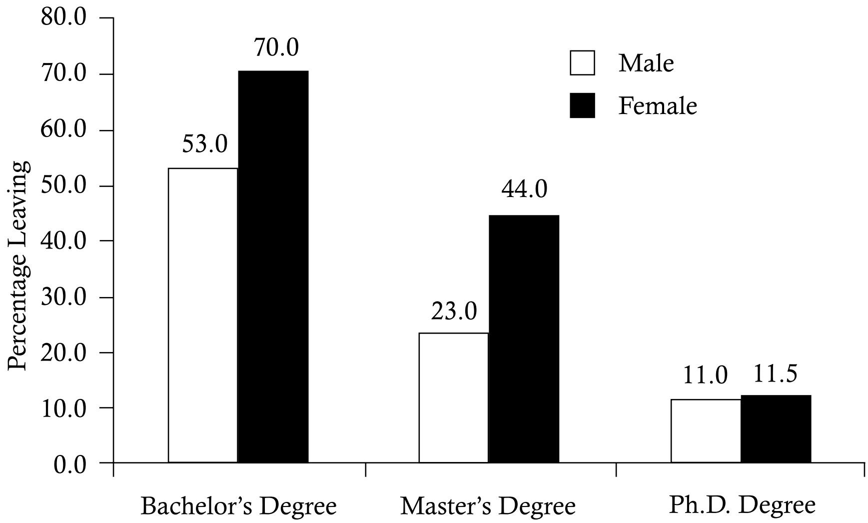
Doctoral degrees prepare a student for research and teaching, and the skills learned in a Ph.D. program, regardless of whether they are in a science or engineering field, are directly transferable to the jobs and career paths expected of this elite group of scientists. Furthermore, there is a selection mechanism ensuring that students who spend the time and energy to earn a Ph.D. are the same men and women who are both talented in and excited about these fields. Both forces tend to discourage exit. According to both the national and the university data sets, Ph.D. recipients were half as likely to exit science as science students who had only earned a bachelor's degree. Probably even more striking was the differential effect for men and women. Comparing Ph.D. recipients in these two surveys, women were equally as likely as men to leave science. Therefore, women who had made the commitment to the doctoral degree had made the commitment to science. But among master's recipients and bachelor's recipients, the percentage of women leaving was roughly twenty points higher than the percentage of men leaving scientific employment (see figure 2.4).

The characteristics associated with the scientific field from which the worker graduated influence exit. Multivariate analysis of the national data show that the probability of exit decreases in fields in which salaries are increasing. Increasing salaries in a field imply that demand for its scientists is increasing, making opportunities and salaries more attractive both in an absolute sense and in relation to alternatives outside of science. As shown in chapter 7, the rates of growth of knowledge vary across fields and across time. In fields where the rates of growth of knowledge are accelerating, scientists are more likely to leave, possibly to avoid the increasing amounts of retraining and skill update that such a fast-changing field requires.

Characteristics of the worker's situation also affect exit. A scientist whose salary is below average for scientists with his or her characteristics, is more likely to leave than one with an average or above-average salary. Low-level earnings signal a mismatch between the individual's interests and abilities and the requirements of the job. If the mismatch is the result of the particular job's requirements, a scientist may relocate to a better fitting job, but remain in science. But if the mismatch is between the scientist's interests and the general knowledge within the field, the scientist is likely to leave science altogether. Part-time workers are more likely to leave science than those on a full-time schedule. Instead of being a stable long-run employment situation, part-time work tends to be a stopping point, a kind of "half-way house" on one's way to permanent exit from the field.

According to the statistical analysis of the national data, being married significantly reduces the probability of exit for all reasons for men and has no significant effects on the probability of exit for

Figure 2.4 *Percentage Leaving by Gender and Level of Science Degree, University Sample*



Source: Author's compilation.

women, except in the instance of exit from the labor force where marriage increases that probability significantly. Having children increases the probability of exit to other occupations for both men and women. However, women with children are more likely to leave the labor force than their childless counterparts, while the opposite is true for men. (For a more complete description of the results of multivariate hazard analysis on the national data, see Preston 1994.) In the university data, having children and being married decreases the probability of permanent exit for both men and women, holding percentage of chores and childcare fixed. However, the more chores and childcare taken on, the more likely the individual is to exit science. Because women take on a majority of household chores and childcare, the true impact of marriage and parenting on the average woman is not likely to decrease the likelihood of exit. (Results of hazard analyses on the university data are further summarized in the appendix to chapter 7.)

These statistical patterns give insight into the types of people who are most likely to leave science; they show how differences in circumstances affect the probability of leaving in a marginal manner—tip the scales a little bit one way or another. Although these statistics can support or refute hypotheses as to why some groups are more likely to leave than others, they cannot pinpoint the major reason for exit. This information is really best uncovered by asking the scientists themselves.

Responses to Survey Questions

In the retrospective work histories, those individuals employed outside of science at the time of the survey were asked specifically why they had left science. Each respondent had the opportunity to cite, at most, three reasons for exit from the sciences. The results, presented in table 2.3, show that men overwhelmingly focused on the low pay in science jobs (68 percent) and the lack of opportunities for advancement (64 percent). However, in decreasing order of importance, they also cited other fields being more interesting (36 percent), the lack of science and engineering positions (34 percent), a preference for nonscience positions (23 percent), and promotion out of science and engineering (18

Table 2.3 Reasons Why Men and Women Left Science

Percentage Who Cited:	Men	Women
Pay better in nonscience and engineering positions	68.0%	33.0%
Career opportunities lacking	64.0	34.0
Other fields more interesting	36.0	30.0
Science and engineering positions not available	34.0	21.4
Preferred other positions	23.0	35.0
Promoted out of science	18.0	2.9
Impossible to have a family and work in science and engineering	4.5	21.4
Demands of the career are too severe	4.5	2.9
Hours required are too long	0	20.0
Science and engineering unfriendly to women	0	19.0

Source: Author's compilation.
Note: Work history sample: n = 1,688.

percent). Although low pay and lack of science opportunities were also important to women, with roughly a third of the women citing each of these reasons, a large number of women also identified a preference for other positions (35 percent), other fields are more interesting (30 percent), a lack of science and engineering positions (21 percent), the difficulty of having a family and working in science and engineering (21 percent), length of hours required of a science and engineering position (20 percent), and unfriendliness of the science and engineering field to women (19 percent). Thus, while men exit science primarily because of a lack of opportunities and low pay, women leave for multiple reasons.

Interview Data

Interview data focus even more specifically on the overriding reason behind exit. As noted earlier, the interview sample of 103 men and women chosen from the 1,688 respondents to the work history survey was constructed as a set of pairs in which individuals within each pair were very similar along the dimensions of level and field of scientific degree, age, and family status. The difference between the two individuals was that one had persisted in science and the other had left. The purpose of the pairing process was to help isolate the important factors behind exiting or continuing scientific careers that could not be identified using standard statistical techniques. Within each pair there was an attempt to find the main difference between the two people that leads to the divergence in labor-market outcomes. The process was not foolproof. The interviews uncovered several pairs where both subjects were still in science or where the subjects were so different that identifying a single or a primary and secondary reason for exit was impossible. While an overriding reason for exit for these pairs could not be pinpointed, their interviews still gave important information on forces affecting success in science.

The results from the interviews are very similar to the results from the survey responses. Table 2.4 gives a summary of the results. The men left science primarily to find better career options in terms of higher pay and better advancement opportunities. Of the nineteen

Table 2.4 Factors Differentiating Leaver from Stayer in Interview Pairs

	Men	Women
Discontent with income and opportunity in science		
Primary factor	15	1
Secondary factor	0	1
Looking for more interesting work outside of science		
Primary factor	3	8
Secondary factor	6	1
Lack of mentor or guidance		
Primary factor	0	7
Secondary factor	0	1
Difficulty shouldering familial and career responsibilities		
Primary factor	1	6
Secondary factor	0	1
Number of pairs for which a factor differentiating leaver from stayer could be identified	19	22

Source: Author's compilation.

pairs of men for whom a primary (and sometimes secondary) factor differentiating the pairs could be identified, fifteen (79 percent) of the men left in response to salary or career opportunity. In four of these pairs, the leaver was responding to insufficient demand for his skills, and the man who stayed did not have to grope with layoffs or declining work. In the remaining eleven pairs, the exiting man voluntarily left science for a career that he felt offered some combination of higher salaries and expanding responsibilities and prestige, and all but one of these exiting men went to work in management-related work with substantial responsibility and pay. Of the ten men who were looking for better opportunities, six mentioned that they were also looking for more interesting work, which they found in management and business. In contrast, in only one pair of women was the desire for greater pay and more promising career opportunities the major differentiating factor behind the leaver and the stayer.

For women, the reasons behind their decisions to exit were more varied, and three important reasons for exit surfaced. In eight of the twenty-two pairs of women for whom a primary factor differentiating the stayer from the leaver could be identified, the reason for exit was a mismatch of interests. The woman who stayed found the scientific field interesting relative to other opportunities; the women who left did not. For three of the eight leavers, this mismatch was clearly characterized by a pull from another field rather than by distaste for the scientific career. These women left science to go back to school in law, theology, and architecture. For three other female subjects, the mismatch of interests was typified by unhappiness with the scientific career. None of these women have gone back to school but are all working: in administrative work, in finance, and in science education. The last two women experienced both the dissatisfaction of a scientific career and the lure of a new career. Both returned to school: one to a clinical psychology Ph.D. program and the other to law school.

A mismatch of interests was also a primary or secondary factor differentiating the men in nine of the pairs. In three of the pairs, interest in science relative to other occupations was the primary factor behind exit. Of these three exiting men, two were drawn to other occupations, one as a fiction writer and the other as a professor of English whose specialty was technical writing. The third was simply disillusioned with the narrowness of science. In six of the pairs, interest was mentioned as secondary to opportunity and pay. All of these six men left science for management-related jobs.

In seven of the twenty-two pairs of women, the positive guidance of a strong mentor was the primary difference between the women who stayed and those who left. Six of the seven exiting women left in response to a lack of support and guidance in college or graduate school. The seven women have established diverse careers in other sectors in the economy: one became a graphic artist specializing in animal illustration, two began careers in computer science, one runs a daycare center and works part time as a mediator, one works in insurance and is studying to be an actuary, one studied theology and is raising her children, and one is the president of a local chapter of the American Civil Liberties Union. In none of the male pairs was lack of mentoring a primary or secondary determinant of the divergence of career paths.

Finally, family responsibilities were the major factor behind occupational exit in six (less than a third) of the twenty-two pairs of women. Within the six pairs, the ways in which family responsibilities fed into the decision to leave science were somewhat different. For three of the pairs, the two women within each pair had very different ideas about the role of the mother in childrearing. The women who left felt that a stay-at-home mother was necessary for care of the infant and toddler. In one pair, both women felt that a stay-at-home parent was necessary for childcare, but the difference between the paired women was their income-earning potential in relation to their husbands'. The woman who remained in science made a substantially higher and more stable income than her husband, who was a carpenter. Therefore, she continued to work while he cared for their child. In a fourth pair, both women felt that being home with children was important, but the timing of the children was different. The woman who had children immediately after college never developed workforce skills to help her reenter science, while the woman who waited until she was stable in her career to have children was able to reenter and continue employment in science. In the final pair, both women were happy to be working mothers, but one woman was employed in a corporation that she perceived to be inflexible and whose managers were unwilling to let her create a work schedule to meet her family responsibilities. In only one of the male pairs was family commitment the reason for exit. A tenured professor gave up his job so that his wife, also a professor, could accept a position in a different region of the country. Although this man had not been employed permanently for several years at the time of the survey, during this period of voluntary labor force exit, he had several temporary, and sometimes unpaid, appointments in positions related to his field of science.

The construction of the interview sample, which was designed to identify a factor differentiating the leaver from the stayer, necessarily downplays some important issues that affect careers of scientists regardless of whether they stay or leave. In particular, to conclude that men leave science because of financial concerns and women leave because of lack of support, a mismatch of interests, and family concerns is too simplistic. For example, family issues are not absent from a man's decision making. In particular, men's preoccupation with financial concerns is closely tied to desires to provide for their families, and family considerations are sometimes the basis of decisions to forgo risky career moves that might ultimately take the scientist away from science. In addition, the small number of female pairs in which difficulties shouldering family responsibilities differentiated the partners occurred not because conflicts between work and family were not present but because they were so prevalent; there were very few married women with children who did not feel these stresses. Similarly, women's perceptions of sex discrimination and double standards were not absent from the interview dialogues; in fact, they were quite persistent. However, sex discrimination and double standards were only secondary factors in exit decisions as they contributed to low levels of mentoring, a mismatch of interests, and difficulties in shouldering the double burdens of family and career. The following chapters explore in depth the factors most important to success and survival in science.

CHAPTER 3

Leaving Science for Income and Opportunity

The topic of financial success and career growth was the issue on which the male and female interviews deviated most dramatically. In more than three-fourths of the male pairs, the desire for greater income and more promising career opportunities was the primary determinant of exit; a majority of these men left for management jobs. For many of the men remaining in science, career decisions were also dictated by monetary concerns. Even those who did not make decisions with salary in mind often pointed out that science was not a lucrative field. Women, however, rarely mentioned the lack of monetary rewards or career opportunities associated with science. While roughly a third of the women in the surveys pointed to salary and lack of opportunity as a reason for exit, these factors were identified in only one interview as a primary reason and in one other as a secondary reason for exit. This chapter begins with an analysis of the interview data to understand the respondents' concerns about salary and career growth and then reviews some of the economic explanations for occupational change and their associated predictions concerning salary growth. Finally, the work history data is analyzed to estimate the actual impact of occupational exit on earnings and earnings growth.

INTERVIEW DATA

The in-depth, personal interviews reveal that men left science not because of salaries that were low in absolute terms but more often because of salaries that were low relative to perceived alternatives. One of the most calculating of the men interviewed graduated as the valedictorian of his college class and entered a Ph.D. program in chemistry at a prestigious private university. Before finishing a semester of work on his Ph.D., he opted for an M.B.A. program instead. He explained, "It was the work quotient, work divided by income. I didn't want that to be too high . . . the amount of studying that you do in six to eight years to get your Ph.D. and then what? I was thinking if you are going to put in that much work, the reward has to be there." He continued, "Leaving science was the smartest thing I ever did. I retired at age twenty-nine to start my own business."

A graduate of a master's program in marine science who worked in an environmental consulting firm described an eye-opening experience.

> I was making 25K a year. The guy who owned the company, his son was nine years old and he had told his dad, "I want to be a truck driver." This guy had the office next to mine, and his whisper was like your shout. He was on the phone with his wife talking about his son. He said "I can't believe he tells me he wants to be a truck driver. How the hell is he ever going to survive on 30K a year?" All of a sudden I realized he's not stupid; he knows I'm not making a lot of money. He knows that he's paying me less than a truck driver.

Within a few months the young man was working in finance and computer services at a Wall Street firm.

Except for the well-known fact that doctors are well paid, knowledge about salary discrepancies between fields was generally incomplete for undergraduates. An understanding of salary differences only started to emerge as students began graduate programs or entered the labor market. For example, a biochemistry major who worked in a cancer laboratory right after school noted, "Somebody at the university . . . should have turned to me and said, 'hey this is a lovely degree but what the heck are you going to do with it when you get out of school? Don't be naive, lab jobs only pay 13K a year.' Nobody ever said that to me until I went out there and said 'hey . . . here I am, what are you going to pay me?' " Having earned an M.B.A., at the time of the interview this young man was working in information systems and finance in a large financial institution. An exception was this financially savvy engineering graduate who explained the motivations behind his job search:

> As I got closer to the end of [undergraduate] schooling I realized there was a natural [salary] curve for engineers and nonengineers. And the engineering curve is, you get out of school, you get a very nice salary, [but it] hits a plateau very quickly and then what are you going to do? You are stuck in a niche. Nonengineering starts out very low but then opens up to a lot of different fields. So I decided to try and combine the two. And I decided to look . . . for something engineering related but in the business end, in the sales end.

Perceptions of relatively low salaries and limited opportunities in science motivated career decisions within the field as well as decisions to exit. A young man who initially had planned to get a B.S. in chemistry looked back:

> In the middle of my junior year I realized that if I just graduated with a bachelor's in chemistry that I would end up being a waste water technician someplace, you know making some small amount of money that wouldn't be able to support me. And I mean maybe that's kind of a narrow point of view but I realized that, if I was going to go anywhere with this, it would have to be at the master's or Ph.D. level, and I wasn't sure that I really wanted to get into that.

He switched to material sciences, earning a B.E. and then an M.E. four years later. His career has remained in science, but over time, his work activities have switched toward statistical analysis and product or process engineering.

Another man who decided to forgo his plans to get a Ph.D. in mathematics and do research explained his reasoning:

> Basically, at the time you saw that some people were graduating with Ph.D.'s [and] taking about a year or two to get jobs teaching but there was a glut of teachers so they were going to Okay Ponokey Swamp University. Whereas with a master's it was taking [graduates] about two months to find a job, and definitely making more money than the people with Ph.D.s. . . . I was initially going to get a Ph.D. and I thought do research. But that changed, and I decided that I'd like to try industry. That was where the money was.

With his master's in mathematics, this young man began a successful career in computer science.

Equipped with a Ph.D. in physics from a prominent private university in the early 1970s, a young man decided to take an industrial position rather than the expected academic job: "I just didn't see a career path for myself in academia. I think I'm a good scientist but I'm not a great scientist, and you know, if you were a good scientist back in those days, really you could get a job as a post doc for a long time, but you were never going to go any where. So part of it was recognition of my own ability and recognizing that maybe there's a better path for me." This man's decision to take an industry job eventually led him into management, and he became president of a small instrumentation company.

Having left his Ph.D. program in marine sciences, a research scientist at a large oil company explained:

> I wanted to get some real experience, go out and work for a while, and at that time in the early eighties the oil industry was just booming, going wild, and I had an interview with a major oil company. I was seduced away; it was that simple. I mean they waved all sorts of dollars in front of you. You start sitting there, saying to yourself, "I could live like a graduate

> student or I can have a real job" I worked much harder as a graduate student than when I first got a job. My starting salary back then was $23,000, and I was living [as a student] on a stipend of $3,100. [My advisor] said, "Why don't you do that for a year, get some experience and then come back." And I told him, "Sure," and never did.

This man, who moved up the ranks of the company to become a high-level scientific manager, understood the costs associated with the move. "I am bought, owned, and controlled by the company. Whatever I do belongs to the company, so I don't have the academic freedom, and I might also add that I don't have the freedom to pursue anything that I want. I have to recommend and propose, and I have to tie it to the bottom line of the company, whether we make it up or not."

The lack of financial rewards in science was also a complaint voiced by many of the men who stayed in science. For these respondents, the absence of a connection between performance and rewards was especially frustrating. The chief engineer of a small electronics company complained, "So that's the extent of my career. After all this time I'm basically not anywhere career-wise. Chief engineer at the defense division of [electronics company X]. Yeah, still not in the money stream. Where I am, there's no cash relationship to what I do or how I do it or how fast I do it." A highly successful engineer at an established aerospace company explained, "I'll be leaving; I sort of have already. I'm at my last step in engineering. I'm called an engineering product manager, but I'm about to go over the fence into program management. Engineers don't get bonuses; engineers don't get stock options; and engineers basically get cost-of-living raises plus anywhere from 1 to 3 percent, based on how good you are."

The notion of two tracks, a management track and a technical track, is prevalent in corporate jobs. A man with a Ph.D. in operations research described the differences, "Advancement comes easier in management than it does in research, so if you choose a management career path you get acceleration in terms of promotion and salary faster than if you stay in research. Although I enjoyed managing, . . . I was probably more suited for doing research." Another man, who after earning a Ph.D. in applied math entered the aerospace industry, gave a tangible example of the differences in treatment of engineers and managers. "One of the things that was a shock to me was when I went to [industry], I had to sit at a desk in a sea of . . . a hundred other people where even . . . as a graduate student I had an office. But they don't do that in the aerospace industry. The only reason they give you an office is if you need one for privacy and confidentiality, i.e., if you're a manager and you have to talk to your subordinates and you have to keep confidential records and stuff like that."

There was recognition by many of the men that the two-tier system resulted in the loss of many talented technical people to management positions. One man described with pride a technical excellence program that his company had started to reward the very productive scientists in ways similar to the rewards of the high-level executives. Unfortunately, this attempt to reward technical expertise seemed exceptional in the world of industry. There were several men who had the opportunity to move to management but decided to remain in the technical track or returned to technical work after a temporary stint in management. One man's reminiscence of his managerial experience echoed a common theme.

> I wanted to get into [management], make a little bit more money and that type of thing, so they made me a product manager of this product group. And it was a year of hell. I had two supervisors and about fifty people reporting to me. When you're schooled in engineering, everything's cut and dry more or less. You get into production and you're dealing with people. . . . When the year was up, you know I sat down with the v.p. 'cause that's who I was working for at the time and he said, "so what do you want to do?" I said "I want out." I just couldn't deal with all the people issues . . . the constant little stuff that drives you crazy. I said I wanted to get back into engineering.

Although the need to develop a secure and often lucrative career was a dominant theme among the men interviewed, there were some exceptions. A young man who earned a Ph.D. in biology but never worked in the field described his motivations:

> I really had very little thought for practical matters, like how I was going to earn my living or anything like that. I sort of treated life as a hobby and it was just following what interested me in an intellectual way without caring very much how it applied to the future. . . . We [the man, his wife, and two children] have sort of muddled along financially, sometimes taking advantage of socialist redistribution of wealth.

More often, for those who stayed in science, the need for income took a backseat to the passion for the discipline. A highly accomplished aerospace engineer, who was active in the space program, estimated that an industry job would increase his paycheck by at least 30 percent. However, this man pointed out, "if you love what you're doing, money is the least of it."

To separate a secure income stream from the need to care for family would be a disservice to these men. Most of the men who talked about income and career growth were family men who perceived themselves as primary breadwinners, working to provide for their families. A man who left marine sciences to work in industry, and who has worked himself up to a high-level position in a large national oil company, explained the impact of marriage on his career: "Being married, and going through that process made me much more focused on money than I otherwise would have been. If I had stayed single I would have . . . [been more likely to go] the 'naturalist' route or the 'pursue the science for the sake of the science' [route] rather than 'if I do this will I be able to earn a living for the family?' [route]." An engineer, frustrated at his inability to break into management, was unapologetic in placing such a high priority on money:

> You know people talk about career all the time. At least to me career is not as important, or at least at this point in my life it's not as important as compensation. I mean my position is, I've got a lot of bills. . . . I've got four children. I've got a house. . . .

> [I live in] one of the most expensive areas in the country if not the world. And someone says "Johnny, I want you to sweep the floor but we're going to pay you twice what we're paying you now." Hey . . . I'll find other ways to get satisfaction in my field of interest.

Another man with a master's in mathematics and working in computing echoed the sentiment, "My goal is to earn money, period. I've got children in college, so I'm going to have to pay for that. I mean as far as a career goal, no, there isn't one. My goal is to make as much money as possible."

The male scientist's preoccupation with income stands in stark contrast to the female scientist's seemingly conscious neglect of this topic. As mentioned earlier, only one woman left science because of opportunity and income. This woman had an M.S. in marine sciences and had worked for several years in a government laboratory where she presented and published her work. She was unwilling to go back to get a Ph.D. because she felt that the postdoctoral positions, which most Ph.D.s entered after graduate school, paid incomes well below her current level. Without the Ph.D., however, she was frustrated with her inability to get promoted or to gain the respect of her supervisors at the government laboratory. As a result she left to start a program in physical therapy.

Of the fifty-one other women, only eleven mentioned displeasure with money and opportunity in science, and usually the frustration was associated with an isolated job as opposed to the field more generally. The discrepancy in concern about money and career growth between scientifically trained men and women may be the result of two factors. First, because of the lack of access that women have had historically to high income and prestigious careers, the types of incomes and opportunities available in science for women may be attractive relative to more traditional female labor-market outcomes. Second, the difference in preoccupation with money between men and women may be the result of the different roles that they traditionally play in the family. The male is most often the primary wage earner and is concerned with supporting the family; the woman, if she works outside of the home, is more likely a secondary earner whose income is only supplemental, although it may be necessary to the support of the family. Interview comments by the eleven women who did mention money and opportunity give support for both factors.

When speaking of job choices and transitions, of the eleven women who spoke of displeasure with money or opportunity, six had either turned down or left a low-paying opportunity. All six of these women remained in science in a job with a more acceptable salary, and all the jobs that they left were entry level, four in the nonprofit sector. A seventh woman, with a M.S. in biology and who was working in a nonprofit laboratory, expected to leave her job for a more lucrative science job in the future. She described her thinking, "I'll do this as long as I can and then when I need to make money or really decide to have a family I'll go look for something else." An eighth woman, with a Ph.D. in ecology, was working as an adjunct at a community college, a position identified as outside of science because the institution is not a four-year college or university. She became frustrated at the low pay, especially in relation to the earnings of full-time professors. She left her position when she was pregnant with her third child, spent time with her children, and returned to the labor force several years later in a nonscience job. For all of these women, salary was an important issue, and, while some science salaries were unacceptable, there were jobs in science that could satisfy their monetary needs. They did not see the science sector as being generally characterized as low pay and low opportunity.

Two women who spoke of the lack of money and opportunity in their current jobs felt that childcare responsibilities rather than science were the determining factors for low pay and stalled careers. However, both women felt comfortable with the choices they had made. A computer scientist explained, "I haven't had a promotion since I've come back, which is two years now, which doesn't surprise me. But then in my own mind, I'm thinking I'm not working fifty and sixty hours like the other people in the department are. So, I've come to terms with that myself, because I thought I can't do it all. I can't be at the office working fifty and sixty hours and be fair to my children." The other woman highlighted how the choice to take on day care responsibilities had helped her husband's career.

> I feel marriage and family definitely hurt my career . . . I have so many other responsibilities outside of work. My son is now a year old, and I'm really responsible for getting up in the morning, getting him out to a sitter. Then coming home and feeding him and taking care of him—all the responsibilities [are] really with him now. So it's good, it enables my husband to keep his career and not to have to really sacrifice at his job. But, yeah, it does hurt me.

ECONOMIC ANALYSIS OF OCCUPATIONAL MOBILITY AND ASSOCIATED SALARY GROWTH

The large number of men leaving science in search of higher salaries and more attractive career opportunities makes one wonder whether these men are really achieving their goals. Because economics, more than any other social science, focuses on monetary returns as a motivator, economic theories of occupational mobility speak directly to the resulting earnings consequences.

Occupational mobility has been analyzed in two different frameworks: as a human capital investment strategy and as an extension of the literature on job matches and imperfect information. Human capital theory (Becker 1993; Mincer 1962; Schultz 1960) has long been used by economists to explain occupational decisions and outcomes. In this theory, just as managers of firms make investments in physical capital, plants, and machinery to increase production and profits, individuals can invest in their own human capital. The stock of human capital for any worker is his or her set of skills and know-how that determines productivity in the workplace. That stock can be rented to employers in return for job opportunities and associated wages. Therefore, an individual, often with family input, makes postsecondary educational decisions that have important impacts on potential human capital. Investments in college and graduate school education determine the human capital stock at labor-market entry, which is characterized by, among other factors, educational degree earned and field of major. Having finished formal education, an individual can continue to invest in human capital creation through countless activities, including on-the-job training, seminars, and informal skill update.

The model of human capital states that an individual decides whether to take on a particular investment in much the same way a businessman decides whether to buy a new machine: by comparing the present value of benefits to the present value of costs. For the individual, the costs are likely to be fairly immediate and will include the direct costs of program and supplies, the opportunity costs of time spent in other endeavors, and possibly nonpecuniary costs associated with the investment, such as unpleasant feelings toward study or an ignored spouse's scorn. Because of the relative immediacy of these costs, they may be easy to predict. Benefits, the increase in potential earnings, and the more satisfying job opportunities, however, are not likely to be realized until a future date and will be more long lasting. At the same time, since benefits are pushed into the future, there may be more error in predicting them. Most human capital models assume perfect information on the part of potential investors.

In addition to activities that increase the stock of skill and expertise, the theory also models actions that increase the value of a given stock as human capital investments. Therefore, job search activities designed to improve the match between a given stock of human capital and a potential job or migration activities to geographical regions where a particular type of human capital is more highly valued have been analyzed as investment strategies in this framework. Along the same vein, Kathryn Shaw (1987) considers the process of occupational change as an investment in human capital—a premeditated move in a well-planned career path. Human capital accumulated within an occupation through on-the-job training or other direct investments will have varying levels of value in other occupations depending on the degree of transferability. Opportunities for human capital development and salary growth vary across different occupations. As a result, in a world free from uncertainty, workers choose occupations to chart an occupational career path that maximizes the present discounted value of the earnings stream. Shaw finds strong evidence that occupational change is positively related to the transferability of skills and the declining opportunity for occupational investment in the initial occupation. Therefore, in this scenario, workers plan an occupational strategy where persistence in an occupation will continue as long as there are sufficient opportunities for profitable skill development and salary growth. Once these opportunities dry up, there is a preplanned exit to a new occupation that will value the skills already developed and offer superior opportunities for further skill development and salary growth.

Alternative theories of job and occupational mobility focus on career decisions in a world of uncertainty. Boyan Jovanovic (1979), who first developed the literature on job matches, job-specific human capital, and turnover, has posited that occupational mobility is the result of worker-employer mismatch. Because of imperfect information surrounding the employment transaction, the quality of a potential match between a job and an employee is not known with certainty ex ante. The employee evaluates a potential job based on expected salary, salary growth, and job characteristics. Predictions of earnings are likely to rest on knowledge of average earnings for employees with varying levels of seniority within an occupation. In such a scenario, unmet salary expectations may arise for two reasons. First, person-to-person differences in salaries within an occupation will depend on the quality of the occupational match, the extent to which the requirements of the occupation match the traits of the individual, or the extent to which the individual can be productive in the chosen occupation. Second, knowledge concerning occupational wage structures at the time of labor-market entry may be incomplete, and unforeseen supply-and-demand forces may alter relative salaries across occupations, making salaries in the selected occupation generally less attractive. Nonwage characteristics, such as hours, work conditions, or flexibility, of an occupation are also likely to be predicted with error for two reasons. First, nonwage attributes will differ within an occupation, and often the full set of nonwage attributes of a job are impossible to appreciate without experience within that workplace. Second, all individuals will not agree on the valuation of a particular nonwage attribute. For example, a working parent may see flexibility as a positive and frequent overseas travel as a negative in a job, while a young single employee may be more likely to rate these features in the opposite manner.

Once the employee takes the job and information is revealed over time, mismatches may lead to exit. The mismatch may take the form of lower than expected salary or lower than expected utility, the economist's catch-all term for happiness. As soon as expected salary or utility in the current job falls below some threshold value, exit will result. The more severe the mismatch, the increased likelihood of occupational exit. There is considerable empirical support for the theory relating mobility to job mismatches. In his analysis of job mobility patterns of young men, Henry Farber (1994) finds that the monthly probability of a job ending increases with tenure at the job for tenure levels between zero and three months and then decreases monotonically with further tenure. This probability pattern is predicted by the job-matching theory if information on the quality of the job match is not revealed fully once the job is taken but instead reveals itself over time. In an empirical test of the theory's application to occupational movement, Jovanovic and Robert Moffitt (1990) estimate a model of occupational mobility that tests the validity of two competing explanations: sectoral shock versus employee-employer mismatch. They conclude that a majority of the mobility between occupations is the result of employee-employer mismatches.

Both explanations of occupational mobility imply that the worker is better off after the move. The human capital explanation of occupational mobility predicts that the exiting worker will enjoy higher future discounted earnings after the move than he would have experienced had he stayed in the initial occupation. Although the job-matching literature does not deal explicitly with postexit outcomes, the implication is that the worker leaves in anticipation of a better match and thus higher utility, which may or may not mean higher earnings. More specifically, if exit is the result of unmet salary expectations, the worker will be searching for a new job with higher earnings; if the employee is unsatisfied with nonwage characteristics of the job, he will be looking for a position with more favorable work conditions, probably at the expense of earnings. There is strong empirical support for the relationship between job change and salary increase. For example, Robert Topel and Michael Ward (1992) find that job mobility in the early career, which need not be occupational mobility, is the source of at least a third of early career wage growth.

The human capital explanation goes even further, predicting that the lifetime earnings profile of the switcher is always above the profile that would have been experienced with another occupational course. In the context of scientists leaving science, at time of labor-market entry, they believe that the present value of the salary profile associated with their chosen path of a stint in science followed by nonscience work will be greater than the present values of the salary profiles of career scientists or career nonscientists. These workers not only anticipate higher future returns outside of science than inside science after exit, but they also anticipate higher returns within science than outside science before exit. Therefore, the explanations for occupational mobility differ in their implicit evaluation of the job experience in the initial occupation from which the worker is exiting. While the human capital explanation argues that time in any occupation is a profitable stepping-stone along an optimal career path, the job-mismatch explanation argues that the initial job or occupation is a mistake; time could have been spent more profitably in an alternative situation.

In the context of occupational exit from science, the fact that individuals who are leaving have high levels of scientific human capital raises two important issues. First, having at least invested in a bachelor's degree in science, these workers should be entering scientific jobs with a good amount of occupation-specific information. Second, high levels of scientific human capital make the monetary returns of scientific exit questionable unless human capital is transferable to the destination occupations. Although exiting scientists may expect to transfer skills, the transferability of science knowledge to nonscience jobs is an empirical question that can only be addressed through data analysis. In analyses of the salary repercussions of occupational exit, it may be helpful to separate those who leave for salary reasons, labeled income seekers, and those who leave in search of more favorable job conditions, labeled amenity seekers, since there is no reason to anticipate salary gains for the latter group. Furthermore, in these empirical analyses, income seekers, who are exiting science as a part of a planned career path, may differentiate themselves from income seekers leaving due to imperfect information because their salary profiles up to and including time of entry into nonscience occupations will be above salary profiles for people who never enter science during the same period.

DO NONSCIENCE CAREERS PAY MORE THAN SCIENCE CAREERS?

The results of an empirical analysis of salaries within and outside of science will necessarily depend on the qualifications of the workers whose salaries are being compared. Given the nature of this study, the focus is on men and women who have earned at least an undergraduate science or engineering degree. Differences in earnings patterns arise among people leaving science according to how much science education they have accumulated, the fields in which they have earned their degrees, how much time they have spent working in science, and how much and what type of education they invest in after leaving science.

Salary Changes Associated with Leaving Science

The first comparison of salaries of science-educated individuals who have left science to salaries of those who have remained uses the 1982 to 1989 NSF data. Using a national sample of respondents who worked in science in 1982, the data chart salary and labor-market characteristics for each of these individuals in 1984, 1986, and 1989. Regression analysis then allows the estimation of the wage gain or loss accompanied by movement from a job within science to a job outside of science.[1] These analyses, as displayed in table 3.1, estimate that men who left science experienced a 4 percent loss in salary, and women leaving science experienced a 10 percent salary loss. These losses represent an average loss for all scientists leaving over this period, regardless of level of education and experience in the labor market. However, further analysis shows that the earnings loss is slightly greater for individuals who have been in the labor market longer, and for men, the loss is more severe for those with science Ph.D.s than with lower level degrees; the opposite is true for women.

The unambiguous salary loss might be surprising except that exiting individuals have not been differentiated according to reason for exit. As noted in the earlier section on economic models of mobility, leaving to improve nonpecuniary attributes, such as work hours, geographical location, or flexibility, is likely to result in reduced earnings. To deal with this problem, leavers are differentiated according to responses to a survey question asking about reasons for exit. Income seekers are respondents who identify better pay or promotion opportunities as their motivation behind exit, and amenity seekers are respondents who report leaving because of locational preferences or desires for a nonscience position. The salary change on exit is then reestimated for these two groups of leavers.

The results of the new analysis are presented in rows two and three of table 3.1. Male income seekers benefited from a 4 percent salary gain on exit from science, while male amenity-seekers experienced a 12 percent salary loss. Similarly, female income seekers experienced no change in earnings on exit, and female amenity seekers experienced a 13 percent salary loss. Clearly, income-seeking leavers earned higher salaries on exit than amenity-seeking leavers. But because of the short window of time in which the respondents are observed, these data do not allow an estimation of the long-term salary effects of leaving science. Alternatively, the work histories of the uni-

Table 3.1 Percentage Change in Salary for Men and Women Leaving Science

	Male	Female
1. All leavers	4 percent salary loss*	10 percent salary loss*
2. Income-seeking leavers	4 percent salary gain*	No change
3. Amenity-seeking leavers	12 percent salary loss*	13 percent salary loss*

Source: Author's compilation.
*Change in salary is statistically significant at the 0.01 level.

versity data can be used to compare longer run salary profiles of career scientists, career nonscientists, and science leavers.

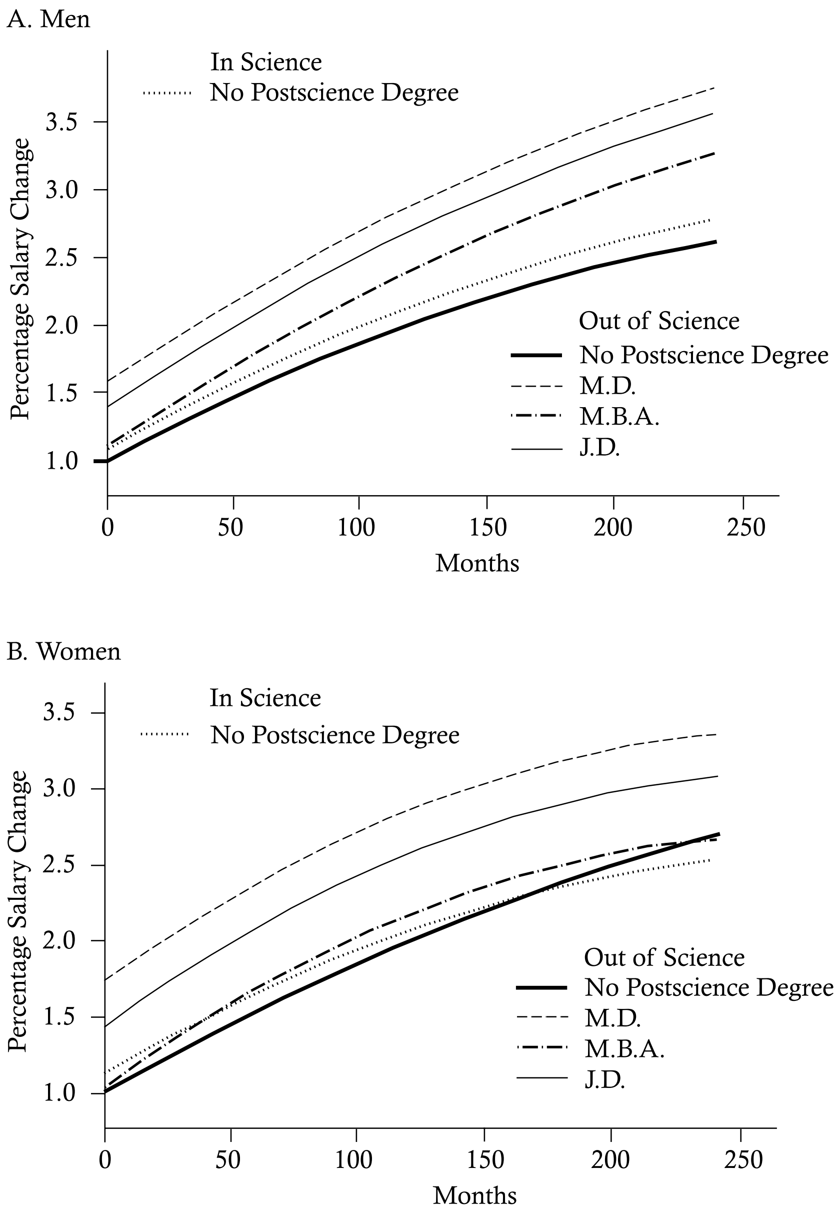
Salary Profiles of Career Scientists Versus Career Nonscientists

The career scientist is a person graduating with a degree in science who lands his or her first job in the science labor market and remains in this area for his or her full labor-market career. The career nonscientist also graduates with a degree in science but lands his or her first job in nonscience work and, either consciously or through the luck of the draw, develops a career solely in nonscience work. Career nonscientists may choose many different paths. As pointed out in chapter 2, a large number of these students, especially the men, use the science degree to help them get into medical school, and they begin careers six to seven years later as doctors. Graduates may also invest in other professional degrees in law or business or even master's or Ph.D. degrees in other fields. Salary comparisons must account for these educational differences.

Figures 3.1A and 3.1B trace the relation between the percentage changes in salary of the average worker and months of experience in the labor force for career scientists and career nonscientists. As noted in the figures, the average starting salary of noncareer scientists without postscience degrees is normalized at one and thus becomes the standard of comparison. All changes from this standard of comparison can be thought of as percentage changes. The comparisons within the samples of men and women are made using statistical analyses that, by holding worker characteristics such as marital status, science education, or time outside the labor market constant, attempt to compare otherwise identical employees. Figure 3.1A focuses on men, and salary profiles are charted separately for men who left science without a postscience graduate degree, men who remained in science, men who left science and invested in a medical degree (M.D.), men who left science and invested in a law degree (J.D.), and men who left science and invested in a business degree (M.B.A.).

Focusing first on men who did not get a professional degree after

Figure 3.1 Career Scientists Versus Career Nonscientists



Source: Author's compilation.
Note: The average starting salary of respondents who are out of science without a postscience degree is normalized at one with percentage salary changes measured on the vertical axis. 1.5 on the vertical axis corresponds to a salary that is 50 percent above the starting salary of a respondent who is out of science and has no postscience degree.

exit, men in science earned starting salaries 9 percent higher than men in careers outside of science. Salary growth was slightly higher inside science than outside of science, ensuring that salary profiles of career scientists remained above salary profiles of career nonscientists who did not invest in further education. The salary profiles of men who earned professional degrees in medicine, law, or business reveal that these professionals experienced much higher rates of salary growth than career scientists or career nonscientists with no further education. With the exception of short-term internships or clerkships, initial salaries in law and medicine were 30 percent and 50 percent, respectively, higher than initial salaries in science, making these careers clearly much more lucrative than science. Although the initial salary in business was comparable to that in science, the higher salary growth in business ensured that the salary of M.B.A. recipients remained above the salary of science graduates working in science. The true return to each of these professional degrees can only be calculated by weighing the salary returns against the costs of obtaining the degree in terms of forgone earnings and direct costs. The most expensive professional degree is probably the M.D. since medical school is the longest program and the one least likely to be accomplished part-time while holding down a full-time job. At the same time, this degree has the highest salary profile.[2]

This same comparison of salaries for women is given in figure 3.1B. Comparing first those women who did not invest in a postscience degree, women working in science received starting salaries about 13 percent higher than salaries of women working outside of science. But science salary profiles reached a plateau before nonscience profiles, and nonscience salaries rose above science salaries fourteen years into the career. As with the men, women who invested in an M.D. or a J.D. experienced much higher salary profiles than women without a postscience degree. Women doctors had starting salaries about 60 percent higher than women in science, and the starting differential between lawyers and scientists was about 30 percent. Furthermore, salary growth was higher for these women with professional degrees. Women who earned an M.B.A. had starting salaries below salaries of women in science, but the higher salary growth pulled salaries of women with

M.B.A.s above salaries of women in science about three and a half years into the career.

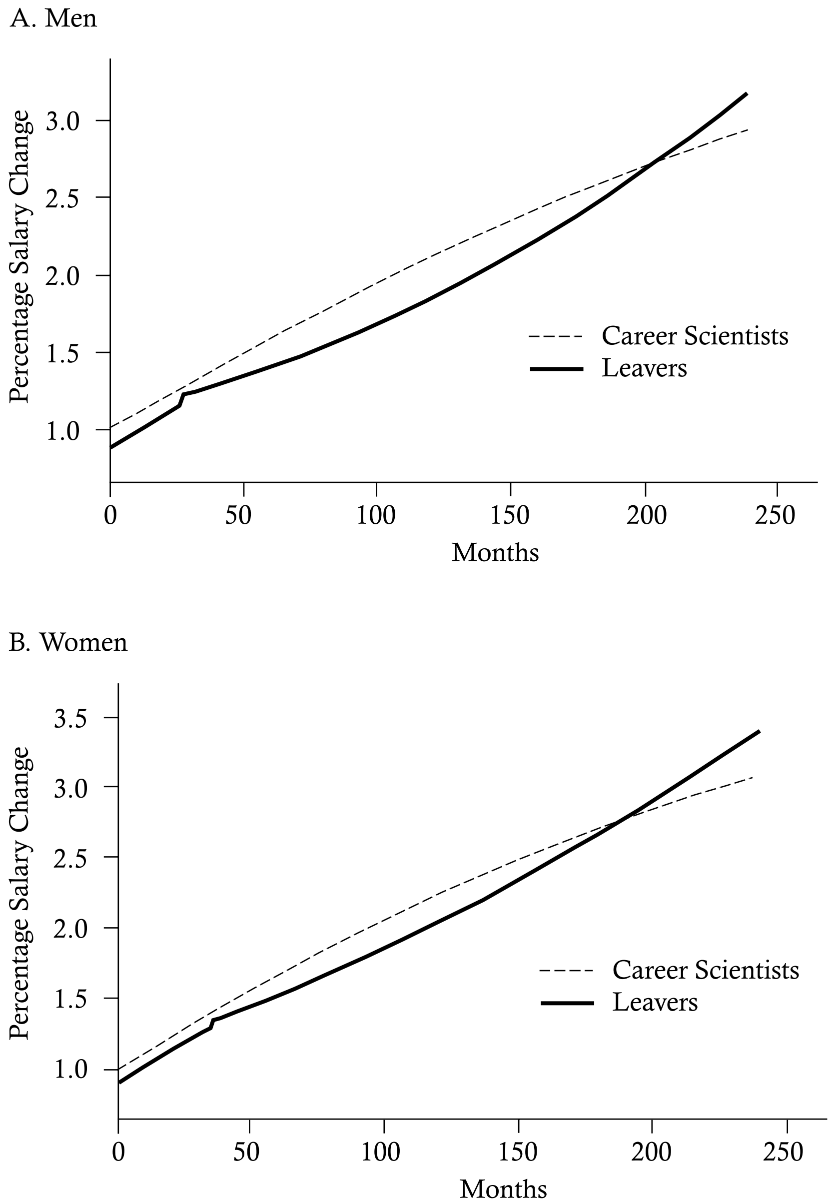
These high estimated returns to nonscience professional degrees and comments in the interviews about high engineering salaries early in the career call for a comparison of salary profiles of career scientists (with a nonengineering degree) and career engineers. Using regression analysis to compare scientists with similar individual and workplace characteristics, the NSF data estimate a 20 percent salary premium for engineers at labor-market entry while the university data estimate a 22 percent salary premium. Although these premiums are below the law and medical school premiums, they are above the salary gains for an M.B.A., and in contrast to the other professions, engineering does not require a postcollege degree. Both the NSF and the university data estimate lower returns to experience for engineering majors than for science majors, but the higher salary growth for science majors never makes up for the higher initial salaries of engineers. In both data sets, the average career salary profile of engineering majors is always above the average career salary profile of science majors.

Figures 3.1A and 3.1B give a consistent picture of salary profiles for graduates with a degree in science. Career nonscientists without a professional degree earned lower salaries than career scientists, regardless of sex. Within the groups of career scientists, engineering majors earned higher salaries throughout the career than pure science majors, even though salary growth was slightly lower. Earning a nonscience professional degree, particularly an M.D. or J.D., increased salary levels as well as salary growth relative to remaining a scientist. This pattern calls into question the wisdom of leaving science for money. Men leaving science in search of higher salaries may find their goal elusive if they do not invest further in a professional degree.

Salary Profiles of Leavers Versus Career Scientists

A comparison of salary profiles of leavers and career scientists is instructive for a number of reasons. First, it is helpful to know how leavers compare to career scientists while both groups are in science. Are they as successful as stayers or is their exit possibly a result of low salaries earned while in science? Who leaves is likely to have an impact on estimates of salary consequences of exit. Also, people who have worked in science have developed skills through these labor-market experiences that may or may not be transferable to nonscience jobs. The amount of time that a leaver has worked in science may affect the initial salary that the leaver can command in nonscience work and even the amount of training investment the new employer is willing to make. The first issue is addressed with an empirical technique called first differencing that estimates the average within-person salary change for leavers as they move from the science to the nonscience job rather than an average salary differential between similar individuals who are within and outside of science. These salary changes are estimated for all leavers and then separately for income-seeking and amenity-seeking leavers because their differences in reasons for exit imply different experiences within science and varied salary consequences on exit. In order to account for the effects of preexit scientific skill accumulation on postexit salaries, the regression model includes an interaction term that allows the salary change to differ according to the amount of science-related experience. As with the comparison of career scientists and nonscientists, the statistical analysis holds constant other potentially important characteristics. Because the earlier analysis clearly shows that investing in a postscience professional degree shifts the salary profile upwards, this analysis only focuses on graduates who did not invest in such degrees. Furthermore, salary changes are estimated solely for individuals who voluntarily left their nonscience jobs.[3] Figure 3.2A gives the salary profiles of men who start careers in science, separating men who stayed in science from men who left. Leavers started out with salaries approximately 12 percent lower than stayers implying that, as hypothesized in Jovanovic's (1979) job-matching model, exit might have been the result of discontent with one's own earnings relative to science norms. Salary growth was similar for leavers and stayers while the leavers were in science. After an average of twenty-seven months, the median duration of time in science for leavers, the leaver switched to a nonscience job, and male leavers experienced a 6 percent salary gain on exit. The change in salary was dependent on the amount of time spent in science before

Figure 3.2 *Comparison of Salaries of Career Scientists and Leavers*



Source: Author's compilation.
Note: Starting salary of the male career scientist is normalized at one with all changes interpreted as percentage changes: 1.5 on the vertical axis corresponds to a salary that is 50 percent above the starting salary of male career scientists.

exit. Since time in science is not as highly valued outside of science as within, the salary change on exit fell with more time spent in science. For example, a man who left after six years in science experienced a 9 percent salary loss at time of exit rather than the 6 percent gain mentioned previously. Earnings growth immediately after exit was slower than earnings growth within science, possibly as leavers were learning new skills outside science. However, as the career progressed, the salaries career scientists earned in science generally reached a plateau while salary growth for leavers started to accelerate. By seventeen years into the career, male leavers were experiencing both higher salaries and higher salary growth than career scientists. However, it is not clear that lifetime earnings of leavers were above that of career scientists. The relative valuation of these earnings streams depends on the length of the career and the rate at which individuals discounted future income. For men with long, uninterrupted careers who have very low discount rates, exit may have increased lifetime earnings. But these are strong qualifications, and ex ante knowledge of these salary comparisons are not likely to have lured men out of science.

The salary profiles of female leavers and career scientists shown in figure 3.2B look very similar to the male profiles. Female leavers started out earning about 10 percent lower salaries than career scientists while in science. After an average of thirty-five months, the female leavers exited science and experienced a 9 percent salary increase that again depended on duration in science. Earnings growth outside of science started slowly, but after a period accelerated at about the same time that earnings growth of career scientists was slowing. At about sixteen years into their career, female leavers started to benefit from both higher salaries and higher salary growth than their peers who remained in science. However, because of temporary labor market departures motivated by familial responsibilities, many women do not have the long uninterrupted career that is necessary to ensure the returns of a career move to a nonscience occupation.

Comparisons of the salary effects of leaving for engineering majors and pure science majors reveals that the skills of engineers may not be as highly valued outside of science as the skills of less applied scientists. Wage loss on occupational exit is lower and subsequent wage growth is higher for science majors than for engineering majors. However, these differences are still small relative to the large initial salary differences earned by science and engineering majors. Again, figures 3.2A and 3.2B give a consistent story. The financial returns to leaving science are neither immediate nor automatic. Only individuals with long careers and low discount rates will prefer the salary profile of leavers to that of stayers. Therefore, the obvious question becomes: Are men and women who leave science in search of more lucrative careers chasing windmills or are they the lucky ones, the ones who do find unambiguous financial success?

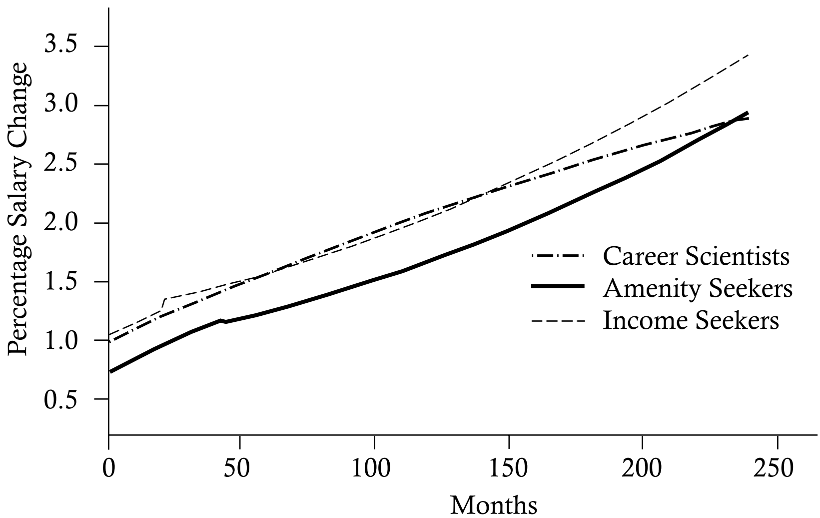
In an attempt to determine whether income-seeking leavers were more successful at earning financial rewards, the analysis is restructured to allow salary profiles to differ for leavers who claim they left for money and career growth versus leavers who left for other reasons, such as improvement in amenities and nonmonetary work conditions.[4] Figures 3.3A and 3.3B present the salary profiles of stayers, income seekers who left for higher salaries and greater opportunities, and amenity seekers who left for better work conditions. For both men and women, income seekers left science after a shorter amount of time in science than amenity seekers, possibly because they were aware that experience in science is not well rewarded in nonscience jobs. In addition, income seekers experienced higher financial rewards in their new positions than amenity seekers, most likely because amenity seekers were trading off income for more favorable job characteristics, such as flexible hours or more enjoyable work.

Focusing first on men, income-seeking men were earning slightly higher salaries than career scientists while in science, and on exit benefited from a 9 percent salary jump. Again, salary growth was slow immediately after the move, causing salaries of leavers to dip below those of career scientists very slightly at about five years into the career. However, by eleven years into the career, these men were enjoying higher salaries and salary growth. By twenty years into the career, leavers were making almost 50 percent more money than career scientists.

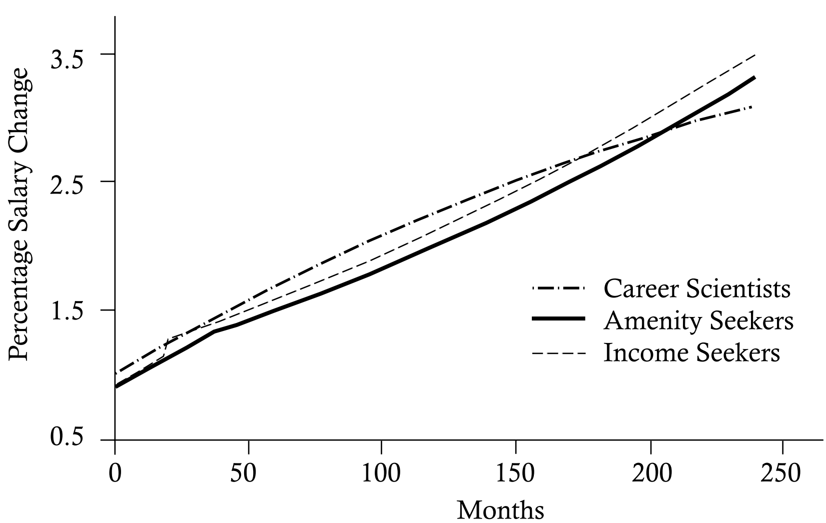
In contrast to the male income seekers, female income seekers' earnings were about 10 percent lower than career scientists' while they

Figure 3.3 *Comparison of Salaries of Career Scientists and Leavers by Reasons for Leaving*

A. Men



B. Women



Source: Author's compilation.
Note: Starting salary of the male career scientist is normalized at one with all changes interpreted as percentage changes: 1.5 on the vertical axis corresponds to a salary that is 50 percent above the starting salary of male career scientists.

were in science, further reinforcing the idea that these women were leaving in response to unmet expectations about their own salaries within science. On exit, female income seekers enjoyed a 14 percent increase in salary, but again the slow salary growth early on outside of science kept the leavers' salaries below salaries of career scientists until about fifteen years into the career. Although it is possible that these women stay in the labor market long enough to reap the returns from leaving science, one has to question whether the salary profile documented is the salary profile that these women expected when they left science.

Both female and male amenity seekers started out with relatively low salaries within science, and their salary profiles remained well below salary profiles of career scientists until nearly twenty years into the career. Even for individuals with long uninterrupted careers and a low discount rate of future income, it is unlikely that the lifetime income of amenity seekers lies above the lifetime income of career scientists. But the amenity seekers were not seeking wealth as they exited science; rather, they were seeking more comfortable working conditions, which often come at the expense of income.

Salary Profiles of Leavers Versus Career Nonscientists

The final question becomes: Do leavers have higher salary profiles than career nonscientists, or would they have been better off never entering science? As in the earlier analysis, the question is only really relevant for people who do not go on to get a postscience advanced degree. Similar to the previous analyses, the comparison is between otherwise similar individuals and separated by sex and by reasons for exit. Assuming that experience profiles are similar, the analysis produces estimates of the difference in the level of salaries of career nonscientists and of leavers while the latter are still in science and estimates of the difference in salary levels of career nonscientists and of leavers once the latter have entered the nonscience career.

Using transitive reasoning, income-seeking men must have higher earnings than career nonscientists since they earned more than career scientists who, according to figure 3.1A, enjoyed higher salary profiles than career nonscientists. According to the statistical analysis, during their time in science, income-seeking men benefited from salary profiles about 13 percent higher than career nonscientists. Once they entered the nonscience occupations, their salaries were 10 percent higher than career nonscientists. Therefore, it seems reasonable that for these men, the career path that began in science and ended outside of science may have been a well-considered plan to maximize lifetime income.

The results are less clear for income-seeking women who earned salaries below career scientists for much of the early and middle career. These women earned similar salaries to career nonscientists both while they were working in science and while they were working outside of science, implying that with respect to lifetime earnings, it does not matter whether or not they started their careers in science. Neither amenity-seeking men nor women benefited from a temporary stint in science relative to career nonscientists. Male amenity seekers earned salaries below career nonscientists while they were employed both within science and outside of science. Female amenity seekers earned salaries comparable to the noncareer scientists while working in science. Once they left science, however, their salaries fell below the noncareer scientists.

Returning to our original question of whether science leavers gain financially, the answer is uncertain. Investing in a professional degree is a ticket to higher salary levels and higher salary growth, but there is a cost in terms of forgone income and tuition. For leavers without postscience degrees, the empirical results substantiate the interviewees' claims that salary growth outside of science begins to accelerate in mid-career when science salaries commonly plateau. In general, exiting science without a professional degree will not improve lifetime earnings. Only income-seeking men and women, who are savvy about finding nonscience work that rewards their scientific skills and who have long careers, potentially increase lifetime income by leaving science. But the deferred salary gains from exit may be another factor contributing to why women did not mention salary as a reason for exit. Many women do not anticipate the long, uninterrupted career necessary to reap these gains.

With respect to the theoretical arguments, only income-seeking men seem to have the high relative salary profiles predicted by the human capital theory, implying that there may be a group of men that is well informed about job opportunities and earnings within and outside of science and is acting on that information. Income-seeking women, however, have low incomes while they are in science and seem to be leaving due to a mismatch of their own talents and those required of science work. Similarly, male and female amenity seekers are experiencing unfavorable job attributes and relatively low salaries while in science, implying imperfect occupational matches along more than one dimension. Since imperfect matches are often a result of a lack of information on occupational opportunities, these results call for improved and more widely disseminated career and salary information for scientifically trained individuals.

CHAPTER 4

Family Responsibilities and Their Effects on a Scientific Career

Family responsibilities affect career outcomes in very different ways for men and women. Responsibilities associated with a spouse and children commonly result in the reallocation of the woman's time away from work and toward the family. However, family responsibilities for a man lead to a reallocation of time toward work to increase the size and stability of his income. While the shift in time commitment for the woman leads to career compromise in a majority of cases, the reallocation of a man's time can have a similar effect as short-term income and stability cannot be sacrificed for long-term advancement. This chapter explores the intricacies of the relationship between work and family for these scientifically educated individuals. After a short account of some of the more prominent economic and sociological work done on this topic, the chapter continues with a blending of the work history and interview data to create a deeper understanding of the often complex conflicts and struggles for both men and women as they try to combine career and family. Finally, the chapter ends with an empirical analysis estimating the quantitative effects of marriage and parenting on continuation in science and on earnings and earnings growth.

ECONOMIC EXPLANATIONS FOR FAMILY EFFECTS ON CAREERS

Economists use knowledge of traditional gender roles in the family to explain how differences in behavior and perceptions of employees and employers result in differing impacts on careers of men and women. Even before marriage or parenting, men and women may make human capital investment decisions in compliance with their expected family life. Anticipating the role of "breadwinner," men may invest in high levels of formal education as well as informal learning that may help to enhance their careers. Women, however, anticipating a role as a secondary and often intermittent earner, may invest in less education and, when investing, may seek skills that are geographically mobile and not prone to decay when not in use. These different patterns of human capital accumulation are likely to result in real differences in earnings.

For those men and women who enter the workplace with similar educational investments, as is the case for many of the men and women in this sample, employer perceptions of future careers may result in differences in training opportunities. Because of well-known differences in housework generally, and childcare in particular, performed by men and women, employers may allocate development resources toward men and away from women because they expect higher levels of career commitment from men. Career progress, seemingly similar at entry, may then diverge with time at work.

Once marriage and parenting occur, economists predict changes in behavior. In order to reap the gains from specialization within marriage and family, men will concentrate on work and career while their wives will take care of household tasks. Not only will this specialization result in a reallocation of time but also one of attention. Women will reallocate time away from market work and toward housework or childcare to varying extents: from leaving the labor force altogether, to working part-time, to reducing overtime hours. For those mothers who remain in the labor market full-time, economists have argued that they will have less energy to apply to work if their home time involves childcare (Becker 1985). With women spending less time at work and placing family concerns above those at the job, they may be less productive. On the other hand, men, free from family responsibilities and having more dependents to satisfy, may be especially industrious. Therefore, careers will move further apart with family formation.

With the women's movement's message of independence and Title IX's doorway to enhanced educational opportunities, traditional gender roles are being challenged, and there are women whose career aspirations and educational investments match those of the most ambitious men. Many of the theoretical assumptions and predictions of the standard human capital models do not do not hold for these women. Recent declines in the marriage premium for men (Blackburn and Korenman 1994), while not fully understood, have been attributed to declining specialization as women have entered the labor market and their husbands have had to take on more family responsibilities (Gray 1997). Gary Becker's (1985) theory that women who care for children have reduced energy for career pursuits has been challenged as men have taken on increasing childcare responsibilities with no evidence to date of resulting negative earnings consequences.

The persistent negative impact of family on careers of high-achieving women has been explained theoretically with models that focus on solutions to informational problems when employers cannot judge future productivity of employees. For example, statistical discrimination in which employers use outdated perceptions of traditional gender roles to guide training and funding opportunities for male and female workers, regardless of their true commitment to work (Preston 2001), can create divergences in the career progress of men and women and can alter career decisions of women. Similarly, institutionalized workplace structures, designed to weed out all but the most dedicated employees, may force tough choices on women who are trying to balance family and work. Renee M. Landers, James B. Rebitzer, and Lowell J. Taylor (1997) cite the work practices of large law firms as an example of a rat-race equilibrium in a historically male-dominated professional labor market where hours of work are signals of commitment. Only those lawyers who work the excessively long hours will make partner since profit sharing among partners ensures that one person's slacking impacts everyone's earnings. Citing statistics from a large law firm where 96 percent of associates and 89 percent of partners feel that "willingness to work long hours when required" is very important for promotion to partnership, they acknowledge that these norms of work hours are incompatible with success of women who are starting families. Academic labor markets may be another example of a rat-race equilibrium. Similar to law firms, academic departments give a junior member several years to prove his or her worth. While there is no monetary surplus shared by tenured faculty members, there are shared prestige benefits attached to the reputation of the senior faculty. Tenured members will only vote to accept a new member if that person has shown high commitment to the field. Again, because the years during which academics earn tenure are the same period during which families are being formed, the excessively high signals of commitment necessary for promotion may come at too high a price for many women.

RESULTS OF PREVIOUS EMPIRICAL RESEARCH ON FAMILY AND CAREER

Empirical economists and sociologists have documented the differing impact of family on men's and women's labor-market success. Earnings studies of large national data sets have shown that marriage is associated with a wage premium for men and at best a negligible effect on wages of women (Korenman and Neumark 1992; Kilbourne, England, and Beron 1994). The positive effect on male wages has been relatively stable over time (Goldin 1990), and most economists attribute the marriage premium to increased specialization in the family, thus a change in behavior of husband and wife once they marry.

Average earnings effects of children are even more dissimilar for men and women as fatherhood is coupled with a significant wage premium and motherhood is linked to a significant wage loss (Korenman and Neumark 1992; Waldfogel 1997). During the period of this study, the "family gap," the difference in earnings between mothers and nonmothers, increased at the same time that the gender gap declined (Waldfogel 1998). Several studies estimate more specifically the wage and salary effects of time spent working in the home. Evidence of the larger burden of household chores borne by the woman of the household than by the man is widespread (Biernat and Wortman 1991; Coverman 1983; Hersch and Stratton 1997; Shelton and Firestone 1988), and estimated income reductions resulting from time spent at home, while sizable for women, are small and usually insignificant for men (Coverman 1983; Hersch 1991; Hersch and Stratton 1997; Shelton and Firestone 1988).

The literature on career outcomes of college-educated women has invariably focused on the fact that women with families have a hard time succeeding in a professional, predominantly male workforce. For example, Claudia Goldin (1997) shows that, in the twentieth century, there has been no cohort of women that has successfully combined work with family. The most recent cohort that she analyzes is women who graduated from college in 1972, a group who, unlike any of their female predecessors, were given wide access to traditionally male professions such as law, medicine, and business. Only 13 percent to 17 percent of these female college graduates had both a career and a family by the age of forty. In a study of graduates of the University of Michigan Law School, where variation in ability and education is relatively small, Robert Wood, Mary Corcoran, and Paul Courant (1993) find that in the tenth year after graduation, salaries of women are only 60 percent of the salaries of their male classmates. Forty-four percent of the gap is due to fewer hours, greater part-time work, or more time out of the labor force for women than for men, which the authors attribute to greater childcare responsibilities.

Literature on the effects of marriage and children on careers of scientific women has concentrated on academic women, and outcome variables analyzed have been rank and productivity rather than earnings. While most scientists encounter the belief that marriage and motherhood do not mix with a scientific career (Cole and Zuckerman 1987), in general, the empirical results are not conclusive. In particular, Jonathan Cole (1979) and J. Scott Long (1990) have shown a positive effect of marriage on productivity, while Robert Helmreich and associates (1980) show no effect. Long, Paul D. Allison, and Robert McGinnis's (1993) work on biochemists estimates a positive effect of marriage on promotion from assistant to associate professor, but no effect on promotion to full professor. Gerald Marwell, Rachel Rosenfeld, and Seymour Spilerman (1979) conclude that, relative to their male peers, married academic women are geographically constrained in job search, are more likely to locate in large labor markets, and tend not to be as mobile as their male counterparts. Long's (1978) work on the effect of work setting on publication rates implies that any compromise in job location by women in dual-career marriages is likely to lead to reductions in productivity.

Estimated effects of children on productivity are also not conclusive. In a study of seventy-three women, Cole and Harriet Zuckerman (1987) find no evidence that these women's publication rates decline after bearing children. They do find that having children does impact careers, however, by reducing flexibility to conduct time-consuming projects and reduced time for informal discussions and socializing with colleagues. Long (1990) does not find direct effects of children on productivity, but he does find that the probability of collaborating with one's advisor is lower for mothers of young children than for childless women, although having young children does not affect the probability of collaboration for male scientists. With collaboration an important determinant of predoctoral and postdoctoral productivity, mothers may be at a disadvantage.

DATA FROM WORK HISTORIES AND INTERVIEWS

Family responsibility data from the work history survey reveal that traditional roles of women continue to exist even in the most educated segment of our society. First, women are more likely than men to be constrained by the career aspirations of their spouses. Second, regardless of the couple's career situation, women tend to take on a larger share of family responsibilities than men. Table 4.1 gives data concerning these issues for men and women. According to rows one and two, 56 percent of women and 34 percent of men were married to spouses with advanced degrees. Women were almost twice as likely as men to have spouses who worked full-time. Similarly, according to rows three and four, women were approximately twice as likely as men to have altered residential localities and sacrificed career opportunities to satisfy their spouses' careers.

With regard to household and childcare chores, the women and

Table 4.1 Impact of Spouse's Career and Family Responsibilities

	Women	Men
Number of respondents with spouses	703	507
1. Percentage of respondents whose spouses earned an advanced degree	56.8*	34.4
2. Percentage of respondents whose spouses predominantly worked full-time during the marriage	95.7*	56.6
3. Percentage of respondents who altered location decisions to satisfy spouse's career	44.6*	23.4
4. Percentage of respondents who sacrificed career opportunities and work effort to satisfy spouse's career	24.6*	11.6
5. Percentage of household chores spouse is responsible for	34.8* (17.8)	65.1 (16.4)
Number of respondents with children	449	363
6. Percentage of childcare spouse is responsible for	15.1* (13.9)	67.0 (26.3)
7. Percentage of childcare individual is responsible for	60.2* (27.9)	17.6 (15.4)
8. Percentage of respondents who took time off from work to care for children	36.3	0.0

Source: Author's compilation.
*Percentage for women is significantly different than percentage for men at the .01 level.

men in the sample give very similar answers concerning the share of these activities that both the female and the male of the household assume. Such consistency is striking given that these respondents are not married to each other. In these highly educated households, the woman performs twice as much of the household work and up to four times as much of the childcare as the man. These figures are similar to those reported in studies using time-use data (Hersch and Stratton 1997; Shelton and Firestone 1988), although time spent caring for children often is not separated from time spent performing other household chores. In previous studies in which childcare is analyzed separately, the ratio of female-to-male time with children is higher than the same ratio for time doing household chores (Coverman 1983). Even when constraining the set of women to those who worked full-time and never took leave from work to provide childcare, the women in the current study still accounted for 50 percent of the childcare, and their husbands performed no more than 15 percent, the same as reported previously. As women worked longer hours, their reduced participation in childcare was picked up by outside caregivers rather than by their husbands. Finally, according to row eight, 36 percent of the 454 mothers in the university data took leave from their careers, beyond the standard maternity leave, to care for their children. Of the 371 fathers, none reported career interruptions to care for their children.[1]

The interview sample confirms the importance of family responsibilities as a factor responsible for exit of women but not of men. Family responsibilities comprised the major factor behind occupational exit in six of the pairs of women and only one pair of men. In three female pairs, the difference between the two paired women was their opinions concerning the role of the mother in childrearing. The women who left their careers felt that a stay-at-home mother was necessary for care of the infant and toddler. In the fourth and fifth pairs, the four women all agreed that a parent should stay at home with a preschool child. The difference between the women in the fourth pair was in their income earning potential in relation to their husbands' potential. The woman who remained in science made a substantially higher and more stable income than her husband, who was a carpenter; therefore, she went to work while he cared for their child. She also was aware that a stint at home would be more damaging to her career growth than to his. The fifth pair of women, who were both in their early sixties at the time of the interview, had children at different stages of their careers. The woman who had children immediately after college never developed workforce skills to help her reenter science; the woman who waited until she had developed a career to have children was able to reenter and continue employment in science. In the final pair, both women were happy to be working mothers. However, one of the pair was employed in an inflexible corporation whose managers were unwilling to let her work part-time to meet her family responsibilities. She was forced to work full-time or quit.

The sole male pair in which family responsibilities led to exit highlights the difficulties in accommodating the dual-career marriage for men and women with Ph.D.s. Both men got Ph.D.s from excellent institutions and have strong long-lasting marriages, but their wives chose very different educational trajectories. The first man gave up tenure at a university to follow his wife to a tenure-track job as a professor after she had spent more than a decade as an adjunct instructor at his institution. While not permanently employed at the time of the interview, he still worked in science in a temporary, and sometimes volunteer, nature. The second man developed his career in science as his wife, who stopped her education after receiving a bachelor's degree, raised their children and managed the family.

The interviews also give a more complete understanding of the complex interaction between career and family that men and women in different careers must manage. For women, exit was not a common response to the difficulties of shouldering family and career responsibilities. A much more common response was a lower level career compromise: limiting job search to a specific location, working part-time, or forgoing promotions that require travel. In all but one circumstance, career compromise was directly related to family responsibilities coming from the respondent's marital family. The exception was a middle-aged woman who left the labor market to care for her ailing parents, a behavioral pattern that may potentially become more prominent as the respondents age. Of the thirty-four women married with children, 80 percent mention at least one lost career opportunity forgone to accommodate husband or children. Of the ten women married without children, 50 percent mention similar career sacrifices, and all relate these compromises to accommodating their husband's career. Not one of these women felt that they had made a conscious decision that would advance their careers at the expense of their families. In retrospect, one woman felt that the problems her preschool child developed might have been related to having a working mother. Of the seven women who were single and childless, six had not yet faced the conflicting pulls from family and work. One woman confessed that she had sacrificed a relationship that could have led to marriage to advance her career.

Of the thirty-five married men with children 54 percent felt that their families had had no negative effect on their careers, and many men talked about the flexibility that their wives' careers, or lack thereof, afforded them in pursuing their own. Thirty-one percent of the men felt that the need to provide income and security for their wives and children limited the extent to which they could invest in their own career growth. In particular, many men felt that they could not return to school for an advanced degree or look for opportunities in different locations. Lost income and the risk of an unsuccessful move prohibited such a change. In addition, as their children aged, many men found that new job searches in response to unexpected layoffs, plant closings, or firings had to be geographically constrained to assure stability for their children's educational and social development.

FAMILY AND CAREER CONFLICTS FOR THE DOCTORAL RECIPIENT

From the interview data, we can identify when the balance between family and career becomes most difficult. The most trying periods occur at different stages of family development for men and women with different levels of education and career aspirations. For women with Ph.D.s who are aspiring to academic jobs, the biggest hurdle occurs early in the career, which is often early in the marriage as well. The typical career for Ph.D. recipients in a scientific field requires a high degree of geographic mobility during this period. Those individuals earning Ph.D.s typically work at two or three postdoctoral appointments before taking a permanent position. Such a career path may require up to four geographical moves after the Ph.D. is completed in order to find a permanent position. Additionally, these first jobs themselves may last only six years, until the time of a tenure decision. Early geographic mobility and then subsequent location of two rewarding jobs within close geographical proximity are challenges that may lead to career or relationship compromises for a dual-career couple. Confirming Marwell and associates' (1979) results, in these situations, married academic women of the study felt geographically constrained in early job searches and subsequently relatively immobile throughout the career.

Women in scientific fields typically have professional spouses (table 4.1) and many are married to scientists (Cole and Zuckerman 1984). These women find it very hard to continue their career paths as Ph.D. scientists when it requires their husbands to switch geographical locations often. Generally, professional women marry men who are older and more established in their careers.[2] The husbands tend to earn more money than their wives for these reasons. Therefore, the costs of relocation are high. Of the twelve married women with Ph.D.s, six were married to men who also had Ph.D.s. The other six all spoke about the geographical constraints that their husbands' careers put on their own careers. While men may also encounter these difficulties, they are less likely to have spouses who have severe occupational constraints. In cases where there are conflicts, because the man is usually older, he has the advantage of establishing himself first, with his wife restricting her job search to accommodate his initial location. Of the sixteen married men with Ph.D.s in the interview sample, four had wives with Ph.D.s, but only two of these four women were pursuing academic careers. However, two other men of the sixteen did have early marriages with women who were also pursuing Ph.D.s; in both cases the marriages dissolved because of the stresses of the dual career. Of the remaining ten, all but two were married to women who worked in flexible, female-oriented occupations, such as nursing, teaching, home management, or childrearing.

The difficulties of the dual-career marriage in which one or both of the spouses have a science Ph.D. are best explained by the scientists themselves. One woman, who was finishing a postdoctoral position in microbiology explained:

> My husband moved with me from New York to Boston when I got this job, and if I got a job in Boston or Chicago or Los Angeles or another major city, I think my husband would be willing to move with me again; but unfortunately a lot of faculty positions, especially first ones, are not in Chicago or L.A. Those positions are really tough to get. At this point, he's

> pretty far along in his career, and he's got a really good job so I just can't pick up and leave and not go to another major city.

In addition, many women felt that they did not have the right to ask their husbands and families to move. They did not want to shoulder that added responsibility. For example, a world-renowned woman in her field who remained an adjunct professor for her complete professional career described her decision not to take a tenure-track position in a university hundreds of miles away from her home and family:

> I didn't want to take the responsibility . . . my husband didn't want to move and I didn't want to take him away from a job, to ask him to redefine his career. That was it. I was afraid of that emotional burden. He said he was willing to do it but I wasn't willing to take the responsibility for his emotional health. I couldn't do it. That's why I never looked for another job.

The outcome of these stresses is not always career compromise; marriages dissolve as well. A mid-career geologist employed in a senior technical position at a large private company remembered his situation as he graduated with his Ph.D.

> My career goal was teaching. I applied for a few teaching positions and I interviewed for two of them but I was not offered a position. Now appreciate at this time in geology, these jobs were getting 100, 150 applicants. It was also a time when affirmative action was having an affect on the hiring practices. For a number of years, through the eighties really, many, many of these available jobs went to women or minorities and rightfully so. But for those of us who were not either, it was very, very difficult unless you were completely outstanding which I wasn't. So I came to [company X] with the thought of not staying and with the acknowledgment that this was not a part of the country that I wanted to live in. My wife was much more adamant about that at the time. She'd grown up in northern California and her goal, our goal, was to get to a

> nicer living environment. To make a long story short, about two years after we got here, she went back to school to get a Ph.D. [on the West Coast] and . . . that was pretty much the beginning of the end of our marriage. We divorced three or four years after that. . . . It was a situation where I had no opportunities that were nearly as attractive as the one that I had here . . . so I stayed here. And she followed her own career in science and we have both done quite well, but not together.

He continued somewhat philosophically,

> I seem to have had to face a decision between a technical career, one in which I was very comfortable and challenged, and rendering my career second to keeping the marriage together, to my personal life. As things evolved, I let the career take precedence. Now, there's no control group right? I can't say what would have happened if I had made the other decision, but there's certainly, certainly a significant amount of baggage that comes along with it.

Every married woman with a Ph.D. in my interview sample narrowed the geographical scope of her job search to accommodate her husband. In the few geographical areas densely populated by universities, women have been successful in landing academic jobs. A woman with a Ph.D. in molecular biology found her job search constrained to the New York City metropolitan area. After two postdoctoral positions in private laboratories on Long Island, she got a tenure-track position in one of the colleges in New York City. She has developed a well-equipped laboratory with grant money and is a highly productive scientist. However, she explains that the geographical constraint made the initial development of her career difficult. "I needed to stay here, based on whatever circumstances. I went to a place where they didn't have the funds that other places might have had, and I started at ground zero with practically no money at all."

More often, the geographical constraints on job searching cause women to look outside of academia for job prospects. A woman with a Ph.D. in oceanography commended her husband for following her to her second postdoctoral position, which she was just finishing at the time of the interview. But he had gotten a good job, and instead of dragging him away once again, she was looking into job openings in foundations and government—jobs that require as much managerial expertise as scientific expertise. Many women also looked to industry jobs to solve the problems associated with dual-career marriages. Another woman finishing a postdoctoral fellowship in molecular biology at a prestigious East Coast university was considering jobs in the biotechnology industry. Although she felt that such a job choice would compromise her career, she was not sure how she could fit her husband and future children into academia.

Many of the men in the interview sample spoke of the importance of having a spouse who accepted the flexibility that is necessary to accommodate the geographical mobility of a science career, an advantage few women have. A Ph.D. in a tenure-track position in computer science at a midwestern university pointed out that his career had benefited from, as well as impacted, the work activities his wife had chosen. "We made six moves, New York to Berkeley and back, Los Angeles, Australia, Berkeley again and then the Midwest, all because of my career. You may have noticed she had a few different jobs—working with mentally retarded adults to property management to administrative work in Australia to retail sales and now payroll." Few men would be satisfied with such a patchwork set of work activities.

Once the early postdoctoral years are over, finding two jobs within the same city is not easy for an academically employed couple. A microbiologist whose early career benefited from having a wife with transferable skills described the problem from the other side of the issue as he tried to recruit young scientists to his university in the Washington-Baltimore area. "A lot of people in my field are scientific couples and most of the candidates have a scientific spouse and they need a position. It's tough. I mean there are worse places than here . . . the best places are Boston and San Francisco where there's plenty of opportunity." In many instances, however, the man is older than the woman and is already established in a job; therefore, the wife has to find the job to accommodate his initial location. As a result, the only instance in which a Ph.D. scientist gave up tenure for a spouse's academic career is the case of a male chemist. He explained,

> that was a very nice job for me, but the academic couple is not happy unless both have good situations. And it was not such a good situation for my wife because she came without a job, and she was seven months pregnant and she didn't work for a year and then she wanted to go back. . . . She took part-time work in the English department as an instructor, and these big state universities depend on exploiting various kinds of people to teach their lower division courses. She got roundly exploited over the space of twelve years. After eleven years we decided we would leave, and we would go to the place where she could find the best job.

Even though the structure of the academic scientific career discourages participation by women with interests in a family, most of the women acknowledge the importance of this early career mobility. A molecular biologist clarified, "It's very important in my field when you do a Ph.D. in one place that you move somewhere else to do a post-doc and then you move somewhere else to get a job. Most of this has to do with different kinds of experiences making a better scientist." A marine scientist described a similar rationale for mobility.

> I got my degree here. They don't want me to stay. They think it would be better for my career to go somewhere else and learn from somebody else. I did do that in Maryland for a while but I came back. . . . but to them they would think well, hey, maybe you should go to Florida. Stay there for a while and go to Washington and then to California. There's truth to that because you learn from different people.

This model of the production of cutting-edge science is deeply rooted in the scientific culture. The costs in terms of lost staffing, and occasional harm to personal relationships, are high. Therefore, it is important to consider whether this mobility is necessary for the advancement of science, or whether there are alternative models that do not compromise quality yet are more embracing of family needs. With today's increasingly sophisticated communication and transportation technologies, there may be alternative ways to have young scientists learn from other more experienced scientists or engineers in other locations.

The issue of family and children surfaced again when women Ph.D. recipients talked about the need to secure grants early in their careers in order to establish a laboratory and succeed in the academic environment. With increasingly sophisticated and expensive equipment and larger numbers of grant applications, these scientists reported increased competition for grant funds, which translated into more of their time allocated to research activities and less to families and nonwork activities in general. With an increasingly uncertain success rate, they were often not sure whether they wanted to make this added sacrifice. The solution of many women was to find jobs in industry where research money was provided, albeit at the expense of autonomy.

A woman finishing her postdoctorate in molecular biology at a prestigious university and pondering her choices noted, "there is a tremendous feeling among scientists both men and women that . . . in order to be a good, productive scientist, a federally funded scientist, you have to put in a lot of hours, and if you can't put those hours in you won't get the grant money, and if you do put those hours in you are doing it to the detriment of your marriage and children." She felt that women, more than men, were passing up the academic career to increase the quality of family life. She lamented that the most successful of the scientists are those who forgo outside interests, thus reinforcing the stereotype of the nerdy scientist.

Another woman with a Ph.D. in geology, who left science, as I formally define it, to engage in teaching and training, described her professors in graduate school.

> They were dedicated to their families but they weren't spending the time with their families, doing the things that their wives were doing. They felt very strongly about going home in the evening. They would work from eight in the morning until six at night, which is a very long day, and then spend time

> with their kids at night, but sometimes they would come back after their kids went to sleep. If their wives were taking the kids some place in the evening they would go to work. [Work] was the only thing they had and it was very obvious to me they weren't cooking and they weren't cleaning and . . . they weren't going to the kids' plays—the things that somebody's got to do and usually the woman ends up doing. Most of their wives either weren't working or they were only working part-time . . . in very nondemanding professions.

Although the voices questioning the "tunnel vision" required to succeed in academia were predominantly female, there were some male echoes. A chemistry Ph.D. concluding his postdoctorate at the time of the interview was discouraged by the immense amount of time that his advisor put in to ensure grant funding; he anticipated looking for a job at a teaching college. "I've pretty much decided that I don't want to go for the big Domo type jobs that are out there and that apparently my advisor thinks I could have been headed for. . . . [I am] just realizing that I don't want to be doing work for eighty hours a week basically until I get tenure. I'd much rather be trying to raise my son or doing stuff with him in the community."

Stressing the difficulty underlying the dual-career marriage is not meant to overlook the troubles encountered while balancing children and scientific work of Ph.D. recipients, a stress felt primarily by women. Many of the women spoke of feeling the need to hide pregnancies as long as possible because of the negative connotations related to work commitment that they might evoke; one prominent scientist, a mother herself, admitted to reducing her opinion of her own female colleagues once they started having children. Having children was not a deal breaker for these women, however. In response to the dual-career conflicts, some of these women had found or were seeking a work situation, possibly outside of science, that could accommodate both marriage and childcare. Others persevered and entered the work-intensive environment of academia and grant proposal writing. These women recounted late nights at the lab, chaotic scheduling, and heavy reliance on relatives and daycare providers, an exhausting balancing act with uncertain success. But the level of commitment to career that had gotten them to that point kept them working through the challenges.

FAMILY AND CAREER CONFLICTS FOR THE SCIENTIST WITH A BACHELOR OF SCIENCE OR MASTER OF SCIENCE

Women who terminated their education with a bachelor's or master's degree and worked in private industry found the greatest difficulty balancing the conflicting demands of young children and companies that were often inflexible to their needs. Generally, these women were trying to establish scientific careers in business, government, or nonacademic nonprofit organizations. Although dual careers can be complicated to balance, jobs in these sectors are not as tied to a specific geographic area as they are in academia. In addition, individuals with a B.S. or M.S. degree often qualify for a broader set of jobs than do Ph.D. recipients with narrow and specialized training. For these women, finding jobs for two professionals was not the overwhelming barrier that it was for Ph.D. scientists. Many of these women, however, found that the most challenging problems arose when the couple started a family. Some women felt the need for one parent to stay at home during the early years of a child's life, and other women were looking for job situations that allowed a comfortable shouldering of the double burden of work and family. Many of the women were looking for jobs with opportunities for part-time work, flexible hours, minimal travel and overtime hours, and no relocation requirements—all characteristics that reduce the potential for increased earnings and promotions. These women often took on the family responsibilities and looked for these workable situations either because the husband was more established and his participation would generate large financial sacrifices, or because the woman felt that it was her responsibility to do so and was something she wanted to do.

The difficulties that women in science careers have balancing children and work are echoed in interviews with men. An electrical engineer working at a large defense firm and married to a woman with a

B.S. in electrical engineering who worked at the same firm described how family impacted her career. "She was doing fine and everything until we decided to start having kids . . . she went back part-time after the first one, and after the second one she retired."

In the business field, there was often a lack of flexibility in meeting the demands of working mothers. Part-time and flex-time work, while increasing at the beginning of the twenty-first century, were rare in science and engineering jobs during the 1980s and early 1990s. Eighteen percent of the women working outside of science and engineering worked part-time while only 8.5 percent of the women working in scientific jobs were part-time. For women in science and engineering, part-time work during childrearing may be an important way to keep skills current so that reentry to a full-time science- or engineering-related job is possible once the children enter school. Companies were also often inflexible concerning time off for sick children, and many women left in response to this conflict. Leaving the labor force during their children's preschool years, these women invariably reentered the job market in a position unrelated to science.

This pattern was apparent in one interview with a successful technical sales employee who had more than ten years of experience at a large, well-established computer company and was denied part-time work after her first child. She left the workforce and does not feel able to return to the same field since so much has changed in the ensuing five years. Similarly, a successful software developer in a large pharmaceutical company described her company:

> This company calls itself a family company, but indeed they are kind of hostile to working mothers in time off and the type of situations that arise when you are a working parent. Supposedly the company has a high divorce rate. . . . You need to take vacation time when the child is sick. In other companies, you get personal days; you can take time without pay if you have to. In this company that's not an option. . . . There is no part-time work; you have to resign.

At the time of the interview, she was hoping to leave the company once she had accumulated the financial resources necessary for investment in further education in order to change careers.

The interviews did uncover positive situations in which companies or their employees worked with women to craft opportunities that would ensure the flexibility needed by these women. One female respondent with a Ph.D. in math and computer science education went to work for a company that developed mathematical software for schools. The president of the company supported her efforts to have a family and a career.

> When I was going to have a baby, he's the one who said "just put him in your office" and I took him up [on it]. I brought my little one to work every day. . . . By the time he was about a year, he was getting too big—it just wasn't appropriate. I needed to work at home. So, instead of coming into the office every day, maybe I'd stay six hours or so and then come home and work. . . . That was always encouraged, and once in awhile I wouldn't go in; I would work at home.

After working for this company for six years, she left to start work toward a law degree. The president of the company who had supported her efforts to blend family and career had sold the company to a large business that did not offer her the sort of flexibility to which she had grown accustomed. Among other reasons, she said that she left because she was looking for the kind of flexible work environment she had under the company's original founder.

Many of the women who were frustrated by the lack of job flexibility questioned the rationale behind their companies' policies. A computer science graduate working in the research and development department of a private company explained. "It just seems very stupid to me—economically stupid—for a company to train somebody and then force her out. That has to cost the company money. They invest money and everybody invests time. So why just lose that because people want to have children? They make it a very hard issue. If they were a little more flexible, I would be infinitely loyal and I would stay with this company—I think I would work harder, really."

All of the women in the interview sample were highly motivated career-oriented women. They had overcome the social pressures discouraging them from studying math and science in junior high and high school. They had succeeded again in a somewhat more alienating science or mathematics curriculum in college and had landed a science-oriented job. Except for a few women who had always planned to stay at home with their children, none of the women anticipated the difficulties they would face balancing career and family. Some women became aware of the struggle during the pregnancy when they saw their responsibilities at work diminished. Others first felt the conflicting demands with the birth of their first baby. Still others first understood the conflicting pressures as they returned to work and attempted to compete for responsibilities and raises with other men and women who did not have the same family responsibilities.

Women respondents who remained employed after motherhood, regardless of education, pointed out that the balancing act was a persistent and ongoing struggle. Some of the persistence of this struggle is due to the natural changes that children and families undergo as they grow. A computer software developer explained. "I'm thinking ahead to see what happens when he [my son] wants to visit friends or he wants to play sports or be a boy scout or whatever—these things are done after school and that is four, five o'clock. I don't want to penalize him—I don't want to say to him 'you can't do it because I have to work.' "

However, other aspects of the persistence of this struggle are due to the nature of science itself. Science is a continually evolving field of study, and often individuals working in science need to work on updating their skills on their own time. Married women with children are immediately at a disadvantage in this respect if they are taking on more of the family responsibilities than their male counterparts. As one woman explained, "The one thing they [the company] seem to highlight now is outside reading, which is not unusual. They want their technical people to read as much as they can to get new ideas and things like that. I understand that and that's great, but I don't have a lot of time for outside reading."

The impact of starting a family is very different for men. Most of the male interviewees talked about their early careers, when they worked long hours to gain higher salaries and better promotion opportunities for the sake of their families. A young mechanical engineer who was moving into management at a large construction company talked about opportunities for advancement, "[I] definitely see an opportunity to move up, but this environment requires pretty intense dedication of your own personal time. So there's no such thing as nine to five or anything even close to that." And when asked whether having children would impact his career, he continued, "I don't think it will impact it immediately . . . [it depends on] whether I can keep this pace up and sort of miss the early years of my child's life. I think the reality is that I work ten- or twelve-hour days, so I'm not really going to see my children except on the weekends."

A man with a Ph.D. in operations research and working in industry described his early career: "I was working a lot of extra overtime hours and I wasn't getting home much. My wife was supportive of that because I was making good money and I was trying to get into a position to buy a home and do other things. We needed more money, but at the same time the extra hours and not having much time at home to spend with the kids and having her burdened with almost all the time at home . . . all was kind of rough."

As many of the men aged, however, family stresses started to put constraints on their careers. A man with a B.S. in computer science who started a family soon after finishing his degree explained. "Early on I had the desire to go to school but I saw the people around me who were doing that and saw what it took and I basically had to make a decision, 'what was I valuing?' And I decided that I wanted to value my family. At some point it may impact how far I can go in my career, but I'm willing to live with that because I place my family above my career." A male respondent who left a Ph.D. program in math after obtaining a master's degree, entered industry and developed a successful career in computer science. With changes in the industry, he found himself laid off in midcareer with a wife and two children. He explained, "My wife and I made an agreement that I wouldn't go pursuing jobs out of state, and we sort of said we're going to stay here and raise the kids. In other words, we're not going to uproot the kids and the family." This man found a good job and felt that the layoff, along with some good luck, had a positive impact on his career. A man with a B.S. in geology who entered the electronics field because of limited opportunities in geology, felt that he could not take any risks to look for new opportunities because of the responsibilities of providing for his five children. "I have to have a job, and I have to make sure I have a decent job with enough pay so that I can support my family. That's a consideration for moving or for taking another job."

At some point, many men just decide the family sacrifices are not worth the income. The operations research Ph.D. who worked such long hours early in his career, was struck down with a life-threatening illness in midcareer. Back in good health and in a good job, he talked about his new position:

> I'm sure there will be opportunities for advancement if I want to try and be aggressive and go for it because of the growth of the company. But I'm getting to the point where I've got a lot of responsibilities at home with my family. A lot of what you do to get ahead is to do a lot of traveling and a lot of hard pressure things, being on the go and all. So it's kind of a trade off for me there—as long as I'm making a good living and I'm enjoying my work and I'm able to keep my wife and kids happy.

FROM INTERVIEWS BACK TO WORK HISTORIES

The interview data highlight the importance of family responsibilities in defining both a man and a woman's career. They also underline the complexity of the interaction between family and career. However, three consistent patterns seem to emerge, which can be tested with the larger university data set. First, with respect to Ph.D.s, the career compromise for women comes early. Marriage to a professional man often requires female Ph.D. scientists to compromise their career goals, possibly through movement to a nonacademic or a nonscience position. Second, women with a master's or bachelor's degree find that the career compromise comes with children. Third, both men and women point out that time with children reduces the time spent developing a successful, well-paid career.

Turning to the 1,688 work histories, statistical analysis is used to determine whether these patterns hold for the full sample. First, the analysis estimates the probability of working in a science job as a function of the amount of previous experience in science jobs, the amount of previous experience in work outside of science, the time spent out of work, and then the variables identifying whether the scientist is married and whether the scientist has children. The samples are separated by level of degree and by sex. The results are presented in table 4.2.

The results confirm the interviewees' impressions. Married women with Ph.D.s are 11 percent less likely to be employed in a science job than female Ph.D.s who are single. However, having children, once the woman is married, does not affect the probability of being employed in science. Interestingly, male Ph.D.s are 12 percent more likely to be employed in science if they are married than if they are single, probably because men marry women with transferable skills and careers who are

Table 4.2 *Effect of Marriage and Children on Employment in Science*

	Marriage	Children
Women with Ph.D.s (n = 113)	11 percent less likely to work in science if married*	No effect
Men with Ph.D.s (n = 118)	12 percent more likely to work in science if married*	No effect
Women without Ph.D.s (n = 862)	No effect	17 percent less likely to work in science if with children*
Men without Ph.D.s (n = 591)	No effect	No effect

Source: Author's compilation.
*Effects are significantly different from zero at the .01 level.

willing to take on the full share of family responsibilities. Although the scientific employment of women with master's or bachelor's degrees in science is not impacted by marriage, women with children are 17 percent less likely to work in science than women who are childless. Family considerations have no impact on the employment of men with bachelor's or master's degrees in science. For women, family formation is strongly and negatively correlated with persistence in science, yet the stage of family formation that creates difficulties differs according to career track. Women with Ph.D.s have trouble merging the dual-career marriage with a scientific career, while women with B.S. or M.S. degrees have trouble accommodating children.

Regression analysis is used to estimate salary profiles over time for men and women with different family situations. These profiles reveal estimated salary growth for men and women while they are single, married but childless, and parents. Each parent in the work history survey was asked to estimate the percentage of childcare that they took on while their children were preschool age. Using their responses, salary levels and salary growth can be estimated for parents with differing amounts of childcare responsibility taken on during their children's preschool years. For both men and women, the percentage of childcare has large, statistically significant negative effects on salary levels. While the effect of childcare on women's earnings mirrors results of Shelley Coverman (1983), Joni Hersch and Leslie S. Stratton (1997), and Beth Anne Shelton and Juanita Firestone (1988), the significant negative effect on male earnings is unprecedented.[3] Also unique to this study's sample of parents, the childcare variable explains the full earnings differential between men and women. Comparing male and female science-educated parents, mothers and fathers who take on the same amount of childcare earn, on average, identical salaries. These large and significant negative effects of childcare on earnings as well as their power to explain gender-based earnings differentials hold up under considerable statistical testing (Preston 2001).

Figure 4.1 presents the estimated salary profiles as the average respondent moves through the stages of family development. The natural logarithm of salary is measured on the vertical axis, which allows all changes to be interpreted as percentage changes. For example, the

Figure 4.1 *Salary Experience Profiles While Single, Married, and Parenting*

Source: Author's compilation.

increase from 9.75 to 10.0 on the vertical axis corresponds to a 25 percent increase in earnings. With respect to levels, 9.75 corresponds to annual earnings of $17,154. Once the individual becomes a parent, the graph traces out three hypothetical salary profiles: one for the parent who takes on 100 percent of childcare, one for the parent who takes on 50 percent of childcare, and one for the parent who takes on 0 percent of childcare.[4]

The salary profiles again confirm the interviewees' comments. Looking first at figure 4.1A, men who take on 100 percent of childcare, of whom there are very few, experience a 28 percent salary loss relative to salary immediately preceding childbirth. Men who take on none of the childcare experience a 12 percent salary gain, possibly as they work harder to provide for the child. Men who take on 50 percent of childcare, still a large percentage relative to the average man, experience an 8 percent loss in salary. After childbirth, salary growth does not vary according to the amount of childcare taken on, but the large differences in salaries persist.

The salary profiles for women are qualitatively very similar. Women who take on no childcare also benefit from an 11 percent jump in earnings after childbirth. Women who take on full childcare responsibilities experience a drop in earnings of 4 percent. And women who take on 50 percent of childcare, a figure slightly below the average, enjoy a 4 percent increase in salary. After childbirth, however, salary growth also varies by the amount of childcare taken on, with women who take on no childcare experiencing the fastest salary growth and women who take on 100 percent of childcare experiencing the slowest salary growth. As a result, the earnings differences between women with differing childcare obligations increase with time, and ten years after childbirth, the dispersion in salary according to childcare obligations for women is as wide as the dispersion observed for men. The results are consistent and strong; time spent with children has a negative effect on one's career, and this effect can be observed through lower salary and salary growth. These results hold for men as well as women.

Analysis of the survey and interview data both support previous conclusions and give evidence for new conclusions concerning the effects of family on professional men's and women's careers. For scientific women, family formation reduces the probability of persisting in a scientific career. The geographical constraints imposed by dual-career marriages are correlated with attrition for female Ph.D. scientists, and the burdens of caring for children and working in science are often unmanageable for women whose science education ended with a B.S. or an M.S. For those scientists who do try to shoulder the double burden, the percentage of childcare responsibility taken on has large negative effects on earnings for both men and women. Comments by mothers did not support Becker's (1985) hypothesis that these women have less energy for work, but more that, similar to Cole and Zuckerman's findings (1987), they cut back on the nonessentials, like eating lunch with colleagues, overtime hours, traveling to conferences, and outside reading—all activities that contribute to career growth. Rather surprisingly, for the parents in the sample, the gender gap in earnings was fully explained by differences in time spent on childcare.

CHAPTER 5

Mentoring

Mentoring stands out as an extremely important factor influencing career decisions and dictating career outcomes of science-educated women in the university sample. Mentoring early in the science career has an immediate impact on the woman's probability of continuation and success in science. Although more prevalent, mentoring of men, especially in the academic arena, has a less pronounced effect on short-term career outcomes. The apparent differences in the extent and impact of mentoring for men and women is not surprising since science is a male-dominated field. Mentoring relationships may develop naturally for men because a large majority of the potential mentors in science are men, but the guidance may be knowledge that the men could gather from interactions with peers. However, female scientists are likely to feel isolated and even stigmatized for violating traditional social patterns, and the science workplace is likely to resemble a foreign landscape. Any guidance for women, while hard to find, may be especially helpful. This chapter analyzes the role of mentoring in scientific careers beginning with an explanation of how mentoring fits into economic explanations of skill development. This is followed by a review of the research on mentoring generally, and in science more specifically. The chapter moves on to an examination of the presence and effects of mentoring for individuals in the interview sample and then relates perceptions of the interviewees themselves on the value of a mentor.

MENTORING AND HUMAN CAPITAL ACQUISITION

The theory of human capital in economics posits that each individual has a stock of human capital, skills, and know-how, which he or she can rent to an employer for a wage. Higher levels of human capital imply higher productivity levels in a workplace and thus higher earnings. An individual builds his or her own human capital through investments in education and postschool training. The decision about whether or not to invest in any strategy is made by comparing the present value of costs and long-term benefits. Susan Athey, Christopher Avery, and Peter Zemsky (2000) have pointed out that mentoring is a process through which a student, or mentee, augments his or her human capital stock. As articulated by scholars of science, the enhancement of the human capital may take varied forms, such as more scientific know-how, better research techniques, improved scholarly connections, and higher self confidence. But each form should lead to increased productivity as a scientist. The magnitude of the benefits to the student depends on the extent and time frame of increased productivity, while costs are primarily opportunity costs of time spent developing and participating in the relationship. Human capital theory also acknowledges that there are possibly nonpecuniary benefits and costs associated with the investment decision, which might also enter into the calculation.

Analyzing the mentoring process as a human capital investment results in three important conclusions. First, because students will be more likely to enter into a mentoring relationship the greater the potential benefits, all else equal, students will prefer a mentor who is more eminent and more productive. Second, the degree of comfort between the student and mentor will translate into nonpecuniary characteristics of the relationship, which may alter investment decisions. Thus, women may prefer female mentors and men may prefer male mentors. Finally, because women are a minority in science and may be naturally excluded from informal interactions through which human capital is shared, a formal mentoring process may have a greater impact on a woman's productivity than on her male peers' productivity.

Therefore, women may be more likely than men to seek out a mentoring relationship.

The theory of human capital assumes perfect markets and no barriers to investment. However, we cannot assume such perfection in the case of mentoring. The mentor has to agree to engage in a mentoring relationship, and as with the students, such a decision hinges on a comparison of costs and benefits. The costs of mentoring are again the opportunity costs of time spent developing and maintaining the relationship, and the more eminent the professor, the higher the opportunity costs. The benefits can be quite varied but might come in the form of research assistance, creative collaboration, and enhanced reputation in the field. All of these benefits will be greater the more productive the student becomes. As a result, the mentor is likely to select only the students who are most able and whose futures are most promising. In such a situation, mentors may steer clear of female students. Jonathan Cole and Burton Singer (1991) maintain that there are no early screening devices to show who among a cohort in a given discipline with similar educational credentials will be the most important producer of science. Cole (1979) further argues that irrelevant characteristics such as race or sex will be predictors of outcomes when there is little other information with which to judge an individual's contributions or when the processes through which rewards are allocated are nonstandard and secretive. Therefore, the practice by which a mentor chooses a student is potentially ripe for biases against women. In addition, practical reasons for passing over a female student for a male student are well documented. Empirical studies show that, on average, female scientists are less productive than male scientists (Cole and Zuckerman 1984; Long 1992), and women are more likely to bear the burdens of family than their male peers (chapter 4).

The mentoring process is different than other human capital investment decisions because there is a matching process between two individuals who are both looking to benefit from the relationship. Neither student nor mentor will engage in a relationship if the expected costs exceed the benefits. Although it is likely that women will benefit more than men from a mentoring relationship, there are two important reasons why women may be less likely to be in mentoring relationships. First, if female students place a large premium on having a female mentor, they may be disappointed, especially in those departments such as mathematics, physics, and engineering where female faculty are scarce. Second, because mentors are also calculating the costs and benefits of the relationship, they may prefer to mentor men over women because of historical differences in success within science.

PREVIOUS RESEARCH ON MENTORING

The role of the mentor in science careers has been analyzed in much of the literature on Ph.D. scientists, and the potential and varied benefits to the student have been well articulated. Studying Nobel laureates in science, Zuckerman (1977) maintains that the mentor educates the student in "what matters" in science and science research. Ann Gibbons (1992) credits the mentor with connecting the student to meeting organizers and to journal editors, helping the student develop a "style," and encouragement. J. Scott Long and Robert McGinnis (1985) hypothesize that the mentor plays three crucial roles: as sponsor, teacher, and collaborator. Concrete effects on the academic's career have also been estimated. In a study of Ph.D. chemists, Barbara Reskin (1978) finds that the productivity of one's dissertation advisor, as measured by publications, is positively associated with predoctoral productivity; the eminence of one's advisor, as measured by awards, is positively associated with placement in a university tenure-track position. In a similar study of male biochemist Ph.D.s, Long and McGinnis (1985) find that the performance and the eminence of a dissertation advisor is positively correlated with predoctoral productivity, the probability of a postdoctoral appointment, the prestige of the first faculty appointment, and postdoctoral productivity. Although the strengths of these positive relations between productivity, eminence, and student outcome vary by outcome, in general, the positive correlation is stronger and the effect is larger in magnitude if the student and the advisor collaborate and coauthor. While the authors equate advisor with mentor, they do point out that the development of a mentoring relationship is more likely if the advisor and student work on joint research projects.

The role of mentor to female scientists has not been as extensively researched. Reskin (1978, 1979) has argued that collegial exchange, a likely by-product of a mentoring relationship, may be even more important for women than men since it may relieve the stresses of role conflicts. Because of societal gender roles, women may feel pressure from their families and their employing organizations to reallocate time from research to more traditional work, such as mothering and teaching. In an empirical study of male and female biochemist Ph.D.s, Long (1990) finds that female students are more likely than male students to have a female advisor, and for women, having a female advisor increases the probability of collaboration. For this same group of biochemists, having young children reduces the odds of collaborating with an advisor for women but not for men. It is well known that female Ph.D. scientists are less likely to have children than their male counterparts (Cole and Zuckerman 1987; Long 1990), so this finding does not give evidence on differences in the extent of mentoring for men and women. In fact, Long finds that men and women are equally likely to collaborate with their advisors. However, the productivity and eminence of advisors to female students are significantly lower than the productivity and eminence of advisors to male students.

The empirical results that show positive correlations between performance of mentor and student outcomes lead to questions about the matching process between mentor and student in science. Do the most esteemed mentors only take on the most able students, as measured by productivity during graduate school, or do the students taken on by the most respected mentors become more able because of the mentor's teachings? An intermediate position may be that the most eminent scientists take on the students they expect to be most productive and then, through mentoring, enable these students to succeed. Although Long and McGinnis (1985) conclude that in mentoring relationships where collaboration occurs, the student's productivity is enhanced through teaching, they do not dismiss selectivity as an additional factor behind the positive correlation between student success and prestige of mentor. Long's (1990) result showing the reduced probability of coauthorship between advisors and female students with small children, further fuels questions surrounding the matching process. One interpretation of the result is that women with small children have little time to coauthor; another is that the professor's impression of the female student is diminished with the advent of motherhood. Suzanna Rose's (1985) study of approximately ninety assistant professors of psychology raises questions about when a mentoring relationship actually occurs. She finds that the networks created by young female professors are less likely to have ties to their doctoral institutions, implying weaker ties to the dissertation advisor. Therefore, assuming a mentoring relationship between dissertation advisor and female students may not be appropriate.

Generally, research on mentoring of minorities has focused on senior minority professionals mentoring younger minority members. In a theoretical piece, Athey, Avery, and Zemsky (2000) analyze firms where there is majority representation at the senior level and a mixed "type" junior workforce, where each senior member only mentors individuals of his or her type and where increased mentoring increases human capital of the young worker. Firm promotion policy that maximizes long-term profits is more likely to perpetuate majority representation at the senior level the more important mentoring is to human capital formation and productivity, since junior minority "types" will lose in the race to accumulate human capital. Only when the short-term costs of promoting less able minority personnel are offset by the longer term advantages of increased mentoring of the most able minorities will firms become more diverse at the senior levels. In addition, affirmative action policies that result in promotion of minorities to senior levels will have long-ranging positive effects on diversity because of increased mentoring of minorities. Translating the model to practice results in the conclusion that mentoring may be one of the forces that perpetuates segregation in the workplace, and because real-life firms are more short-sighted than their theoretical peers, they are not likely to alter the status quo without government-mandated programs.

Empirical work on women mentoring women has had little success identifying any benefits, possibly because the mentoring relationship is not well established or the benefits are not well defined. For example, Brandice Canes and Harvey Rosen (1995) find no evidence that increasing the number of female faculty members in science and engineering departments increases the number of undergraduate women choosing to major in those fields. David Neumark and Rosella

Gardecki (1998) examine the effects of the gender of the dissertation advisor and the female representation in the graduate department on the career progress of women in economics Ph.D. programs. Although not a natural science discipline, economics is the social science discipline that has the lowest representation of women with only 26.6 percent of economics Ph.D.s awarded to women in 2000 (U.S. Department of Education 2002). They find that the women with female dissertation advisors and women in departments with higher percentages of female faculty do not get more prestigious jobs than their female peers with male dissertation advisors or in departments with lower female representation. However, they do find that women with female advisors and women in departments with more females do finish more quickly and are less likely to drop out of graduate school than their peers with fewer female contacts. Using these results to downplay the value of mentoring relationships between women seems misdirected. First, the study never establishes a mentoring relationship for any of the women studied. Second, even if there were a mentoring relationship between two women, its effect on prestige of first job is likely to be insignificant or negative if the student is being compared to other female students who are mentored by men, the majority group in the economics profession. Finally, the positive effects on persistence—if they are indeed the result of mentoring of women by women—are important in a field where Ph.D. dropout rates of women are more than twice the dropout rates of men (Kahn 1995).

INTERVIEWS

In seven of the twenty-one pairs of women for whom conclusions about exit could be drawn, the positive guidance of a strong mentor was the primary difference between the women who stayed and those who left. Six of the seven exiting women left in response to a lack of support and guidance in college or graduate school. All seven women have established diverse careers in other sectors in the economy: one became a graphic artist specializing in animal illustration, two began careers in computer science, one runs a daycare center and works part-time as a mediator, one works in insurance and is studying to be an actuary, one studied theology and is raising her children, and one is the president of a local chapter of the American Civil Liberties Union.

Many interviewed women, outside of this group of seven pairs, felt that positive mentoring was an important prerequisite for career success in science. Seventy-three percent of the women interviewed described situations where either positive mentors advanced their careers or the indifference, and even hostility, of potential mentors impeded their careers. Especially at the educational institutions, mentoring of women was rare. Of the fifty women interviewed, 13.5 percent had guidance as an undergraduate, and of the thirty-three women who were in a graduate program at some time, 20.5 percent were assisted by senior scientists. The presence of a mentor was extremely influential in determining success in graduate school, increasing the probability of finishing the graduate program from 0.6 to 1.0. Similarly, mentoring by supervisors or colleagues in the early stages of the career was important to the success of women in the scientific workforce. Of the forty-four early employment situations described by interviewed women, mentoring relationships were present in only twenty-three. However, having a mentor increased the probability of a successful employment situation from 0.52 to 1.00.[1]

Mentoring proved less important in career development for men. First, in the eighteen pairs of men for whom a primary reason for exit could be identified, mentoring was never identified as the factor differentiating the scientist who stayed and the scientist who left. In general, men did not speak of the importance of mentors as frequently as did women. Second, men were more likely than women to have mentors in college and graduate programs, but their success in graduate programs was not dependent on mentoring. Forty percent of the men had mentors as undergraduates, and 65.7 percent of the men had mentors in graduate programs. The probability of completing the intended plan of study at the time of entry to graduate school was 0.75 for men without mentors and 0.74 for men with mentors. Finally, although men were equally as likely as women to have mentors in early employment situations, success in employment was not as closely tied to these relationships. 51 percent of the men cited having mentors in early employment, but the probability of a successful employment experience for mentored men (0.83) was not much higher than the probability of success for men without this guidance (0.70). While the estimated short-term career impact was not large, it becomes clear from the comments about mentoring that follow, the relationship offered long-term personal and professional benefits for many men.

The role of mentor in both men's and women's careers was less as a role model or inspiration but more as a teacher or guide. In productive mentoring relationships, there was a transfer of human capital in the form of knowledge and skill from mentor to student. In the case of young scientists working to complete a master's degree or a Ph.D., the mentor was most often the advisor or another departmental professor who worked closely with the student, introducing them to research questions, methods, and presentation, or even helping them to network with other professionals. Often the mentor helped the young scientist to get his or her first grant or first job. As a result, the mentor may have had long-term impacts on the student's research career and teaching, both in terms of style as well as substance.

The importance of the role of advisor was not lost on these students. A midcareer Ph.D. chemist, who at the time of the interview was working in a start-up company, described his Ph.D. advisor as "the first person that stood out as a pivotal element in my life. . . . He changed my life in a very real way, ways that I can still think back to . . . [and] really affected the way I look at certain things professionally, if not personally as well." He continued to describe the laboratory situation that his advisor created:

> We had a reasonably small group: I think three or four graduate students, one post-doc. . . . There was a lot of intimacy in the group. And he [the advisor] was not aloof in any way. . . . He was in the lab every single day working side by side with us and very involved with the attention to detail, understanding that he had to be participating on the levels that involve details as opposed to just giving the bigger picture. . . . I think that these principles, that on some level I internalized at the age of twenty-three or twenty-four, are still with me twenty years later.

A young woman who received her Ph.D. in molecular biology and is now a successful young scientist with tenure at a college in New York City, gave a similarly enthusiastic depiction of her advisor whose style, while very different, was also successful: "My mentor was very supportive and was an excellent scientist. I think that part of being able to pursue a Ph.D. depends a lot on who your mentor is. He was really very good as a person and also in terms of just guiding you." More specifically, she continued, "It's just the kind of science that he does. The atmosphere of his lab was very conducive for creativity—a big lab, a lot of discussion. There were maybe twenty-five people in the lab and there was a lot of opportunity to talk with other people—not just with him, but with other people in the lab which is a very good environment." Another woman who got a Ph.D. in math education at a prestigious university recalled her Ph.D. experience: "I truly had a mentor there and she's a woman involved in math. . . . She was my advisor; it was ideal. I had the best doctoral experience of anybody I know."

Even though the importance of a positive relationship between mentor and students was well known, there were many instances, especially for women, of advisors who were indifferent or even antagonistic toward their students. I call these latter advisors "anti-mentors." A woman who left science to go to art school after earning a master's in zoology in the 1980s recalled her graduate school advisor. "I didn't get much feedback from this professor at all on how I was doing. Only when I was leaving and decided to go back to art school, did he tell me, 'It was too bad. You were a good scientist or you're going to be a good scientist.' I thought, 'really? I didn't know that. You never told me that.' . . . If I had had an advisor who was more nurturing or just a little more sensitive, maybe I would have stayed in the field."

Men who had indifferent advisors were less likely to find fault with this approach. A man who earned an M.S. in oceanography depicted his graduate advisor, "He wasn't one of those professors that got involved with you a lot. He let you do a lot on your own, which kind of suited my style of peaceful coexistence. But I probably could have benefited more from a mentor . . . [gotten] more insight into what it's all about. One of the problems I had in graduate school was a sense of isolation." These comments were in spite of his initial assertion, "I had a great advisor. I liked him a lot." Another man, who was an identical twin and earned his master's degree under a professor who was raising identical twins, acknowledged that their relationship was not what he expected a mentoring relationship would be:

> I always wanted him to be the kind of mentor that I had heard about. You know, they invite you over to their home. They take you under their wing, that kind of stuff. . . . I was ready to give him all sorts of advice about how to raise twins. . . . And he didn't 'cause he was really introverted and was never around. So I took independent study with him, but it wasn't that he really guided me. If anything he taught me how to be self-sufficient, because . . . [he said] "okay here's your study and now you just have to go out and do it. I'll review it and I'll tell you what things need work but I'm not going to be here every day." So it was a different kind of mentor, but I trace everything back to him.

Examples of anti-mentors for women were plentiful, and without exception, each woman scientist felt that a contributing factor to the antagonistic relationship was her sex. For example, the woman who earned a Ph.D. in freshwater ecology in the late 1970s and then went to work at the American Civil Liberties Union, described her advisor's input into her thesis. "I think my major professor thought I was doing some sort of game, and whatever I did was all right because it really didn't count. I think if he were more supportive he would have been more careful to make sure that I did a thesis that I could apply to a position somewhere. My thesis was extremely esoteric and had no practical application." When asked if he helped her get a job, she related, "I think his attitude toward me was that I wasn't a serious student, that I was doing this before I had a kid, and that I was just kind of a cute little thing to have around. . . . A sweet little young thing to have around probably was how he wrote the references, and I'm sure they did not help." This woman never received a tenure-track position at a college or university and, after several years as an adjunct professor in a community college, left science for her current job.

The relationship between student and advisor often became so adversarial that it jeopardized the completion of the Ph.D. A young woman recounted her relationship with her advisor while she was working for a Ph.D. in chemistry: "We got along for a little bit. . . . The whole thing started out because he started doubting my chemistry. Things weren't working so he said 'you must be doing it wrong.' As it turned out, I wasn't doing it wrong. We had very different thought processes and personality conflicts—it would get to the point that I would come home in tears. In the mornings I would come in on the train, and I would be nauseous because I didn't want to go see him. I said 'enough of this' and started looking for a job." This woman quit school with a master's degree in chemistry and joined the research department of a private firm.

Another woman who eventually earned a Ph.D. in physics remembered her experience in graduate school in the 1960s:

> When I got to graduate school there was no mentor that I attached to until finally when I passed the prelims, I had to sit down and kind of pick somebody. I worked with this guy. . . . I thought maybe I'd do research with him, but he assigned me to this . . . old-fashioned kind [of work] when in fact he was flying things in space and designing things to fly in space, and he trained all his men students to do that. But I was put in a closet to work a dull type of data. I never, never complained.

Ultimately she dropped out of the program.

In the small number of instances where men were part of an antagonistic advising situation, the men were more likely to attribute the difficult relationship to faults of the advisor, and the impact on the student was less severe. A man who earned a Ph.D. in geology at a prestigious university and has had a successful career in the research department at an oil company describes his advisor: "My advisor when I was in graduate school working for my Ph.D. was a very difficult personality, and he and I communicated very poorly. We had kind of an antagonistic relationship." The man persevered and the relationship did not alter his career plans in any way. In fact, the two men keep up with each other, and the oil company employee has analyzed the problem more specifically, "Since I graduated, he has gotten over what he has since told me were the very worst years of his life—when I was his student. Not because I was his student but because of many other things going on in his life."

Because men and women with bachelor's or master's degrees do not anticipate careers in academia, the influence of professors is generally more limited for them than it is for Ph.D.s. However, once in the workforce, and especially in the first job while the scientist is developing confidence, mentors can be extremely important. The transition from student to employee is often difficult, as the theoretical concepts of the classroom do not transfer easily to the day-to-day hands-on work at the job. Therefore, efforts by a colleague or supervisor to take the scientist under his or her wing, to support her efforts, and to help in training reduce the probability of departure and increase the likelihood of career success.

A female chemist at a government agency, whose career has taken on managerial responsibilities, identified factors important to her development of a successful career in the sciences. "Actually one of the things that really helped me along is the person who is above me who is male. He has really helped me a lot. He has probably taught me every single thing that he knows involving working in a laboratory. Some of the attitudes you might find in chemistry about women, I guess he didn't believe in them. . . . He just helped me." A master's degree recipient in computer science who started his employment career in a shipyard recalled what he learned from his mentor: "There was a chief engineer in the nuclear design department that I helped . . . get familiar with some of the programmatic issues that he had when he was responsible for a submarine design. After a few months I just moved directly under him and reported to this fellow and became the staff engineer. I learned a tremendous amount from him on how to manage people in a technical environment. That was probably the best learning experience I've had in my fifteen years working."

Scientists who did not have this type of relationship often felt that they were floundering and having difficulties making a positive impact in their work. Employed in a private defense-related company, a computer science graduate remembered her first job. "In retrospect it wasn't a good place for a college graduate to start. I mean, just thrown into something—I didn't have a mentor, I didn't even have a supervisor, so I was really thrown into projects, like five-year contracts . . . where you kind of spin your wheels for a couple of years to figure out what's going on. Part of it was my fault because I didn't get any guidance at all and so I fell into a 'what do I do?' type syndrome and I think I felt like I was floundering."

The interview data make clear that company culture has much to do with how new employees, and possibly new female employees especially, are incorporated into the work environment. Responding to a question about whether she had a mentor at her first job, a woman who worked for a large oil company explained,

> It's hard for me to identify any one person as being a mentor. I don't really feel like I had that kind of relationship with anybody my first few years at work. The culture at [company X] is good in that everybody is very helpful about teaching new employees so I got a lot of attention and help, but not that different from any new employee because people would just take the time to explain things to you and teach you. That's definitely a company culture. People liked doing that and that is very helpful to new employees.

Another woman found her company very different. "They had no way of bringing me into the group other than to say 'well, if you see somebody going to do something, tag along with them.' I was supposed to listen to this guy get a phone call, say 'we have a problem on the airplane' and I'm supposed to say 'oh, can I go with you?' That was the extent of their training, orientation type of program. That was it. They just made me flounder."

Although small in numbers, the interview data are striking in results. Every woman who identified a period of work with a positive mentor also identified a successful science experience. Since creation of a mentoring relationship involves a matching process, as noted previously, one can argue that mentors choose to help those scientists who they anticipate will succeed, and student success is not necessarily the result of mentoring. The small number of mentored women in the study may be the select few who have the talent and drive to succeed. The interview data, however, give concrete examples in conflict with this explanation. Even with the small numbers there are numerous instances of women who failed in their early graduate education or work experience because of the lack of mentors or even the presence of antimentors. These same women, moving on to other science positions with positive mentors, experienced renewed confidence and success.

The same woman who was floundering at the defense-related private company thrived at her second job. In response to an inquiry of whether she had mentors at this new position, she stated,

> Yes, two actually. . . . One was actually my supervisor. He was just smart and real bright, but very down to earth and he just would show me a lot of stuff. He was always open and receptive. . . . [The second was] his supervisor, who's a woman and our manager for the department. She was always taking people under her wing, and you would be able to go into her office and just ask her any type of a question . . . technical questions—labor related, management related, anything like that. . . . She was always pointing people in the right direction.

Similarly, the woman who got nauseated on the train while commuting to her laboratory every day, recalled a very different relationship with her boss in industry. When asked to identify the factors that contributed to her becoming a successful scientist, she responded, "Having a good boss—when I got the job at [the company] he allowed me to develop at my own pace. Industry is very different from academia, and when I first hit industry I was like a fish out of water. He brought me along very nicely. He always encouraged me to do more. It's essentially getting a good mentor."

There were even instances of changes in outcomes with changes in the mentoring relationship for women who had not substantially altered their work or educational environment. A woman who worked for a telecommunications firm since earning her master's in mechanical engineering described her mentoring experiences:

> When I first came to [firm X], I had a supervisor that was not very good for me. In talking with other people he was not good for them either. I needed a lot more guidance than he provided. After about three or four years, I changed advisors to a woman . . . she did not do design [work] so that aspect of my work was not brought up. But she mentored me in that she made me more assertive. She gave me projects that gave me more visibility and in that sense she was my mentor.

Later on in the interview, this same woman was asked to identify any obstacles in her career. She noted, "Not having a strong supervisor when I first started working. That was something that I had to overcome because it created an impression of me that was not very good." Similarly, the woman who was assigned dull data work in her physics Ph.D. program eventually started another Ph.D. program in physics, worked with two mentors in theoretical physics, earned her Ph.D., and became a successful research scientist.

While the transfer of human capital is the outcome of the mentoring relationship, it is clear from the men's comments that this conduit only functions if there is a personal connection between the two participants. In one of the most adamant statements, a male Ph.D. in chemistry asserted, "It is my opinion that mentoring relationships basically are, for most people in academia, . . . responsible for what people are. You don't fall in love with a subject matter by and large. You fall in love with a person and this person leads you to the subject matter. I'm really convinced of that." Another scientist who earned a Ph.D. in geology after first spending several years in a physics Ph.D. program related his view on the key to success: "I really feel that having a good personal connection with the advisor is perhaps the single most important requirement for success. If you don't click with your advisor on a personal level, not just on a scientific level, it's very much harder." And the personal connection is not just important for the academic mentor. A midcareer scientist who used his B.S. in biology to become an investigator for the county medical examiner was asked whether he had a mentor. "Definitely my senior partner . . . he's taught me everything about my job that I have to know, and we became personal friends."

Although the women were less likely to comment on the personal nature of the relationship, they did develop mentoring relationships with women, often purposefully, to a greater extent than did men. Of the fifty-two women, twelve, or 23 percent, reported having had a female mentor in science. Of the fifty-two men, only one reported a female mentor in science and one reported a female mentor in English, the field in which he ultimately earned a Ph.D. The personal connections that women feel with other women may help to ignite the mentoring relationship. One woman, who earned a Ph.D. in neuroscience, had two female mentors but found the first relationship unsatisfying. She described this woman as a mentor in a professional status, "but not someone I could relate to on a personal level. When I was with her she was a man in woman's clothes. She was a woman who acted like a man and she hated working with women. All her favorites were men who drank a lot, who bragged a lot, who were chauvinists, not all of them, but many of them were. So I did feel out of place there." But her second female mentor was different. "She was my mentor in the sense that she had more technical expertise, and I would go to her to consult when I had an idea or methodological difficulties. . . . She definitely had an impact on me in terms of allowing my feelings to come through and evaluating what's important in my life . . . [and letting me] acknowledge that my children and my family life are very important."

This theme of finding the mentor, male or female, who understands the woman's familial concerns was prominent among the interviews. The mentoring relationship can be especially valuable in the continuation of the career of a new mother when the mentor is aware of the conflicts between family and career and supports the woman's efforts at balancing these two responsibilities. A woman with a Ph.D. in biology, whose career has been in research, related, "my chief at the Veterans Administration is more of a mentor than other people have been. She has been encouraging, and she's seventy years old so she fits into the category of super-achiever. She went to medical school in 1946. She also delayed having children and regretted it so she was very encouraging and accommodating about my having children."

Several women, both in academia and in industry, pointed out that they sought mentors or supervisors who not only had families but also enjoyed spending time with their families. A molecular biologist who received a postdoctorate at a prestigious university describes the process by which she picked the professor with whom she worked.

> I made a conscious decision to go to work for someone who was married and who had children. That wasn't the first thing I looked for but I wrote to about five people, and I interviewed with all of them. The person whom I'm working for now has pictures of his daughter up in his office, and he is married and has a home life. That was very important to me because I felt he wouldn't be someone who would pressure me to work a twenty-hour day and he would allow me to spend time with my family. A lot of scientists are single and don't have any family or home life.

Although women were less likely than men to point out instances where the mentor became a fast friend, clearly the most successful mentoring relationships were the ones where the woman felt a shared connection. This connection seemed more difficult to create between a man and a woman than between two women. In a telling statement, a Ph.D. in biology differentiates between his advisor and his mentor:

> The one who definitely stands out, he was one of the professors in the program. . . . He was the one who I enjoyed most and probably learned most from in the short time with him. Obviously I was close to him throughout my whole time in the program although he was not my advisor. He was the one I went to if had a problem and [I liked] his whole approach to everything. . . . my advisor . . . I was very close with him, too. He was a different culture, he was Indian and so he was less of a mentor to me than an advisor.

Exploring the effects of ethnic and racial diversity on mentoring relationships is beyond the scope of this study because a large majority of the respondents are Caucasian. However, it is clear from the preceding quote, and many like it, that the connection made in a mentoring relationship requires a level of comfort that is harder to establish when there are real cultural and experiential differences between the participants.

The interviews give evidence that mentoring has a crucial impact on persistence for women in science. While mentoring does not impact persistence of men to the same extent, many of the men who remained in science felt that the mentoring process had positive long-term impacts on their success within the field. Women in academic settings, however, were less likely than men to be mentored, possibly because of the small number of potential mentors who understand the needs of a woman in science and possibly because of potential mentors' differing expectations about the success of men and women in science. Being a minority in science creates a double jeopardy for women. First, women are less likely than men to develop positive mentoring relationships. Second, for those men and women who never develop a mentoring relationship, the probability of career continuation and success in science is much lower for women than for men.

CHAPTER 6

Leaving Science Because of Discontent with Science Itself

According to the university data set (table 2.3), more than a third of both men and women who exit science relate that they find alternative careers more interesting and rewarding than scientific careers. The interview data (table 2.4), however, reveal that discontent with scientific work is more likely to be a primary reason for exit for women than for men, and many women who remain in science express similar reservations with their own work and the field in general. In this chapter, the interview data identify the forces that initially draw men and women to science and then the characteristics of a scientific career that drive many scientists away. Finally, combining results from analysis of the men's and women's insights with previous research findings gives some understanding of why dissatisfaction with science is more pervasive for women than for men.

WHAT DRAWS YOUNG PEOPLE TO SCIENCE?

According to the interviews, men and women chose science predominantly because they had an aptitude for the field. They discovered, usually in junior high or early high school, that they could shine in science and math. Whether the interest preceded or followed this realization varied by individuals. But their successes in their studies carried them through college and into a career.

What sparked the scientific interest also varied by individual and somewhat by sex. In general, the men were much more likely than the women to talk of hands-on experiences with science as children. These experiences commonly consisted of experimenting with chemistry sets or microscopes, tinkering with lawn mowers or cars, or exploring nature. Approximately one-third of the men and one-tenth of the women identified these types of experiences as their initial motivation to study science. A man who got a Ph.D. in neurosciences and worked for several years in academia before leaving to go to medical school, talked about his early interest in science, "I was about six. I caught butterflies. I collected leaves . . . I was interested in . . . chemistry sets and microscopes to look at things bigger than they were—looking at drops under water and that sort of thing. As far back as I can remember, I enjoyed science and nature and did everything that I could to learn as much about it as I could." Another man who is working as an electrical engineer related, "I was always interested in building and how things worked. . . . In high school I took some remedial electricity-type courses. I wound up becoming the neighborhood handy-boy. The toaster oven would break, I would fix it and stuff like that. . . . By the time I ended high school I was doing full electrical work for people in the neighborhood." The exceptional women who did participate in these types of childhood activities always identified a family member, father or mother, who initiated the experience. Possibly because social custom has labeled these hands-on science activities as "male," young girls were less likely to initiate them on their own.

Women were more likely than men to identify family members as reasons why they chose science. Based on the data, the family member most likely to steer them to science was their father, for both men and women. Of the twenty-one women who cited the influence of a family member, seventeen targeted their father and of the fifteen men, thirteen identified their father. In most cases, the father was working as a scientist or engineer and thus served as a role model. Many of the fathers went further to develop their child's interest in science. A midcareer male scientist with a Ph.D. in an interdisciplinary science program related:

> My father was a mechanical engineer. I guess he was one of these intuitive engineers—that is to say he could look at things

> and could see how they work. . . . He was also a pilot. He flew in WWII and airplanes entranced him. He was in the air force when I was a kid. So I was around air force bases with all of that technology. In other words, I was just surrounded by airplanes and he flew all day long, and then he came home and talked about flying and then we built model airplanes. So a lot of my earliest experiences associated with the natural world had to do with things that flew—watching birds fly and paying attention to butterflies and bumblebees. He was just a flight crazy sort of person.

Eight of the women and none of the men cited their mother's influence on their choice of study. Only two of these eight mothers had degrees in science—both in chemistry—and only one went to work in science after school. During their elementary and junior high school years, however, the children of these two women accompanied their mothers to their labs and started learning the basics of scientific research. One woman recounted, "she [my mother] used to take me into the lab on weekends when she went in to do extra work or something. She would let me 'help her.' Of course, everything had to be redone, but she had some cute miniature glassware and stuff like that. That's how it evolved. I always liked it. I always wanted to do science." The other mothers wanted to help their daughters succeed in areas where they did not. When asked whether her parents supported her interests in science, an African American woman replied, "my mom especially . . . my mom always felt that the only way that a woman could survive was if she had an education and could fall back on her own self to support the family. My mother never worked outside of the house. I think she felt kind of trapped because of that." She continued, "[she] was always into me exploring . . . the bathtub, it was the perfect place to incubate things. . . . So I was always making all these concoctions . . . I was mixing bleach and ammonia and all kinds of stuff and nearly passing out, but it was fabulous. Salt and pepper and some yogurt or whatever the hell it was back then and mixing it and checking it out and seeing whatever would grow depending on what was in there." Another mother had started college in an aeronautical engineering program but had never graduated. Strikingly, of the eight women who cited their mothers as helping spur their interests in science, five studied for their Ph.D.s and four earned their doctorates.

Prior research relating parental education to children's decisions to study science support the finding that family influences may be greater for women than for men. Judith McIlwee and J. Gregg Robinson (1992) find that female engineers come from more highly educated families than male engineers. The National Academy study on gender differences of doctoral scientists and engineers (Long 2001) reports that in the early 1960s, women with Ph.D.s in science were one and a half times as likely to have a college-educated father and twice as likely to have a college-educated mother than were their male counterparts. Although the gap in parental educational attainment has fallen as the percentage of individuals earning a college degree has risen, female Ph.D. scientists still have better educated parents than male Ph.D. scientists. While the link between parental education and parental influence is implied and not proven, the comments of the interviewed women strongly support this connection.

Publicity of important scientific events has the potential to woo men and women into science with unrealistic expectations. However, relatively few of the scientists identified these types of events as the impetus behind their interest in science. Only two of the men and one of the women spoke of becoming infatuated with marine sciences by watching Jacques Cousteau specials on television. A woman who was a postdoctoral scientist in a prominent marine sciences department at the time of the survey did point out that the reality of a career in marine science took years to sink in.

> I was real naive like a lot of people are today and maybe looked at too much Jacques Cousteau . . . younger people . . . all want to go into marine sciences and work with the dolphins. That's Jacques Cousteau—that's what he does. [But] that's not real marine sciences. That's the glory end of it; very few people do that. If you are going to work in the northeast, you don't go play with dolphins. You worry about pollution; you worry about how excessive nutrients affect Long Island

> Sound. You don't play with the whales. You play with bluefish.

While this woman is looking for a job outside of science, she does not cite an incompatibility with the work as the main reason.

Slightly more influential, the space race was the initial spark that kindled the scientific interest in four of the young men and two of the young women. Three of the men and both women earned undergraduate degrees in fields related to space exploration. However, all but one developed successful scientific careers in other fields. The remaining man earned a master's in astronautics and has worked at NASA in space exploration for many years. Although not an astronaut himself, he was active in the team that developed the Mars Pathfinder.

WHAT ARE THE CHARACTERISTICS OF A SCIENTIFIC CAREER THAT DRIVE SOME SCIENTISTS AWAY?

According to the interview data, in three of the male pairs and eight of the female pairs the primary determinant differentiating the leaving and staying scientists was discontent with the science itself. The one common thread in all the discussions of men and women who leave science because of discontent with the field was the narrowness of science. Many scientists found the work too specialized. In particular, individuals with a broad set of interests, of which science is a subset, were likely to become dissatisfied with a scientific career, even careers afforded to Ph.D. scientists. One woman described her career in computer science, "It's not as rewarding as I thought it would be. It's a nice income; it's a nice environment in some ways but it's not what I want to look back on when I'm seventy years old. I want to have other experiences." A man who left science after earning a Ph.D. in ecology and evolution to work in a museum and write novels, related the main obstacle he encountered in science: "I would say maybe a temperament obstacle because by temperament I am a generalist rather than a specialist. I like doing lots and lots of different things. In the museum where I work, I do blacksmithing and antique woodworking using the methods of the seventeenth century. . . . Outside of that, in the home I've learned electrical wiring, and plumbing and spackling, painting—all the homemaker-type skills, expansive gardening in the backyard. All of these things are distractions from concentrating on a specific career." The individuals who remained in science and engineering were different. They were much more directed early on with narrowly defined interests, and they often decided on a college major well before graduation from high school.

Other exiting scientists, especially those at the Ph.D. level, expressed concern that the scientists themselves have to become very narrow in order to succeed in the field. Because of the intense competition for funding, only those individuals who are extremely focused and limited in their interests can compete. A man who left sciences after earning a Ph.D. in molecular biology explained, "While I was in graduate school it was clear what you did was who you were. . . . Then being back in New York, back in the whole vibrant atmosphere . . . I was living in an apartment building [where] everybody did something different and theaters, authors, business, and real estate, and just everybody had a life, but they had a life outside of what they did. And I kind of realized I wanted to make that kind of distinction too between what I did and who I was. And it seemed to me, at that time, to be successful in the sciences in a pure research environment you couldn't make that separation. You had to be so devoted to what you were doing that it had to be your life. That's not what I wanted."

Another man who left a Ph.D. program in biology to get a Ph.D. in English recounted, "I didn't want to be cooped up in a lab for fifteen hours a day. That was too limiting for the kind [of person] I am, the kind of lifestyle I want." One woman in a biology postdoctoral program lamented that science is likely to become dominated by the stereotypical "nerd" scientists. Scientists with outside interests and families will not be able to compete with those who spend all their time in the laboratory. Upset by the narrowness of the scientists who were succeeding at the higher levels, she expressed concern that eventually science, itself, will suffer.

Many women, in particular, were troubled over the isolation associated with science. They reported becoming dissatisfied with the lack of personal contact or the lack of any connection between science and personal relationships and emotions. These women tended to look for new jobs that were more "people oriented," such as teaching or clinical psychology. For example, a woman who earned a Ph.D. in neurobiology was always interested in understanding individuals' emotions and thought processes. Early in her education, she thought that studying the brain would satisfy these interests. She explained, "Well, it's interesting how people behave and it's particularly interesting why people think the way they do. Those aspects of life interest me and grab my attention, and I thought with my background in science, if I go into neuroscience, possibly I could try to figure out some of the processes underlying that and the relationship to nature." Although there were early signs that she would not be satisfied with a career in science, this woman persevered: "I took a course in neurochemistry and I totally hated it when I was an undergrad. All these subjects I hated [and thought] were boring. I recognized they were challenging and they were fascinating in their own right. I had mazes to go through and logic puzzles to solve, and I liked being part of that, but there was totally no emotional connection. However, it took me a long, long time to accept the fact that I needed emotional connections with my work to make myself happy, and that's one of the reasons why I switched." More than ten years after that first course in neuroscience, she gave up her first grant in neuroscience and started a Ph.D. in clinical psychology. At the time of the interview, she was much more hopeful about creating a productive and meaningful career.

A woman who had early aspirations in religion got hooked on geology as an undergraduate. After a successful undergraduate career, she enrolled in a master's program in geology. She explained her desire to make the study of geology more meaningful: "I really wanted to integrate the geology, because I loved it and still love it, into life. I didn't want to do this sterile thing out there. I wanted it to be relevant in some way, at least to my life." After a semester of study, she dropped out of the master's program. She described her decision to leave science, "I couldn't integrate it on my own; I couldn't find any whole people that were dealing with it, and as a woman I couldn't find any peers that were working in science. . . . I think the biggest [obstacle] for me was that science was not relational. That's a fairly obscure statement but . . . the people, the scientists, didn't relate well and the material was not integrated very well. Both those things. No one was really interested in making connections." This woman returned to her first interest and earned a master's degree in theology. At the time of the interview, she was considering, among potential career moves, going back to school to get a Ph.D. in clinical psychology.

Although respondents of both sexes focused on some aspect of the narrowness of science, there were some interesting differences between the three exiting men and the eight exiting women. The three men had either earned or worked toward a Ph.D. in the biological sciences. The eight women were in a number of different fields and had varying levels of degrees. While the exiting men left science during or immediately following graduate school, the women were not necessarily leaving at the very early stages of the career. For some women, such as the geologist-turned-theologian, the frustration with science and the resulting departure did occur early on. However, five of the eight women left later in their careers. Some of these women, similar to the neuroscientist, persevered in hope that the initial frustration in science would abate and left after amassing several years of experience. Other women found that as they grew and developed as human beings, their interests expanded, and their desire to leave science surfaced after many relatively contented years in the field. Therefore, exit that results from the mismatch between the individual's interests and the nature of a scientific career may occur at any stage of the career. The financial sacrifices of leaving science after substantial work experience, however, are much higher than those associated with leaving early in the career, possibly explaining why women, who may rely on their husband's income to cushion financial losses, are more likely to leave for this reason after substantial work experience.

WHY WERE WOMEN MORE LIKELY THAN MEN TO VOICE DISCONTENT WITH THE PRACTICE OF SCIENCE?

According to the interviews, both women who had left science and those considering exit were more likely than their male counterparts to cite discontent with science. Although there are several hypothetical explanations of this pattern, some or all of which may ring true, this study can give no definitive answers, only insights gained by interview comments. Whatever the answers, there seems to be a link between stated differences in discontent of men and women and their differential priorities concerning income, opportunity, and nonpecuniary conditions of work. There is considerable meta-analytic evidence in the psychology literature that there are significant gender-related differences in social interaction and personality and that these differences conform to gender stereotypes. In particular, women's behaviors tend to be socially sensitive, concerned with others, and friendly; men's behaviors are dominant, controlling, and independent (Eagly 1995). Such differences in attitudes and interactions are likely to affect work decisions. Helen Astin (1979) notes that when students were asked about career interests, women were more likely to answer that their future work would contribute to society, help others, give them the opportunity to work with people and ideas, and to express themselves. Men were much more interested in pay, prestige, and advancement. Analyzing surveys of career aspirations of college freshmen from 1969 to 1984, Stephen Cole and Robert Fiorentine (1991) find that early in the period, status attainment values were much more important to men then women, while nurturance values were more important for women. By the end of the period, the gap in percentage of men and women who felt that being "well off" was very important fell from twenty-two points to nine points, and the status attainment values became as important for women as nurturance values. The fact that many of the women who exited because of discontent with the practice of science established new careers with more of a nurturing component, such as lay minister, high school teacher, and clinical psychologist, supports the hypothesis that gender-based differences in attitudes about work may have contributed to differences in the evaluation of and response to scientific work.

This gender-related difference may also be due to the fact that women are more likely than men to act on this disillusionment. Women acknowledged that the financial security of their husband's income often allowed them the freedom to leave. Social and cultural norms may also give women further freedom. Cole and Fiorentine

(1991) posit that the ties to occupation are weaker for women than for men because there is a culturally defined difference in the importance of occupational success attained by the two sexes. Because women may attain "adult status" through family or career while men are confined to achieving "adult status" solely through occupational success, men may be more persistent in face of difficulties or obstacles. Therefore, even if men do feel the same discontent with a scientific career, they may be less willing to respond to this dissatisfaction with exit. With exit not a real possibility, men may be less willing to articulate the frustration. Interestingly, one similarity that stands out among the three men whose primary reason for exit was a mismatch of interests is that all three men were not driven by career ambition. They uniformly felt free to pursue areas that they enjoyed. This liberation from cultural restraints may liken their incentives to those of women who are often making career decisions in the context of the familial roles of wife, mother, and secondary earner: the status of the occupation receives lower priority than other lifestyle characteristics. The biologist-turned-novelist related, "My career decisions have been motivated by just what I felt like doing." He does point out that there have been financial sacrifices. "Some people wouldn't be satisfied with the neighborhood we live in. Some people wouldn't be satisfied with the house that you have to fix up yourself. Some people wouldn't be satisfied with ten-year-old cars." The young man who switched from a biology to an English Ph.D. program stressed that individuals should make career decisions by following their hearts and worry about employment possibilities later.

Another potential reason why women are more likely to leave due to discontent is that the typical structure of a man's scientific career results in a broadening of responsibilities that satisfies expanding interests while women's careers may remain more narrow because of fewer opportunities and more nonwork obligations. There were several examples of men who had developed careers in science that would have addressed the concerns of many of these exiting women. A man who got his B.S. in earth and planetary sciences was working at the Environmental Protection Agency (EPA) in a job that involved both diverse activities and close interactions with people. He described his job, "I work a lot with the public trying to make a difference in people's lives . . . you know how complex it is to try and get these super fund sites cleaned up. . . . I try to get around the obstacles . . . between all the attorneys and all the legal requirements. There are a lot of opportunities to meet with the public one-on-one as well as in large groups. It's not uncommon for us to have the media present at different public meetings . . . lots of questions and lots of heated moments also. It gets pretty exciting sometimes." He also felt that he connected to his colleagues at work and had a life outside of his job, "I work with a great group of people. Working for the government you get more time to yourself. So a lot of the people are in similar situations you know as far as families and kids and like to spend time with them. We're allowed to work a compressed work schedule. I'm off tomorrow cause it's my day off. You get off every other Friday. Work a nine-hour day." There were very few women who spoke so glowingly of their jobs.

Just as some leavers described their frustration with the science career, there were several stayers who were eloquent about their passion for the field. A male Ph.D. geologist explained, "I became interested in geology as a historical science and what fascinated me most about it was the time element, the unfathomable length of time that geology seems to demonstrate. And that placed mankind and all of his philosophical musings in a perspective, in a position of some insignificance I guess on the broader scale of the history of the planet. And that's what really interested me." When asked if he ever thought of leaving science, he responded, "I'll say almost not at all because I just can't think of anything else that I can make a living at that I enjoy as much." The employee at NASA described his job, "I mean it would be nice to get new shoelaces and a second car and that type of stuff but you know when I have a three-day weekend I think that's another day I'm not going to work. It's stuff that I really love doing. . . . that really no one has done before." Enthusiastic about a new project, he continued,

> We have a mission that we're toying with where you would send a balloon to Mars and in the daytime it would float around and then at night when it gets cold it would sink and the gondolier would touch the surface and then analyze the

> soil. The next morning when the sun comes up it would float up again to a new site. . . . Can you picture coming into your building where there's a big spiral staircase and you see this big balloon on the basement and then in the afternoon it's up in the ceiling and the next morning it's down on the floor again?

When asked what it is about science that interests him, a man finishing his chemistry Ph.D. responded, "the thing I like most about it is being able to put various pieces together and to form this sort of larger picture in maybe a way that someone else or the field in general has not seen it before. . . . it's [the] discovering aspect I guess."

With a couple of exceptions, female stayers did not convey the excitement and passion for science that was evident in comments of a relatively large subset of the males. Women in science have to find their place in a male-dominated, often unwelcoming, environment in which men find a more natural fit. Women are often left to navigate these potentially treacherous waters without guidance from a mentor or a role model. In addition, they frequently have to shoulder the burdens of both work and family, a double burden that they perceive few male counterparts either share or understand. For some, dealing with all these other pressures may wear the passion thin. For others, the passion may still burn, but a discussion of careers focuses on these other issues first.

CHAPTER 7

Does the Rapidly Changing Knowledge Within Science Affect Exit?

The most important defining characteristic of science as a field or body of knowledge is change. The constancy of change is the direct result of the nature and quantity of scientific research. Assembling building blocks that are dependent on the research that came before, scientific researchers are constantly expanding and reconfiguring the edges of our knowledge. They are conducting experiments, solving systems, and developing proofs to solve the mysteries of our bodies and environment. Although much of scientific research is expensive with highly technical equipment being a prerequisite for successful experiments, funds for scientific research dwarf research funds in all other academic areas. Researchers in science, different from research personnel in other disciplines, find homes in colleges and universities, corporate R&D departments, government laboratories, and nonprofit think tanks. Therefore, the nature of the field and the extensive research activity within the field ensure that the body of knowledge that we term "science" is evolving rapidly both in absolute terms and in relation to the knowledge in other fields.

With rapid scientific development come the often-concrete benefits of technological progress. But change can be stressful to scientists working in the field since there are constant pressures to "keep up," to remain current with all the new developments. For those who are researching at the cutting edge of the field, keeping up might be a part of the day-to-day research activity. For the rest of the employees, however, keeping up may mean using off hours to read journals, going to training seminars, and often learning new techniques. As long as employers pay for the training and it is incorporated into the workday, the monetary costs are relatively low. Invariably skill update impinges on nonwork time. Change also ties employees to their work in ways that are not evident in fields where change is relatively low. A leave of absence to care for an ailing relative or a stint in a charitable enterprise has the normal costs of lost earnings and experience, but also the increased cost of skill depreciation. Time away from work means that skills developed on the job may erode and lose their value as new techniques replace the old. Employees who leave scientific fields for even a short period of time may face difficulties reentering the field, and when reentry is possible, salaries may fall below salaries earned at time of exit. Furthermore, reentering employees may find that they are on a different career track than the one they left, and salary growth may be lower. A study on exit from scientific occupations cannot ignore the effects of rapidly changing fields on decisions to leave. This chapter begins with theoretical explanations for the impact of knowledge growth on career outcomes, continues with a description of the measurement of knowledge growth across fields used in this study, and then uses the work history data to estimate the quantitative effects of knowledge growth on the probability of exit and on salaries after exit.

THEORETICAL EXPLANATIONS RELATING KNOWLEDGE GROWTH TO CAREER OUTCOMES

How do high and differing rates of knowledge growth impact decisions to exit science? Does acceleration or deceleration of knowledge growth impact incentives to stay or leave? Economic theory can be used to give some clarity to these complex issues by focusing on the concept of skill depreciation. Just as physical capital can depreciate and become obsolete, so can human capital, and that process is usually called skill depreciation. When a science-educated man or woman enters the scientific labor market, his or her stock of human capital can be characterized by level of education, field of study, and market value. Over any period, the value of this capital stock can depreciate for two reasons. First, if the scientist is working in a scientific job, he or she maintains mastery of the expertise learned in school: but without further investment, the scientist may fall behind the recent advances in the field and the value of the human capital stock in the labor market will fall. Here the stock has not changed, but its value has diminished. Second, if the scientist takes time off from the scientific job, not only might the existing stock become less valuable in the marketplace, the skills mastered at time of exit are likely to become rusty with disuse and the actual stock of human capital will diminish. Therefore, for both working and nonworking scientists, skill depreciation is potentially a drag on career progress, and the higher the rate of growth of knowledge within a field, the more serious will be the drag.

Human capital theory predicts a number of career outcomes that will vary with skill depreciation of a field. First, following a period of temporary occupational departure, earnings on reentry into a scientific field are likely to be below earnings at time of exit since the stock of human capital as well as its value will have fallen. The earnings loss will increase with more time out of the scientific field and will be higher in fields that achieve higher rates of knowledge growth during the scientist's departure. Because of the potential earnings loss, individuals anticipating episodes of occupational exit during the lifetime are likely to choose fields where the rate of knowledge growth is relatively low. Specifically, women who foresee periods of nonwork while they bear and raise children will be less likely than men, who tend to be freer of time commitments associated with child-raising, to choose science as a career, and once in science, will choose to concentrate in more stagnant fields. In a related prediction, scientists in fields where knowledge is accelerating will be less likely to engage in a temporary exit than those in fields where the growth rate of knowledge is stagnant or decelerating. At the same time, unanticipated acceleration in rates of knowledge growth within a field during periods of departure may force temporary exits to become permanent ones. Finding a new job will become increasingly difficult as the length of time away from science grows. Ultimately, some scientists will not be able to find a new job within science because their skills will have become obsolete. In all fields there is likely to be some threshold level of skills below which reentry becomes impossible, and how fast one's expertise can fall to that level during periods of nonuse will depend on speed of knowledge growth within the field.

For those scientists who remain employed in the scientific workplace where change is a constant, the optimal activity to ensure earnings growth and career progress involves shifting investment in skill development from earlier to later stages of the career as well as potentially increasing lifetime investment in order to combat the continuous loss of human capital. Whereas individuals in completely stagnant fields may invest in an educational degree at the start of the career without any further training over the life cycle, in fields where knowledge growth is increasing, human capital investment profiles will become more constant over time or, in extreme cases, where knowledge growth is accelerating, may even require increasing investment with time in the career. While all scientists are likely to expect some degree of training updates throughout the career, those workers whose skills begin to depreciate at higher than expected levels will be required to engage in higher than anticipated skill update at later and later stages of the career. Because this unexpected level of retraining requires unbudgeted time and resources, it is likely to make inroads on time spent at leisure and on earnings. As a result, some workers will bail out of the field, making a permanent exit to an occupation with fewer demands on training. Unexpected increases in knowledge growth and resulting skill depreciation are likely to increase the probability of permanent exit.

PREVIOUS EMPIRICAL FINDINGS RELATING SKILL DEPRECIATION TO CAREER OUTCOMES

Empirical attempts to test the theoretical predictions associated with skill depreciation have been hindered by data limitations and measurement issues. However, using a large national worker data set to derive depreciation rates from earnings profiles, Sherwin Rosen (1975) estimates lower bounds on depreciation rates for high school graduates (0.15) and college graduates (.10).

As an alternative to estimating depreciation rates directly, many empirical economists have tested for empirical patterns that are predicted by the theory of skill depreciation. The early literature focuses on skill depreciation as an important factor behind differences in male and female labor-market outcomes. In particular, the periods during which women leave the labor force to care for children are when valuable job-related skills depreciate. As a result, women who interrupt their careers will have lower salaries and salary experience profiles than their male counterparts. Jacob Mincer and Haim Ofek (1982) find evidence of skill depreciation in a longitudinal analysis of wage profiles of married women. They find that wages on reentry to the labor market after a time of nonwork are lower than wages at time of exit, and the wage loss is greater the longer the interruption. They also find that there is relatively rapid wage growth after return to work as these women try to restore skills that eroded during nonwork.

Measurement issues associated with knowledge growth and obsolescence were first addressed by sociologists studying science. Derek Price (1965) states that patterns of citations can give important information on research activity within a field. In 1970, he developed an index that uses the percentage of references to works published within the last five years as a proxy for obsolescence. Calculating this index for journals in a variety of fields, he finds that obsolescence rates are higher in fields such as physics and chemistry than in social science fields. In an attempt to measure knowledge growth within a field, Duncan MacRae (1969) estimates a model of age distribution of citations that controls for parameters measuring growth in the amount of literature within a field. He also finds that citations in sociology refer to older articles than citations in the natural sciences. John McDowell (1982) estimates a literature decay rate in seven broad-based academic disciplines (physics, biology, chemistry, psychology, sociology, history, and English) to measure obsolescence of knowledge, or skill depreciation, for Ph.D. recipients. As one would expect, his measure shows that the humanities have more durable knowledge than the sciences. In support of his theoretical predictions, the output profile of scholars is more constant in fields where knowledge is less durable and where investment is more constant than in fields where knowledge is more durable. He also finds that female Ph.D. recipients are more likely than men to locate in fields with more durable knowledge and they are more likely to concentrate on teaching rather than research, potentially because teaching is less affected by obsolescence of knowledge.

James Ragan and Qazi Rehman (1996) also focus on academics in looking at earnings profiles of department heads. They find that department heads experience lower future wage growth after their terms as department chairs than before these spells, and they attribute the reduced wage growth to depreciation of skills during the administrative post. Furthermore, they find that the reduction in wage growth is most severe in the sciences, fields that they assume have the highest rates of skill depreciation.[1]

Only one study has analyzed the effect of knowledge change on permanent labor-market exit. Ann Bartel and Nachum Sicherman (1993) look at the relation between technological change, which leads to skill obsolescence, and retirement decisions of older workers. Using industry-based measures of productivity change as proxies for technological change, they find evidence that older workers are more likely to retire in response to unexpected increases in the rate of technological change. They hypothesize that these retiring men are responding to unanticipated and unwelcome requirements to invest in retraining.

MEASURING KNOWLEDGE GROWTH ACROSS SCIENTIFIC FIELDS

The rate of change of knowledge varies greatly within science, across subfields and across time depending on the nature of the field, what stage it is in its development, the funds allocated to research in the field, and public excitement about the field. Empirical measures of the rate of growth of knowledge, although not commonly constructed, tend to resemble Price's index (1970) and McDowell's literature decay rate (1982) and thus focus on age of citations of academic articles. Specifically, a field with newer citations (that is, lower age) in any given year is a field in which knowledge is changing more rapidly as new research is building on more recent results. McDowell's measure, the percentage of all cited articles within a journal-year that are five years old or less, reveals that literature within physics is decaying and making way for new findings at six times the rate at which literature is decaying in English. The measure of growth of knowledge across time and field created here also uses age of citations in the leading journals in a scientific field. The annual Science Citation Index (Institute for Scientific Information 1975–1992) includes the *Journal Citation Reports,* a volume that identifies journals that publish scholarly articles for each specific scientific field, and then calculates several measures of age of citations and a measure of impact for each journal. The measure of age of citations used in the variable construction is the citing half-life, the median age of all cited articles in the journal during the year. For example, a citing half-life of 3.2 years for *Nature* in 1988 means that 50 percent of the cited articles in *Nature* in 1988 are 3.2 years old or younger. The impact factor is a measure of the frequency with which the average article in a journal over the past two years has been cited in a current year. Journal X's impact factor in 1988, for example, is the ratio of total number of 1988 citations of articles published in Journal X in 1987 and 1986 to total number of citable articles published by Journal X in 1987 and 1986. Therefore an impact factor of five would mean that, on average, an article published in Journal X in 1987 or 1986 was cited five times in 1988.

Within each field-year is calculated an average citing half-life, CITE,[2] which is the weighted average of the citing half-lives of the five highest impact journals where the weights are the impact factors. This average citing half-life is calculated annually for the roughly fifty fields identified by scientists in the survey from 1975 to 1992.[3] While CITE measures growth of knowledge at a particular point in time, it can also be used to determine whether growth in knowledge is decelerating or accelerating over time. The change in knowledge growth over a time period becomes the difference between the citing half-life at the period's beginning and end.

Table 7.1 ranks selected fields according to the percentage change in citing half-life over the period and gives the average citing half-life for these fields for 1975 and 1992. The fields at the top of the chart have the highest percentage change in CITE, and for these fields, the growth of knowledge has been slowing most rapidly. The fields at the

Table 7.1 Citing Half-Lives in 1975 and 1992 for Selected Fields (Ranked According to Percent Change in CITE)

Field	Percent Change in CITE–1975 to 1992	CITE–1975	CITE–1992	Percent Female[a]
1. Astronomy	42.0	4.62	6.56	0.097
2. Physics	41.4	4.74	6.70	0.097
3. Operations research	35.7	6.22	8.44	0.112
4. Geology	31.3	6.13	8.05	0.129
5. Mathematics	24.1	7.80	9.68	—
6. Applied mathematics	21.5	6.78	8.24	0.311
7. Environmental biology	18.0	5.89	6.95	—
8. Applied physics	15.2	4.29	4.94	0.156
9. Paleontology	15.2	8.24	9.49	—
10. Computer science	15.2	5.27	6.07	0.293
11. Chemistry	12.4	5.71	6.42	0.292
12. Agronomy	6.6	8.93	9.52	—
13. Microbiology	–1.4	5.57	5.49	—
14. Immunology	–1.6	3.82	3.74	0.382
15. Ecology	–4.7	7.87	7.50	—
16. Marine biology	–8.7	8.95	8.17	—
17. Biochemistry	–13.7	4.22	3.64	0.341
18. Genetics	–14.9	4.30	3.66	—
19. Cell biology	–18.6	4.78	3.89	—
20. Parasitology	–21.7	7.42	5.81	—
21. Neurobiology	–25.3	6.59	4.92	—
22. Biology	–29.5	6.77	4.77	0.281

Source: Author's compilation.
Note: A positive percent change means that knowledge growth has slowed.
[a]Percent female is calculated from working scientists in 1982 in the Survey of Natural and Social Scientists and Engineers.

bottom of the chart, however, have the lowest and most negative percentage change in CITE. For these fields, the growth of knowledge has been increasing most rapidly. The changing values of CITE are consistent with changing national priorities. Over the period, public and government attention has shifted away from space exploration, defense-related research, and alternative energy research, all of which fueled the prominence of physics, astronomy, and geology in the relative rankings of the natural sciences prior to this period. Similarly, the attention to environmental issues has waned. During this same period, however, there has been an explosion of interest in microbiology and the diverse uses of biological discoveries in technology and health, thus the acceleration of knowledge in biology and health-related fields.

The rate of knowledge growth in any year is also informative. In 1975, the fields in which knowledge was growing most rapidly were immunology, biochemistry, genetics, applied physics, astronomy, electrical engineering, and physics. By 1992, the fields where knowledge growth was highest were biochemistry, cell biology, immunology, genetics, neurobiology, and applied physics. Given the fifty fields and the eighteen years analyzed, the fields and years during which knowledge was growing most rapidly were information science in 1988 (CITE = 3.2 years), applied physics in 1989 and 1990 (CITE = 3.3 years), and environmental science in 1982 (CITE = 3.5 years). The fields and years where knowledge was growing most slowly were mathematics in 1990 (CITE = 10 years), paleontology in 1988 (CITE = 9.75 years), and mechanical engineering in 1985 (CITE = 9.7 years).

Column four gives the 1982 percentage of female scientists employed in science-oriented jobs for pay for as many of the fields as was possible using data from the Survey of Natural and Social Scientists and Engineers (NSF, 1982). Surprisingly, the fields in which knowledge growth is slowing generally have a low percentage of women; knowledge growth is accelerating in fields with a high percentage of women. Except for environmental biology and applied math, the nine fields with the greatest deceleration in knowledge growth employ a labor force that is less than 20 percent women. The fields where knowledge growth is accelerating, rows thirteen to twenty-two, are either biology- or health-science-related, all of which have relatively high concentrations of women, close to or in excess of 30 percent.[4]

To determine whether this pattern is replicated in the survey data, table 7.2 presents average citing half-life in field at time of graduation

Table 7.2 Average Citing Half-Lives of Men and Women at Graduation and at Survey Date

	CITE at Graduation	CITE at Survey Date	Total Change in CITE	Average Monthly Change in CITE
Men	6.53*	6.48*	–0.056*	–0.003*
	(1.33)	(1.67)	(1.438)	(0.017)
Women	6.75	6.26	–0.481	–0.007
	(1.25)	(1.85)	(1.484)	(0.017)

Source: Author's compilation.
*Male mean is significantly different than female mean at the 0.01 level using a one-tailed test.

(column one) and at time of survey (column two) for men (row one) and women (row two) separately. At the time of graduation with most recent science degree (column one), the scientific fields in which women majored had an average citing half-life of 6.75 years; the scientific fields in which men majored had an average citing half-life of 6.53 years. As predicted by the theory, at time of graduation, women on average were locating in fields with lower growth rates of knowledge than men. However, at the time of the survey, the fields in which women majored had an average citing half-life of 6.26 years, and fields in which men majored had an average citing half-life of 6.48 years. Therefore, over the period of study, the fields in which women majored experienced much higher acceleration in knowledge growth than the fields in which men majored, probably because women are concentrated in biology and health-related fields of science. In fact, growth of knowledge accelerated in the fields of biology and health science and decelerated in the fields still heavily dominated by men.

INTERVIEW DATA

In none of the interviews was growth of knowledge identified as a major determinant of the decision to exit. However, the fast rate of information growth in science was often noted, with some attention to its impact on careers. Many scientists observed that the ability and desire to learn new skills continually were important attributes for success in science. A midcareer man who had earned a Ph.D. in oceanography in the mid-1970s felt that his flexibility and adaptability saved his career when he could not find a good match within oceanography. Employed by an aerospace company at the time of the survey, he recollected, "They brought me in to do optimization . . . not that I knew that much about it but I was capable of learning in the field and always changing. You always have to keep learning."

Having a different take on this same concept, a mechanical engineer stopped just short of identifying the need to update skills as a necessary pursuit to progress in science His viewpoint was colored by the experiences of his father, who was a linotype operator in the printing trade. He recalled, "Early on when I was growing up, my dad was laid off a few times. The linotype machine was actually being phased out as newer technology came in. So having observed that, it was clear that one needs to stay current." He identified the narrowness of some jobs within science as an impediment to this requirement.

> Well I think early on when I was in the design engineering group, I was concerned that I was the design engineer for an eighteen-inch hull valve on a submarine. I was concerned that, if my skills didn't change and develop in a different area, it would be very difficult to stay employed or have any career options because my skills would be pretty much limited. I would have been an expert with this hull valve, but you can only use them on submarines so it would be very difficult to move to another position.

This particular man continued his education while he worked, earning both an M.B.A. and a master's in computer science. He eventually moved into a managerial position within science at his initial company.

As pointed out earlier in the chapter on family responsibilities, the need to update skills constantly and digest new ideas is often more of an impediment to women with families. Since they are, in essence, working a double shift, there is little free time for enrichment and skill update. The female computer scientist who worked in development at a computer software company and identified skill update as a necessary activity for promotion, pointed out that, with her husband working long hours, she is the major caretaker of their two children when she is not at work. She felt like she did not have even an hour to spare for professional reading.

WORK HISTORY DATA

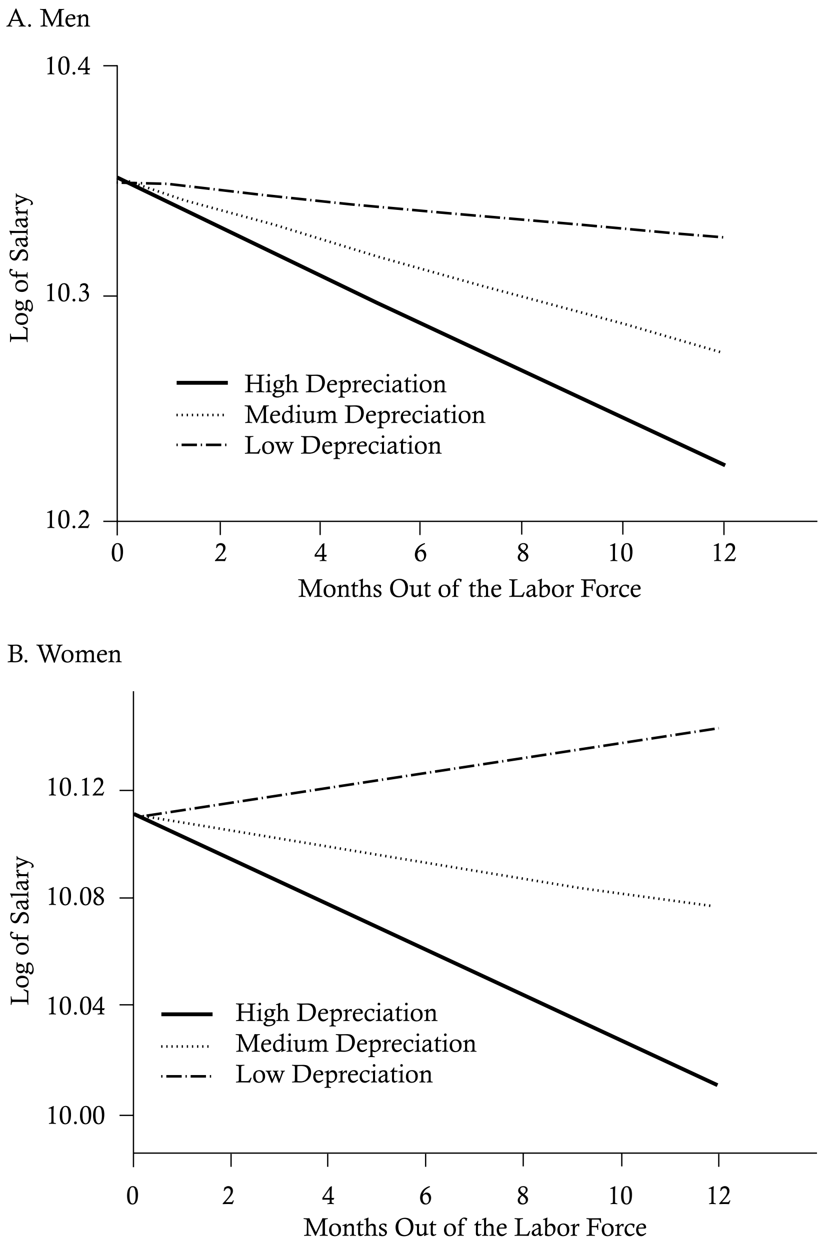
The need to update skills was a common theme that surfaced in the interviews; some respondents saw skill update as an opportunity while others viewed it as an obstacle. Although no one specifically identified this characteristic of their work as a major determinant of exit, some did feel that it put them at a disadvantage, thus contributing to these respondents' decisions to leave science. In order to examine whether differing rates of growth in knowledge had marginal impacts on exit rates, multivariate statistical analysis was performed on the work history data. The first theoretical issue addressed is whether the variation in rates of growth of knowledge across scientific fields affects the salary loss on reentry to science after a temporary exit from the labor force. Because the work history data encompasses several data points on each individual, it allows the estimate of the salary loss for each person leaving the labor force and an analysis of how this loss is related to the length of time off and to the growth of knowledge in the individuals' field. The average duration of labor force exit is relatively short, as one might expect, given the relatively high rates of growth of knowledge. The mean duration of exit is eleven months for men and twelve months for women, and 93 percent of all temporary labor-force exits are concluded within two years.[5]

I estimate salary loss on reentry as a function of time out of the labor force, the average annual rate of knowledge growth of the scientist's field during exit, time spent in science before departure, and a set of demographic characteristics. For both men and women, the longer time out of the labor market, the greater the wage loss on reentry. As predicted, this earning loss varied by rate of growth of knowledge. Figure 7.1 displays the impact of time out of the labor force on the natural logarithm of salary at reentry, in comparison to natural logarithm of salary at exit for individuals in high-, medium-, and low-skill depreciation fields. Salary at exit corresponds to the salary at zero months out of the labor force, and for men, 10.35 corresponds to an average salary of $31,257; for women, 10.11 translates to an average salary of $24,588. Because salaries are transformed to natural logarithms, movements along the vertical axis correspond to percentage changes in salary. For the mean duration of exit, men who had exited fields where the high rates of new knowledge creation was causing rapid depreciation of older knowledge (CITE = 3.5 years), reentered science with earnings 11 percent below their earnings at time of exit eleven months earlier. Men exiting fields where knowledge was growing at the mean rate (CITE = 6.0 years) only experienced a 6.8 percent salary loss, and men leaving fields with low growth rates of knowledge (CITE = 9.5 years) suffered a mere 2 percent loss.

The pattern was similar for women. Women reentering fields with high growth rates of knowledge, medium growth rates, and low growth rates, experienced a 10 percent salary loss, a 3 percent salary loss and a 3.5 percent salary gain, respectively. While the salary gain in fields where knowledge growth is low is surprising, one needs to remember that these fields, such as math and mechanical engineering, are where women are underrepresented, even for science standards. During this period, the increased attention to equal employment opportunities may have pressured employers in these fields to increase female representation possibly prompting increased salaries for women in general. The earnings analyses confirm the human capital prediction that scientists engaging in temporary labor force exit experience earnings losses that are more severe the higher the rate of growth of knowledge in their field of science. Furthermore, they validate the use of age of citation data as measures of knowledge growth.[6]

Models estimating the probability of exit from science were developed differentiating permanent and temporary exit. Temporary exit is defined as any exit that concludes with reentry to science before the survey date. Exit is permanent if the respondent has not returned to science by the survey date. This definition is slightly imprecise in that some of the permanent exit is temporary exit in process. Therefore, the extent of temporary exit is most likely underestimated, and the extent

Figure 7.1 *Log of Salary at Reentry to Science for Men and Women Who Left the Labor Force but Did Not Go to School*



Source: Author's compilation.

of permanent exit overestimated. The average probability of permanently exiting science at the end of any science job is 10 percent, while the average probability of exiting science temporarily is closer to 7 percent.[7] As with other measures of exit, these probabilities are roughly twice as high for women as for men.

In order to determine the effects of skill depreciation on decisions to exit science, a competing hazard function where exit can take on two values—permanent or temporary—is estimated. The model estimates the probability of permanent departure from science and temporary departure from science conditional on surviving in science for some specified time period. Covariates predicting departure include months of time out of science, months out of the labor force, and variables representing level of science degree, type of employer (nonprofit, for profit, public), full-time status, marital status, and children, and two variables representing responsibility for household chores and childcare. The skill depreciation variable that is important in predicting exit is the average annual change in CITE from the time of graduation with highest science degree until the point of time at which the individual is considering exit.[8]

The empirical results reveal that increases in citing half-life, corresponding to deceleration in knowledge growth, have significant positive effects on the probability of temporary exit for men and women. For men in fields where knowledge growth is decelerating, the probability of engaging in temporary exit is 5.2 percent while it falls to 3.8 percent for men in fields where the growth of knowledge is accelerating. Similarly for women, the probability of leaving science temporarily is 10.6 percent in fields where knowledge growth is decelerating and 7.3 percent in fields where knowledge growth is accelerating.

Turning to the results for permanent exit, which is more important to the current analysis, for both men and women, decreases in the citing half-life, that is, an acceleration in knowledge growth, result in significant increases in the probability of permanent exit. Women in fields where knowledge growth is slowing have a 10 percent probability of permanent exit while this probability increases to 15 percent in fields with high levels of acceleration. Similarly for men, in fields where knowledge growth is accelerating, the average probability of permanent exit is 8.3 percent while it falls to 5.5 percent in fields where knowledge growth is decelerating.

Although not considered a major determinant in the decision to leave, individuals in fields where knowledge growth is accelerating are statistically more likely to leave science permanently. The requirement of constant skill update may be a frustration to some science personnel, another factor leading them to consider exit. Moreover, temporary exits are more likely to stretch into permanent departures as skills depreciate at increasingly rapid rates. Because women, in this sample specifically and over the time period more generally, were more likely to experience accelerating growth rates of knowledge than men, and because women have family obligations that often preclude skill update during off hours and require temporary exits, rapidly changing knowledge may be more of a factor in their decisions to exit than in men's decisions.

CHAPTER 8

Perceptions of Discriminatory Treatment

While perceptions of discriminatory treatment and unequal opportunities were not a direct cause of exit for any of the interviewed women, a majority of the women recalled instances when they felt that they were not respected or not treated appropriately solely because of their gender. This unequal treatment may have led to fewer connections to potential mentors or less interesting assignments or lower pay that may ultimately have been the reasons for exit. As a result, we cannot rule out discriminatory treatment as an indirect factor behind exit of women. However, proving discrimination is almost impossible since differences in outcomes and opportunities can also be a result of differential choices on the part of women in the labor market. This chapter begins with a partial review of the voluminous sociological and economic literature on gender discrimination generally and in science, and continues by outlining some of the difficulties involved in measuring discrimination. Turning to the data collected for the study, the chapter highlights the types of complaints voiced by women in the interviews and examines the larger data sets to estimate gender differentials in labor-market outcomes in the science workplace.

THEORETICAL AND EMPIRICAL DISCUSSIONS OF GENDER DISCRIMINATION

Gender discrimination occurs when two equally qualified and productive individuals are treated differently solely because of their sex. If gender discrimination occurs in employment relationships, the direct result may be different labor-market outcomes for men and women. In particular, women may earn lower salaries, have less promising job opportunities, face limited occupational choices, and have higher workforce separation rates than do comparable men. Women who perceive discrimination in the labor market and the resulting diminishment of employment outcomes, may make labor market choices based on this information. They may decide to invest in less human capital formation, such as education, training, and job search, because the forecasted returns are not as high as for similarly situated men. They may decide to stay home with children because the opportunities in their career are not as interesting or as lucrative as those offered to their male peers. As a result, there are indirect effects of discrimination as women engage in behaviors that further solidify the less attractive labor-market outcomes.

Economic theories of discrimination attempt to describe how discrimination and the resulting differential outcomes can arise and persist in a market economy. Gary Becker's theory of discrimination (1971) is based on discriminatory preferences on the part of employers, fellow employees, and customers. He posits that there are economic agents who prefer to employ, work with, or buy from one group—in this case men—rather than another, women. These economic agents are willing to sacrifice income to satisfy their own preferences. In all three scenarios, the theory predicts largely segregated workplaces with higher wages paid to the favored group. Customer discrimination also predicts that women will be pushed into less visible and less customer-oriented occupations while men remain the more publicly visible employees. In the long term, the theory predicts that competition between nondiscriminating and discriminating employers will result in expansion of the lower cost, more efficient establishments of the nondiscriminating employers at the expense of discriminating employers, forcing a move toward equalization of labor-market outcomes between men and women. Discriminatory preferences on the part of coworkers or customers are not necessarily incompatible with efficient behavior on the part of employers and may result in ongoing differential outcomes.

Statistical discrimination (Phelps 1972) is an alternative theory that, rather than dwelling on personal prejudices, focuses on profit-making behavior in an uncertain environment. Because employers cannot judge the true productivity of a new job applicant, they look for an observable trait, such as skin color or gender, as a predictor. Using the average historical productivity of a group as a whole to predict the future productivity of a member of that group, the employer makes early employment decisions. Because of fewer opportunities and societal pressures to conform to gender stereotypes, past productivity of women falls well below productivity of men, leading to discriminatory treatment. The impact of statistical discrimination on persistence of differential outcomes is not immediately evident. For those persistent women who experience early labor-market discrimination but continue to work, time at the job will reveal true ability, and women should catch up to equally able men. Furthermore, as women improve performance and persistence in the labor market, productivity distributions of men and women should merge, nullifying the validity of gender as a predictor of productivity. However, feedback effects may occur as women, faced with less attractive early employment opportunities than their training would predict, make decisions that compromise their own labor-market futures as well as those of their female peers. In particular, they may alter their behavior in ways that reinforce gender stereotypes both within the labor market and within the family, and thereby continue to validate discriminatory behavior on the part of the employer.

Occupational crowding models predict that occupational segregation that results in "male" and "female" jobs may also lead to male-female salary gaps (Bergman 1974). If the supply of women for female jobs is high relative to demand, wages will be pushed down. With lower wages in female jobs, employers will find it profitable to use more labor-intensive production techniques keeping female productivity low. With higher wages in male jobs, however, employers will implement more capital-intensive production techniques pushing male productivity up. Occupational crowding models then focus on the factors driving women to continue to crowd into low-paying jobs. Some theorists contend that these jobs offer nonmonetary characteristics especially valuable to women (Killingsworth 1985). Other theorists contend that there are barriers preventing working women from choosing male jobs. These barriers may be created by discriminatory preferences on the part of the employer (Bergman 1974) or by co-worker hostility at the male job (Jacobs 1987). Or they may be the result of socially constructed gender stereotypes that have developed within the family and spread to the workplace. Institutional economists focus on institutional arrangements that perpetuate segregation. Examples include strength requirements or veteran's preferences (Reskin and Hartmann 1986), internal labor markets, which, immune to market forces, establish separate job ladders with differential mobility to men and women in the same firm, or nonstandard employee searches that bias the applicant pool for certain jobs. Such historically embedded practices are likely to continue through organizational inertia or short-run accounting where the costs of changing practices exceed benefits in a short-term perspective.

In contrast to economists, sociologists are more likely to look at the social and organizational contexts that give birth to and perpetuate inequality. Jonathan Cole and Burton Singer's theory of limited differences (1991) was developed initially to understand the web of factors leading to gender inequalities in scientific career attainment. It offers a theoretical explanation of changing dynamics of the relative standings of groups, in this case men and women, over time. Individuals sharing a general career path are likely to encounter a series of similar events as they progress through their professional life. Associated with each event is a kick, the outcome of the event, and a reaction, the individual's response to the outcome. At the individual level, they posit that small and limited differences in reactions to certain events may have lasting consequences on long-term career attainment, and discrimination or unequal treatment may manifest itself in differential kicks across groups. For example, an early event that all science Ph.D.s encounter is admissions to a doctoral program. If women have a lower chance of getting into high-powered programs than men (a differential kick), they may react with a lowering of aspirations. Cole and Singer contend that the accumulation of these responses can result in inequalities that should not be attributed to a single cause, and a deep understanding of these inequalities requires a complete knowledge of the individuals' career histories and the social and organizational networks in which they operate.

Measurement of Inequality

The existence of discrimination and the extent of the inequality are often estimated using regression analysis on large data sets of employees. The conceptual experiment is to compare otherwise identical men and women and estimate average outcome differentials. Regressions are run with a particular outcome, such as income, as the dependent variable and a set of independent variables that encompass all the personal and workplace characteristics that determine income. With sex included as an independent variable, the estimate of discrimination becomes the residual inequality in income between men and women, once all the relevant personal and workplace characteristics are accounted for. Estimating discrimination in this way is problematic. First, it is often impossible to account for all the characteristics affecting the outcome. In the case of income, we want to compare two equally productive individuals, but productivity may be multifaceted, not observable and difficult to measure. Second, if some of the inequality in income is a result of inequality in education, and the inequality in education is itself a result of discrimination, residual estimates of discrimination after differential education is accounted for probably underestimate the extent of discrimination.

Regardless of the problems, the technique of estimating discrimination persists, and, with appropriate qualifications, it gives benchmark estimates that can be compared across workplaces and over time. Francine Blau and Lawrence Kahn (1997) use the Panel Study of Income Dynamics to estimate the changing male female wage differential in the United States during the period from 1979 to 1988. They find that with controls for human capital, education, experience, and part-time status, the female hourly earnings loss for full-time employees in 1988 was –21.7 percent, a reduction from –33.54 percent in 1979. With addition of industrial, occupational, and collective bargaining status variables, the loss in 1988 falls to –12.6 percent, but differential occupation and industrial location and union status, which account for slightly less than half of the original differential, may themselves be direct effects of discrimination.

Occupation specific studies, which take advantage of greater homogeneity of the workers involved, have also estimated differentials in salary and opportunity. Examining promotion rates of a sample of lawyers who entered corporate law firms in the 1970s and 1980s, Stephen Spurr (1990) finds that women were only half as likely to make partner as males. Controlling for background characteristics and productivity, he estimates that the standard for promotion of a woman was 50 percent to 70 percent higher than for a man. Robert Wood, Mary Corcoran, and Paul Courant (1993) estimate salary differentials for 1973 to 1975 graduates of the University of Michigan Law School fifteen years after graduation. Gross male earnings were two-thirds higher than those of their female peers; however, men worked significantly longer hours than the women in the sample. Controlling for personal, work history, and job characteristics, the differential fell but remained significant at 13 percent.

Studies of Ph.D. scientists are especially informative because data on publications give a good measure of productivity. Cole (1979) examines occupational attainment, as opposed to income, for a sample of American Ph.D. scientists in the period from 1965 to 1970. During this period, academic women had significantly fewer publications than their male peers, and, controlling for this difference, the prestige of the academic department was similar for men and women. But there was a 10 percent lower promotion rate between 1965 and 1970 for women than for men, even after differences in productivity and labor-market attachment rates were considered.

In a more recent study of the population of Ph.D. scientists that does analyze salary differentials (Long 2001), the 22 percent gross advantage in median salaries earned by male scientists in 1995 falls to about 7 percent once controls for career age, field, and sector of employment are added to the analysis. Comparing academically employed scientists, the differential falls to between 4 percent and 10 percent with controls for professional age, rank, quality of doctoral institution, quality of employing institution, and number of publications. Comparisons to 1973 show that, while the gross advantage in median salaries of men does not change over the period, the 1995 residual differences (after accounting for relevant factors) are roughly half the magnitude they were in 1973.

Measuring discrimination more directly has been attempted in some creative quasi experiments. In an audit experiment where comparably matched men and women applied for jobs as restaurant waiters, David Neumark, Roy Blank, and Kyle Van Nort (1996) find evidence of substantial discrimination against women in high-priced restaurants where they were 40 percent less likely to be interviewed and 35 percent less likely than their male peers to be offered a job. Claudia Goldin and Cecilia Rouse (2000) compare the success of women auditioning for symphony orchestras in blind versus open auditions. They find that women are significantly more likely to get a callback if auditions are conducted when the performer is hidden behind a screen than if the performer is observed by the judges. Discrimination in hiring practices of scientific institutions is less likely to be the focus of one of these studies because of the complexity and length of the hiring process. However, L. S. Fidell (1970) sent resumes of equally qualified men and women to psychology department heads with a request for an evaluation of each applicant. Male applicants were more likely than female applicants to be appraised favorably and levels of recommended appointments were higher for men than women.

The remainder of this chapter relates the interviewed women's perceptions on discrimination in the scientific workforce and estimates differences in labor-market outcomes using the work histories and the NSF data. The intent is not to prove discrimination but to understand the perceptions of these women and to recognize the interrelation between perceptions, behavior, and outcomes.

INTERVIEW DATA

A large number of the interviewed women perceived that they had been treated unfairly at some point in their career solely because of their sex. This fact stands in stark contrast to interviews conducted by Cole and Harriet Zuckerman in the late 1980s (Cole and Singer 1991) in which most of the women scientists denied ever personally experiencing discrimination. The difference in perceptions may be attributed to two factors. First, the samples interviewed are very different. Cole and Zuckerman interviewed women who had earned Ph.D.s and become academically employed. These women were the success stories, and their success may have been due to the fact that they did not experience discrimination or that they refused to acknowledge unequal treatment and opportunities. The sample for this study is more representative of the American female science major, and only a few of them ever attain university faculty or research jobs. Not being "stars," they may be more susceptible to perceptions of discriminatory treatment. Second, the two groups may have had different definitions of discriminatory treatment. The women in the Cole-Zuckerman sample were older than those interviewed in this study, with two-thirds having earned a Ph.D. before the late 1960s, and definitions of discrimination may have changed over the period from blatant, discreet events to more subtle and pervasive attitudes.

Deliberate illegal acts were not commonly cited by the women in the interview sample, and those that were mentioned occurred exclusively in the earlier half of the period. A young woman with a master's degree in mathematics who worked for a textbook company was forced to resign in 1969 when she became pregnant. Several years later the company was the subject of a class-action lawsuit. A Ph.D. mathematician was denied an assistant professorship at a university in 1969 because her husband was finishing a Ph.D. in English and would probably move her elsewhere. The job was eventually offered to a man who had not even finished his Ph.D. and whose wife was also working toward a Ph.D. in English. Working as a professor at a small college, this same woman describes the early years of her employment: "I was one of two people in the math department. I had a Ph.D., the other person didn't. He was always paid more than I because he was a man, and I was told that. It was open." Even in the mid- to late 1970s, women were still facing rigid barriers. In an interview for graduate school, a woman was discouraged from pursuing her dream to become a veterinarian when she was told that the university only accepted two females to their veterinary school per year.

More common than facing blatant and illegal treatment, many women found that their male counterparts were at a loss as to how to treat them, and the perceived result was inequality in opportunity. Some found themselves working with men who felt that a female colleague's sexuality was a threat to the normalcy of their work and family lives. In such circumstances, the woman was usually excluded from certain work situations. A woman in an engineering master's program in the early 1980s describes how she was denied study in corrosion engineering: "I initially wanted to go and pursue the field of corrosion engineering. However, the professor that was in that area came out and told me that he didn't want to work with a woman doing the research project . . . because he was recently married and he didn't want to have problems with his wife and because he didn't want to have to watch his language around me." One of only a handful of women employed at a large engineering company related her boss's justification for not taking her on business trips in the late 1980s: "When you go on a business trip, there is not much to do and a lot of times we sit down in a hotel bar at night and have a few drinks and, well, you never know what can happen." A woman with a master's in mechanical engineering who worked for an engineering company recalled that her male co-workers purposely excluded her from socializing at lunch. They explained it to her, "Nothing personal, we just want the guys." Finding it impossible to develop friendships with her colleagues at work, another female engineer recounted, "Every time I made a friend of someone, I was accused of having an affair with him." The general attitude of her male colleagues about her socializing at work was, "talk to the secretaries . . . stay with the women." There were also situations when the isolation was self-imposed because the women felt that the work or social environment involved sexually offensive language and, in fewer instances, pictures. The segregation that many of these women faced hampered their career trajectories since a lot of business and networking is conducted in groups or in social situations.

Other women described circumstances where men, unclear on how to treat their female colleagues, fell back on stereotypical sex roles common in patriarchic societies. In the most literal case, a woman who earned a Ph.D. in mathematics describes her relationship with her advisor: "He perceived me as his next wife. . . . I drove his mother to work, I picked him up at the airport when he was out-of-town, I taught his classes." One woman described how, as a graduate student in geology, both her fellow graduate students and professors often commended her good secretarial skills and put more administrative responsibilities on her than on her male colleagues doing identical work. Another woman, who earned a Ph.D. in math education, described an incident where a male professor patted her on the head as he told her how much she would enjoy graduate school. Finally, there were stories about male colleagues being protective of their female coworkers. An engineer describes the results of a study in her company concerned with why female employees were being rated lower than male employees: "They found a lot of it had to do with the assignments that the people were given, and a lot of it was that the supervisors were being very protective towards the women. They weren't giving them the meaty assignments because they didn't want them to fail so they were giving them the safe, easy jobs which they could do but couldn't get any fame and glory for them." Because sexual stereotypes reinforce the subordination of women, women subjected to these attitudes were not likely to advance as quickly in their careers as their male colleagues.

Most prevalent of all were comments about how pregnancy was a condition to be hidden as long as possible because of the negative impressions that it gave male scientists. Even successful Ph.D. scientists were treated differently once pregnancy became an issue. One woman described her female advisor's reaction when she told her that she was pregnant, "she asked me if I knew how to use condoms." Another woman doing her postdoctorate in biology at a prestigious private university describes the situation in her program: "Initially male and female postdocs are treated equally, but I think that, if you become pregnant, there is a definite change in how they will treat you. You are not taken that seriously anymore. Maybe this is unfair for me to say because I have never been pregnant, and to be really frank I'd be a little bit afraid to because it's perceived as such a negative thing. . . . Very often you will get your project taken away from you." A woman, with two successful postdoctorates in biology, felt that it was necessary to wear baggy clothes and to hide her pregnancy as she applied for assistant professorship jobs. Another woman talked of hiding her pregnancy during her master's program in geology: "I didn't tell them I was pregnant. By the time I started I was six to seven months pregnant—but I never showed. I always had the impression that a man would say about himself, 'I am a geologist' but would describe a female colleague as a 'female geologist' and a pregnant colleague as a 'pregnant female geologist.' I never wanted people to focus on me like that." A female engineer working in sales for a computer software company, who was pregnant at the time of the interview, felt that short-term projects and rewards would be altered when her bosses discovered her condition: "Case in point, even now when I'm pregnant, I haven't told them yet. I don't know if you know about sales—our year starts November 1st and that's when we get our new quotas, our new assignments, our raises. I chose not to tell them until after that." Finally, a woman with a master's in engineering who worked at a prestigious communications company described the management's response to her pregnancy: "My projects were taken away from me. . . . I knew I was going to be away, out. So obviously I had to transfer responsibility but I was told 'you're transferring responsibility for this project, you're not going to get it back.' That was hard. Both times they were projects that I had started from the ground. I had designed them from the very beginning. I'd come up with the concept for them and I had to let them go before I felt they were complete."

Often just the potential of a pregnancy closed doors. A woman in development at a computer software company described the male management's attitude toward women: "Women are not really treated very seriously because I think that they feel like 'she's going to have a baby next week and leave' and that's it. I just get the sense that they don't invest a whole lot of time with the women in the department—a case in point—seminars or [outside] training will come up and they will send some of the men to go do that . . . and they don't do that with the women."

And it is not just men who treat women in this way. A woman with a B.S. in chemistry, who has two children and runs a government laboratory, confessed that she was reluctant to hire a pregnant chemist and looks at a male job applicant more favorably than a female job applicant. A female Ph.D. in physics who encountered tremendous obstacles as she attempted to get her Ph.D. in the 1960s admits, "I have prejudices against women. I see a woman student and I tend to think she is not as serious as the men until proven otherwise." However, there were also women who favored female students and workers because of characteristics unrelated to their reproductive system. A woman with a master's in geology and working for a computer science company, gave her impression of female employees: "I see a lot of women trying harder than a lot of men. I like to have women on my team—I take three or four women on my team—by and large they have a more intense feeling about their work than some of the guys do."

A large majority of the women interviewed felt that they were judged by a different standard than their male peers. There was a small minority of women who had never been in any situations where they felt that they were treated differently. These women tended to be relatively young, less educated, and more likely to be employed in industry. Not only did the younger women have shorter careers over which they might experience discriminatory treatment, but they entered a labor market where equal employment opportunity laws had existed for more than two decades. Additionally, discriminatory treatment in academe seemed to surface in graduate programs with very few women feeling any differential opportunities during their undergraduate years. Finally, perceptions of unequal treatment during employment were quite pervasive and only absent in a small number of organizations where a culture advocating equality had been forcibly put into place by the management hierarchy.

More common were acknowledgments that double standards permeate the field. For some women, the double standards manifested themselves in differing interactions with their male colleagues. A woman with a master's in chemistry talked about different treatment afforded men and women by her advisor: "He tends to be more lenient with the guys. For a girl, he would give you something to do on Friday at six o'clock, come in Monday morning at eight o'clock and ask you if you have it. And he'll rib you about taking time off or not being there, you know, and the guys—they don't ever get asked anything." Similarly, a woman who earned a Ph.D. in biology recalled that in graduate school, the few female students called their male professors by their last names and titles while the male students were all on a first-name basis with their professors. But most insidious was how hard the women felt they had to work to be taken seriously. A woman with a biology Ph.D. related, "I know men who bullshit, and they sound really good, but they know nothing. They are taken seriously by colleagues, whereas women could say anything they want, and they are just not taken seriously." One woman who was a marketing executive in biotechnology found the road to success especially hard for women: "The industry that I've spent most of my career in is so male dominated that if you're not really, really good you're just going to get chewed up and spit out." And not only do these women have to be really good, she continued, "they have to be leaders or they will be 'walked all over' by their male colleagues." A computer scientist in development at a software company described the problem in very plain terms: "In order to be taken seriously, you have to do double what the men in the department are doing." These comments blend into a well-tuned chorus to Evelyn Fox Keller's description (1991) of how women have fit historically into science: "Successful assimilation has thus tended to require not equal ability, but extra ability—the extra ability to compensate for the hidden costs incurred by the denial or suppression of a past history as 'other.' "

Most of these women had been proving themselves since high school, although the different standards often only became evident in graduate school or at entry into the workplace. Many women accepted these reactions from male superiors and colleagues as a way of life, but one with costs. The constant battle became wearing, taking a toll both emotionally and mentally. A woman with an M.S. in mechanical engineer recalled, "I found many women who I had worked with who were successful in the sciences, at least from the exterior, had hardened themselves and become more manlike." Justifying her decision not to continue study for her Ph.D., a female chemist felt the struggle to earn a master's degree had changed her:

> I'm a different person now, I'm more hostile and more abrupt. . . . Writing my thesis, I couldn't focus on things. I

> would sit with people and I didn't even want to hear what they said after awhile. I'm not like that—I like people. I always did before and I just thought, "How different would I be after I got my Ph.D.?" Would that grating every day really wear as it's beginning to wear? . . . I'm less likely to be friendly, and I'm more defensive on a daily basis, and I can't see any other reason for it other than I'm working seventy hours a week and tired, and not getting any credit, and not getting any respect.

STATISTICS BEHIND THE PERCEPTIONS

From the interview data one cannot determine the extent to which the reported cases of discrimination are real or only perceived. Regardless of the veracity, perceived discrimination is likely to cause feelings of inadequacy, helplessness, and anger—all emotions that may lower the quality of the female scientist's personal and professional lives. Turning to the survey data, we can document a host of unequal labor-market outcomes between male and female scientists. The extent to which these differences are due to differences in treatment and differences in choices and behaviors is hard to establish, even with sophisticated statistical techniques.

Statistics on attachment for respondents to the university sample, presented in table 8.1, reveal that even after graduating from college, women are dropping out of the scientific pipeline at a faster rate than men. Thirty-two percent of women who start Ph.D. programs never finish, roughly twice the male drop-out rate. Similarly, a much larger percentage of women with degrees in science (36.5 percent) than men (27.4 percent) never step into a science career. At the time of the survey, twice as many women as men who had started science careers had left them permanently. We can blame these differences on choice, but we then have to question why women are consistently making different choices than men. Attributing the different choices to family responsibilities is a possibility, since expectations about future familial roles and responsibilities were certainly a factor even in the early career decisions of many of the interviewed women. But from the analysis of surveys and interviews, family burden is just one of several reasons for

Table 8.1 Differences in Postgraduate Attachment to Science by Sex (Percentages)

	Male Science Graduates (n = 711)	Female Science Graduates (n = 977)
Percentage who never start a science career	27.4	36.5
Of those who start a Ph.D. program, percentage who never finish	15.0	32.0
Of those who start a science career, percentage who exit science	15.5	31.5

Source: Author's compilation.

exit. Furthermore, in previous statistical analysis of the NSF data (Preston 1994), that is replicated with the university work histories, the direct impact of family on occupational exit of scientists was not able to explain the male-female differential in exit, and single women were more likely to leave science than single men. However, the indirect effect of "family" in a generic rather than personal sense cannot be ignored if employer and co-worker expectations about the impact of family on women's careers alter opportunities afforded women and the diminished opportunities lead to decisions to exit.

Salary differences between men and women in science careers are also quite significant. Table 8.2 presents female salary differentials estimated using ordinary least squares (OLS) regression analysis conducted on both the NSF data and the university work history data. The dependent variable, the natural logarithm of annual salary for men and women working in science at the time of the survey (1982 to 1989, NSF; 1993 to 1994, university data), allows us to interpret the differential as a percentage difference. Each row of the table presents alternative estimates with different controls included in the analysis. All differentials presented are significantly different from zero at the 99 percent confidence level unless otherwise specified. The initial analysis with no controls (row one) reveals that women in science earned on average 28 percent to 30 percent lower salaries than men. Confining the group to full-time workers, the differential falls to 24 percent to

Table 8.2 Female Salary Differentials (Percentages)

Controls	NSF All Workers[a] (n = 37,959)	NSF Full-Time Workers[a] (n = 37,119)	Work History All Workers[a] (n = 1,503)	Work History Full-Time Workers[a] (n = 1,359)
1. None	–28	–25	–30	–24
2. Age	–22	–18	–27	–21
3. Experience	–21	–17	–25	–19
4. Experience and highest science degree	–22	–18	–26	–20
5. Experience, highest science degree, and engineering degree	–18	–15	–19	-15
6. Experience, highest science degree, engineering degree, and family characteristics	–16	–12	–19	–14
7. Experience, highest science degree, engineering degree, family characteristics, and percent of early child-care responsibilities and percent of household chores taken on		–3*	–6	

Source: Author's compilation.
[a]Worker counts are based on 1982 information for NSF data and time of survey for work history data.
*Differential is not significantly different from zero.

25 percent, a magnitude slightly smaller than economywide estimates of male-female salary differentials. Additionally, while not shown in the table, all the female differentials in both the university and the NSF sample are between five and ten percentage points higher when the sample is not constrained to working scientists, implying that salaries are more equal within than outside of science. Because women are

slightly younger than men in the work history sample and appreciably younger than men in the NSF sample, the differential falls three percentage points in the work history data and six percentage points in the NSF data when controls for age are included (line two). Labor-market experience, more directly related to skill level or productivity, differentiates men and women since women, on average, will have more time out of the labor market than men of the same age. However, controlling for years of experience may undermine attempts to estimate discrimination since differing experience levels of same-aged men and women may be the result of differences in workplace treatment and social norms dictating gender roles in the family. Nevertheless, comparing men and women working in science with the same amount of experience, the female differential falls two percentage points for the work history samples and one percentage point for the NSF samples (line three). Adding controls for a master's degree in science and a Ph.D. in science increases the magnitude of the female differential insignificantly (line four) since, even though these degrees have positive impacts on salaries in science, there is not a marked difference in the percentages of men and women earning them. However, the female differential falls to 18 percent to 19 percent for all workers and 15 percent for full-time workers with a control for engineering degree (line five). Within science careers, engineers earn between 15 percent and 20 percent higher salaries than nonengineers, and women are much less likely to be engineers than men. Controlling for marriage and children makes little further impact on the magnitude of the female salary differential (line six) in the work history data but reduces the differential by two percentage points in the NSF data.

Interestingly for all rows, the differentials estimated with the two data sets are very similar even though the data cover slightly different periods (1980s versus 1990s), and the breadth of the samples are very different. Furthermore, the impact of specific controls on the magnitude of the estimated earning differential is almost identical across the two data sets. These similarities in magnitude and pattern across time and sample signal the stubborn persistence of these earnings differentials.

Because of the common perception that childbearing was a roadblock to career success and that family responsibilities conflicted with work responsibilities, the final analysis (line seven) includes controls for share of household chores and share of childcare for preschool children assumed by the respondent. These measures of family responsibility are only available for the university work histories. Once included in the regressions, the male-female earnings differential falls markedly. For the full sample, the differential becomes an insignificant 3 percent, and for full-time workers the differential is 6 percent. The larger decline of the differential in the full sample, which includes part-time workers, is probably due to the fact that much of the variation in salaries for part-time workers, who are predominantly female, is due to variation in hours, and family responsibilities are likely to be highly correlated with hours for part-time workers. Regardless of the sample analyzed, the results are clear: men and women who take on the same family responsibilities earn similar, although not necessarily equal, salaries. But in fact, as noted in chapter 4, men do not take on the same extent of family burden. On average, women take on more than twice the load of family responsibilities as their spouses, and family responsibilities have large negative effects on earnings. Whether the women choose a less committed career profile once the family responsibilities mount or employers take away opportunities when children and other family responsibilities become evident is unknown, although the comments from the interviewed women imply that both factors may be occurring. The clarity of the results makes a strong statement about career equality. If there were more equality in family responsibility between men and women, equality in career attainment would be likely to follow. Economic theories of discrimination against women need to underline the fact that attitudes and behaviors on the part of employers, co-workers, and the women themselves that lead to differential outcomes of women in the labor market are directly related to the traditional role of wife and mother in the family and the gender stereotypes that those roles imply.

The relevance of the perceptions of the interviewed women and the statistical results to the experiences of current and future female scientists is high, possibly evoking feelings of both hope and resignation. On the one hand, many of the identified patterns of behavior are likely to disappear as women become a larger portion of the scientific workforce. Several of the issues discussed arose because female scientists were oddities—unknown quantities in a traditionally all-male workplace. As men become more used to dealing with female students and colleagues and as women move into powerful positions in science, a growing body of experiences within an integrated workplace will guide individuals on how to interact with scientists of the opposite sex. On the other hand, the issue of childbearing and childrearing will always be a factor. As long as pregnancies are equated to a lack of commitment, all women will be subject to the accusation that they are not as serious as their male counterparts. They will be guilty until proven innocent, and the burden of proof will be placed squarely on the women's shoulders.

CHAPTER 9

Policy Initiatives

The factors leading to occupational exit rates from science are likely to contribute to diminished entry as well. Although the number of women pursuing doctoral degrees in the sciences has been increasing steadily since the 1960s, with female representation increasing from about 5 percent of total recipients in 1960 to 25 percent in 1996, the number of men has not. Estimates of the percentage of men with a B.S. or B.E. who earn a Ph.D. in science within eight years of the undergraduate degree show a reduction from 15 percent in 1970 to 8 percent in 1990. Without the increasing participation by women and foreign-born scientists, our science workforce would likely be shrinking. At the same time, our communication, transportation, and production processes are becoming increasingly technological. Even outside the scientific community there is a growing awareness that a productive and well-trained scientific workforce is essential to maintaining a technologically sophisticated, competitive, and growing economy. The standard of living in the United States depends on this workforce. Understanding these factors is only useful if it leads to policy prescriptions that will enhance the attraction of science as a career.

The four major reasons for exit identified in the preceding chapters can help to organize thoughts on policy, and each reason will be addressed separately in making policy recommendations. It will become obvious fairly quickly that because a lot of the reasons are interrelated, policy to address one factor may be helpful with others as well. Furthermore, while the factors behind exit separate very clearly along gender lines, addressing a factor most commonly cited by one sex is likely to benefit individuals of the other sex as well. Policy prescriptions designed at enhancing the attraction of the scientific career should benefit all who choose to participate in that career.

POLICY TO ADDRESS UNMET SALARY AND CAREER EXPECTATIONS

For many men who have exited, science as a career lost its attraction because of low pay and less promising career opportunities relative to alternative professions. Although medicine was the profession of comparison for men early in the career, as the men aged and the rigors of medical studies ruled it out of consideration, management and finance were almost always the professions of comparison. The attraction to this field and its stature as the basis of comparison is documented by the fact that during the period from 1970 to 2000, the number of Americans earning master's degrees in business increased more than fourfold. The M.B.A., or its equivalent, is second to education as the most highly awarded postgraduate degree. With financial success becoming increasingly attractive over the period and, in the 1990s, increasingly attainable in the management professions, scientific careers naturally were losing their luster. Since a large portion of the scientific labor force is employed by government and nonprofit organizations, it is unlikely that salaries, especially at the high levels, will ever compete with top managerial salaries. In conversations with many of these scientists, certain actions were identified that employing institutions could take to alleviate the problem of unmet salary and career expectations.

First and maybe foremost, the scientific community—especially undergraduate institutions, graduate institutions, and professional associations—must educate potential scientists about the careers they can expect with a given degree. Students can only make good career decisions if they have appropriate information. That information should include the type of jobs and career trajectories that might be available for a graduate with a B.S. in biology, or an M.S. in marine sciences, or a Ph.D. in applied mathematics, as well as starting salaries and salary profiles throughout the career.

Informational problems surrounding career choice of potential scientists are widespread for three reasons. First, there is an asymmetry of access to information, with the educational institutions and professional associations having greater access than the students who need the information for decisionmaking. Second, institutions may also have only partial information on careers, the information relevant to its employees. Obviously, scientists are not interested in conducting labor-market studies, and there is no institution that centralizes the information-collection function. Finally, there is a long period of education and training between career choice and job location, so the information collected at the date of career choice may be out of date by the time the individual starts working as a scientist. While the third issue can never be addressed thoroughly without the powers of a psychic, the first two can be addressed fairly easily with advances in information technology.

Ideally, a government agency such as the National Science Board or a professional association should conduct workforce surveys periodically by field with reports on job options, salaries, and salary growth for scientists with differing levels of education and in varying cohorts. The cost and time of such studies can be drastically reduced by use of Web technology, making such a policy prescription realistic. Reports on the studies should then be disseminated to all institutions of higher education, so that individual departments can post the results of these surveys for their students on well-publicized career websites. Increasing the frequency of updates of the studies can keep students well informed as they progress through their studies.

Once students enter these professions with their eyes open, the match between the individual and the career is more likely to be successful. People choosing science careers will be those who value scientific work enough to forgo income earned elsewhere. Even with perfect information, however, there will still be individuals whose needs and preferences will change over their lifetime so that they may feel the need to leave science for higher-paying occupations. Improving information collection and flow will not solve the problem of unmet salary expectations completely, but it will go a long way to reducing its severity.

Second, and equally important, pay and benefits for postdoctoral positions must be set at acceptable levels. In 2001, the annual salary for a first-year postdoctorate funded through the National Institutes of

Health (NIH) was just over $28,000. Furthermore, outside of NIH there is wide variability in pay across fields and institutions. Most postdoctoral scientists are in their late twenties through their mid-thirties, a time of life when many individuals are starting their adult lives with partners and children. This low pay puts stress on this normal progression of life events. With the increasing dependence on postdoctoral positions for early employment opportunities in the sciences, and the biological sciences especially, low pay at these jobs is discouraging young scientists from pursuing a Ph.D.-level career (Freeman et al. 2001). Since many of the postdoctoral positions are financed by federal grants from the NSF, the NIH, and the Department of Defense, it is up to these organizations and the science community to educate Congress of the importance of acceptable salaries and to budget for them. The situation has improved slightly with the NIH making a commitment to increase annual stipends for entering postdoctorates to $45,000 over a number of years. This one-time increase will not be enough. It is important to the future of scientific research in this country that the issue not recede from the public consciousness and that it be addressed every couple of years to ensure adequate salaries for the scientific elite.

Several of the men interviewed implied a need for more imaginative compensation schemes and career trajectories. One man questioned why there was not more pay-for-performance schemes for scientists. Another spoke with pride of the technical excellence program instituted by his company in which technical fellows, scientists with national and international reputations, are given fancy offices and perks similar to those given top executives. Compensation schemes should attract, motivate, and retain employees. For many of the men interviewed, scientific compensation is not effective in the latter two areas. Compensation-for-performance schemes are notoriously difficult to design in organizations not driven by profits, and for employees who work in group settings and whose satisfaction is not tied solely to income. Interview respondents confirm that many scientists find satisfaction in a host of nonmonetary attributes, which might include prestige, creative accomplishment, intellectual recognition, and responsibility. In this arena, desired performance must be articulated and measured with care, and rewards must be continually reevaluated for relevance to the targeted employees. In order to retain employees, compensation must increase with seniority. Deferred benefits or benefits that grow with seniority encourage a continuing employment relationship. Since career trajectory and opportunity was also a complaint, scientists seem to want not just more money but the promise of a broadening of responsibilities with increased time with an employing institution. Designing compensation schemes for scientists that reward both good performance and longevity might go a long way to quieting complaints about the lack of opportunity in scientific careers. Here the private companies with more flexibility in how they spend their resources should take the lead, but the government and nonprofit organizations will have to follow suit in order to stay competitive in the labor market.

POLICY TO HELP BALANCE CAREER AND FAMILY

Policy to address family issues can come in a number of forms, especially since these concerns seem to arise at different stages of family formation for scientists with different educational levels. Dual-career issues are especially thorny for Ph.D. scientists for a number of reasons. First, training is often highly specialized, resulting in limited job opportunities. Second, the job opportunities that exist are often tied to universities or laboratories that are naturally geographically dispersed. Third, because of large space needs, universities are often built in nonurban areas that do not have vibrant labor markets outside of the university. Fourth, the early Ph.D. career, which coincides with early marriage and partnership, often requires several geographical relocations before the permanent job. Finally, the compromises of the dual-career marriage are disproportionately made by female scientists, who are more likely than their male counterparts to be married to an employed professional, and who are likely to be younger and less established than their spouses. Relocating universities is obviously not an option. Still, especially within out-of-the-way university communities, there can be stronger efforts to employ spouses of desired job candidates. Currently, such efforts are most often observed for "star" candidates, and often the spouse's job offer is a step down in the career trajectory. Increasing the coverage of such efforts and ensuring that the job opportunities to spouses are attractive on their own terms would help ease the problems of the dual-career couple markedly. These programs can only be successful with considerable administrative support, since departments do not usually have the know-how or resources to put together a joint package on their own.

Ph.D. scientists make a number of geographical moves in the early stages of the career as they learn from different scientists in graduate school and postdoctoral appointments. This requirement must be reexamined. With the increasing ease of communicating and traveling, long distance collaboration and short-term collaborative research experiences might substitute for numerous geographical relocations. The extent of this substitution will necessarily differ by discipline, and it is likely to depend on the type of lab work performed and the extent to which researchers are tied physically to their laboratories.

Because scientific career paths are well established and deeply entrenched in the scientific culture, change is not going to come easily. Furthermore, change will not come about at all unless it is supported by leaders of the scientific community. Discipline-based associations, together with the National Academy of Sciences, should commission panels to study alternative ways to teach Ph.D. scientists. In the biological and health sciences, biotechnology firms seem to be offering alternative career paths already. Many firms will hire an employee after graduate school, giving him or her a postdoctoral position that often leads to a permanent position. These relatively permanent employment opportunities in urban settings create solutions to the problems of the dual career. There have also been proposals to create staff-scientist jobs in university laboratories for scientists who are looking for a more permanent and predictable employment situation (Marincola and Solomon 1998). Although both of these options help with dual-career issues, there is concern that since the female scientist is more likely than her male counterpart to find a solution to the dual-career marriage by compromising her career, we risk a two-tier workforce where women take the predictable and permanent jobs and only men choose the riskier and more prestigious academic route. Leaders in the academic community need to address the issues of the academic career path, since experience has shown that such a gender-based allocation of scientific talent has not been conducive to attracting women into scientific pursuits.

According to the interview and work history data, policies that help to balance the demands of childrearing and a scientific profession are likely to be most effective at reducing attrition for scientists working outside of academe where work hours and benefits can be rigid. But these policies are likely to improve the quality of life and the productivity of all scientists who take on both career and family responsibilities. Employing institutions have endless options to improve the quality of life of working parents, including but not limited to maternity or paternity leave, increased flexibility of work hours, telecommuting, unpaid personal days for childhood emergencies, a temporary part-time work option, and on-site day care. These reforms are crucial for the success of working parents in all areas of employment, not just in science workplaces. At the time of the survey, respondents felt that these policies were more likely to be implemented in the academic institutions than in the private sector. These impressions may not be valid in the current workplace where, according to media coverage of workplace benefits, family-friendly work policies have become more prevalent economywide throughout the 1990s.

Although Ph.D. scientists in the academic community often find that the flexibility and autonomy these policies create helps to coordinate childrearing demands, the flexibility is often an illusion in the early years when, working toward tenure, the scientist is putting in sixty- to seventy-hour weeks. For these scientists, these childcare benefits improve the quality of the individual's work-life but do not diminish the work time necessary to attain tenure. Giving a parent extra time on the tenure clock for each child born during its duration, a policy increasingly considered in academia, allows the working parent the opportunity to make up for some of the research time lost to early childhood parenting and to spread the time at research over a larger span of calendar years.

Together these policies will help with the day-to-day strains of working parents—mothers in particular—but they are not enough.

Participants at a discussion of problems facing female Ph.D.s in science at one of the most prestigious science universities in the country almost uniformly agreed that taking extra time off after giving birth and stopping the tenure clock would be the kiss of death to one's career. In addition, while these benefits were offered to both male and female faculty, the discussants could not recall any men who took advantage of them. Similarly, in a discussion with female faculty at a female college, the women pointed out that, according to their collective memories, of all the women who had taken maternity leave before tenure, only one female professor was actually awarded tenure. While there are institutions where maternity and paternity leaves and slowed down tenure clocks are used by male and female scientists as they successfully work toward tenure, they are still not the rule and are not the top-tier research institutions. In general, the women interviewed in the study and at these female faculty forums did not trust that these activities would be viewed neutrally in the tenure decision. The result is that some women delay childbearing until after the tenure decision, a seemingly risky strategy for a woman who wants a family. Others take only a minimal maternity leave and return to work to compete as if they were childless. Still others take advantage of the benefit and hope that the gains of the extra time will outweigh any negative perceptions. The distrust felt by these women highlights the fact that, if such benefits are put into place in a college or university, the administration has to stand by them and make sure that the academics, who largely control tenure decisions, stand by them as well. A special committee should be set up to review each tenure case where the individual has taken advantage of a childcare-related benefit that gave the parent extra time away from teaching or on the tenure clock. Ensuring that such activities are not penalized during promotion decisions is paramount to the success of working parents.

There are two important issues here. The first is that there is a predominant feeling in the scientific community, and in American society more generally, that childrearing and careers are in direct conflict, and one has to be compromised for the other. Second, overwhelmingly, expectations are that women will make this compromise. Since employers assume that women will eventually take time off to care for children, they are likely to give them reduced opportunities early in the career. Once career options are decreased, the decision to put childrearing ahead of work is much easier. Thus the prophecy becomes self-fulfilling. Claudia Goldin's (1997) finding that only 13 percent to 17 percent of the college-educated women who graduated in the late 1960s through the 1970s had both a family and a career by age forty is striking evidence of the fulfillment of these expectations. These two issues are difficult to address because both are based on long-standing cultural norms concerning work, family, and gender roles. The American workplace encourages competition and rewards stars with money, prestige, and opportunity. Technological developments, which have recently increased labor productivity, have had little impact on the childrearing function that offers no acceptable substitute for adult-child personal contact; therefore, childrearing is becoming increasingly expensive to American employers. Because childrearing does take time away from work and career development, even for full-time employees, the stars in the American workplace in fields as diverse as business, science, and the arts are not likely to be men or women who spend a lot of time with children and family.

Both issues will become less problematic when men start taking on an increased share of childcare. Once men assume these responsibilities, childcare will be given higher status, and policies to help balance work and family will be given more attention. Furthermore, men and women will be treated much more equally in the labor market. If, in some ideal world, 50 percent of the childrearing responsibilities were taken on by men, employers would not have differential expectations about the long-term commitment to work of men and women. Women and men would be given the same career opportunities leading up to childbirth and before the childrearing choices have to be made. Although there may have been some change in the gender allocation of childcare over the past thirty years, my data reveal that men still take on only a small portion of the childrearing responsibility. Even men who might be interested in staying home with children for a time often resist taking advantage of policies such as paternity leaves, which they feel send the wrong signals to employers. Therefore, change will occur only if upper-level management in these employing institutions, whether they are corporate, academic, or government, give credible promises that there will be no negative repercussions in response to decisions to take advantage of childcare benefits. Other advanced countries, Sweden most dramatically, have national policies aimed at equalizing male and female participation in both childrearing and work. Sweden's Equal Opportunity Act of 1992 requires employers to achieve a well-balanced sex distribution in many jobs and to facilitate the combination of work and family responsibilities. Paid maternity or paternity care, at 80 percent to 90 percent of the salary, is mandated for twelve months. Sweden falls short of requiring men to take some part of this leave, but statistics show that about 70 percent of fathers take some time off and that these leaves have recently been getting longer. Given the difficulty involved with passing the Family and Medical Leave Act of 1993, it is unlikely that this type of workplace policy will be replicated in the United States. Such a policy would go a long way to easing burdens faced by working parents and to putting women and men on equal footing in both arenas.

POLICIES TO ADDRESS MENTORING

A lack of good mentoring experiences is more problematic for women than men, because women are less likely to be mentored than men and because the effects of mentoring on retention and performance are greater for women. According to the interview data, the sex disparity in mentoring is greatest in academic institutions. Mentoring tends to be quite informal in these institutions and thus arises naturally between male professors and male students. With more female professors, female students may find that developing a mentoring relationship is becoming easier. However, because sex ratios of science professors continue to be highly unbalanced, formal mentoring programs for female science students, which have been growing in number in the last ten years, should continue to be set up and supported in all academic institutions. Women who are having trouble developing a personal relationship with a professor can then be directed to professors or graduate students who are willing to take on the role of mentor. Women in science programs that have arisen in a variety of universities, such as the

Stony Brook University, have used multilevel mentoring where a junior biology major may mentor a freshman and also be mentored by a postdoctoral student. Such a program creates a network of women to whom individuals can turn with questions. Social occasions for participants have also been successful in making the relationships more personal and in developing ties with a whole community of women in science. These activities need not be limited to women although, because of the ease with which men seem to develop these relationships in academe, female mentoring programs may make sense for now.

According to the interview data, men and women in industry were equally likely to be mentored, and generally mentoring relationships developed in organizations where mentoring was the cultural norm or where formal mentoring programs had been put in place. Again, for these institutions, mentoring programs are most likely to take hold when upper-level management puts its weight behind them. Besides being a good way to reduce turnover of female scientists, mentoring programs should further productivity. Mentoring, as described by interviewees, is a sharing of human capital and thus a type of informal training that is likely to improve the performance of all employees.

POLICIES ADDRESSING THE INDIVIDUAL–FIELD MISMATCH

Mismatches between an individual's interests and the requirements of the scientific career are addressed in some of the policies advocated earlier in this chapter. Good career counseling for degree recipients in the different scientific disciplines is likely to ward off bad matches due to uninformed expectations. Mentoring relationships and well-developed networks of scientists with similar interests are likely to increase the personal connections that a given scientist makes with other scientists, thus reducing feelings of isolation. The trend toward interdisciplinary work, which has taken place in the last twenty years, should give the individual scientist the opportunity to choose areas of work where the science itself can be connected to a bigger picture. The National Science Foundation and private foundations such as the Alfred P. Sloan Foundation have taken the lead in funding broad multidisciplinary research efforts. Historically, universities have had fairly rigid disciplinary boundaries. In order for scientists to feel free to participate in these interdisciplinary projects, the rewards and promotions processes of employing institutions may have to be restructured to value this type of research.

POLICIES TO ADDRESS CHANGE

Finally, in response to the finding that permanent exit is higher for men and women who are in fields that are changing at rapid rates, institution-sponsored skill update and training programs will alleviate stresses associated with change. The NSF sponsors programs for women who have left science to help them rebuild skills for entry. These types of programs help temporary exits remain temporary. Training programs and skill updates are especially important in academic institutions where separation is not an option for tenured employees, who feel that their skills have become out of date. Foundations such as the Mellon Foundation have been instrumental in supporting programs of career development for professors at all levels in liberal arts colleges. According to the interview data, private companies in the early 1990s did not engage in wide-scale training of existing employees in new techniques and knowledge. Companies may be comfortable with the attrition of older employees who are not willing to engage in skill update because new employees, fresh out of the university, have the updated skills and are less expensive than older, more senior employees. But if the pool of new hires becomes insufficient to replace this attrition, companies will have to face this issue head-on.

The goal of current federal science personnel policy is to build and maintain a sufficiently large and competent national scientific workforce. In the last twenty years, the focus has been on early pipeline issues, building competency and interest in the kindergarten through twelfth grades, and on engaging and retaining women and minorities in the secondary school and college years. But there has been too little attention given to the workplace. Risks of attrition do not disappear at the conclusion of the educational pipeline. Choosing a science career should not be choosing a career of hardship and sacrifice. In addition to interesting and challenging work, science careers should offer a strong support network, the possibility of having a real family life, an income throughout the career that allows a comfortable family lifestyle, and possibilities for continuous advancement and development. Students in undergraduate science programs at public universities will make up the core of our future scientific workforce. According to interviews, these individuals are competent, motivated, and often feel a deep passion for the field. Our nation has an obligation to keep this passion alive.

APPENDIX

Selected Analyses by Chapter

CHAPTER 2

A. Kaplan-Meier Survival Estimates of Figure 2.2

Let t_j, $j = 1 \ldots$ denote the times, measured in months, at which permanent exit can occur. Let n_j represent the number of scientifically trained individuals at risk of exit just before t_j, and d_j represent the number who exit at time t_j. The Kaplan-Meier nonparametric maximum likelihood estimate of the survivor function is

$$S(t) = \prod_{t_j < t} ((n_j - d_j) / n_j)$$

The survivor function is estimated only for the university data, which does not have the problems of right-hand censorship exhibited by the national data. The survivor functions are estimated separately for men and women over the twenty-five-year period following graduation, and chi-squared tests confirm that the functions are not equal at the 0.01 significance level.

B. Statistical Analysis

The effects of personal and job characteristics on the probability of leaving science are determined from a set of competing hazard analyses estimated with the university and national data sets separately. In these analyses, each scientist is represented with an observed data vector (T_{ij}, E_{ij}, Z_i^t). T_{ij} is months of experience in science accrued by individual i before jth departure from science. E_{ij} is type of exit that, in the national data, can take on four values, exit to other occupations due to promotion, exit to other occupations for reasons other than promotion, exit from employment, and exit from the labor force. In the university data, E_{ij} takes on two values, permanent or temporary exit. Z_i^t is a set of covariates, some of which will vary with time and which vary somewhat over the two data sets. The model then estimates the probability of a specific type of departure from science conditional on surviving in scientific work for time Tj.

In estimating a competing hazard function, the likelihood factor for each type of exit, k, is assumed to be the likelihood that would be obtained if the other type of exit is considered censored at the time of departure of type k. These assumptions allow standard estimation methods for two state conditional probability functions to be used in the competing risk case. Cox proportional hazards model with time varying covariates are used to estimate the type specific probability function. The conditional probability of leaving for reason k is given by: $\lambda_{ik}(t_{ik}) = \lambda_0 \exp(Z^t\beta_k)$ where λ_0 is the unspecified baseline hazard and Z^t is the set of covariates. Cause-specific probabilities are assumed to be independent of each other, and unobserved heterogeneity is assumed to have no effect on the probability functions.

The analysis allows more than one exit by an individual scientist, a necessary condition for the university data analysis of temporary exit. According to the construction of the data, the analysis uses observations that correspond to the end of an activity in science or to working at science at the survey date. Covariates are specific to the activity that is ending. Future activity, which can either be another job in science, permanent exit, temporary exit, or continuation in the current science job, determines the value of the exit variable. After a temporary exit from science, the individual returns to the analysis with the reentry date being the new date at which the individual becomes at risk for leaving, but Tij represents total months in science from time of graduation with highest science degree.

CHAPTER 3

A. Table 3.1

Fixed effect regression analyses were run on the pooled cross-section of individuals from the national data who were working in science in 1982 and who responded to the national survey in subsequent years. The number of observations on any individual could range from two to four. Only natural scientists and engineers were included in the analysis, and all analyses were separated by gender. The dependent variable is the logarithm of annual salary; independent variables include: calendar year; years of experience; years of experience squared; and dummy variables for nonprofit organizations; government organizations; level of degree; part-time work; married; divorced or widowed; managers; and parents with children under five years of age. The variable of interest for the analysis is a dummy representing employment outside of science. This variable is also interacted with a dummy representing reason for departure to determine whether salary on exit differs by reason for exit. Fixed-effect regression analysis controls for fixed traits of the individual and estimates within-person changes in salary as opposed to across-person differences in salary.

B. Figure 3.1

The graphs are created from ordinary least squares (OLS) regression analysis of the logarithm of annual salary on a sample of respondents to the university survey who spent their full work-life either in science or out of science. Dummy variables are included for working in science, having a postscience medical degree, having a postscience law degree, and having a postscience business degree. Coefficients on these variables determine the vertical axis intercepts for the figures; the difference in salaries for the five different groups (those in science, those outside of science without a postscience degree, and those outside of science with one of the three postscience degrees) at time of labor market entry. Variables representing months of experience and months of experience squared for each group are also included in the analysis to allow for differences in curvatures of salary profiles (table A.1). Con-

Table A.1 Relevant Coefficients for Ordinary Least Squares Estimates of Salary Equations on University Data—Sample of Career Scientists and Career Nonscientists (Figure 3.1)

Variable	Men	Women
Working in science	0.090***	0.103***
	(0.028)	(0.026)
Months of experience in science	0.005***	0.005***
	(0.0005)	(0.0006)
Months of experience in science squared	–0.00001***	–0.00002***
	1.83 e-06	2.67 e-06
Months of experience outside of science	0.005***	0.005***
	(0.0007)	(0.0006)
Months of experience outside of science	–0.00001***	–9.18 e-06***
squared	3.21 e-06	(2.24 e-06)
Months of experience outside of	0.0019***	0.0008*
science—professional degree	(0.0005)	(0.0005)
Postscience medical degree	0.464***	0.580***
	(0.040)	(0.039)
Postscience law degree	0.305***	0.296***
	(0.056)	(0.099)
Postscience M.B.A.	0.085*	–0.0066
	(0.050)	(0.083)
Postscience master's	0.057	0.038
	(0.043)	(0.036)
Postscience Ph.D.	–0.196	–0.032
	(0.200)	(0.087)
Master's in science	0.146***	0.095***
	(0.024)	(0.022)
Ph.D. in science	0.101***	0.128***
	(0.027)	(0.028)
Adjusted R squared	0.664	0.564
Sample size		
(person-observations)	2,175	2,763

Source: Author's compilation.
***Coefficient is significantly different from zero at the 0.01 level using a two-tailed test.
*Coefficient is significantly different from zero at the 0.10 level using a two-tailed test.

trol variables include year of observation, months at current job, months out of the labor force since graduation, percentage of chores and childcare responsibilities taken on, and dummy variables for self-employment, nonprofit employer, government employer, new job, full-time employment, management position, last activity out of the labor market, marital status, and children.

Hypothesis testing revealed that there were no significant differences in the experience profiles of doctors, lawyers, and M.B.A. recipients, so the professional experience variable holds for all three professional groups. While the figure does not include lines for postscience master's degree recipients or postscience Ph.D. recipients, these individuals fare no better in terms of salaries than those who invest in no postscience degree. In addition, having a Ph.D. in science or a master's in science has positive effects on salaries.

C. Figures 3.2 and 3.3

In order to compare salary profiles of science stayers (SP_{sci}) to salary profiles of science leavers ($SP_{sci\text{-}nsci}$) fixed effects are used to estimate:

$$\begin{aligned} \mathrm{Ln}(\mathrm{salary}_{it}) = a &+ b(\mathrm{ED}_{it}) + c0(\mathrm{EXP(science)}_{it}) + c1(\mathrm{EXP(oosci)}_{it}) \\ &+ d0(\mathrm{OOSCI}_{it} \times \mathrm{amenity}_{it}) + d1(\mathrm{OOSCI}_{it} \times \mathrm{seekinc}_{it}) \\ &+ d2\,(\mathrm{OOSCI}_{it} \times \mathrm{EXP(science)}_{it} \times \mathrm{amenity}_{it}) \\ &+ d3(\mathrm{OOSCI}_{it} \times \mathrm{EXP(science)}_{it} \times \mathrm{seekinc}_{it}) \\ &+ f\,(\mathrm{controls}_{it}) + e_{it} \qquad \text{(A.1)} \end{aligned}$$

EXP(science) and EXP(oosci) represent months in science and non-science occupations respectively. OOSCI is a dummy variable equal to one if the individual is working outside of science, seekinc is a dummy variable equal to one if the individual left science to seek income, and amenity is a dummy variable equal to one if the individual left science in search of better amenities.

The average earnings effect of leaving science at time of exit for amenity seekers is $(d0 + d2 \times \overline{\mathrm{EXP}}(\mathrm{science}))$, and the earnings effect for income seekers is $(d1 + d3 \times \overline{\mathrm{EXP}}(\mathrm{science}))$. Where $\overline{\mathrm{EXP}}$ is average experience at exit, these estimates become the salary shifts in figures

3.3A and 3.3B at time of exit. The estimated coefficients d2 and d3 can be used to calculate estimates of the extent of skill transferability to new occupations for income seekers and amenity seekers—how valuable science experience is in the new nonscience job. Earnings growth in science and out of science can be compared by comparing the magnitudes of c0 and c1. Figures 3.2A and 3.2B display the results of a simplified version of equation A.1, where leavers are not separated into amenity and income seekers. Therefore, the estimated equation behind figures 3.2A and 3.2B is:

$$\begin{aligned}\mathrm{Ln}(\mathrm{salary}_{it}) = a &+ b(\mathrm{ED}_{it}) + c0(\mathrm{EXP(science)}_{it}) + c1(\mathrm{EXP(oosci)}_{it}) \\ &+ d0(\mathrm{OOSCI}_{it}) + d1(\mathrm{OOSCI}_{it} \times \mathrm{EXP(science)}_{it}) \\ &+ f(\mathrm{controls}_{it}) \\ &+ e_{it} \end{aligned} \tag{A.2}$$

Controls for both equations include year of observation, percentage of childcare and household responsibilities, months on current job, months out of the labor force, and dummy variables for: previous activity out of the labor force; nonprofit status of employer; government status of employer; self-employment; full-time status; marital and family status; starting a new job; and having a managerial job. Results from equation A.1 are presented in table A.2.

Construction of the figures requires knowledge of differences in salaries between leavers and stayers while in science and median duration of time in science. Differences in salaries are estimated using OLS salary regressions on individuals working in science and then estimating residuals for those who leave. The results are presented in table A.3.

D. Salary Profiles of Leavers Versus Career Nonscientists

In comparing salary profiles of leavers ($\mathrm{SP}_{\text{sci-nsci}}$) and salary profiles of those who never worked in science ($\mathrm{SP}_{\text{nsci}}$), it becomes most important to compare the salary profile before exit for those who leave the science occupation to the salary profile over the same period for those who never entered science. Therefore, the sample is restricted to science

Table A.2 Relevant Coefficients for Fixed-Effect Estimates of Salary Equations on University Data—Sample of Scientifically Educated Workers Who Start Science Careers (Figure 3.3)

Variable	Men	Women
Out of science × amenity seeker	0.219**	0.087*
	(0.067)	(0.048)
Out of science × income seeker	0.122*	0.228***
	(0.070)	(0.081)
Out of science × months in science × amenity seeker	–0.006***	–0.002**
	(0.002)	(0.001)
Out of science × months in science × income seeker	–0.002*	-0.004
	(0.001)	(0.002)
Months in science	0.011***	0.012***
	(0.003)	(0.002)
Months in science squared	–0.00001***	–0.00001***
	(0.0000)	(0.0000)
Months outside of science	0.0052*	0.0069***
	(0.0032)	(0.0024)
Months outside of science squared	0.00002***	0.00002**
	(0.0000)	(0.0000)
Adjusted R squared	0.801	0.737
Sample size (person-observations)	1,597	2,039

Source: Author's compilation.
***Coefficient is significantly different from zero at .01 level using two-tailed test.
**Coefficient is significantly different from zero at .05 level using two-tailed test.
*Coefficient is significantly different from zero at .1 level using two-tailed test.

graduates who never enter science and to science graduates who start science careers but leave, thus excluding the science stayers. Fixed-effects estimation is not possible because the comparison is between early careers of different sets of people rather than before-after comparisons. During the early career years, the leavers are in science and those who never entered science are out of science, so a simple "in science" dummy variable gives us the earnings effect of this choice. Once out of science, experience profiles are similar, but the salary at entry to the nonscience occupation may be different than the salary of those with the same amount of experience who never worked in science.

Table A.3 Characteristics of Amenity Seekers and Income Seekers by Sex

	Male Amenity Seeker	Male Income Seeker	Female Amenity Seeker	Female Income Seeker
Median duration of time in science (in months)	43	20	39	20
Log salary residual in regressions run on workers in science	–0.1828 ($p = 0.0$)	0.0576 ($p = 0.32$)	–0.0722 ($p = 0.0$)	–0.0570 ($p = 0.14$)

Source: Author's compilation.
Note: Figure in parentheses is p value associated with testing the null hypothesis that the average residual for stayers is equal to the average residuals for leavers.

This difference may be related to experience in science. Therefore, OLS estimates of the following regressions are used to compare $SP_{sci\text{-}nsci}$ and SP_{nsci},

All leavers:

$$\begin{aligned} \mathrm{Ln}(\mathrm{salary}_{it}) = a &+ b(\mathrm{ED}_{it}) + c0(\mathrm{EXP}_{it}) + d0(\mathrm{INSCI}_{it}) \\ &+ d2(\mathrm{OOSCIi}_{it} \times \mathrm{EXP(science)}_{it}) \\ &+ f(\mathrm{controls}_{it}) + e_{it} \end{aligned} \tag{A.3}$$

Income-seeking and amenity-seeking leavers separated:

$$\begin{aligned} \mathrm{Ln}(\mathrm{salary}_{it}) = a &+ b(\mathrm{ED}_{it}) + c0(\mathrm{EXP}_{it}) + d0(\mathrm{INSCI}_{it} \times \mathrm{amenity}_{it}) \\ &+ d1(\mathrm{INSCI}_{it} \times \mathrm{seekinc}_{it}) \\ &+ d2(\mathrm{OOSCI}_{it} \times \mathrm{EXP(science)}_{it} \times \mathrm{amenity}_{it}) \\ &+ d3(\mathrm{OOSCI}_{it} \times \mathrm{EXP(science)}_{it} \times \mathrm{seekinc}_{it}) \\ &+ f(\mathrm{controls}_{it}) + e_{it} \end{aligned} \tag{A.4}$$

INSCI is a dummy variable equal to one if the individual is working in science. Therefore, if leavers earn higher salaries in science early

Table A.4 *Relevant Coefficients for Ordinary Least Squares Estimates of Salary Equations on University Data: Sample of Science Leavers and Science Educated Who Never Enter Science*

Variable	Men	Women
In science × income-seeking leavers	0.1356***	0.0208
	(0.0549)	(0.0637)
In science × amenity-seeking leavers	–0.1091**	–0.0077
	(0.0436)	(0.0301)
Out of science × experience in science × income-seeking leavers	0.0058**	0.0019
	(0.0027)	(0.0033)
Out of science × experience in science × income-seeking leavers squared	–0.00004***	–0.00004
	(0.0029)	(0.00003)
Out of science × experience in science × amenity-seeking leavers	0.0033	–0.0012
	(0.0081)	(0.0024)
Out of science × experience in science × amenity-seeking leavers squared	–0.0002**	–0.00004
	(0.0001)	(0.00004)
Adjusted R squared	0.650	0.568
Sample size (person-observations)	576	1,152

Source: Author's compilation.
***Coefficient is significantly different from zero at the 0.01 level using a two-tailed test.
**Coefficient is significantly different from zero at the 0.05 level using a two-tailed test.

in their careers than they would have earned in nonscience occupations, d0 in equation A.3 will be greater than zero. If only income seekers earn higher salaries in science early in their careers than they would have earned in nonscience occupations, d1 in equation A.4 will be greater than zero, while d0 will be less than or equal to zero. If having been in science puts leavers at an advantage over their peers who never entered science once they enter the nonscience occupations, d2 in equation A.3 and d2 and d3 in equation A.4 will be greater than zero. Controls are those included in the analysis for figures 3.2 and 3.3. The relevant results from equation A.4 are presented in table A.4.

CHAPTER 4

A. Table 4.2

In order to estimate the probability of working in a science job, assume a latent variable Insci $\times_{it}$, which gives individual i's preferences for a science job at time t. Although the latent variable is unobservable, orientation of job, $INSCI_{it}$, is observable.

> If Insci $\times_{it} \geq Insci_{threshold}$, $INSCI_{it} = 1$, and individual 1 works in a science job at time t.
>
> If Insci $\times_{it} < Insci_{threshold}$, $INSCI_{it} = 0$, and individual 1 works in a nonscience job at time t.

Assuming $Insci_{it}$ follows a normal distribution and is determined by a vector of explanatory variables X, probit analysis is used to estimate the coefficients B relating X to the latent variable. The vector of explanatory variables include months of experience in science, months of experience outside of science, months out of the labor force for reasons other than school, months out of the labor force for nonscience schooling, and dummy variables for marriage and children. Results of the probit analysis explaining the zero-one variable, work in science, are presented in table A.5.

B. Figure 4.1

To determine the effects of children and childcare on salary profiles, fixed effects are used to estimate the following earnings equation:

$$\begin{aligned} \mathrm{Ln}(salary_{it}) = a &+ b(Children_{it}) + c(Daycare_{it}) + d(Exp_{it}\,(single)) \\ &+ e(Exp_{it}(married)) + f(Exp_{it}(parent)) \\ &+ g(Daycare_{it} \times Exp_{it}(parent)) + f(controls_{it}) + e_{it} \quad (A.5) \end{aligned}$$

$Children_{it}$ is a dummy variable equal to one if individual i has children in time t and $Daycare_i$ is the percentage of childcare of preschool children individual i is responsible. Three work experience variables include

Table A.5 Probit Estimates of the Probability of Working in Science—University Data: Table 4.2

	Women with Ph.D.s	Women Without Ph.D.s	Men with Ph.D.s	Men Without Ph.D.s
Months of science experience	0.004***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Months of non-science experience	–0.018***	–0.004***	–0.002**	–0.004***
	(0.000)	(0.000)	(0.038)	(0.000)
Months out of labor force—nonscience education	—	–0.010***	–0.017**	–0.003***
		(0.000)	(0.020)	(0.000)
Months out of labor force—other reasons	–0.003*	–0.005***	–0.012***	–0.005***
	(0.051)	(0.000)	(0.000)	(0.000)
Married	–0.108**	0.019	0.120**	0.020
	(0.011)	(0.348)	(0.014)	(0.421)
Children	–0.016	–0.172***	–0.034	–0.011
	(0.728)	(0.000)	(0.475)	(0.711)
Log of likelihood function	–333.28	–2246.03	–295.37	–1433.42
Sample size (person-observations)	626	3,664	596	2,459

Source: Author's compilation.
Note: Coefficients have been translated to $\partial F/\partial x$, where F is the probability of working in science, and p values are given in parentheses.
***Coefficient is significantly different from zero at the 0.01 level using a two-tailed test.
**Coefficient is significantly different from zero at the 0.05 level using a two-tailed test.
*Coefficient is significantly different from zero at the 0.10 level using a two-tailed test.

months of work experience while single (EXP_{it}(single)), months of experience while married but childless (EXP_{it}(married)), and months of experience with children (EXP_{it}(parent)). Controls include human capital characteristics: dummy variables representing highest degree (master's, master's in science, medical degree, Ph.D., and Ph.D. in science) and months at current job; job characteristics that include dummy variables for whether the job is a new job, whether the job involves science and engineering, whether the main work activity is management, and whether the job involves full-time work; and year of observation.

The effect of having children on salary levels is given by b + c(percentage of daycare). The returns to a month of experience while a parent is f + g(percentage of daycare). As a result, salary profiles can be created for individuals with different levels of childcare responsibility. Relevant coefficients for the fixed-effect equations are presented in table A.6.

Table A.6 Fixed-Effect Estimates of the Effects of Children and Share of Childcare Responsibilities on Salary Profiles—University Data: Figure 4.1

Variable	Men	Women
Children	0.1151***	0.1102**
	(0.0435)	(0.0583)
Percentage of childcare	–0.3954**	–0.1530*
	(0.1810)	(0.0915)
Months of experience, single	0.0080***	0.0080***
	(0.0003)	(0.0003)
Months of experience, married	0.0078***	0.0079***
	(0.0005)	(0.0004)
Months of experience, children	0.0075***	0.0083***
	(0.0004)	(0.0007)
Percentage of childcare × months of experience, children	–0.0010	–0.0032***
	(0.0014)	(0.0010)
Adjusted R squared	0.779	0.731
Sample size (person-observations)	2,857	3,870

Source: Author's compilation.
***Coefficient is significantly different from zero at the 0.01 level using a two-tailed test.
**Coefficient is significantly different from zero at the 0.05 level using a two-tailed test.
*Coefficient is significantly different from zero at the 0.10 level using a two-tailed test.

CHAPTER 7

To test whether temporary departures from science have salary implications that vary with the rate at which knowledge is changing within a field, the following log salary equation is estimated for the sample of men and women working full time in science.

$$\text{Ln}(\text{Salary}_{it}) = a + b(\text{Months}_{it}) + c(\text{Months}_{it} \times \text{Dep}_i) + d(\text{controls}_{it}) + e_{it} \tag{A.7}$$

Because of the possibility that there are human capital restoration effects that will mask the effects of temporary exit long in the past, the focus of the analysis is on the salary effects of returning from a temporary exit from science immediately preceding the current science activity. Months_{it} represents months that individual i spent out of the labor force immediately prior to activity at time t, and is equal to zero for those individuals who did not exit the labor force. Months out of the labor force is also interacted with the average citing half-life of the individual's field for the period of absence, DEP_i. Therefore, the monthly salary penalty for exit is b + c(DEP). The coefficient b on the months variable should be negative since real salary should decline with a loss in skills. If the theoretical predictions hold, c, the coefficient on the interaction term, should be positive as the penalty for exit is lower in fields that have lower skill depreciation (higher citing half-life).

Controls include variables measuring months of experience in science, months of science experience squared, total months of time out of the labor force prior to last period, total months out of science prior to last period, year of observation, share of responsibility in home chores if married, share of responsibility in childcare if a parent, and dummy variables representing level of degree, marital status, children, manager, and a new job. In order to determine whether there is a restoration effect, a variable measuring months of tenure at the job immediately following a temporary exit is included. The wage equations are estimated for men and women using fixed effects to control for any selectivity bias on the coefficients measuring returns to the nonscience activities in the case that people who leave science work are systematically different from those who stay. In addition, fixed-effects estimation allows us to make comparisons of salary before exit to salary after exit since the within-person variation in earnings and status of last activity identifies the returns to nonscience activity coefficients. Because a vast majority of temporary labor-force departures are short and the few outliers corresponding to lengthy temporary departures may bias the results, the equations are first estimated with departures under a year in duration (76 percent of all departures) and then with departures under twenty-four months in duration (93 percent of all departures). The results are presented in table A.7.

B. Results from Competing Hazards Analysis

Competing hazard analyses were used to determine how changing rates of skill depreciation in a field influence decisions to leave science temporarily or permanently. These procedures estimate the probability

Table A.7 Salary Effects of Temporary Labor Force Exit Figure 7.1—University Data

	Spell of Nonwork Is Less Than or Equal to Twelve Months		Spell of Nonwork Is Less Than or Equal to Twenty-four Months	
	(1) Men	(2) Women	(3) Men	(4) Women
Months out of the labor force	–0.0545***	–0.0529***	–0.0301**	–0.0244*
	(0.0178)	(0.0179)	(0.0131)	(0.0126)
Citing half-life × months out of labor force	0.0066**	0.0069***	0.0030	0.0041*
	(0.0026)	(0.0025)	(0.0021)	(0.0017)
Sample size	1,403	1,599	1,403	1,599

Source: Author's compilation.
*Significantly different from zero at the 0.10 level using a two-tailed test.
**Significantly different from zero at the 0.05 level using a two-tailed test.
***Significantly different from zero at the 0.01 level using a two-tailed test.

Table A.8 Determinants of Temporary and Permanent Exit from Science: Estimates from Hazard Analysis—University Data

	Temporary Exit		Permanent Exit	
	Men	Women	Men	Women
Half-life at time of graduation	–0.028 (0.118)	–0.001 (0.079)	—	—
Half-life at time of exit	—	—	–0.024 (0.084)	0.089 (0.058)
Increase in half-life	21.43** (9.78)	27.13*** (5.16)	4.91 (12.51)	25.51*** (5.72)
Decrease in half-life	13.04 (12.06)	11.45 (7.48)	24.97*** (7.51)	24.41*** (4.85)
Experience outside of science	–0.091** (0.045)	–0.010 (0.009)	0.003 (0.005)	–0.007 (0.005)
Ph.D. in science	–0.843*** (0.371)	–0.073 (0.281)	–1.669*** (0.533)	–1.372*** (0.389)
Master's in science	–0.326 (0.369)	–0.346 (0.254)	–0.599* (0.331)	–0.880*** (0.208)
Nonprofit employer	0.874** (0.410)	0.320 (0.287)	0.950*** (0.369)	0.433** (0.224)
Government employer	0.092 (0.354)	0.050 (0.240)	–0.676* (0.399)	–0.052 (0.193)
Full-time	–0.858 (0.854)	–0.880** (0.348)	–0.634 (0.693)	–0.120 (0.358)
Married	–0.777 (0.732)	–1.370*** (0.483)	–0.140 (0.486)	–1.105*** (0.409)
Children	–1.089** (0.504)	–0.365 (0.487)	–1.017*** (0.396)	–0.890** (0.423)
Months out of labor force for family	—	–0.020 (0.016)	—	0.005 (0.006)
Months out of labor force for other reasons	–0.004 (0.021)	0.004 (0.011)	–0.002 (0.018)	0.006 (0.012)
Percentage of childcare taken on	2.020 (1.296)	0.012 (0.817)	1.550 (1.008)	0.911* (0.510)
Percentage of chores taken on	0.939 (1.408)	2.395*** (0.670)	–0.317 (0.995)	2.347*** (0.528)
Log of likelihood function	–583.809	–583.847	–344.411	–855.613
Sample size	883	948	898	1,002

Source: Author's compilation.
***Coefficient is significantly different from zero at the 0.01 level using a two-tailed test.
**Coefficient is significantly different from zero at the 0.05 level using a two-tailed test.
*Coefficient is significantly different from zero at the 0.10 level using a two-tailed test.

of temporary or permanent departure from science, conditional on surviving in science until the time of observation, and were described in detail in the section on chapter 2. The dependent variable is accumulated time in science, and control variables include months of experience outside of science, months out of the labor force, percentage of childcare taken on if a parent, percentage of household chores assumed if married, and dummy variables for level of degree, sector of employer, full-time status, married, and children.

The skill depreciation variables included are half-life at time of graduation, included in models predicting temporary exit, half-life at date preceding potential exit, included in models predicting permanent exit, and measures of average monthly change in half-life from time of graduation until the date preceding potential exit. First, a monthly change variable (CHANGE) is calculated as half-life at end of the science activity minus half-life at graduation divided by months of time between graduation and end of science activity. Then the change variable is divided into an increase in half-life (INCREASE) and a decrease in half-life (DECREASE) variable.

INCREASE = CHANGE if CHANGE > 0;
INCREASE = 0 if CHANGE < 0.

DECREASE = –CHANGE if CHANGE < 0;
DECREASE = 0 if CHANGE = 0.

An increase in half-life corresponds to a reduction in skill depreciation, and a decrease in half-life corresponds to an increase in skill depreciation. The results of the competing hazard analysis are presented in table A.8.

NOTES

CHAPTER 1

1. All quotes in the book are from initial survey respondents who were subsequently interviewed.
2. An active alumnus is one whose address is on file with the alumni office. One in three of the active male alumni were surveyed, so that the same number of men and women were surveyed.
3. The response rate was higher for women (40 percent) than for men (30 percent).
4. Only fifty-one women were interviewed. The fifty-second woman had died between the time she filled out a survey and the time of the scheduled interview. This woman had a Ph.D. in physics, and because of the small number of women with Ph.D.s in physics, no similar woman could be found.
5. Because of the differing field distributions of men and women, where men are relatively overrepresented in engineering and women are relatively overrepresented in biological sciences, there are three pairs of men that have different subject areas than their female counterparts.

CHAPTER 2

1. More recently, the National Academy of Sciences and other professional societies have been very adamant that secondary-school teaching in science is an important application of science training.
2. In fact, not all of the original scientists and engineers responded to the 1989 survey. Exit rates are based on the members of the original group in 1982 who also responded to the 1989 survey.
3. Retirees at any point over the seven-year period were excluded from the sample so no individual exiting science was actually retiring. Also, any in-

dividual who left the labor force to go to school, regardless of degree, was labeled as a leaver.

4. A maternity leave is not included as a labor-force exit unless the woman has explicitly defined the period as a period of nonwork and it lasted for more than three months.
5. These numbers give the percentage of respondents working in a paying job outside of science at the time of the survey who have earned degrees in nonscience fields. In order to be classified as never entering science, the respondent must have zero years of experience in a science job.
6. Physician-related healthcare careers might include nursing, medical technician, physical therapist, or nutritionist.

CHAPTER 3

1. The technique used in this analysis and later analyses supporting figures 3.2 and 3.3 is first differencing regressions, which estimate within-person changes in salary as the individual moves from the science to the nonscience job. In the regressions on the NSF data, I include controls for years of experience, year, type of employing institution, whether the individual is academically employed, whether the individual is a manager, part-time status, and family characteristics.
2. For presentation purposes, I chose not to represent salary profiles of men and women who get nonscience Ph.D. and master's degrees. Initial salaries for master's recipients are not significantly different, and initial salaries of nonscience Ph.D. recipients are lower than salaries of career nonscientists without a postscience degree. Salary growth is lower for these individuals, making these investments not particularly lucrative. Clearly, science graduates who earn nonscience Ph.D.s choose this route for the love of the field rather than for money.
3. Empirically, I use two techniques to achieve figures 3.2 and 3.3. For all individuals working in science, I use ordinary least squares regression (OLS) to estimate salary differentials for those who eventually leave. This technique estimates difference in salary levels for the stayers and leavers. Then, using first differencing regression on a sample of workers who start their careers in science, I estimate experience profiles through changes in salaries with changes in months of experience and changes in sector of employment.
4. I use information from table 2.3 concerning reasons for not working in science to define amenity seekers and income seekers. Individuals looking for pay, promotion, and career opportunities are listed as income seekers. Individuals who give alternative reasons for exit are amenity seekers. Two-thirds of the exiting men and one-third of the exiting women are classified as income seekers.

CHAPTER 4

1. When asked about maternity leave, many of the interviewed men responded that taking a paternity leave would not be a good career move and would signal a lack of job commitment.
2. For the population in general, the average age difference between husband and wife is between two and three years (Goldman and Lord 1983; Smith and Zick 1994).
3. There is always concern that individuals who take on high amounts of childcare are those who are less able in the labor market. However, statistical tests do not support this hypothesis. The percentage of childcare is not related to prechild earnings, and the first difference technique measures the within-person change in earnings over the period in which the child is born (Preston 2001).
4. These are only hypothetical percentages. In the data for men, 90 percent of the distribution is above 50 percent with a mode at 17 percent; there are a small number of male respondents who report taking on 100 percent of childcare. The distribution of childcare responsibilities is more spread out for women, with two modes at 100 percent and 50 percent. However, there are several women who report taking on zero percent of childcare.

CHAPTER 5

1. The success of the early employment situation is self-reported. But a successful early employment situation would be one where the scientist progresses in the job with increased knowledge, confidence, job responsibilities, and earnings. An unsuccessful employment experience is one that might end in firing or layoff, or one where the employee never gains the respect of colleagues and never contributes in a way that he or she feels is necessary.

CHAPTER 7

1. This difference in the slope of the wage profiles before and after administrative duties is contrary to Mincer and Ofek's (1982) finding that even though wages fall with periods of exit, postexit wage profiles are steeper than preexit wage profiles (at least temporarily) as women try to restore human capital.
2. CITE is the name given to the skill depreciation variable created for this study. Since it gives the average citing half-life of articles in a scientific subfield during a given year, lower values of CITE correspond to higher rates of knowledge growth and higher rates of skill depreciation.

3. The citing half-life for any journal is always truncated at ten years. However, there is only one instance in the data set when the field citing half-life, the weighted average of half-lives across five journals, is ten years: mathematics in 1990.
4. I have not included engineering fields in this table because the percentage of women in engineering is markedly below the percentage of women in other science occupations. However, chemical engineering, the field with the highest percentage of women, also had the highest rate of acceleration of knowledge growth over the period.
5. The duration of temporary exit from science to a job in a nonscience field is, on average, longer than temporary exit from the labor market. The mean duration is closer to two years than one.
6. In the regressions estimating effects of exit on earnings at reentry, the effects of exit on salary growth after reentry are also examined. Earnings growth after reentry does not differ by duration of exit or by rate of knowledge growth within the field.
7. These exit measures are less than previous estimates because they give the percentage of all jobs in science that end in an exit, either permanent or temporary, rather than the percentage of individuals who exit science.
8. This analysis allows more than one exit by an individual scientist. According to the construction of the data, the analysis uses observations that correspond to the end of an activity in science or to working at science at the survey date. Covariates are specific to the activity that is ending. Future activity, which can either be another job in science, permanent exit, temporary exit, or continuation in the current science job, determines the value of the exit variable. After a temporary exit from science, the individual returns to the analysis with the reentry date being the new date at which the individual becomes at risk for leaving. *Tij* represents total months in science from time of graduation with highest science degree.

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