practical advice... proven techniques

Put Your Science to Work

The Take-Charge Career Guide for Scientists

Peter S. Fiske, Ph.D.

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Illustrated by Aaron Louie

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The transferable skills (page 12) and personal qualities (page 13) lists are modified, with permission, from lists compiled by Stanford Career Planning and Placement Center, Stanford University, California.

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Foreword

The training of graduate scientists and engineers is a crucial investment—one that provides great dividends by producing both the knowledge and the personnel that America needs, if we are to remain a leading nation in the twenty-first century.

The job market today presents challenges and opportunities for young scientists. Many new graduates remain concerned about the "traditional" job market in academic research and teaching. Yet, from my viewpoint in Washington, DC, it is clear to me that we also need scientifically educated people in many other places besides universities. The traditional value system in academia has seemed to be: you are not really a scientist unless you are actively doing research. Research has been the litmus test, regardless of its quality.

This attitude is changing today. When I took my first job at Princeton University as an assistant professor in the Department of Chemistry, I unconsciously adopted the attitude of other professors. I thought that my job was to take these bright young undergraduates, decide who could really do science like mine and who couldn't, and get those young people who were not like me in their interests or abilities out of science and into some other university department.

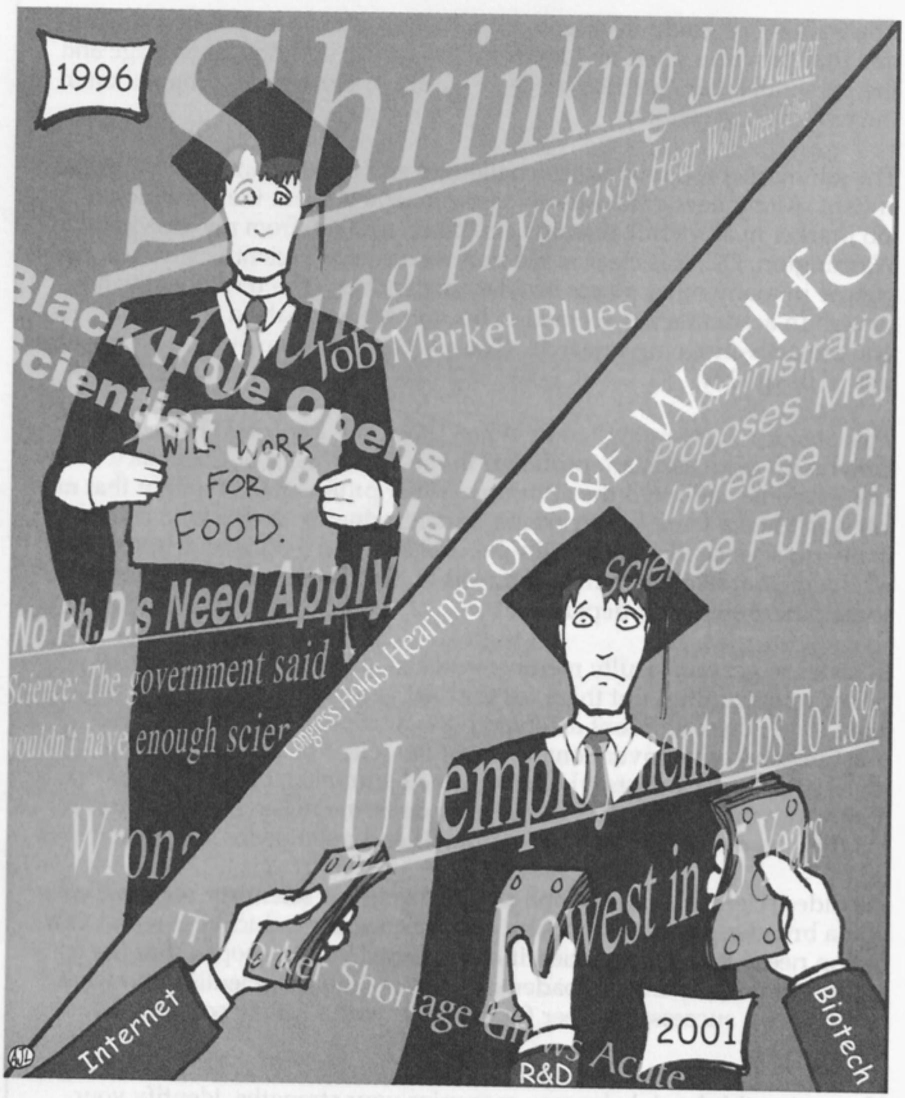
In order to get our faculty members excited about the true breadth of career opportunities out there for the next generation of scientists, we need to get them to adopt an enlarged view of who is a scientist. We must expand our conventional view of the scientific community and invite all those scientists who have turned journalist, teacher, policy maker, or whatever back to our science departments on our campuses to tell their stories and to act as role models and mentors for students.

We older scientists have an obligation to younger scientists: we must offer you a broader pathway for using your science in productive careers. Our nation needs many more scientifically trained young people. But the scientific community must broaden its view of who is a scientist, and what constitutes a successful career for someone with a strong scientific education.

I hope that this book helps you recognize your strengths, identify your opportunities, and explore your options.

I wish you the best of luck in your future endeavors.

Dr. Bruce Alberts
President, National Academy of Sciences



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Preface

There is a tendency on the part of faculty to want to clone themselves and, by their attitude, to make students feel that "success" means a career in research at a university or at one of the few large industrial laboratories that are left. This tendency is misguided, for most jobs for our graduates have always been in industry and not in research. One of the reasons society supports us is to train people who will transform the work done at universities into something of more direct benefit to society.

Burton Richter, 1995
Past President, American Physical Society

What a Difference 5 Years Makes!

In 1996, when the first edition of this book (*To Boldly Go*) hit the bookstands, it was a grim time for young scientists. Across all fields of science, newly minted Ph.D.s and Masters students were facing the combined effects of falling employment for young scientists, rising Masters and Ph.D. production, and a glut of job seekers in academia. The crisis was covered in leading newspapers and news magazines and was even featured in the popular cartoon series "Doonesbury."

Fast-Forward 5 Years.

The landscape of science employment has changed dramatically. Unemployment rates in the United States have fallen to historically low levels and economic growth and low inflation have fueled one of the longest economic expansions in American history. Much of the growth in the "New Economy" has been stimulated by the innovations of scientists and engineers. Some fields in science and technology are so hot that graduate departments are scarcely able to keep their students in their seats. Given today's booming economy and low unemployment figures, especially in the technology sector, it might be tempting to conclude that the scientist glut of the early 1990s was an aberration, a temporary downturn on an otherwise robust path of growth.

Today, young scientists face a dizzying array of career choices that were barely conceivable 5 years ago. Entire new scientific disciplines have sprung up to address new opportunities in biology, engineering, mathematics, and computer science. Universities are becoming increasingly entrepreneurial, cultivating partnerships with technology companies and building start-up business incubators. Twenty-two-year-old computer science grads are starting their own companies. These would seem to be the best of times for a young, smart person such as yourself.

However, amidst all this innovation and growth, graduate education in the sciences hasn't changed very much. Despite calls for change from the National Research Council, the U.S. Congress, professional societies, and many individuals, graduate education in the United States still focuses on the preparation of young scholars for careers in academia, a minority employer of today's Ph.D. scientists and engineers.

Young scientists today are asking a range of questions about career prospects and opportunities that their advisors, department chairs, and universities are unable to answer. This process of exploration is often difficult and frustrating. While in graduate school, students are rarely exposed to career fields outside research science and, at its root, graduate education remains a process of apprenticeship in which students prepare themselves for a life in science. Having completed an advanced degree, many graduates find themselves far from their schools, without access to on-campus career centers and other resources that can provide information and counseling.

To be fair, graduate students and young scientists are as much to blame for our current job predicament as the institutions that trained us. Very few of us objectively surveyed the landscape of the research science career, weighed the relative merits and drawbacks of the lifestyle, or dispassionately asked ourselves if the geometric growth that employed our advisors could continue indefinitely. Most of us went to graduate school because we loved doing science, we were good at it, and at the time it seemed a relatively secure profession. We pitied our college friends who spent their senior years applying for job after job, and we assumed that the hard time we would spend in graduate school would allow us to side-step such unpleasantness. In reality, we simply deferred it for a while.

This Book Is About Creating Options and Recognizing Opportunities

Career planning is a process of professional development that is important for every type of career, including research science. This book is not an exhortation for you to abandon your research career goals. Rather, its goal is to show you that a wealth of opportunities exist for you in many career fields, especially because you have an advanced degree in science. Far from being a liability, a scientific training provides powerful problem-solving tools that are valuable in nearly every type of career. We scientists have much to offer the world beyond scholarly research. Ph.D. and Masters degree holders do encounter perceptions from the scientific community, the "outside world," and even within themselves that tend to reduce their career options. This book will help you attack those preconceptions and explore your true range of career options.

Exploring alternative careers can be a liberating, empowering, and enjoyable experience. Who knows? Maybe your exploration will confirm your original career goals. No matter what the outcome, you will be better off for the experience both in terms of your own career development and in the advice you may give to your students in the future.

Only you can be in control of your career and nobody cares more than YOU about your future.

Acknowledgments

This second edition would not have been possible without the support, encouragement, ideas and suggestions of many individuals. I am grateful to those who made direct contributions to this edition. I thank all the individuals profiled in Chapter 2 for allowing their interesting stories to be retold, in some cases, for a second time. I am also grateful to the individuals whose true stories and resumes form the basis for the case studies in Chapter 10. I am indebted to my colleague and friend Margaret Newhouse for allowing the use of some of her self-assessment exercises in Chapter 5, and to Stanford University's Career Planning Center for use of their career planning pyramid. Al Levin guided me through the field of career counseling for the first edition. His guidance resonates through this edition as well. Chris Gales edited an early version of this edition. Finally, I am grateful to my cartoonist, Aaron Louie, for wielding his wit and pen on this project.

I have benefited enormously from the suggestions, ideas, and support of young scientists, activists, administrators, and career counselors around the country. Wendy Yee and Nicole Ruediger, two founding staff members of *Science's* Next Wave (www.nextwave.org), gave early support and encouragement for this second edition and have provided me with information and resources along the way. Emily Klotz, Crispin Taylor, and the current staff of Next Wave have continued that support and encouragement. Members of the Association for Science Professionals (ASP), especially Victoria McGovern, Steve Smith, Kevin Aylesworth, Finley Austin, Bob Rich, and Patricia Bresnahan, have fed me stories, statistics and research material that have greatly enriched this edition. Geoff Davis, my friend and partner on the Grad School Survey (http://survey.nagps.org/frontpage.shtml), provided a wealth of material through his web site, Phds.org. Eliene Augenbraun and Kelly Kirkpatrick supplied ground truth and much more.

Many of the changes in this edition have come about from conversations I have had with the students, post-docs, administrators, career counselors, and the parents of young scientists I have met in the course of my lectures around the country. Thank you all for sharing your thoughts and insights.

My heartfelt thanks go to Michael Teitelbaum and the Alfred P. Sloan Foundation for supporting this project through a grant to the Center for Science and the Media, and to Lawrence Livermore National Laboratory for allowing me leave to pursue this endeavor.

Finally, this book would not have the quality, depth, and accuracy it has without the care and editorial precision of Jennifer Giesler. Her tireless efforts to improve and extend career development services at AGU, and her research on the job market, have improved the lives and careers of many young scientists. Her career data for geoscientists can be found at: http://www.agu.org/sci_soc/cpst/employment_survey.html.

Science has a great tradition of unselfish cooperation and community service. In this spirit I hope you, the reader, will share your thoughts, observations, and suggestions about jobs, careers, and this book with me and other readers. AGU has set up a companion web site for this book which will feature additional information and resources. Please visit us at: http://www.agu.org/careerguide

Peter S. Fiske, September 14, 2000

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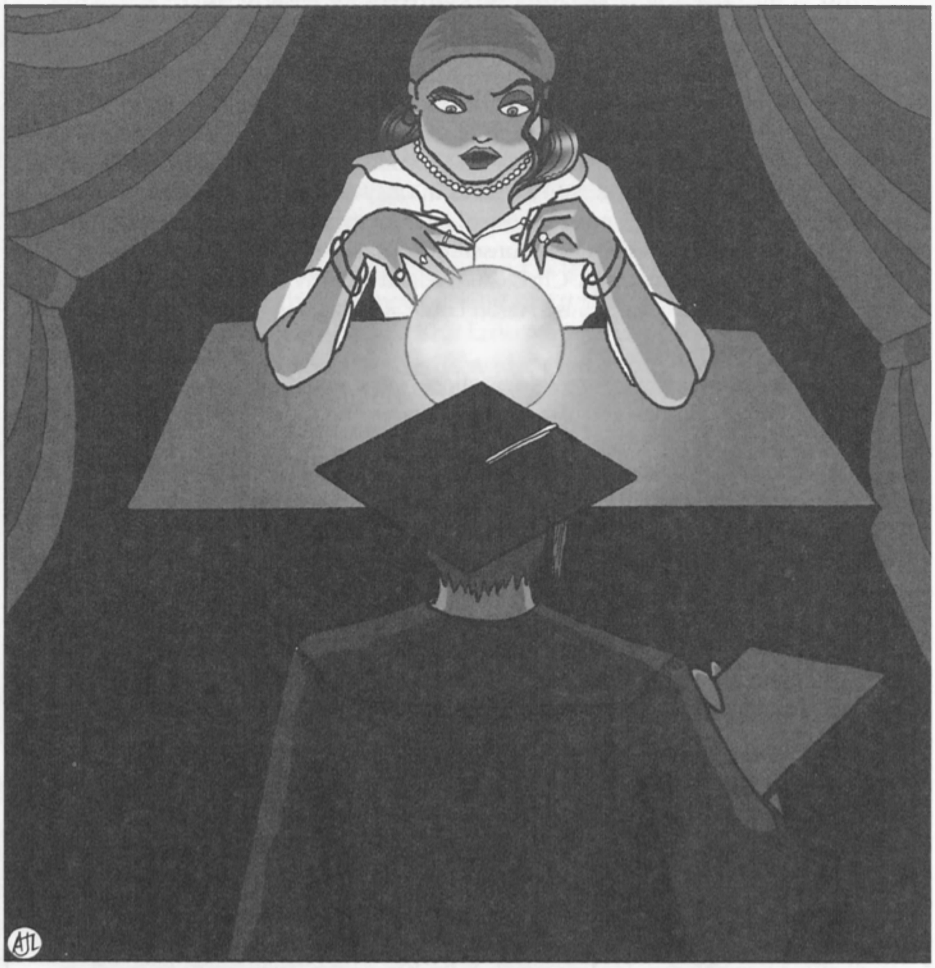

"Let's see. You might get a job. . . or maybe not. Hang on . . . nope. Wait. Yes, you will. I think . . ."

Beyond the Event Horizon

Science Employment Trends in the New Millennium

1

The size of the scientific enterprise, which began its expansion around 1700, has now begun to reach the limits imposed on it by the size of the human race.

David Goodstein
Scientific Elites and Scientific Illiterates
1993 Sigma Xi Forum

A decade ago, Richard Atkinson, then incoming president of the American Association for the Advancement of Science (AAAS), declared the supply of scientists and engineers in the United States a "national crisis in the making." Atkinson was responding to projections by the National Science Foundation (NSF) of a looming shortage of new scientists. Subsequent investigation by young scientists and Congressional staffers revealed that the NSF's projections were dead wrong. As a result, 5 years of science and engineering graduate students marched optimistically into one of the worst job markets for scientists in the past 40 years.

Predicting supply and demand in employment has always been a perilous activity. While near-term supply is fairly easy to judge given the number of students in the pipeline, estimating demand for newly trained scientists and engineers is a black art at best! Not only is it difficult to estimate future hiring trends in academia, industry, and government, but these estimates are predicated on economic and federal policy conditions that can change dramatically over the time frame of a single graduate student. Put simply, there is no way for entering graduate students to know what the job market will be like when they graduate.

This does not mean that graduate students must march into a black hole of uncertainty. While job supply may be difficult to gauge, it is possible to understand some of the macroscopic forces that affect science employment and think strategically about your career in science by asking some basic questions.

What will federal R&D support look like in my future?

As you know, money is the mother's milk of science. Practically every measure of growth in science (number of Ph.D.s, number of publications) is highly correlated to the amount of research funding provided by the government. Most of the R&D money spent in the United States is spent by industry. Basic research—the land most academic Ph.D.s and researchers inhabit—represents only 15% of the total amount of R&D spending, but the federal government funds most of this.

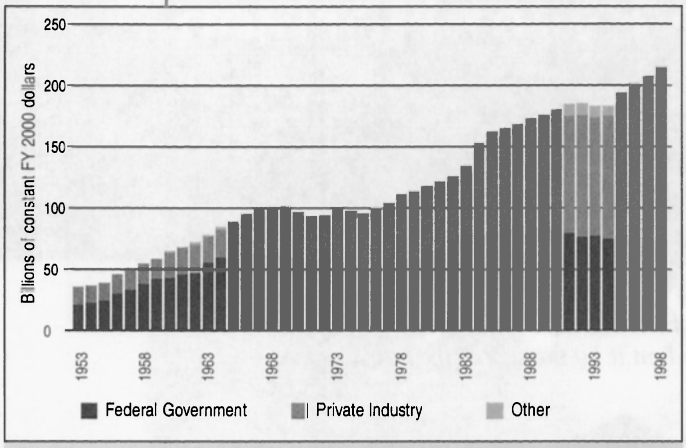

Figure 1. Growth in R&D spending over the last 50 years. The private sector now accounts for two of every three dollars invested in R&D.

The AAAS has amassed figures and data on trends in R&D funding in the United States and abroad. The data, summarized in Figure 1, show that the federal government's spending in R&D has been more or less constant over the past 25 years. Nearly all the growth in total R&D spending has been in the industrial sector. This investment ebbs and flows depending on the health of the economy and the health of particular sectors. "Rich" sectors, such as information technology and biotechnology, spend proportionately more on research while sectors that are highly competitive and have low profit margins, such as the steel industry, tend to shave their R&D investments.

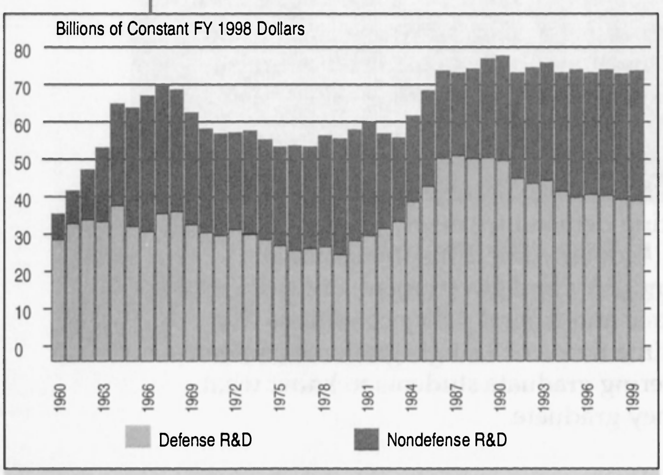

Figure 2. The proportion of federal R&D funding to defense and non-defense areas has changed. Today, nearly half goes to non-defense R&D.

So, in answer to your question, government spending on science and technology probably won't grow much faster than the rate of inflation during your career. Most of the growth will be in industry.

Are there important trends in how the U.S. government is investing in science and technology?

Indeed there are. The proportion of defense-related R&D has fallen substantially since 1990 (see Figure 2). This is due not only to the end of the Cold War but also to an increasing reliance on "Commercial Off The Shelf" (COTS) technology in new defense systems. The Defense Department has substantially cut its basic science funding, relying on industry to come up with the innovations it will need for the future. The needs of the military are changing as well. The United States no longer faces a single, large, technologically comparable adversary. Today we live in a world of numerous small threats that include terrorist groups not aligned with any particular country. As a result, Defense R&D will likely continue to shift toward information technology; light, mobile, and precise weapons systems; and defense against weapons of mass destruction.

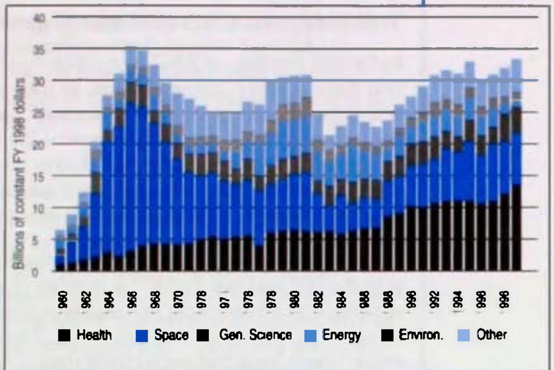

Figure 3. Trends in Federal R&D spending by field. Only health-related research has grown steadily.

In the non-defense part of federal R&D spending only one field of research has shown steady increases in funding year in and year out: Health. Other areas, such as space and energy, have waxed and waned as priorities shifted and crises passed. With the graying of the American electorate, and the huge direct costs borne by the government for health care, one can only expect the proportion of R&D funding for health to increase in the future.

So, in answer to your question, the life and health sciences appear to have the rosiest futures for federal funding. But, as we discussed earlier, the overall level of federal funding for science will not rise dramatically during your career.

But what about those calls in Congress for doubling of science funding?

It is true that in the last few years several members of Congress have called for a "doubling" of funding for science over the next 5 years. Science seems to enjoy popular bipartisan support these days, and many members of Congress believe that the federal investment in science has substantial economic rewards. However, before any of you young scientists get your hopes up, let me caution you that we have heard these words before. Congressional calls for more funding are just that: recommendations. But when it comes to slicing up the shrinking wedge of "discretionary spending"—those federal dollars that are not already committed to Social Security and other entitlement programs—science has to compete with all those other hungry mouths: education, transportation, housing, etc. While science may pay out big dividends in the long term, other "investments" pay far more handsomely in the short term, a.k.a. the Congressional term! Until R&D can compete better with these short-term issues it is likely that federal R&D spending will not get a substantially larger slice of the pie.

Will industrial R&D continue to grow?

Industrial funding of R&D as a whole has been growing for some time, and there is every indication that, as the economy grows, industrial R&D will grow as well. Some new industries, such as information technology and biotechnology, are R&D-intensive. As these grow they will draw in more scientific talent. Some in industry and government are worried that rapid growth in these industries will be limited not by funding but by a lack of technical professionals to fill new jobs.

However, it is important to realize that the bulk of industry's R&D investment is in the "D" and not the "R"! A number of economists, science policy experts, and government leaders have noted a shift in industrial research away from long-term basic science and toward more applied, near-term areas. Many large industrial laboratories, such as Bell Labs, have been dismantled or restructured, and in nearly all of them, the era of basic "curiosity-driven" research appears to be over. Many in the science community have bemoaned this relentless pursuit of the short-term and lament that breakthrough technologies of the future may fail to emerge in such an environment.

However, along with the dismantling of their in-house basic research, many companies and industrial sectors are forging stronger ties with universities—the repositories of basic science and the source of new scientists. Companies are finding it more profitable and reliable to scour the world for breakthrough technologies in universities, smaller companies, and national laboratories, and then license those technologies, rather than rely on their staff of in-house researchers to produce all the breakthroughs they need. Thus, the trend away from big, centralized industrial labs is less of a retreat from long-term research and more a move to outsource the research function. Where once industrial R&D was vertically integrated—with every step from idea to product taking place under one roof—now industrial R&D is becoming distributed among numerous players. Basic science is becoming a commodity.

This trend has important implications for the careers of young scientists. In the past, a young scientist could look to a large company or a national laboratory for the best facilities and most secure employment. Today, many smaller companies and start-ups are leading the technological revolution. They are nimble, focused, and fast-paced. The rewards of working in a smaller company can be staggering, especially if the small company gets much bigger or is bought out by a large firm. For example, two out of three employees at Qualcomm, a telecommunications company, became millionaires in the course of a single year. However, the success rate for most technology ventures is not high. Many more stall before they reach a big pay-out. To thrive in such a dynamic environment, scientists must remain flexible, versatile, and well-connected.

I remain seriously interested in a career in academia. Are such careers possible today?

Absolutely! Academia remains one of the principal career goals of young scientists, even though most Ph.D. scientists do not end up there! In 1995, only 46% of the Ph.D. scientists and engineers in the United States worked in academia. Today that number has fallen further. Furthermore, of those who do work in academia, only a small fraction have jobs in research universities. Many more work in a very diverse set of environments, from small liberal arts colleges to junior and community colleges. There will always be opportunities in academia, but the number may be highly field-specific.

Academic employment faced a number of pressures in the 1990s, and will continue to do so in the future. Mostly, this pressure is due to money. Colleges and universities continue to be under financial pressure to cut costs and slow tuition increases. The recent economic revival in some states has permitted funding increases to some state colleges and universities, but after years of budget freezes many schools find themselves using the new money to fill gaps created during the lean years. As a result, the number of full-time faculty positions for scientists and engineers has fallen slightly, from 173,000 in 1991 to 171,000 in 1995.

Tenure itself is under new pressures. Some schools have flirted with the abolition of tenure altogether, but most are reacting incrementally by hiring more adjunct and temporary faculty and fewer tenure-track faculty. If this trend continues, and there is every sign that it will, colleges and universities will be staffed by a few tenure-track professors and a sea of temporary or non-tenured staff.

There are also new mandates on institutes of higher education. State legislatures and boards of regents are requiring colleges and universities to increase their focus on teaching. As a result, some schools are moving away from a research-focused agenda and more toward one that balances the roles of knowledge production and dissemination. The days in which faculty could lovingly dote over their own research with little care for students or teaching are just about over!

Because of the relentless cost pressures on colleges and universities, the trend toward hiring a greater proportion of temporary and adjunct faculty and lecturers will likely continue. In 1977, full-time faculty accounted for 88% of all science and engineering positions in academia. Today, the percentage has fallen to 79%. This will come as a disappointment to young scientists trapped in a cycle of temporary or part-time academic employment. However, for those who plan a career in industry or government, the number of opportunities for teaching a course or two may actually increase.

Finally, the recent end of mandatory retirement for college and university professors may result in slower attrition of senior faculty. While some studies indicate that the number of professors who "overstay their welcome" is small, lack of mandatory retirement may adversely affect the job supply in other ways. First, senior faculty members are more expensive and a university can afford fewer of them. Second, older senior faculty members may be unable to move into new fields of interest to students or funding agencies.

There are reports—again—that there is a glimmer of light on the horizon. The children of baby boomers, now in elementary and secondary school, are starting to hit the college scene. California, for example, expects a 43%

increase in the number of high school graduates over the next 10 years, and many of those students will be moving on to 4-year colleges. Much of the growth is expected in the west, in states that have seen a tremendous increase in population over the last decade. How these states, notorious for their aversion to higher education spending, expect to pay for this influx of new students is uncertain. In any case, it is likely that more college professors will be needed to teach them.

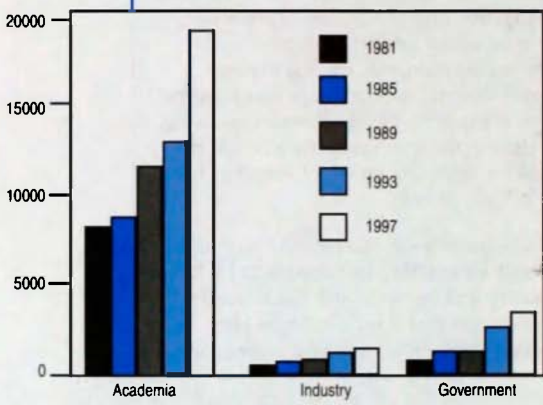

Figure 4. Growth in the proportion of new Ph.D.s taking postdoctoral positions.

What are the trends in postdoctoral positions? How long can I expect to remain a postdoc?

Postdoctoral appointments have always been around in science (heck, my Dad did one). But until recently the issue of postdocs has been shrouded in obscurity. Few meaningful statistics were gathered on postdoctoral populations, employment rules and compensation levels were poorly and inconsistently regulated, and no national organizations existed to speak to the needs of postdocs.

The number and percentage of new doctorates going into temporary postdoctoral positions immediately after graduate school has grown substantially over the last 20 years. In the past, postdoctoral appointments lasted only 1 or 2 years. Today, they can stretch on for as many years as it takes to get a Ph.D. In some disciplines, such as the biological sciences, many Ph.D. graduates and their advisors consider it "normal" to be employed as a postdoc for 4-6 years. In many cases, postdocs are in a holding pattern, building up publications and research portfolios that will make them competitive for permanent positions. As we will discuss in Chapter 7, postdoctoral work can help a young scientist sharpen and broaden his or her skills, professional network, and competitiveness. However, there is a limit. Statistics show that the probability of transition from postdoc to faculty member drops substantially after 4-5 years as a postdoc.

The large supply of new Ph.D.s, continued cost pressure on research organizations, and the growing "acculturation" to the postdoc process suggest that we will continue to have a large number of postdocs in the future. There are some reform initiatives now underway to improve the plight of postdocs—improving benefits, employment status, workplace rights, and professional development opportunities. However, no matter how "nice" the postdoctoral experience may become, many young scientists remain frustrated that they must work for so long before they can compete for a permanent job in research. Indeed, in the "good old days," young scientists used to build their publication and research portfolios while employed as assistant faculty members. Today, new assistant faculty members have as much experience as a "tenureable" faculty member had 20 years ago!

Beyond science, what general job trends should I watch out for?

Many of the changes in industry, academia, and government science employment reflect broader changes in the nature of jobs and job development in the United States and the rest of the world:

- The push toward globalization is rewarding workers who come from multilingual and multicultural backgrounds.
- Job mobility is increasing. People are not only switching jobs more often but moving from field to field more frequently.
- Free agency is on the rise. More individuals are working on their own or as independent consultants. Those in organizations are increasingly being evaluated on their individual impact on the organization.
- Technology is everywhere. Workers with technology skills continue to be highly valued here and abroad.

What about Ph.D. supply?

Enrollment in science and engineering Ph.D. programs peaked in 1993 and has been dropping ever since. News of a difficult job market is finally propagating back into the population of undergraduate science majors and many are choosing greener pastures than graduate school. Enrollments for 1997, the most recent data that is available, show an 11.5% drop overall. Astronomy is down 22%, physics is down 25%, geosciences are down 10%, math is down 26%, and chemistry is down 4%. Biology, on the other hand, is up 2%, with big increases in cell biology, genetics, and pathology.

Much of the growth in the total number of Ph.D.s produced over the last 15 years has been among noncitizens. Despite an increase in the number of overseas Ph.D.-granting universities, the United States remains the "OPEC" of graduate education. In general, foreign-born graduate students are happier with the graduate school experience than U.S. citizens, and some recent studies (e.g., Levin and Stephan, 1999) show that foreign-born scientists in the United States produce a disproportionately high number of ground-breaking scientific discoveries. High-tech industries and universities are now calling for further increases in the number of visas for foreign nationals to study in the United States, and there is every indication that the trend toward an international population of graduate students will continue.

Workplace Basics

The Essential Skills Employers Want...

summarizes a recent exhaustive survey by the American Society for Training and Development along with the U.S. Department of Labor on the skills most desired by employers. They list the following:

1. Learning to learn—the ability to absorb, process, and apply new information quickly and effectively
2. Reading, writing, and computation
3. Communication—the ability to communicate and listen effectively
4. Adaptability—Creative thinking and problem solving
5. Personal management—Self-esteem, motivation/goal setting, and career development/employability
6. Group effectiveness—Interpersonal skills, negotiation and teamwork
7. Organizational effectiveness and leadership

Despite calls for limits to Ph.D. production on the part of some policy makers, academia is unlikely to ever adopt any significant controls on Ph.D. production. Ph.D.s are the most cost-effective means of producing scientific research. While the supply of eager U.S. citizens may be waning somewhat, the demand for higher education from noncitizens is huge and is only likely to grow.

Summing It All Up: The Scientist of the 21st Century

The 6+ year lag time between enrollment and graduation in a Ph.D. program ensures that new Ph.D. graduates will encounter a job market that is significantly different from the one they inhabited when they decided to go to graduate school in the first place. One theme this book will return to again and again is the fact that young scientists have a huge range of career opportunities in front of them if they are willing to consider their training more broadly. Ph.D. scientists and engineers are EVERYWHERE in today's economy; in law, business, government, the non-profit sector, and the entertainment industry. While the health of the job market in each of these industries will wax and wane with the overall health of the economy, there will always be a premium placed on bright, creative, hard-working individuals. The challenge for many young scientists is to understand how their skills and training translate into opportunities outside of the ivory tower...

Summary

- As a scientist you need to be aware of the larger trends shaping funding and employment.
- Federal funding for R&D will grow, but not as fast as industrial funding.
- Postdoctoral appointments will continue to grow and more young scientists can expect to spend at least a few years as a postdoc.
- Ph.D. production will continue to climb, limited only by federal funding and the supply of interested students.