away from science, and how these experiences have impacted her teaching of science, as well as her scholarship as a science teacher educator.

Finally, this section offers readers several representative experiences of women in who have begun their career in the academic sciences and have transitioned into science education research based on a desire to expand not only their own opportunities for learning, but also their students by implementing pedagogical practices that provide students with greater access to resources and by engaging in on-going, critical self-reflection on their own teaching and research practices.

I am both a biochemist and science educator professor in a Department of Chemistry and Biochemistry at Florida State University. My original doctoral training was in biochemistry at the University of California, Berkeley. My research was fast reaction kinetics of the binding of a vitamin B6 analog to a transaminase enzyme. I determined the pH dependence of the overall equilibrium constant and the on and off rate constants for the enzymatic aldimine formation.

As a faculty member, I conducted my biochemical research for 15 years at which time I started to become interested in understanding learning and in particular, science education. Eventually, this new interest led to my earning a second doctorate in Science Education through Curtin University of Technology in Western Australia. I just finished my 31st year as a faculty member in the same department. I focus my research now on science education, mainly at the undergraduate and graduate levels.

Originally, I wrote this chapter in conjunction with a chemist, Jennifer Lewis, but we decided to keep our chapters separate, as we wrote enough to comprise two chapters. Therefore, you may want to read her chapter in this same book in conjunction with mine. We compared our experiences and agreed on using the wind as a metaphor, either a deterrent or an aid in our academic journeys in chemistry or biochemistry. In my case, I saw the wind more as an obstacle in my movement through the academic ladder while she saw the wind as something that helped propel her forward—she could feel the wind at her back. Although I felt energized with the wind in my face, stimulating me, I felt the struggle, trying to move forward in my career against the force of the wind.

Jennifer Lewis and I became scientists and academicians at quite different times (Penny in the 1970s and Jennifer in the 1990s). I feel gratified to see that the climate for women becoming chemistry faculty has improved since I started on my quest to become an academic scientist. There are elements in common to both journeys, but there are enough differences that I feel an optimistic note for the future.

In 1993, there were 80 women who composed just 8% of the full professors in chemistry departments in the entire United States (Long, 2000). I was not in that group but became a full professor two years later. Women full professors were a rare breed at the time. Women faculty members in chemistry departments are still rare, and full professors are rarer still.

This chapter outlines the struggles and joys I have experienced as a budding chemist, becoming a biochemist, and now a science educator. I always felt I was going upwind against the current of males forming the wind in my face (Figure 1).
The struggle may have been doubly hard, considering that I chose to move to the southern part of the US, a conservative region of my country. Even though finding my own pathway was difficult, I feel I gained energy and confidence in myself from the struggle.

VENTURING INTO CHEMISTRY

Mine is a journey of being a female who, to become a scientist, had to be serious about her learning of mathematics and science and now is just as earnest about learning science education. I have been on this upwind journey for all my life. I knew in 6th grade that I loved science. Mr. Dudley Bragg, my 7th and 8th grade teacher at a small rural elementary school, taught me a love for learning, and I realized my talent and interest in mathematics and science. From my interest and love of chemistry and mathematics while still in high school, I knew that the pathway would be difficult for me being a young woman and that I would meet great resistance. I dared to go where few women had attempted to tread.

However, I experienced a window of opportunity to enter in the sciences. I was 14 at the time that the Soviets sent Sputnik into space, circling the globe. This call to Americans, much as there is now in the US, pushed for more young people to go into science, mathematics, and engineering. I felt patriotic for entering into a field in which my country needed me. Here was one time when the wind of change was with me—the launching of Sputnik helped propel me into a science track in high school and later in college and graduate school.

In my freshman year of high school, my homeroom happened to be the chemistry room. I remember getting to school early and sitting there, becoming fascinated with the periodic table and how the size of the covalent radii gets smaller as you move across the periodic table elements, so the elements in the same period become denser as they have more mass and less volume (see chart of elements on Purdue University Web site, 2006). I asked my high school principal if I could take the chemistry course in my sophomore year. Through that course, I learned that the answer to my question about the density of elements lies in understanding the inner structure of atoms and their electron arrangements. How fascinating I thought!

In high school I struggled at first with chemistry but persisted as science captivated me, and I did well. I remember during my junior year of high school we used the brand new physics curriculum developed by MIT physicists through the Physical Study Science Committee (PSSC). I fell in love with learning about waves and how they worked, and what waves meant about the nature of light. As I graduated from my high school, I listed myself in the "class will" in the yearbook as leaving the answers to all the mathematics problems. All my peers knew I had figured out all the problems. However, in those times, a young woman who was interested and excelled in science and mathematics was still very strange.

What propelled me to become an academic scientist against so many social odds, despite the Sputnik opportunity? Upon reflection, what I liked most about science is I could make sense of the world. There was so much in those times, especially when I was in college with the civil rights strife and the cold war that did not make sense to me. At least in science, there were theories that made sense to me, that added some order to my life. I could predict the physical and chemical behavior of materials. I felt that there were things knowable in the universe. I felt that at least there was a part of the world that made sense. For me, the world was full of chemistry.

At the time I felt that attending a coeducational institution would have been harder socially for women to excel in the sciences, so I chose to attend a women's college. Half of my college professors at Douglass College (the women's college at Rutgers University) were women. I did have the opportunity to do organic chemistry research, even before I took the course in organic chemistry with a male professor, Dr. Bean. I got to synthesize new molecules that no one had ever seen or characterized beforehand, so I felt enabled and empowered. During another summer I participated in biochemical research with a woman faculty member, Dr. Lillian Ellis. However, I do remember there was one male physical chemistry professor who said to all five of the women chemistry majors in my senior year, "I wonder why I spend my energy teaching you when you'll just become mothers." That really bothered me, and in a way, his saying that motivated me further, to go to graduate school. I wanted to prove him wrong.

FOCUSING MY INTERESTS IN BIOCHEMISTRY

When I got to graduate school, I really started to push myself academically, especially after I got my master's degree in organic chemistry at Bryn Mawr College and went for the doctorate in biochemistry at University of California, Berkeley. Berkeley was the first place where I was no longer at the top of my peer group.
I found myself more in the middle of a group of motivated and talented young biochemists. Being at Berkeley gave me room to grow and pushed me. However, I remember there was a negative incident with one of the members of my doctoral committee, which reminded me of when my undergraduate professor thought the women chemistry majors would just have babies when we graduated. This second incident reignited my drive to excel in my chosen career.

The doctoral research was not a bed of roses. When I started at University of California, Berkeley, I was suddenly in a program in which most of my peers knew a lot of biology. I had only taken one high school biology course and none in college (although I did take biochemistry in my master's program). In my first semester at Berkeley, I took a course in protein synthesis offered by world-renown geneticist, Bruce Ames. Rather than a textbook, we read recent journal articles as the news was breaking on protein synthesis. Without any in depth background in biology, I had to figure out what the genetics must be for these articles to make sense, an unusual way to learn genetics. The challenge stimulated me. Meanwhile I switched my emphasis from organic chemistry to bioorganic chemistry to biochemistry.

My research mentor, Dr. Jack Kirsch, was on sabbatical in West Germany during the third year of my four-year doctorate at Berkeley. I collected most of the experimental data—temperature-jump and stopped-flow kinetics as well as equilibrium data during the year Jack was away. In the early 1970s there was no way to communicate electronically, not even by facsimile. Instead, I would type (on a manual typewriter) a 5-page, single-spaced letter once a week on what I had discovered, what problems I had, and where I was headed in my research. By the time I received Jack's response by airmail two weeks later, I had solved those problems and was on to new ones. What I realized is I could solve my own problems.

Jack Kirsch told me that I was his first woman graduate student who wanted to become a university professor. He was surprised but did encourage me. In fact, Jack called me during my postdoctoral research at Stanford University to say, "Penny, they're looking for you at Florida State University—they advertised for an assistant professor in one of three fields—immunochemistry, fast reaction kinetics, or membrane-mediated phenomenon—all three are your specialties."

BECOMING A CHEMISTRY FACULTY MEMBER IN THE DEEP SOUTH

Indeed the interview at FSU went well, and I was offered and accepted the job. However, moving to Florida was a big change for me, not only because I had a tenure track faculty line, but also I had just separated from my first husband after seven years of marriage. Also I moved into the Deep South of the US, in which I had never lived. The culture in Tallahassee, Florida was very different from the Bay Area in California.

I was the first woman to be hired in my department on a faculty line equivalent to my male colleagues, to do research, teaching and service. However, I knew my primary mission as an assistant professor was to conduct research, attain grants, and publish! Again, I felt like I was going upwind, as there were so very few women faculty in the sciences within my university, and only one other in chemistry.

My one female colleague, Katherine Hoffman, in chemistry did an elegant job with her teaching and service, but she was not hired or expected to conduct research. I felt that my male colleagues were uncomfortable with me, not only that I was their first female colleague who did research like they did, but also because I was a single woman. For many of my chemistry colleagues' their wives stayed at home and never had careers. I did not fit into the nice little box in their minds for women. Therefore, I was obviously different and felt isolated.

I was also different in terms of my research. At that time I focused on immunochemistry, studying cell-cell interactions between an immune cytotoxic T cell and the tumor target cell towards which the T cell had been primed. I wanted to understand the chemical and physical factors that modulated that immune T-cell-mediated recognition event. There was no one else in my department who studied membranes or anything to do with immunology. Therefore, I had to make my own impact. My graduate students and I published how the cell-surface density of major his to compatibility class I antigens on the tumor cell surface influenced their recognition by the immune T-cells. In addition, we purified these same transmembrane antigens by affinity chromatography and inserted the transmembrane antigens into model membranes with defined lipid composition and containing cytoskeletal proteins. We demonstrated that they were immunologically specific.

However, earning tenure and promotion to associate professor was a tough road. My second husband (also a chemist and a colleague) and I had chosen to have our first child while I was still an untenured assistant professor. One female colleague from another department told me later in my quest for promotion and tenure that my male colleagues did not like that I got pregnant and had a child before my tenure decision. To my colleagues, bearing a child was a signal that I was not committed to my career in biochemistry.

I chose to become pregnant because I wanted to have a child and felt there was a time crunch, and were I to wait, I might never become pregnant. In retrospect, I think having my two children (the second was after I was tenured) was one of the important things I have done in my life. Therefore, I do not regret it, and I learned how to survive in academia despite (and maybe) because of those hard times.

One of the important things that I learned in those tenure-earning years and the fight for tenure was that everything is political. Beforehand I had thought I was above politics, but I learned through that fight, that I must pay attention to politics, and I have ever since.

REDIRECTING MY RESEARCH TOWARDS EDUCATION

Once I was tenured and promoted to associate professor I started to branch from traditional biochemical research and teaching. I applied for university funding to offer an innovative interdisciplinary science course in which ethics in science was a prominent theme. In retrospect, I realize that I became well known nationally initially through my innovations in teaching. At that time there were
very few scientists that were teaching science ethics (Gilmer & Rashotte, 1989;90). A US congressional committee invited me to become a witness in 1989 hearing on “Maintaining the Integrity of Scientific Research” (Gilmer, 1989). The committee wanted to hear what I had to say about bringing ethics education to practicing scientists. The National Institutes of Health (NIH) had not yet started to include ethical training in programs for graduate assistants and postdoctoral fellows. In fact in 1990, the NIH invited Dr. Ruth Bulger and me to help shape what has become the training program required for Public Health Service trainees.

While I was still an associate professor, I had a fast-growing tumor with which I had to contend. I chose to be as aggressive as I could be in the medical treatment to increase my chances of surviving. My two children were 10 and 12 years old at the time, so I had great motivation to survive. I utilized radical surgery plus seven long months of chemotherapy, and then still had to recover from the insult to my body. I lost all confidence that I had in myself during my illness and initial recovery, because my body had forsaken me. I struggled to put myself up for promotion to full professor, but I did not want to die as an associate professor, so I proceeded. Therefore, having cancer was another critical point in my personal and academic life. I have written about this time in my life (Gilmer, 2002), but after my full recovery I found myself and have lived a richer life, both professionally and personally, since then, now 14 years.

Through my efforts in ethics education within the sciences plus other innovative educational projects in teacher preparation and teacher enhancement, I decided to prepare my binder for promotion. I knew my department chair in chemistry was behind me, and the full professors in the department were too when I put forth my folder for promotion to full professor. However, at that point, I was still going upwind in a College of Arts & Sciences that was not ready to accept educational research, even when my research was nationally recognized, even with a national award (Spiegel, Collins & Gilmer, 1995). With persistence, I gathered forth the energy to challenge the negative vote from the college (Gilmer, 2002). Fortunately, I made a convincing enough case that my colleagues on the university committee recommended my promotion to professor. At that point only 7% of the full professors in the sciences at my university were women, so I was isolated from the other women professors and felt lonely. There was only one other woman full professor in my own department at that time, and we had about 35 “brothers” as colleagues (the number varies depending on how you count, as some were half retired, etc.).

Long (2000) compiled statistics for the 2000–2001 academic year of women faculty at the three professorial ranks for the 50 universities who have spent the most money on chemical research. Since my promotion to full professor, we have added four more women faculty, three of whom are now promoted to associate professors and one newer assistant professor. For a while we had one other full professor but she was hired to be a provost at another institution. One of my former women colleagues, an associate professor, moved to another university, so we have five women faculty members in our department. However, FSU was one of the top universities listed in the 2000–2001 year, with 14% of its full professors and 38% of its assistant professors as women. The average for the women chemistry faculty for these 50 institutions was just 10%. FSU’s chemistry average for women at all ranks was 17%, and the highest ranked was Rutgers (the institution where I got my undergraduate degree) with 26% women at all ranks. I was one of the pioneers at FSU that started the change towards more women.

Although I knew I had “made it” as one of the few women full Professors of Chemistry, I chose to go upwind again. Becoming full professor in chemistry gave me the freedom to explore and learn education more deeply. Learning the field of education, critically reading the literature, presenting research papers at educational conferences, publishing research papers, editing books, and directing graduate students in education have pushed me to expand my expertise. I have read different styles of research (Ellis, 1997; Lincoln, 1997; Richardson, 1994) and have learned to express myself in writing using alternative forms of representation (Gilmer, 2002; 2004).

DIRECTING SELF TOWARDS A SECOND DOCTORATE

In order to keep learning I decided in 1997 to work towards a second doctorate in science education through Curtin University of Technology in Perth, Western Australia. I had taken graduate courses at FSU as a special student for two years at that point, and decided to go forth and learn more. I thought this effort would help me focus and survive the cancer. I traveled with my 15-year daughter, Helena to Perth, so I could enroll in the graduate program at Curtin. That one semester counted as my semester in residence. Helena attended high school for a semester while I edited a book (Taylor, Gilmer & Tobin, 2002) and took a graduate course in constructivism with Peter Taylor at Curtin. During this time I thrust myself into science education.

Peter Taylor and Kenneth Tobin became my co-major professors, with Peter more in the beginning and Ken more in the end of my program. I chose to use a qualitative methodology (which was very different than my very quantitative research for my doctorate in biochemistry) and to conduct action research in my own biochemistry classroom. By action research, I mean that I did research on my own actions (in this case in my own classroom), and how others (my students and colleagues) interpreted them. Instead of teaching using traditional lectures, I taught the first semester course in biochemistry utilizing technology (especially the Internet) with students working together in collaborative groups to develop topics in biochemistry, and then presenting some of the biochemistry content in their Web sites to each other. Students peer reviewed other group’s presentations and self assessed their own presentations.

My method of teaching was radically different than what my colleagues used at my university. I chose this, as I wanted students actively constructing their knowledge, using the language of science, while working collaboratively as they struggled to understand and learn biochemistry. I still presented each week an
overview of each assigned chapter. However, during the other two days of class per week the students learned how to use the technology and presented their Web sites to each other.

I chose to write up my doctoral research rather unconventionally, especially the fictionalized short story about my classroom and the metalegacy that I had with one of my biochemistry colleagues on the problematic issues of bringing reform to higher education. I also had more traditional ethnographic data as part of the doctoral thesis (Gilmer, 2004). I have a book contract with Springer to make my dissertation study into a book, which I am finalizing.

Since finishing the doctorate I put my energy into a grant called GK-12 funded by the National Science Foundation (NSF). I was the internal evaluator of the program and followed the progress of our GK-12 Fellows (who are science graduate students and work about 20 hours per week in the schools and are paid $30,000 per year plus tuition). I also developed a comparison group of graduate students who were not part of the GK-12 program, so we would have some sort of a comparison to the GK-12 Fellows. I was the senior editor of a monograph on this research, with chapters by seven of the nine original fellows (Gilmer, Granger, and Butler, 2005). I accepted an award for FSU from the NSF in GK-12 Dissemination for this monograph in 2006. As a result of this program, I have become interested in the progress of graduate students in the sciences.

Currently, I have a subcontract with the Panhandle Area Education Consortium (PAEC) to offer scientific research experiences to 80 K-12 teachers in rural northern Florida. To prepare my teachers for these opportunities to conduct research I taught them an on-line, distance, graduate class called Nature of Scientific Inquiry. This summer while the students take more science graduate credit from me, I travel to 15 research sites to interact with the teachers and their scientists at state parks, wildlife refuges, estuarine reserves, coastal research laboratories, fish and wildlife services, and state of Florida research sites.

GIVING BACK TO MY PROFESSION

Almost four years ago I accepted the nomination of becoming President of the Tallahassee Scientific Society. I wanted to provide avenues for the general public to become involved in and knowledgeable about science and technology. I served in this position for two years.

In 2005, I decided to run for some national and international positions in professional groups. I ran for four elections, hoping to win one or two of them, and I won all four! The most prominent includes being elected President-elect of the National Association for Research in Science Teaching and Board member of the Association for Science Teacher Education (and Co-chair of the Awards Committee). I also became Member-at-large of the Education section of the American Association for the Advancement of Science and Area 4 Director of District 11 of Zonta International. As you might guess, I am extremely busy but thrilled at the opportunity to lead science education. As a woman who is both a science educator and a scientist, I have a unique perspective. I have the opportunity to make a difference.

REFLECTING ON THE METAPHOR OF "GOING UPWIND"

This metaphor of "going upwind" gives me energy and empowers me to find my way. The power enables me as I move against the winds of the culture. Originally for me, I went upwind against the culture in chemistry and biochemistry as a woman in a male dominated field, and more recently I went upwind as a scientist using qualitative methodologies in my educational research. By doing what I do, I am helping to change the culture within science and change the direction of the wind, which helps other young women chemists and biochemists utilize their talents and achieve their dreams.

IN CLOSING...

For science educators to work within academic science departments, there needs to be a recognition that research in the discipline of education needs to be part of the academic science department. I am trying to convince my colleagues that doctoral students in our department of chemistry and biochemistry should be able to examine chemical or biochemical education for their doctoral research. To date, I have been a major professor to four doctoral students in biochemistry, analytical chemistry or molecular biophysics and eight doctoral students in science education. All students in science education are enrolled in the College of Education. Currently, I now also have two doctoral students in science education. My chemistry faculty colleagues are slow to move from their position of research needing to be in chemistry or biochemistry, but I have convinced at least some of them that this research in chemistry and biochemistry education is worthy of a doctorate in chemistry or biochemistry. Time will tell if this type of research continues after my retirement in a year.

REFERENCES


INTRODUCTION

When I was initially asked if I could contribute a chapter to this volume, it was in conjunction with Penny Gilmer, a fellow Floridian and extremely well known Chemist, but someone whom I had never met. I confess I was intimidated, nervous, and very conscious of my junior status, but when she called me to discuss the chapter, she was so warm and friendly that my insecurities dissipated. As we explained to each other how we made sense of the events in our lives that had informed our career paths, we hit upon the theme of the wind as a narrative thread that could tie both of our stories together. Penny had utilized autoethnography as part of her dissertation in science education, so she suggested a few references that could help me understand the form. From reading these references and a few others I understood that I did not know how to do autoethnography! What I committed to, however, was to narrate a story from my real life with relevance to the situation of women in science education, to use my authorial voice to expose rather than to obscure my vulnerabilities (as much as possible for a reserved Midwesterner), and to avoid the analytic impulse – i.e. to let the story speak for itself. When Penny and I put our stories back together, each of us had enough story to tell that the narratives could stand on their own. However, in reading our two chapters, remember that they were conceived of together, and notice that we have treated the wind in different ways, reflective of our different experiences with the larger culture. What follows is a story about how I came to claim the identity of chemical education researcher.

COMING TO CHEMISTRY

In high school, I would not have been chosen as the student most likely to go on in science. I participated in band, debate, speech and theater, and I wrote a humor column for the school newspaper, eventually serving as editor. I really liked interviewing people, and I also liked to write, so I thought of journalism as my most likely future career. As a college-bound student, however, I took the standard college preparatory courses in biology, chemistry, and physics. Since I generally enjoyed school, I enjoyed these courses as well, but still did not envision myself as a potential scientist. I had friends, who participated in science fairs, but I never felt an urge to join them – it seemed boring! From my perspective, they spent a lot of time alone, repeating experiments until finally something worked, and I couldn't...