"It took me over forty years to learn from experience what can be learned in one hour from this guide."—Carl Djerassi

A PhD IS NOT ENOUGH!

A Guide to Survival in Science

REVISED EDITION

PETER J. FEIBELMAN

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To Lori, Camilla, and Adam

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PREFACE: WHAT THIS BOOK IS ABOUT

My scientific career almost never happened. I emerged from graduate school with a PhD and excellent technical skills but with little understanding of how to survive in science. In this, I was not unusual. Survival skills are rarely part of the graduate curriculum. Many professional scientists believe that "good" students find their way on their own, while the remainder cannot be helped. This justifies neglect and, perhaps not incidentally, reduces work load. There may be some sense to the Darwinian selection process implicit in "benign neglect," but on the whole, failing to teach science survival results in wasting a great deal of student talent and time, and not infrequently makes a mess of students' lives.

Because science survival skills are rarely taught in a direct way, most young scientists need a mentor. Some will find one in graduate school, or as a postdoctoral researcher, or perhaps as an assistant professor. Those who do not have an excellent chance of moving from graduate study to scientific retirement without passing through a career. The unmentored can only succeed by being considerably more astute than the naive, idealistic, and very bright young persons who generally choose a science major.

These thoughts have been on my mind ever since I almost had to tell Mom and Dad that their golden boy was not good enough to find a permanent (or any!) job in physics, a job for which his qualifications included eight years of higher education and four more of postdoctoral work. The agony of those days is not easily forgotten—the boy with the high IQ, who had skipped a grade, graduated from the Bronx High School of Science at 16 and from Columbia summa cum laude at 20, found himself in a muddle at 28. How do you choose a research problem? How do you give a talk? What do you do to persuade a university or a national or industrial lab to hire and keep you? I hadn't a clue until, midway through my second postdoctoral job, I had the good fortune to spend some months collaborating with a young professor who cared whether I survived as a scientist. Although this mentoring relationship was brief, it helped me acquire a set of skills that graduate education did not, skills without which my lengthy training in physics would have been wasted.

This book is meant for those who will not be lucky enough to find a mentor early, for those who naively suppose that getting through graduate school, doing a postdoc, etc., are enough to guarantee a scientific career. I want you to see what stands between you and a career, to help you prepare for the inevitable obstacles before they overwhelm you. In short, I hope to enable you to use your exceptional brainpower in the way that you and those who put you through school have dreamed about.

I begin with some brief case histories. This may help to put your own early career in better perspective. At least I hope it will give you a feeling for how important mentoring can be.

Important or not, you are likely to wonder whether an elder who emerged into the scientific marketplace when times were flush, and advanced technology looked very different from today's, can possibly offer you useful advice. Chapter 2 argues that one can.

Succeeding chapters are arranged in parallel with a career trajectory. Please skip ahead to whichever may be relevant to your situation. Chapter 3 deals with choosing a thesis or a postdoctoral adviser. My choice of thesis adviser was based on two criteria: Who is the most eminent professor in the department? And whose students finish soonest? Was this intelligent, or did it represent a first mistake? Chapter 4 concerns oral presentation of your work. However brilliant your insights, they will be of little use if you cannot make them appear interesting to others. If no one pays attention, what difference does it make if your results are clever? There are of course Nobel prize–winners whose orations are Delphic, whose visuals look as though they were put together during a particularly turbulent flight, and so on. But you are not one of them yet, and if that is how your talks are prepared, you never will be either. There is more to Chapter 4, though, than advice on preparing appealing slides. It contains a range of important ideas on making your oral presentations effective.

In Chapter 5, you will find a discussion of paper writing. Through your scholarly articles, you can make yourself known nationally and internationally. This means that your reputation in science does not just depend on what your boss says about you but also on documentation that is readily available on the Internet. You should therefore view publishing as a means to attaining job security and take the task of writing compelling journal articles very seriously.

Chapter 6 is devoted to career choices, mainly the merits and defects of positions in academia and in government or industrial labs. The focus is on being reflective and rational rather than naive or romantic about key decisions in your scientific life. In Chapter

7, I discuss job interviews. There is more to an interview than wearing your Sunday best and having a firm handshake. Doing your homework and persuading your potential employers that you have a sense of direction are the most important issues. Incidentally, this is not a matter of deception—knowing who your colleagues will be and developing an idea of what you want to know, scientifically, are keys to having a productive career. There are also a few choice words in this chapter about negotiations, once you do get an offer. Negotiating for what you will need when your leverage is maximal can make a large difference to your happiness and to your success.

In Chapter 8, I discuss what—to many—is the bane of scientific life, namely, getting money. This used to be the exclusive headache of those in academia, but nowadays it is also a significant part of the lives of government and industrial scientists. I suggest that you view the preparation of a proposal as an important scientific exercise. Coming to see and being able to articulate how your work fits into "the big picture" is essential not only to winning financial support but also to being a first-class researcher. Learning to distinguish extravagant "pie in the sky" from promises that you have a chance of fulfilling is also very valuable.

The most difficult problem in being a scientist is selecting what to work on, and it is even more difficult when you are just launching your career. Therefore, in Chapter 9, I venture a few comments on establishing a research program. Jumping into the hottest research area may not be a very good idea, nor is taking on a project that you have no realistic hope of completing before your short-term employment comes to an end. The main idea is to establish a program that simultaneously maximizes your chances of continuing employment *and* of scientific achievement. The focus is on strategic thinking.

As this book is written, economic times are tough worldwide, and funding for scientific research is contracting. I hardly need to emphasize that when resources become scarce, competition intensifies for what remains available. To win a permanent position in scientific research, and the funds to carry on serious work, you will have to be exceptionally thoughtful about your career choices. My hope is that this "pocket mentor" will help you to become more introspective about what it will take to succeed.

—ALBUQUERQUE, NM
August 1993 (updated in January 2010)

The past seventeen years have seen revolutionary changes in how we communicate information. Virtually all journals are available electronically. Preprints can be published on the Internet before or without ever being refereed. Overhead projectors have disappeared from scientific meetings in favor of LCD projectors and laptop computers. Résumés are often distributed electronically. This update of *A PhD Is Not Enough!* comes abreast of these changes, though the basic content of the 1993 original remains timely. The communications revolution cannot be ignored but has not made it less important to be thoughtful about choosing your career path or to respect audiences and readers. I still attend talks that make me squirm and struggle to read sleep-inducing scientific articles. I hope attentive readers of this book will reap the rewards of doing better.

—ALBUQUERQUE, NM
January 2010

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To make this handbook accessible to people whose backgrounds, experiences, and scientific interests differ from my own, I have prevailed on several friends and colleagues for advice. I am very grateful to Professors Michael J. Weber and Alison P. Weber of the University of Virginia for numerous constructive criticisms of the first draft. I also thank Dr. Ellen Stechel, my colleague at Sandia National Laboratories, and Professor George Luger of the University of New Mexico for their critical readings of the manuscript. Lastly, I thank my wife, Lori, for many editorial improvements.

CHAPTER 1

Do You See Yourself in This Picture?

The brief stories in this chapter have a common theme: that understanding and dealing rationally with the realities of a life in science are as important to science survival as being bright. Once you leave graduate school, the clock is ticking. Unlike a fine wine, you do not have many years to mature. As a young professional, you must be able to select appropriate research problems, you have to finish projects in a timely manner, and you ought to be giving compelling talks and publishing noteworthy papers. When job opportunities present themselves, you should be able to assess their value realistically. Romanticizing your prospects is a major mistake and is likely to have serious consequences, not excluding dropping out of scientific life prematurely. The first story is an excerpt from my own scientific beginnings. The others are also nonfiction, though I have altered locations and personal characteristics to avoid invading the privacy of the protagonists. I have deliberately identified the various characters with initials, rather than names, to avoid any ethnic implications.

What Do Scientists Do?
Technique Versus Problem Orientation

Virtually all classroom work and much of what happens in a typical thesis project is aimed at developing a student's technical skills. But although the success of your research efforts may depend heavily on designing a piece of apparatus or a computer code, and on making it work properly, *no technical skill is worth more than knowing how to select exciting research projects.* Regrettably, this vital ability is almost never taught. When I signed on with a research adviser in my first year of graduate school, I was thrilled to be given a problem to work in the physics of the upper atmosphere. That I had no idea what motivated the problem did not prevent me from carrying out an analysis, on a supercomputer of the day, and publishing my first paper at the age of 22. For my thesis, I consciously switched to a project that would require learning the tools of modern quantum physics, but again I found myself assimilating technical skills without ever grasping the significance of the problem, without understanding how or whether it was at the cutting edge of science. This way of working became a habit, one that seriously threatened my career. My first seven publications were in seven different areas of physics. In each case, I relied on a senior scientist to tell me what would be an interesting problem to work on; then I would carry out the task. I assume it was my ability to complete projects that impressed my superiors sufficiently to keep me employed. It certainly wasn't my depth in any field.

Four years and two postdoctoral positions after earning a PhD—still having little sense of what I wanted to learn as a scientist—I was on the job market. More than anything else, I needed good recommendations from faculty at the university where I was employed. I was asked to give the weekly solid-state physics seminar and realized, at best dimly, that my performance in this venue was either going to make or break me as a scientist.

The talks I was giving at this point in my career reflected my approach to science. There was little in the way of introductory material. Much of the presentation was technical. I would describe a few "interesting" sample content of A PhD Is Not Enough!: A Guide to Survival in Science

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