CHAPTER 11

THE UNDERGRADUATE RESEARCH ERA: 1961-1997

My experience with undergraduate research covers a longer time span (36 years) than with graduate student research (31 years). Because research heightened my interest in science, I thought others might have a similar positive reaction. As a consequence, when I had the opportunity to teach a six-week course at Rocky Mountain Biological Laboratory (RMBL) in 1961, I had all 24 students in my course on comparative limnology do a research project. I was warned about the substantial increase in personal time that this requirement would take, particularly if I supervised four National Science Foundation (NSF) undergraduate research participants in addition to teaching the course. The students were all enthusiastic about their projects, even though they knew that their experiments would have a narrow focus and would require a great deal of work for them to finish within a six-week time frame. RMBL was then not well equipped for course research on this scale, particularly in the field of limnology. I borrowed equipment and supplies from the Academy of National Sciences Philadelphia. Fortunately, both Ruth Patrick and the institution were supportive of my effort.

I loaded my Volkswagen microbus for the trip from Philadelphia by placing a board with supports from the motor to the front seat and stuffing all the teaching materials and a tent (for camping on the trip to Colorado) under the board. Personal gear went on top the board and a small aluminum boat was placed on the roof. This set up would all be illegal today, because our youngest daughter Heather was then under 3 and had no restraining device on her seat. In fact, had the microbus turned over, hundreds of pounds of equipment would have landed on us, a thought I had constantly during the trip.

The students finished their research on time, and some presented the results at state academy meetings when they returned to their home institutions. Without exception, they were all more enthusiastic at the end of summer than they were at the beginning because, for practically all of them, this experience was the first research they had done. I did absolutely no personal research that summer. The people who told me how much time the undergraduate research would take outside of normal classroom hours were absolutely right. Also, the students scattered in many different directions, and I spent a great deal of time visiting each research site at least twice during the six weeks. I taught this undergraduate research class in the same manner through summers of 1961, 1962, and 1963.

In summer 1964, I moved to the University of Michigan Biological Station (UMBS) to teach freshwater protozoan ecology. This session was eight weeks long, and I intended to continue the practice of having a research component in the course. Fortunately, the first year's enrollment was under 10 students (my recollection is 8 or 9). Although the type of research was different and the UMBS had all the necessary equipment, I was still challenged because all but one of the students was foreign.

Years later, Dr. Frederick K. Sparrow (then director of UMBS) was able to obtain new microscopes for my class. I surmised that the protective polyurethane foam material that was used in the packing of the microscopes could be anchored near the surface in the lake to constitute an ecological island. The material was inert and provided a reasonably complex surface for colonizing microorganisms associated with substrates. This approach enabled students to observe microbial community dynamics. The research at UMBS also inspired me to follow the publications of Edward O. Wilson, an event that has benefited my professional career greatly (although our interests at that time might have been perceived as enormously different). Most important, the design showed the students that research could be carried out with relatively inexpensive materials—in this case, materials that would have otherwise been discarded. I found it satisfying that the packing material for the microscopes furnished the collecting device for microbial communities to be studied with the microscope. This serendipitous event resulted in many theses and dissertations and many undergraduate presentations at state and regional professional meetings.

Since I did my research in the laboratory where the class was taught and the students also did their research there, they could see the hours I invested, discuss problems with me whenever they chose, and the like. I obtained a better understanding of undergraduates than I would have had opportunity to do on a campus where faculty often appear unapproachable to students, especially outside normal classroom hours. Students told me that it was very important to them to see how I managed my time, although they may not have stated it to me in exactly those terms.

I continued to be involved in supervising undergraduate research for several years after I retired. In fact, my deep involvement with both undergraduate research and graduate student research only ended in 1997 when my last PhD candidate graduated and the last honors students, who had been carrying out research with me and my graduate student, left for graduate school.

Although I have discussed my experiences with undergraduate and graduate students in two separate chapters, both types of students were closely linked. I frequently involved graduate students in the supervision of undergraduate research, when both the undergraduate and the graduate student felt this coupling was a good idea; this extension of graduate student activity helped my professional relationships with them significantly. Issues that might not otherwise have been discussed were raised frequently; the graduate students had experiences they might not otherwise have acquired until their first professional position, and the undergraduates had a role model closer to their own age.

I estimate that, from the period of 1961 through 1997, I supervised, with or without help, approximately 630 undergraduate research projects. The peak number of students at field stations was usually 24 per summer for all but a few summers; and, during the academic year, I always had a minimum of 4 undergraduate honors research students (and once 12) or regular independent undergraduate research students. I have had undergraduates from the early 1960s, as well as in more recent years, tell me at professional meetings how much the research meant to them, although over three decades had passed in some cases. Also, a few former undergraduate research investigators have even sent money to the alumni fund to help support undergraduate research. All this research supervision was an enormous effort and did not qualify as teaching by those who consider stand-up lecturing in a classroom the only sort of teaching that occurs. In my opinion, such supervision is the most valuable sort of teaching, although the number of hours a researcher spends with each student would lead many to believe it is not cost effective. I pity both the faculty and students, both graduate and undergraduate, who cannot enjoy the exhilaration of these activities! The joy of students when their first research project works well, as it did in most cases, was as stimulating to me as good results in my own research. As E. O. Wilson (1998) notes, one can invest 40 hours in a professional position and probably function adequately. An additional 20 hours per week is necessary for some degree of success and a further 20 hours for noteworthy achievement. Dedicating hours does not guarantee any particular level of achievement, but even the most skilled and highly motivated people must work more than 40 hours weekly to pass these thresholds. Some researchers may be exceptions to this arduous work schedule, but not many.

In my opinion, research should begin with students in high school or earlier and, certainly at the very latest, in the undergraduate years. When students thank me for the hours I gave, I tell them that this involvement is a partial payment on an old debt to Professor Robert K. Enders, my advisor at Swarthmore; Professor David Wenrich, my major professor for both the MS and PhD degrees at the University of Pennsylvania; and Dr. Ruth Patrick, who became my mentor at the Academy of Natural Sciences Philadelphia. I hope that some of my students will have the opportunity to enjoy the same experiences I have had with students and that some academic institutions still permit this time-consuming work, regardless of budgetary constraints.

My own conviction is that the most effective form of teaching is solving problems together (e.g., Cairns 1998; see Appendix 4). In this situation of a student and teacher, the student, whether undergraduate or graduate, learns about the process of science, the synthesis of information, the ability to construct a testable hypothesis, and the commitment needed for an above average or exceptional level of professional achievement. This set up requires a significant effort from the teacher; Marston (1977) notes

> the knowledge a faculty member acquires in graduate school is similar to the principal in a bank account. If an individual draws on the principal but has no source of income, the principal is soon gone and bankruptcy follows. Research investigations prevent intellectual bankruptcy and basic research, as a consequence, makes possible competent teaching.

Every professional must engage in some form of continuing education! Physicians, who are burdened with HMO, Medicare, and other forms, as well as a heavy daily practice, must make time to read professional journals; this type of education is also necessary for engineers, geologists, economists, sociologists, statisticians, and the like. Professional, continuing education is absolutely essential for them to stay abreast of the rapidly evolving and expanding basic knowledge and techniques in their respective fields. The professional who does not regularly read the scholarly journals, recent books, and attend professional meetings will soon fall behind colleagues. All competent professionals are crucially dependent on this process of professional renewal. During my entire 57-year career, I have never been able to accomplish this in a 40-hour week, including summers. In fact, during the first two decades of my career, every professional article, book chapter, or book of mine was written evenings, weekends, and holidays.

Human society depends primarily on its universities to both generate new knowledge and to graduate creative, research-oriented students. Corporations have reduced basic research, as have state and federal governments. At the same time, governments in many American state universities have reduced the percentage of funds available to both students and research investigations—extramural funding (i.e., grants and contracts) has become increasingly important. *Intellectual properties* (i.e., patents) is a term now common at universities. Universities will have to adjust to this new, probably durable, shift in emphasis, and the adjustment must be done in a way that will enhance creativity. Many believe that a robust measure of the potential for increasing the number of jobs is related to the availability of venture capital. A country with a substantial debt load, such as the United States, will have less venture capital.

Another important point is that society has placed primary responsibility for the vital process of research and professional renewal on its major comprehensive research universities. These institutions are epicenters for the production and refinement of knowledge and the correction of faulty hypotheses. With all the problems facing the world today, society simply cannot afford to neglect research as it is now doing. Some research titles, even on nationally competitive grants, sound hilarious to the lay person and even to faculty in other areas of specialization. Members of the US Senate and House of Representatives have used these titles to good advantage when assigning such tongue-in-cheek awards as the “golden glove” and in criticizing how federal research money is spent and how some of their institutional support is being wasted. Without doubt, some faculty members waste research money, but then waste in government is not unknown. Surely, the research establishment has done as well as many government programs in terms of wastage. Even wasted research efforts, in the sense that they produce negative results, is not money lost because they identify unprofitable research areas or unprofitable approaches.

I am no longer being paid for carrying out research and am, in fact, using some of my own money to finance my writing, as I have done throughout my career. Passing the process of science to future generations is necessary for society to survive, given the world’s problems today and those likely to be faced in the future. Society cannot leave this problem solving knowledge to future generations without diverting a significant portion of its resources to this end. Accountability in science is exceedingly important, but judging should not come from managers, but from world-class scholars who are best able to identify other creative research investigators necessary for quality control. This responsibility is essential in the profession of science.

During my entire career, I have never taken a sabbatical leave (for the first 18 years, I was not entitled to do so). I have always feared losing research momentum and felt that the professional

renewal could be carried out in other ways. Nevertheless, large blocks of time at the professional's disposal are essential for research in a variety of ways, including reading the professional literature, discussing ideas and concepts with colleagues, and the like. Academic institutions may have to re-evaluate the sabbatical leave in this era of quick travel and electronic communication so that a set of mini-sabbaticals (of which I have taken many) are available; in some ways, these leaves are more effective than an entire year of renewal every seventh year. Absence for an entire year might be hard on one's students. Fortunately, many institutions encourage faculty to take sabbaticals of one or two quarters or one semester because it impacts students and teaching less. Although some members of faculties have been known to use sabbaticals as extended vacations, most are working as hard as normal but are freed from classroom teaching and committee service. Spending full time on research generates a momentum otherwise difficult to achieve.

Although I primarily worked with university undergraduates through 1997, I worked with high school students for my entire career and continue to work with high school students in the 21st century. The most enjoyable has been working with Charles Jervis' class at Auburn High School in Riner, Virginia, USA. I was impressed with their insights into complex problems involving both science and ethics, for example, to what extent are precautionary measures justified to reduce the probability of catastrophic climate change? Because all my travel has been restricted due to four spinal compression fractures, I never actually met either Jervis or his students. Still, we managed a very stimulating exchange of ideas via email and the Internet. For me, the major benefit is knowing that the next generation of citizens will have people like this class. Arrangements have been made to continue this relationship during the coming school year. I am reassured by the ability of the class to combine robust science with personal ethics and societal value judgments. I am still deeply concerned about the future of humankind and the planet's biospheric life support system, but I sleep more soundly because I had the good fortune to interact with these high school students and their teacher.

I find some problems with the current academic environment that are unsettling. Binge drinking by students, who are supported financially by their parents and society, seems irrational since the students are presumably in college to improve their minds. Additionally, life and career threatening behaviors are associated with drunkenness, such as drunken driving, AIDS, and inattention to dangerous situations. Not unimportant is the inability to attend or appreciate class the next day.

A close second to this primary concern is the increasingly common belief of students that class attendance is optional—as one student remarked, like buying a ticket for a football game. Faculty members are regarded by students as paid performers, not intellectual guides. This view denigrates both the structural and reasoning components of the educational process. Even if faculty members are merely performers, a listless audience is not likely to elicit the best in the teacher's performance.

Related to the first two concerns is a markedly diminished sense of student responsibility. Some years ago, a major donor provided money for academic fellowships with the condition that the awards be presented to the students at a ceremony—no student appearance, no fellowship (I am confident that illness or a death in the family, etc. would have been a mitigating circumstance). Some students viewed this requirement as unfair. As a student of another era, I would have viewed the award as a public acknowledgment that I would perform to the best of my ability, as the donor had the right to expect a fellowship recipient to do. My last grant provided funds for two graduate research assistantships, and a prospective graduate student asked, "Like, are there any responsibilities?" When informed that the sponsor expected quarterly reports showing significant efforts, the student was stunned. I was fortunate that practically all my students, both graduate and undergraduate, whose work depended on extramural funding had a well developed sense of responsibility. I believe that this attribute is not as widespread as one might reasonably hope it to be.

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APPENDIX 4
letter from undergraduate student

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6/29/98

Dr. John Cairns, Jr.
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Dr. Cairns:

Thank you very much for your letter. It was interesting to read the draft of your book chapter "The Undergraduate Research Era: 1961-1997." From the limited view that I have, I didn't see any inaccuracies or anything that was difficult to understand. I only have one additional idea. In my case it was not only applied science experience (i.e., lab and field work, etc.) that I gained from working with you and Heckman. Indeed, the more scientific aspects of research I had largely already learned from lab classes and previous commercial lab experience. What I did learn as a member of your lab that I feel like I could have never gotten from a book or class was in-depth training on the way that scientific interaction and scientific communication works.

Before entering your lab I had no understanding about the role of scientific journals, scientific meetings or grant funding to the progress of science. I had no idea whatsoever about what it really took to carry out science beyond the simple steps of putting reagents in test-tubes, balancing chemical equations or counting cells under a microscope. However, when I arrived in your lab, Heckman had me writing a grant proposal within the week. When I didn't win that one, I tried again, and as you know, by the time I left there I had personally won three grants and had helped John get money from the Debris Landfill to help pay me for the last summer I was there. Most new graduate students have not applied for any grants before they enter graduate school. Furthermore, the vital importance of the communication of scientific work (i.e., publications) was NEVER DISCUSSED in any of the classes that I took at VPI, Portland State or University of Georgia. Without your own advice on the subject, I might have learned the lesson about publications the hard way when I looked for my first job.

I hope that this is of some help. It is difficult for me to comment further because I was, as you mentioned, only in the lab during an atypical time period of your career of teaching undergraduates. Good luck with the book.

Sincerely,

signed

Andrew Heaton