2012

Publish and Flourish

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STEPHEN K. TAYLOR PH.D.

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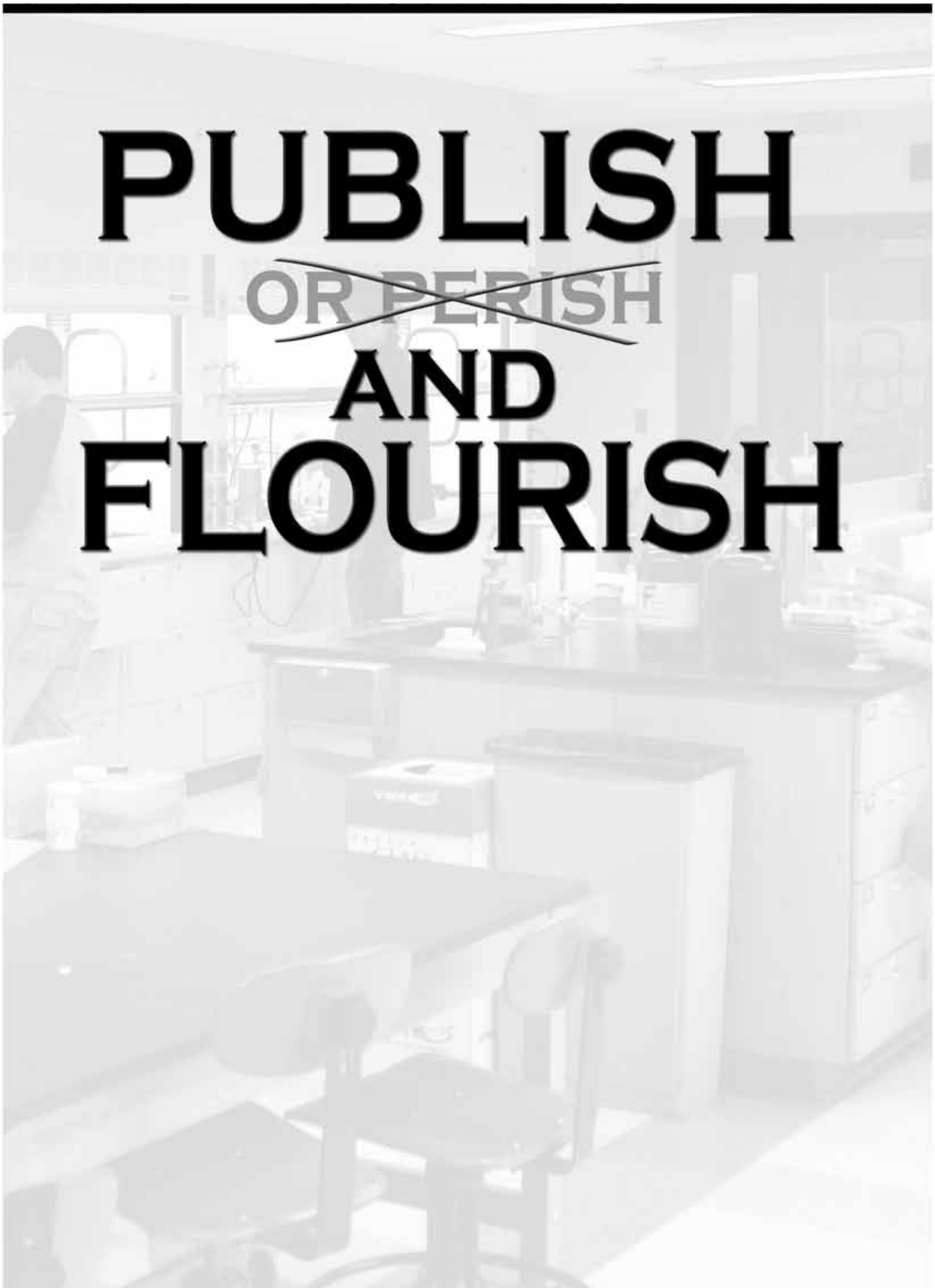

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Introduction

This manuscript is the result of a two-year quest. I wanted to determine and highlight the attributes of people who are successful researchers at undergraduate institutions and who regularly publish their results. I wanted to answer **thoroughly** the question as to what it takes to be successful as a publishing undergraduate professor.

Often, physical scientists identify one simple (but important) factor that drives researchers—"It takes a fire in the belly." Although this is a common factor that can highlight certain individuals, the concept may mask the identity of some really good but less outspoken or assertive people. What is the rest of the story? I hope to clarify what it takes to pursue a **model** research-involved career.

The characteristics of successful researchers in graduate programs will not be considered here except as an occasional side comment. That subject will be left to the Ph.D.-granting institutions. However, some of the principles herein could be of interest to researchers in graduate schools.

At primarily undergraduate institutions (**PUI**s), teaching is usually the primary responsibility. Many **PUI** professors do not regularly produce publications, even if they were hired to include research as an important responsibility. Most instructors at these schools are busy enough with just teaching and other academic responsibilities. It can seem intimidating to think **also** of doing research, writing a research proposal, then a publication, and so on. Perhaps the sum of these duties may seem like a daunting set of tasks, and a "fear factor," consciously or subconsciously, may slow or even stop the research initiative. But at **PUI**s, it is not just "publish or perish," and how much of that representation exists depends on the undergraduate institution: The best schools may push publication performance, and the weakest may ignore it. Either way, I would like to suggest a new emphasis—"Publish and flourish."

I have also given attention to the possibility that the attributes discussed can be improved upon. And, if the attributes can be improved or enhanced, how can they be, and by how much? As I read about these personality traits, I was surprised to learn that even one I thought was inborn could be "enhanced" (Creativity, Chapter 7). I am indebted to my current Dean, Dr. Moses Lee, who emphasized that I should pay attention to the possibility of improvement.

If I have compiled all this information in a way that helps some people pursue a productive research-involved career, then I will rejoice and feel that I accomplished a noble goal. At times, it may look like I have just clarified an incredible number of obstacles to such an involvement, but that is not what I intend. Many can succeed without all the ideal qualities, but being aware of these qualities can crystallize some important goals for self-improvement: The pursuit of this type of career has enormous fulfillment to it.

I hope this book provides a **forum** around which successful strategies can be debated, and that it promotes ways that lead to productive **PUI** researchers. If you disagree with my interpretations of the data I have accumulated, great! I am not surprised when different people look at the same data and come up with different conclusions. Also, I have been surprised that there are situations where the data provide distinct differences, but lack clear-cut explanations. I freely admit that I don't have all the answers. See if you can come up with some good explanations.

Chapter 1
Fire in the Belly

I began this task by asking several people what it took to succeed in research. They often replied, "It takes a fire in the belly."[1] Sounds simple, and it was said with deep conviction. This reply included the responses of prominent **PUI** researchers as well as graduate school researchers.

Even officers of key foundations have used this phrase. Our former Dean, Dr. James Gentile, now the president of **Research Corporation**, used the phrase in *Academic Excellence*,[2] an important book subtitled, "The role of research in the physical sciences at undergraduate institutions," edited by Michael P. Doyle, who was Vice President of Research Corporation at the time. In the same book, the executive director of the *Camille and Henry Dreyfus Foundation* at that time suggested researchers maintain the same "fire in the belly" in continuing their studies. Jerry Mohrig of Carlton College, one of the cofounders the *Council on Undergraduate Research* (**CUR**) suggested this as a critical factor, too.

My Experience with an Excellent Representative

I left an excellent job at the Du Pont Experimental Station to begin teaching at Olivet Nazarene University (ONU). I was not unhappy at Du Pont, and didn't have to leave, but for many years I had wanted to teach and do undergraduate research. However, Olivet Nazarene was a school with no research tradition and almost no working equipment. I had a long way to go to establish an undergraduate research program.

How would I get an NMR (nuclear magnetic resonance spectrometer) a mass spectrometer, and other equipment needed to do organic research? How would I legitimatize research at a **PUI**, especially when no research had been successfully done before? One undergraduate student researcher of mine even asked the question, "Is this [research] really a legitimate activity for an undergraduate college that is devoted to teaching?"

I went to visit Michael P. Doyle at Hope College for guidance. He was another cofounder of **CUR**. When I was at Du Pont, I consistently saw his name on publications, and he was doing just what I wanted to do. I wanted to know how he did it.

In the morning, during my visit, he took time with me, and carefully explained what he did and how he did it. Mid-morning, he excused himself to deal with his fourteen undergraduate students and one postdoc. I went to lunch, and returned to meet with him again at approximately 2:00 p.m.. He then instructed me further, and later even had me over to his house for dinner.

After leaving there, and trying to follow his leads, I had one of the most productive periods in my life. Within seven years, I had seven publications and eight research and equipment grants. I also obtained two major instruments from Hewlett-Packard through its gifts program.

I resigned from ONU to go to a different college. However, I left behind an NMR a GC/mass selective detector, a UV/Vis, an IR (their purchase as I left), a large amount of glassware, and various other pieces of equipment. Fortunately, the school let me take to my new school a high-performance liquid chromatograph (with multiple detectors) and a gas chromatograph, instruments that were critical to my research. Two of my former Olivet Nazarene University undergraduate researchers are now professors at Northwestern and Purdue Universities.

I have no regrets for leaving a more lucrative career at Du Pont to join ONU. It was a fulfilling time, and the students helped make it so. The ironic thing is that later I left ONU to go to Hope College. I'd never say that I replaced Mike Doyle. That would be impossible to do. However, I filled the position he vacated two years earlier. He had the fire and lots more (see the rest of this document for "more" stuff).

I wanted to clarify the meaning of this vague statement "fire in the belly," and I asked Brian Andreen* (a former Research Corporation representative) what it really meant. He was also one of the founders of **CUR**, and I had gained tremendous respect for him when I was on the **CUR** Council. He seemed to have a sixth sense about who was going to be a successful researcher. (Incidentally, it was at Brian's invitation that he and ten chemists met in 1977 to discuss ways to promote undergraduate research in chemistry. Out of that initial meeting came **CUR** in chemistry, and what evolved out of that is amazing—the **CUR** of many disciplines and **the National Conference on Undergraduate Research** and their merger, etc.) He replied that a successful researcher had to approach research with a passion. This term seemed like a more concrete concept and one that could be evaluated better as a contributing factor.

There are even books on this subject that sound very helpful. For instance, Charles Kovess' book, *Passionate People Produce,*[3] seems right on target. His book breaks down the idea of passion into useful component parts.

For example, he says passion is, in some sense, a burning desire that provides energy, helps clarify a person's vision, and enables that person to produce extraordinary results.[3]

Furthermore, as a by-product of that passion, one's energy can **regularly** be improved, but the person's vision and commitment to the goals being pursued must be maintained.

Persistence can result by maintaining this vision and, long-term, that is important. Too many researchers start off well, but don't continue long into their career.

Kovess also makes the important point that we need to be kind to ourselves, and not worry too much about what others think of us. For a sensitive person like me, that is important to remember.

Other perspectives about a productive **passion** that leads to accomplishments are described in Bruch and Ghoshal's book, .[4] Some of the principles they repeat, compared to Kovess' book, are included because their perspectives give additional insights. They also point out that sometimes it is necessary to forget about what other people think of you, or at least not worry much about it. If you make some mistakes, don't dwell on them: Be kind to yourself and move on.

To point yourself in the right direction, you need to ask yourself, "Am I doing the right things?"[4] After that, narrow down your tasks and ignore some that don't contribute to your goals: Ask, "What needs to go?"[4]

The authors also point out that the most critical barriers are not from outside the individual, but within. That is a tough pill to swallow, but each individual needs to accept some personal responsibility for his or her productivity, or lack of it. We should commit to a vision and go for it.

They emphasize that good results depend less on ability than they do on effort,[4] and that you must harness your **willpower** and focus it properly. If you do, it can be the force behind the energy necessary for purposeful action.

We also need to be sure we are not just spinning our wheels (my paraphrase of their discussion). This produces a very active but nonproductive action,[4] but that's not that we want. It just wears us out.

Bruch and Ghoshal[4] also point out that all people are capable of enhancing their action-taking ability and focus. An emphasis of the book is on the helpfulness that comes out of *Cultivating a Company of Action-Takers.*[5] That is the type of culture **CUR** helps facilitate, and we need to make the most of this assistance and combined expertise. Bruch and Ghoshal's[4] book outlines some very good principles on how to accomplish your goals, and more is given there than I can summarize here.

It is interesting that an incredibly popular and influential book, *In Search of Excellence,*[5] has a chapter with the same title as Bruch and Ghoshal's book.[4] In their chapter 5, Peters and Waterman state, "There is no more important trait among excellent companies than an action orientation." This book had an amazing impact when it came out. Perhaps a similar statement could be made for excellent, productive undergraduate research mentors.

Summary

A "fire in the belly" is a blanket description that we often use to identify a person who will succeed at a position that includes or emphasizes research. But haven't you observed an intense, energetic person who doesn't "make it"? Perhaps the person just has a temper. That is a reason I prefer the word "passion" to the phrase fire in the belly.

If someone has all the attributes and the passion that implies success will come. But what are the right attributes, and can they be improved on or added to a person's repertoire? This chapter began with a focus on the most common answer as to what it takes to succeed in research, and then I tried to delineate what that answer meant. It briefly and vaguely describes what I believe is a necessary but not sufficient personality trait to establish and maintain a research program.

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2. Michael P. Doyle, ed. *Academic Excellence*, Tucson, Research Corporation, 2000.
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CHAPTER 2

Psychologists call it, Achievement motivation"

Let's look to the psychological sciences to discuss the characteristics that are necessary for success in research. What is it that motivates those who have the fire in the belly?

Psychologists have studied achievement-oriented behavior (similar to what is described in this book), and they surprisingly enough call it "Achievement Motivation" (or something very similar[6-13]). Some of their findings and conclusions are very pertinent and enlightening. They have much to say about what leads to achievement, and their perspective is a good one with which to view the subject.

Some psychologists also focus in on a key feature of motivation, and use a single phrase or term that is analogous to fire in the belly, and it is "grit." This essential quality is defined as a perseverance and passion for long-term goals.[14.15] Most of the time, it is discussed as relevant to ambitious, clear-cut goals, not just any goal.

A key worker in the area even made the far-reaching comment, "One personal quality is shared by the most prominent leaders in every field: grit."[16] This grit means working strenuously toward goals despite failure, adversity, and slowdowns in progress: You need to persist despite obstacles toward major achievements.

Psychologists Martin Seligman and Angela Duckworth at the University of Pennsylvania have popularized the term and the ideas behind it. One *Psychology Today*[16] issue featured the idea as the cover story under the title, "The Winning Edge." The article discusses grit, suggests how to increase it, and gives examples of it.

Though we are typically highly educated scholars (in the physical and psychological sciences) with a thorough perspective, we have tended to focus on a single idea or concept that identifies the most important characteristic of a highly productive person. Without this, a person will not emerge from the pack. Fire in the belly or grit seems like a way to describe something about individuals who will distinguish themselves as more productive persons: ones that we want on our team. The concept describes most of the things that could lead persons to distinguish themselves.

However, grit, though it is a convenient concept, is not always easy to identify. Sometimes a person has great outward signs of it (e.g., an emotional passion), but sometimes it lies beneath the surface. It is not always recognized quickly, but can be proven over a long period of time (even 10 years[15,16] or more). One can easily think of persons who have the potential because they stand out in energy and enthusiasm, but sometimes it just doesn't show up quickly in the personality of the professor. I hope this book will help point out some less-obvious qualities. When I was a **CUR** councilor, some fellow council members showed this grit overtly, but others **quietly** went about doing their teaching and research, and were productive nonetheless.

Certain aspects of fire in the belly or grit may cause concern that people with these qualities might be hard to get along with. However, though we have all seen people who seem to almost fight for more recognition than they deserve (and hence can be difficult to deal with), it is worth noting that, in general, highly achievement-motivated people tend to be recognized as having an ability to get along with others.[9]

Distinguishing Factors

What are the factors that can be gleaned from the books and articles on achievement motivation? For example, how much of a researcher's success is due to intelligence, ability, and hard work? One worker summarized the field and estimated that variance in cumulative achievement is due 25% to true ability, 50% to motivation for the critical endeavor, and 25% to motivation for alternative activities. [10]

When the same investigator looked at the data in a different light, he concluded[10] that less than 25% of cumulative achievement is due to heredity and innate ability. This implies that we are not completely stuck with what we are born with, and that improvements can be made in research performance.

Motivation always influences efficiency in the execution of an activity and persistence in that venture. Psychologists have also asked the question:

Can achievement motivation be increased? Some reliable researchers suggest that it can be,[8,10] and one way is by taking the right attitude.

One of the books I refer to rather often reports that achieving goals is an essential for motivated people (p. 390).[10] To be internally driven by this need can be the best true motivation: This could be behind the overall performance of many productive faculty members at **PUI**s.

With a unique focus, Franken[7,13] suggests that the pleasure of achievement is in developing and exercising skills, not necessarily in the achievement itself: The **process** may provide the motivation for achievement. On top of that, as an **outcome** of research, it can produce fun, fulfillment, or both.

Franken[7] also points out that many motivation writers, particularly Atkinson,[10] say that people do need to achieve, but they also have a need to avoid failure: The desire to achieve can produce a hope to spur us on, but the fear of failure can cause an avoidance of achievement efforts. Or, an excess of fear can cause excessive worry and an uptight career striving[10] (p. 387): Even though it may result in hard work, it would be counterproductive in nature.

Stated differently, we do need a drive to overcome obstacles and also some positive expectations about the results of our research[6] (e.g, completing and publishing it), but some of this should have come from, or at least been demonstrated and developed during, Ph.D. training. However, somewhere in our career, there should be expectations of eventual success. One author has said these expectations are the greatest source of motivational impetus (Raynor, p. 372).[10]

Seligman, who was mentioned earlier, has written a national best-seller entitled *Learned Optimism.*[17] In this book, he points out that the traditional view of achievement needs to be changed (p. 12).[17] He believes that an optimistic style is a key to persistence, and that people who are chosen for challenging jobs should show three characteristics:

1. Aptitude
2. Motivation
3. Optimism.

All three, he believes, determine success. Motivation and optimism are things we can change to help us achieve more. It takes effort, but there are many books that purport to help people in these areas.

Another concept[17] he points out, and warns us of, is what he calls "learning to be helpless." Avoid it with a passion. Too often, we develop a pattern of excuses to cover up our lack of productivity. Excuses are presented as though they are genuine reasons, but are they? We do have a lot to do, and doing research is not just adding one more thing to our agenda.

As we try to identify the attributes that lead to achievement, we should still remember, as a leader in the field said, there is a "ubiquity of interaction effects." (p. 408).[10] It is not just "my way or the highway"; it can be many different ways with some similar features to everyone's journey.

Whatever criteria we recognize as necessary, there are always overachievers who outdo whatever predictions are made[10] about them (p. 397). Perhaps some people should be identified as possible overachievers. We could draw that inference if we know the person well and see some intangible factors that are going to distinguish him or her. We need consistency to do our studies, but people's success stories don't always fall into our clear-cut paradigms. Nonetheless, we still recognize achievement in our field. If we publish, we can personally enjoy the fulfillment and recognition that comes with it. We can also enjoy the rewards of our hard work, and feel more optimistic, which should lead to even better performance. This sounds like a good cycle to be in.

Finally, I will summarize and paraphrase a statement that gives an overview of the whole field of achievement motivation. It comes from a key book on the subject.[10] The summary is written in a way that requires good judgment in the application of it:

For people to achieve cumulative, long-term success in their field, they need to focus in on a single area of interest, and not be interrupted from it very often. If they are interrupted, they need to return to it soon and in a productive way. This goes for conducting research, especially during the summer, and, I believe, teaching during the school year.

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Chapter 3
Is it the Graduate School Attended?

We almost always look for a faculty job candidate with a Ph.D. degree from a top-notch university. That makes sense because we want the brightest and best-prepared faculty member we can get. But we can look at the leaders of undergraduate research and see where they earned their degrees to check this assumption. Academic pedigrees do not appear to always tell the whole story, at least for the origins of some **PUI** professors. My conclusion, after looking at all the data in the **Tables**, is that an excellent school can help, but it is more the person than the school he or she graduated from.

The American Chemical Society has records of the number of Ph.D. graduates from the various schools, and these numbers are available from their website. The number of Ph.D.s awarded by each major institution from 1996-1999 were tabulated and are listed in the **Appendix, Table 1.** These data were chosen because they could be compared with data extracted from the most recent directory of **CUR** (the 1999 *Directory of Research in Chemistry at Primarily Undergraduate Institutions)*, which records faculty research activities for 1993-1996. The number of Ph.D. graduates was then compared to the number of what we call productive **UG** researchers who publish. In the investigation of the *CUR Directory*, we looked at faculty at **PUI**s who had five publications in the four-year period the directory covered. This was done to limit the faculty members to those who produced one more than the one publication per year average[19] reported in a Project Kaleidoscope survey investigating their undergraduate science (biology, math, physics, and chemistry) programs. Though this information is a bit old, it was the most useful and closest to overlapping data currently available. A more general survey of programs suggested an average of 0.54 publications per year for natural science faculty.[20]

The Tables in the Appendix took a tremendous amount of effort to compile. They are worth studying because they have useful data for most of the graduate schools in chemistry, and worthwhile comparisons can be made that we are not discussing. Use them for your own reasons (e.g., the number of Ph.D.s your own graduate school produced compared to another one, the number of graduates that have become productive undergraduate researchers, and so on). Our discussion will be limited to the production of **PUI** researchers, and a complete discussion of the data would not allow for good flow in writing.

Table 1 in the **Appendix** shows that, not too surprisingly, the University of California at Berkeley graduated the most Ph.D.s, with 173 students earning their doctorates from 1996-1999. Fourteen of their graduates (not necessarily from the same group of 173) during 1993-1996 went on to produce five or more papers. **Table 2** in the **Appendix** lists the **number of productive researchers** produced by each school in descending order. The choice of the designation "**productive researchers" only in terms of the number of publications is arbitrary, and ranks them only by those numbers**. There are other ways to be productive in research (impact factors, raising research money).

Again, Berkeley tops the list. But how large a **percentage** of their graduates went on to be productive **PUI** researchers? Those data are listed in **Table 3**, where the schools are ranked by the **percentage** of productive **PUI** researchers produced. Berkeley does not top this list: Iowa State does. Stated differently, ISU was 14th in terms of how many chemistry Ph.D.s it awarded, but was second in the number of productive undergraduate researchers it produced.

The school that produced an unusually high number of productive **PUI** researchers is worth noting.

I asked Iowa State's Professor Walter Trahanovsky, Dr. Michael Doyle's Ph.D. advisor, about why the school had produced more than its share of productive undergraduate researchers. He seemed to feel that ISU **attracted** more students that were interested in this type of profession, particularly if they liked research, and wanted to continue doing it. After all, ISU has always emphasized research. This same thing can be said about many graduate schools of the same caliber, so there may be subtle factors at work here.

I asked Dr. Ron Blankespoor of Calvin College, one of the productive **PUI** researchers, if going to ISU for his Ph.D. had made a difference in his choice of a **PUI** career and his success at research. After all, he earned his Ph.D. at ISU within three years of when Michael Doyle did. However, he did not feel he gained the difference by going there. But he had gone to Dordt College for his bachelor's degree, and the successful **UG** research he had done there at a school, even with limited resources and equipment, was an important factor. He felt strongly about this. That is interesting: small program but big effect. Take note of this, small schools.

I had a similar experience at Pasadena College (which moved to San Diego and became Point Loma Nazarene University). My advisor and undergraduate research mentor was Dr. Victor Heasley, who now has more than 80 publications. He definitely had a fire in his belly. This had a major impact on me. Fortunately, the college was still in Pasadena, close to Cal Tech and Jet Propulsion Labs: This helped, too. The culture, library, and equipment available close by at these places influenced me.

Two Related but Intangible Factors

If high-quality institutions attract only the best students, is it a surprise that they produce the best? It would not be hard to produce the best if you only start with the best. Alternatively, did the school do the best job of training its students? That can be a different question. The schools that attract the best students can be gratified by their reputation: the ones that attract the outstanding graduates. However, they should give attention to whether or not they **prepare** the students best.

A second, less obvious point is that **students learn a lot from one another, not just their teachers**. When I interviewed for a job with Du Pont, I pointed out to the recruiter that though I went to a less-recognized school for my Ph.D., I worked for someone who had earned his Ph.D. under Harvard professor R.B. Woodward, and that some alternative professors I could have chosen had also earned their Ph.D. under famous chemists at top-ten universities. He responded that he was concerned about the level of students that were around me, and how much I learned from them (relative to the students at, say, the University of Illinois). I didn't have a good response for him because some of them were not as motivated as students at the more-recognized schools. I wish I could have responded to his concern better. A part of the value of a high-quality school is the environment and learning interactions created by excellent students. This is overlooked too often. Fortunately, most of the professors at my graduate school had had an open door policy, and I learned a lot from them.

An intangible factor that can play a large part in a **professor's** productivity is the idea of being a "finisher." Many people start things but don't finalize them. My colleague Will Polik brought this up as a key to being a productive researcher. He said that at U. C. Berkeley, where he earned his Ph.D., you were expected to finish your research and also to write it up for publication as an important, final step in the overall training process. This is good to emphasize, and the expectations also help to motivate in an important way.

Explanations:

The data on productive undergraduate researchers are debatable, and the threshold of five publications in the four-year period s**hould be based only on manuscripts published with student coauthors, but that may not be the case**. In the *CUR Directory*, student coauthors are supposed to be indicated with asterisks, but that was **often** overlooked (presumably by those submitting their data). This made reliable data in that area (student-coauthored papers) hard to assemble. Also, some of the publications counted were done based on postdoctoral and doctoral studies (see reference 19, which cites a similar problem), and that is hard to distinguish, too. Accordingly, the number of productive undergraduate research professors was based on the total number of publications, be they student coauthored or not (determined from the 7th edition of the *CUR Directory*). Productivity should be recognized whenever it is achieved. If some people were recognized with more credit than was due them, so be it. We recognize that some productive schools did not surface as a result of our thresholds. I am sure there are some (schools and people) out there who will remain "under the radar," but still deserve a pat on the back. Sorry if this didn't do it.

Also note that names are not used in the tables, though you could find them in the *CUR Directory* after some digging.

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21. The average publications per year are misleading because some **PUI** professors never publish, and this would skew the figures.

Chapter 4
What About "Publish or Perish?"

When a student or faculty member discusses what gets a professor ahead in a competitive graduate school, the idea of "publish or perish" often comes up. It is a convenient and informative concept.

It seems like a harsh statement, but the really top-notch, research-intensive graduate schools seem to have that in mind when a professor pursues tenure or advancement.

Many schools also take that into consideration when they evaluate prospective faculty members: It is hard to ignore a candidate who has a long list of publications. Even in the smaller universities and in predominantly undergraduate institutions this can be so. This is an easily quantifiable criterion. It is hoped the articles cited will have a significant impact on the professor's field.

But at most **PUI**s, excellent teaching is usually the most important factor in promotion and tenure. Certainly many faculty members at these types of schools publish regularly, but that makes them kind of special. It is not "Publish or Perish"; it is that they "Publish and Flourish."

This title phrase of this section certainly implies that "publications" are important, and that is good. It is a phrase that has been in the back of my mind for many years. I have always tried to publish my research results. More importantly, I have always tried to get the students responsible for the research listed as coauthors.

So how do we live on, and not "perish"? We don't necessarily live on through our publications. In twenty years or so, they may not be read or even looked at. Some of my articles bring up a sense of gratification, but it is our students who go on and keep our influence alive and well.

We live on through our students and, furthermore, all teachers have students who have outdone them. Thankfully, previous students don't become our competitors; they become our best products.

I spoke with Mike Doyle recently, and the name of one of his former **PUI** researchers came up: Dr. Jeffrey Bode. He is now a professor at the ETH Zurich (ETH Zürich - Eidgenössische Technische Hochschule Zürich) in Switzerland, one of the premier research institutions in the world. He also produced students who are at other research universities, including Stanford and Washington Universities. I already mentioned my two students who are now at top-notch universities. Moreover, other faculty members named in this document would have similar stories.

With a nonacademic focus in mind, Dean Moses Lee and I shared stories with one another about **PUI** researchers who have gone on and done extremely well in pharmaceutical companies. They can make valuable contributions to health and important medicines, even though their contributions may not become public knowledge.

For example, Dr. Roger Brummel went to Calvin College and did **UG** research. He ultimately became Vice President of Chemical Development at Parke-Davis, Holland, and Vice President of Pfizer, Ann Arbor, until 2001. Under his leadership, the large-scale synthesis of Lipitor was developed. It has been a top-selling therapeutic drug, and a real success story.

It is important to emphasize that publishing research is **not** the only way to contribute to the vitality of a **PUI**. Committee work, planning new courses or improving existing ones, and other service works are necessary. However, over-involvement in these ancillary activities can occur, and that is not helpful toward research productivity.

Physical scientists need reliable criteria to predict who will produce research and publish it in peer-reviewed journals. It takes more than just a "fire in the belly." That cannot be the only factor in considering a candidate: We need more assessment tools for evaluation processes. I hope this book will provide additional useful criteria.

An analogy: We have all heard advice about health matters, and it usually includes the advice to "eat right and exercise regularly." For me, research forces me to keep healthy professionally: Eat right (or read in my area), and exercise (do chemistry) regularly.

CHAPTER 5

IS IT MULTITASKING?

Doing research is not just adding one more task to your already demanding teaching schedule. You will need to write successful proposals to get the money to do the research, and you will have to write reports on how you spent the funding agencies' money. Unfortunately, every funding agency has its own format for proposals and for reports. To prepare reports that meet the agencies' varying requirements demands real flexibility and hard work.

If you don't publish the work, you may not get a renewal for additional funding. The phrase "publish or perish" still applies loosely. Journals also have their own rigid guidelines for formatting. Elsevier wants it one way, and the American Chemical Society wants it done differently, for example. Unwritten and intangible guidelines abound in the rumor mill about what is valued by each funding agency.

Recruiting good students is also required, and that may take some different skills. It is not too difficult to get some students to present their work in posters or in talks at various meetings, but they need guidance. That requires your time and attention.

The faculty member needs to present his or her work at meetings, too, which takes preparation and practice time.

These additional responsibilities, on top of lecture preparation, committee work, advising, and grading, may sound intimidating, but many people have done it, and have succeeded to become productive researchers. It can be enjoyable, and not stress-inducing, as long as you enjoy it and are fulfilled by it. Again, summers should be dedicated mostly to research and research-related activities such as grant writing and publication preparation.

Interestingly enough, Professor J. Fraser Stoddart in a discussion of his A. C. Cope Award (C&EN, February 25, 2008) mentioned his knowledge of multitasking as a key to his productivity. He learned it in his experience on the farm, of all places, in his youth. Since he has over 800 publications, he seems like someone we could look to for good insights.

If we don't go by a correct definition of multitasking,[22-26] what he suggested may be misinterpreted. I spoke with one of Dr. Stoddart's former postdocs, who thought he would do almost nothing but write during his postdoctoral study. He was surprised when he observed that Dr. Stoddart wrote many of his own papers. He seemed highly impressed by Dr. Stoddart's **focus** during his productive periods of writing.

Certainly highly productive people can handle many tasks, but do they do it by handling many tasks at the same time? Researchers in the area disagree on some things, and the research is in a state of flux, but it clearly shows that **doing more than one thing at a time can come at a cost.**[22-26]

Multitasking is a popular term to use these days. When I asked chemists in the hallway of the science building at Hope College what it meant, at least half of them said: "It means doing several tasks (or at least more than one) at the same time." This also seems like the way multitasking is defined in the popular press.

However, a key article on the subject points out an important question:[22] "How can a time-management strategy that has been become part of the common wisdom actually be so off base?" The bulk of the research indicates that the minute you start to do more than one task at a time, the first one becomes less efficient, and the second one suffers as well. A Johns Hopkins University study[25] (entitled "Can We Really Multitask?") even uses this point to argue against using a cell phone while driving (I agree).

When I asked one of our psychologists at Hope, Dr. **Thomas Ludwig,** what multitasking really was, he gave insightful descriptions. The Psychology Department thought he was the most knowledgeable on this subject. The following is a paraphrase of his comments:

True multitasking, in the form of parallel processing, happens constantly in the brain. For example, when we merge onto a busy freeway, our brain is simultaneously tracking the location and speed of several different vehicles. But the task of merging requires our full attention. If we tried to merge while multiplying numbers in our head, our performance on both tasks would suffer. Attention is a limited resource: We generally can only apply focused attention to one task at a time. Therefore, some of what we think of as multitasking is actually fast-attention switching. Parallel processing (i.e., multitasking) can occur in the brain, but attention is a selective factor.

So, if two tasks both require constant, significant attention, we probably cannot do them well simultaneously. On the other hand, if the tasks require intermittent attention, we could successfully perform both tasks during the same time period, by switching attention from one task to the other when needed. So, a chemist's multitasking can involve running a reaction, while writing up the procedure in a lab book. These tasks involve different brain circuits, and some creativity is needed to plan out how to do them both at once. These tasks are not too similar, and therefore can be done well during the same period by alternating attention between the two tasks. This increases output, and at no real cost to quality.

However, even toggling[22-24] between tasks takes time and effort. Perhaps this is where a significant difference in productivity comes: Can some people switch between tasks faster or better than other people? I believe so. That assumption explains the productivity of many people.

Think back to my hallway survey: The other "half" of the faculty members suggested multitasking means "working on several tasks within a given time period" (not necessarily at the same time). This definition seems more reasonable when you look at how the human mind works and it is probably more helpful in understanding why some researchers are more successful than others.

Doing research and publishing gives you clear-cut, focused objectives. Yes, you need to do experiments, work with students, and communicate the results (and in different ways), but it is all done with highly focused objectives. These seemingly dissimilar tasks (experiments, formal writing, oral presentation) all narrow into a final goal of presenting and publishing your results. You must focus the experiments to make a story that is publishable. The focus leads to a measurable goal that gets into print and communicates what you are doing. The priorities are forced upon you through the publication process. If you are goal- oriented, this helps the final product output (publications)!

I include a very personal illustration that I believe clarifies some important things about multitasking. I have multiple sclerosis (MS). After I was finally convinced that I had it, I began to commiserate with a former undergraduate classmate who also had it. He was now an incredibly competent M.D., but was forced out of practice by MS. His description of the intellectual progression of the disease was that we slow down, but don't lose our natural intelligence. We also begin to be like a switchboard that has fewer connections. That can be a descriptor for a reduction in multitasking, and it seemed to be going on in my life. The extreme fatigue brought on by MS also proved challenging. I finally quit research, and was encouraged to do so by some who observed me. It was tough to do, but it seemed realistic. By either view of multitasking, I was less effective.

In summary, some time management skills are necessary to accomplish the many seemingly competitive tasks of being a productive **PUI** researcher. These overall accomplishments require a disciplined organization, wherein patterns of behavior are established and exercised. A person should be comfortable with many different tasks, but be able to focus on one in particular at a given time. People doing these things need encouragement such as a pat on the back from colleagues at school, from professional sources, and from recognition. Also, it will take less energy if a person finds a groove (establishes "flow") in the performance of these tasks.

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CHAPTER 6

WHY TEACH AT A PUI?

Some people could do well in just about any scientific vocation. Why would someone choose to spend his or her career at a **PUI**, especially if that person had enough ability and high-quality training to succeed as a graduate school professor?

Hope College has a professor who earned a bachelor's degree from Dartmouth College and a Ph.D. in physical chemistry from the University of California at Berkeley: His training and innate ability in his field could not have been better. Let's see, in his own words, why he chose Hope College (a **PUI**) instead of a prestigious university for his career. Stephen Taylor emailed this to Will Polik on September 2, 2008, at 11:17 a.m.:

> Will,
>
> You were very successful in an excellent graduate school. Some people would have expected you to pursue a career as a graduate school professor. Why did you choose an undergraduate school?
>
> Steve

This was his email answer:

> Steve,
>
> At the moment, we are on our way to Australia, awaiting our trans-Pacific flight in the Los Angeles airport. I will reply now, as it could be quite awhile before I have internet access again.
>
> There were many reasons why I chose an undergraduate institution over a graduate institution, but the main reason is one

> of "BALANCE." I wanted to work at an institution that both truly valued undergraduate teaching and offered genuine opportunities to do research with students. I also wanted an institution where I felt that my work and family responsibilities could be balanced. While graduate institutions generally claim that they value teaching, tenure decisions are typically based almost exclusively on research. Also, while undergraduate institutions generally value faculty doing research with students, most do not offer appropriate resources (time, supplies, student interest, funding, etc.) for faculty to be productive, which is evidenced by faculty research publication records.
>
> Hope College is one of maybe 20 undergraduate institutions that support faculty research well. Hope has allowed me to excel in both teaching and research. And Hope values hard-working but life-balanced faculty. It is a difficult combination to match! So my choice was not for an undergraduate institution per se, but rather for an institution that allowed me to meet my professional and personal goals.
>
> Will

This is an "aside," but isn't it wonderful that we can take a sabbatical leave (in academia in general) to achieve personal and professional balance and development? This came from Dr. Polik en route to Australia. This is a special benefit available to those in college and university professions. We should be thankful for that, and also make the most of it. This perk helps us avoid burnout and "the same old job" malaise.

When I asked another professor at a prominent **PUI** why he chose this route, and yet did research successfully, he responded that it took the "Eye of the Tiger" (a song from a *Rocky* movie, or just another way of expressing "a fire in the belly"), but he resonated highly with the idea of balance. That word, and the ideas behind it, has been a key concept in both my professional and personal life. I wanted to devote enough time to my family, my professional responsibilities, and my course work.

During the school year, I emphasized the teaching responsibilities—they were important to me. During the summer, I switched to making research the priority. To be good at both teaching and research requires diligent, hard work year-round. Being able to balance the tasks mentioned in the previous chapter is important, but it is also **important to be able to switch back and**

forth to the priorities that are to be balanced: from teaching priorities during the school year to research priorities in the summer.

Fortunately, undergraduate investigators do most of their research during the summer, usually a time when teaching responsibilities are at a minimum. This eliminates most of the excuses we put forth, including the perception that doing research adds too much to what is already a juggling act. But **it is critical that we preserve the majority of the summer for undergraduate research!** This time needs to be protected if we plan to do research.

Other Benefits of Teaching at a PUI

Mike Doyle had an unusual gift of taking struggling students and motivating them through undergraduate research.* I still remember when I visited Hope College to see how he achieved so much in undergraduate research. During the visit, I talked with a student who was incredibly thankful for the chance to do research, even though he did not excel in organic chemistry class. Mike's gift in this way was unselfish, and it showed a genuine concern that he had for the student as an individual, relating to him as more than just a pair of hands. This clearly helped the student. And the story illustrates another benefit of a career at a **PUI**: relationships.

Relationships

Close relationships are a key to the difference between a major university setting and a **PUI**. In a large university setting, this type of student may not have been noticed and become involved in research. At a **PUI,** this same kind of student would be more likely to have contact with professors, chemistry majors, and teaching assistants. This may not always be the case, but the probabilities would be more favorable at a research-rich **PUI**. Also, we know that there are students who are good experimentalists even if they are not good at taking tests. These students could emerge more readily in a smaller setting.

Another factor that our current dean, Dr. Lee, pointed out is that students are impressionable at the college age. The research-rich undergraduate environment will attract and inspire many students at this time in their life. Jerry Mohrig (another **CUR** founder) states that the right culture, where

* A former dean of the college, Irwin Brink, pointed this out in a history of Hope's Chemistry Department.

research is seen as of value to students and faculty, is another major factor in success in undergraduate research. Students could encounter the effective research culture at a **PUI**, and it may even occur without them being aware of it. However, if it is there, it will have a definite and positive influence.

I would like to emphasize the possibility that relationships and the beneficial outcomes of them can be fostered more easily in a **PUI**. This can be a strong advantage to teaching and learning at a **PUI**.

However, if two people are not likely to get along, their potential for conflict could be exacerbated in a small department. The chances of a clash would be more likely to occur in this smaller setting. Persons should evaluate the people they would work with before accepting a job. They should ask themselves about how they would fit in, would someone rub me the wrong way, and so on. If they are already employed where there are conflicts, some adjustments should be made to minimize those problems. This may require some good, outside advice from professionals in areas of psychological expertise.

CHAPTER 7
CREATIVITY

People who are very creative are quite likely to come up with good ideas for research. This seems obvious, and it makes the study of creativity worth consideration. Here it comes.

I have had an interest in creativity since my freshman year in college, when I wrote a term paper on it for my psychology class. But for this chapter, I wanted to be more thorough and even start from basics: I looked up the term in my dictionary, which defines creativity as "the quality of being creative." **Thanks a lot**! When I looked up "creative," it didn't get much better.

The books[27-31] I used to study the subject did not come right out and define creativity, either. An exact definition might narrow the study down to just things within the scope of a restrictive definition: The lack of a specific definition could be good, and allow an openness and expandability to the subject.

How important is creativity to society in general? The book I consider the most scholarly[27] of those I consulted said, "Without creativity, it would be difficult indeed to distinguish humans from apes." (p. 2). Though this quote is taken out of context, it dramatizes the importance of creativity, and suggests it is more than just one of my favorite topics. Don't ask me to justify his statement, but it was made by scholar and professor Mihaly Csikszentmihalyi of the University of Chicago.

I have known creative people, and wondered how they got that way. Some people believe that creativity is an inborn trait, not something that can be changed or improved upon. But Csikszentmihalyi's book *Creativity*[27] has a special section (Chapter 14) on "Enhancing Personal Creativity." The assumption inherent in that chapter has to be that you can at least improve on what you already have.

Another reference book[28] I used was a compilation of the works of approximately twenty creativity coaches, all of whom make their living *Inspiring Creativity*. This book offers insights and ideas on successful creating. Although the book stresses artistic or social science creativity, it has some excellent general suggestions on how to improve your creativity. Apparently, the view of a fixed, innate amount of creativity is incomplete**.**

A thorough book[27] on the subject has many examples of how creative insights have produced artistic and scientific breakthroughs of all kinds (including those of Einstein and many scientists).

I'll get to the subject of creativity in research, but first I'd like to talk a bit about **creativity in teaching**. Some professors give very good lectures, but they seem to be "right out of the textbook," and sometimes they are. The textbook is chosen because it communicates very well, and following its organization and content can save time and insure good communication. However, relying on this approach too much may minimize the contribution of creative approaches to teaching chemistry.

One of the positive statements on my teaching evaluations was that I brought in interesting and specific applications of the chemistry I learned during my experience in research at Du Pont. Yes, the textbook says Nylon is a polymer, but how was it invented and why is cold drawing so critical to its practicality? Usually, the inventions you could talk about result from creative or serendipitous breakthroughs that are interesting. Sometimes the students are literally wearing and/or sitting on the chemical that you are lecturing about. That applicability makes the science more meaningful: Tell the students about it. They are illustrations of creative processes, and you can use them to "jazz up" your teaching—that is creative teaching.

You may argue that this could take too much time and effort, and that you have no such experience. But the advent of Google or Yahoo makes those arguments less convincing. You can type your subject into the search engine subject box, and in seconds have a host of "hits" that you can draw from. I just did it for "polyesters," and a lot of pertinent information came up in seconds (or less). Wikipedia can be an excellent resource, too. A professor can use creative approaches to spice up lectures, which would increase fulfillment in the teaching of science and can reduce boredom for the students.

But what is **creativity in research**? The description I'll use is that of the psychologist Csikszentmihalyi, who[27] suggests "it is a process by which a symbolic domain in the culture of the subject is changed," and that it usually involves the crossing of boundaries of domains. (pp. 8-9). The best example I can think of is that when I was in college and graduate school, nonclassical ions were the subject of hundreds of papers and the source of heated debates in physical organic chemistry.

Hyperconjugation was not highly reported on or discussed as a widely accepted idea in this domain. However, Frederick R. Jensen of UC Berkeley resolved the hot issue of the 2-norbornyl cation by explaining its rate of formation in terms of hyperconjugation.[32] This breakthrough essentially eliminated a domain and made the idea of hyperconjugative stabilization viable. Now you will read about it in organic chemistry textbooks.

It is too bad that his creative breakthrough was not attributable to him specifically. But the domain was changed, and it took a creative leap that crossed some real boundaries into a previously less accepted domain.

The example of Jensen is one involving a faculty member at UC Berkeley, a large, outstanding graduate school. However, Corwin Hansch,[35] known as the pioneer of QSAR, or Quantitative Structure-Activity Relationships, was a faculty member of a **PUI**, namely Pomona College. He has been one of the most cited chemists in the world, and an entire journal is devoted to this field.[35] (he started at Pomona College in 1946 and the Web of Science records that since 1955 he has been cited 12,456 times.) This example shows that undergraduate researchers can have a transformative impact on their field.

The story of Jensen's breakthrough illustrates two key requirements of creativity: novelty and risk. The solution was a novel approach, and it was also in an area where two of the major players of the previous theories were incredibly prominent (one was a Nobel Prize winner). Would he be discredited by these prominent (and strong-willed, I believe) researchers? No. His work stood the test of time.

I was surprised when a professor at Occidental College and another at Harvey Mudd emphasized that undergraduate research taught them that they **could take risks, and that learning that was a key to their success**. As I mulled over this assertion, I remembered that to succeed in research, you need to write proposals that can be turned down, and write papers that can be refused publication, but I had just put my head down and started the required processes. I thought of them as requirements, not risks. But they were. And if a person takes himself too seriously, that would not be good.

The willingness to take risks can lead to what several writers have called "luck."[30] Many have experienced this type of thing in research, when we do our experiments and serendipitously the results turn out better than we had hoped for or planned. This argues that if we do many experiments, we will have a greater probability of "having a lucky break."

When I started out in research at a **PUI**, I tried to rearrange a medium ring compound in the solvent toluene. Surprisingly, the compound reacted with the solvent. In the process of the rearrangement, it also underwent through-space ring closure and a Friedel-Crafts reaction with toluene—a highly selective one (Friedel-Crafts reactions are not normally selective). This reaction became one of my favorite areas of research. I wish I could say it resulted from my foresight and research acumen, but it came because of "luck."

The pursuit of research resulting from "lucky breaks" can be a way of avoiding the pitfall of making a domain too rigid.[27] Although we need to establish an area of research expertise, we should be open to a new area that broadens our interest and output.

In his excellent book on *Creativity,*[27] Csikszentmihalyi describes the 10 traits of creativity (pp 58-76), and also describes the nine states of flow (p. 110-113). These are worthwhile summaries, and they can be very useful to think through. Csikszentmihalyi has also written a book[34] on *Flow,* too, and it is a useful resource.

In a piece of advice, Csikszentmihalyi suggests we should be comfortable with idle time (p. 99).[27] Maisel suggests we let ideas incubate,[30] or give them time to develop and grow to fruition. There may not be the time unless you make it. Take time for rest and relaxation: Constant busyness is not good.[27]

To have the best chance of creativity, there should be a good environment for it. At Hope College we have weekly seminars, and these may help to generate creative ideas. They also involve connecting with people who are doing research, often at highly recognized schools. We have a strong commitment to the seminar program. This also gives us a chance to get other professors' perspectives, another way of promoting creativity.[30] If there were no seminar program, I'd go to seminars at a nearby university.

We should never stop exploring.[4] and this I hope this document can help promote that. If we are physical scientists, usually we have definite ideas and proofs for much of what we teach and believe. However, we need to think and get out of our "box" and come up with some new ideas.[31,33]

If this subject interests you, you can search the internet under "creativity" and add another term to it (e.g., "sustaining," "enhancement," or "quotes") into the search engine, and you will find a lot to read about. Be selective about your choices.

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33. Ref. 31 also has an excellent section on Self-change (Ch. 16) and asserts that all change is self-change.
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35. (journal) *Quantitative Structure-Activity Relationships.* See especially Vol. 7, issue 3 for an editorial acknowledging him as the pioneer of QSAR.

CHAPTER 8

Multiple Interacting Factors

A favorite among the books I read while preparing this manuscript was *Building the Bridge As You Walk On It,*[31] by Robert Quinn of the University of Michigan business school. His approach of improving while you are "on the bridge" gives a great perspective. He also brings out some interesting and helpful paradoxes:

Excellent leaders often exhibit two seemingly opposite traits, and they can generate more positive outcomes than those who have just one of the attributes. For example, someone who exhibits "tough love" will ideally be "both assertive/bold and yet compassionate/concerned."[31] (p. 89). These may seem like opposites, but the author regards the combination of these traits as being a creative state (p. 89). For our purposes, a "fire in the belly" may connote someone who is bold and assertive, but by itself that can bring about conflicts among faculty members and/or students. That trait needs to be balanced with a concern for people.

Usually we regard these states as mutually exclusive, independent attributes. For example, the book points out that the data of many studies showed a **high beneficial correlation between task orientation and a concern for people, but because of our tendency to think of these two attributes in separate categories, investigators didn't see the correlation** (pp. 90-91). I regard this insight as critical to an effective research-productive undergraduate professor or undergraduate institution. We can't ignore our students, who may pay $30,000 a year or more for their education: They must see the value of their education. They will see the value better as they learn and do research in a productive setting where "learning is best achieved by doing science" (a favorite statement of Hope College's Dean of the Natural and Applied Sciences).

Three things can follow an appropriate commitment to research: (1) a "fire in the belly" that gives enthusiastic direction, (2) a student-centered commitment that gives the proper focus, and (3) a research environment that leads to a creative state, or at least improved creativity. These three benefits of an ideal undergraduate research program create better than a win-win situation.

It is easier to think and write about separate topics, and that is why we do it, but somehow the combination of these traits needs attention. Remember, in Chapter 2, I quoted a book (ref. 10) that said there is "a **ubiquity of interaction effects**." That was a blanket statement that lacked illustrations, and it exemplifies the difficulty in discussing these interacting effects.

1. The Task Orientation: Research

Think about Mike Doyle and his career. Early on, his research was very good, but now it is state of the art (he is now Chair of the Department of Chemistry and Biochemistry at the University of Maryland) and he is a leader in enantioselective synthesis. Picture also someone like Professor George Whitesides, a recognized leader of chemistry in many areas. I am also amazed at his creativity at interfaces of chemistry and other fields. He has been more and more recognized for these ground-breaking accomplishments as his career has progressed.

2. Concern for Students

Remember that Mike Doyle was concerned about his students, even the ones who did not excel (p. 31). He told me to disappear for a short time while he dealt with his 14 undergraduate students and one postdoc. He was committed to them as persons, and also to their research.

Dealing with students is certainly the focus of **PUI**s. As William Daub of Harvey Mudd and Don Deardorff of Occidental College said, we are concerned about the research, but the outcome has the benefit of the students borne in mind. Students sense that the research is not just for research's sake, it is also to develop them. At the same time, it is intended to contribute to the body of scientific knowledge. The balance varies with the individual, but both the learner and the science should count.

3. The Outcome

Why are Mike Doyle and George Whitesides growing in stature and recognition as they progress through their careers? Usually, you would expect a slow-down as people age. Not so with them.

At the risk of being speculative, I would say that their creativity is improving with time. As was summarized from the *Handbook of Creativity,*[36] "It is possible that creativity is not a general ability or process, but that creativity behaviors and products emerge when a competent and knowledgeable person is motivated to engage in a cumulative effort over a long period of time."[36] Is their creativity improving with time, as the statement suggests? They are certainly knowledgeable and competent, and I believe their creativity and output are greater now than at the beginning of their careers. As it says on page 9 of the *Handbook of Creativity,* "Creativity may not only require motivation, but also generate it." Perhaps they are motivated by their creative output of research. The process is not a vicious cycle, it is a synergistic one. Motivation and confidence are increased, productivity is increased, and interests are broadened, too.

For an additional perspective, I'll quote writers Collins and Amabile,[36] who say, "One thing we can conclude with confidence is that love for one's work is advantageous for creativity." (p. 308) A love for one's work can lead to a feeling that "I am not working, I am having fun." That is an ideal state, but approaching it can help our work situation, which should result in higher productivity and a lower likelihood of burnout.

A study on the "Benefits of Undergraduate Research Experiences" was summarized in *Science* in 2007.[38] In it, the research experiences were found to give increased understanding, confidence, and awareness. The full article can be obtained by email from susan.russell@sri.com. The conclusion section says, "…the inculcation of enthusiasm is the key element—and the earlier the better." In the writing of this book, I encountered the word "enthusiasm" rather often. Here, it says it is the key element.

Creativity can motivate, provide ideas for research, and stimulate the work. It feeds on the cycle of synergy flowing out of a love for your work. Is it just one thing that leads to a productive undergraduate researcher? No, it is several. It is not just creativity, enthusiasm, hard work, a love for one's work, a task-centered or a student-centered personality, it is all of them. And if you are short on one of them, make up the difference by emphasizing one of the important ones (e.g., hard work or enthusiasm).

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CHAPTER 9

Collaboration

Conducting scientific research requires expertise, time, financial resources, equipment (expensive or not), and raw materials (chemicals, specimens, animals) Some of the expensive items may not be available on a small campus. Active programs require a lot of things, not just a "fire in the belly."

There can be needs that are best overcome by establishing collaborations with a neighboring college, university, or national laboratory. An extreme example is that of two colleagues at Hope College who use a particle accelerator for their research. Dr. Graham Peaslee and Dr. Paul DeYoung are part of the Modular Neutron Array (MoNA) collaboration that built and uses a sophisticated detector at the National Superconducting Cyclotron Lab at Michigan State University. This required the establishment of a relationship with the facility, and that took some sustained funding from the National Science Foundation. However, the result has been remarkable: Since coming on line in 2003, 16 different experiments have been conducted with MoNA and more than 85 undergraduates from 15 institutions have been actively involved with MoNA construction and experimentation. This work has resulted in 14 Hope College publications in peer-reviewed journals (three with undergraduates as the lead author), and over 70 talks and presentations at professional meetings. As evidence of the positive outcome on the lives of these undergraduates, 26 of them have already entered graduate school in physics, engineering, or chemistry.

On a less dramatic scale, many schools don't have a high-field NMR and need to reach out to a neighboring school. Fortunately, many colleges do have one, and they can be approached for help. Hope College has received a grant to support the purchase of a second 400 MHz NMR; these instruments are central to our active program. Other instruments that are essential for a research effort may have to be located and even used at another campus.

Again, when I first started in research at a **PUI**, I had little equipment that could be used. Fortunately, I found help on high field NMR from Dr. John Grutzner at Purdue University. The instruments were excellent and his expertise far exceeded mine, and I will always remember him as a key person who helped me succeed in undergraduate research, both at Hope College and at my previous school. It was not just a one-way proposition, because I later sent him one of my best undergraduate researchers to pursue a Ph.D. at Purdue under him. He now works in MRI for General Electric. That was a win-win situation.

While I am on the subject, I want to point out one of those nonquantifiable, intangible factors that lead to success in research. The platitude, "No man is an island," is very pertinent to research success. We should never forget the contributions of associates in this game. We acknowledge the foundations and other sources of financial support, but it is too easy to forget the people who made things possible. For me, one summer I had decided to collaborate with Dr. Frank De Haan at Occidental College on the kinetics of some Friedel-Crafts reactions. He routinely did this, and I hadn't done any kinetic investigations. He allowed my students to work in his lab, provided expertise, a constant temperature bath, and GC for the experiments. A publication came out of it, and it was one of my favorite studies (a linear free energy plot, or functional group effects study). Frank and I served on the **CUR** council together, and he had a major impact on me at that time. Our Research Corporation grant also paid for a considerable percentage of the travel expenses for four students and me for the trip from Illinois (Olivet Nazarene University) to Occidental College in Los Angeles, where the research was done.

At that time, I met Dr. Don Deardorff at Occidental, who had recently finished a postdoc with E. J. Corey at Harvard. He was incredibly helpful on the organic chemistry aspects of the research, whereas Frank De Haan was a physical chemist and an indispensable help on the kinetics side of the experiments.

I have recently spoken with Dr. Michael Hill of Occidental, who has published over 70 papers on his research. I learned that he collaborates with Professors Harry Gray and Jacqueline Barton of Cal Tech. I thought his productivity might be the result of his benefitting, in a one-sided way, from the help of these famous professors at this excellent institution. However, it is a symbiotic and intellectual collaboration, and the professors at Occidental and Cal Tech actually share expertise and even students in the different environments: It is not just a one-way arrangement.

It is fairly common for a husband and wife team to teach, and husband and wife collaborations can have unique advantages and challenges (when are the advantages and challenges not coexistent?). The existence of these options is covered in Sophie Rovner's excellent article, "Two-Body Solution," in *Chemical and Engineering News*. This is a must-read for couples who are considering a dual career option. See the Bibliography for the full citation of this article.

CHAPTER 10

To Much work? Make it a Hobby or a Passion

In a previous section, hard work was mentioned: This is important enough to be repeated. Also, hard work in erratic spurts is not enough: It must be sustained for significant periods of time: perseverance.

I enjoyed research, and did not consider it a second job (on top of teaching). It was something I felt fulfilled by, and summer research was a way to avoid the monotony of "nothing but teaching." It just made sense that I should pursue it. There was no great philosophical debate or jolt out of the blue, just an intuitive "go for it!"

I know of teachers who work at a second job in the summer, such as painting or carpentry. However, those were not interests I wanted to pursue.

My wife said, "If you couldn't do research, you'd go nuts." Well, I haven't done research for a few years now, and I hope that hasn't happened (but don't ask **all** of my colleagues about it). But, look at what I am writing about! Maybe she is right.

Someone who knew I was committed to research tried to "nail me to the wall:" He said, "I want a definite answer, which do you like most, teaching **or** research**?!!!**" My answer was, "**Both.**" I believed I was doing the best job as a professor when I was doing both. My students benefitted more by doing research, too. The data do not suggest that you become a "better teacher" (e.g., better lecturer) by doing research, it is just that the opportunities for positive influences increase with it.

When I asked a friend about developing a hobby for fulfillment (and a distraction from "work"), Don Deardorff of Occidental College said, "Research **is** my hobby." That is a nice way to think of it, as long as you put the effort into doing a thorough job and following the rest of the things that make for good research. It would be hard to sustain research if it were viewed as a second job on top of an already busy teaching job. But it can be a very manageable "hobby," and one you can love and do with passion.

However, most of the progress will be made in the summer when little or no teaching competes. This mitigates against real or perceived "overload." Also, a love of the job can make it less like work, and more like a hobby or passion.

Nobel laureate Thomas Cech has written an excellent article entitled, "Science at Liberal Arts Colleges: A Better Education?"[39] In it, he points out that an independent research project is often the most important and memorable experience of a student's college education. Often, too, the experience is mentored by a faculty member rather than a postdoctoral fellow or Ph.D. student, as can be the case at a major university.[39,40]

The personal attention given to the student and the research can be an advantage in the **PUI** setting. I'll quote a statement at the end of Cech's article (just before the Summary and Outlook): "Intelligence, creativity and hard work can take a student far, but they constitute an even more powerful combination when channeled, guided and motivated by excellent teachers in an environment supportive for learning." Let's do it!

References:

39. Thomas Cech, "Science at Liberal Arts Colleges: A Better Education?, Daedalus, vol. 128, January 1, 1999, p. 195-216.
40. Susan H. Russell, Mary P. Hancock and James McCullough, *Science*, Vol. 316, 2007 p. 548-549.

Chapter 11

Writing

When I was on the Petroleum Research Fund (PRF) advisory board, I reviewed approximately 185 proposals per year for three years (1993-1995). Of these many proposals, some were not funded because of writing weaknesses, and some were not funded because the authors didn't propose good chemistry. Rarely were they excellent in both regards.

To sustain successful research, we need to write up our work for publication and write successful proposals (we need money). This implies that we should write about our work in the best possible way. Some people have this skill after they complete their Ph.D., and some do not. On my particular **PRF** committee, we were sometimes able to overlook some writing problems and just evaluate the chemistry being proposed: That is not always easy to do. Therefore, it is in our best interest to make sure the proposal and manuscript are extremely well written.

Recently, I had an interesting student outcome that is worth describing. One of my students consistently turned in poorly written assignments. We had a discussion when the student openly admitted he was not a good writer. The class grading was based mainly on writing about one's personal philosophy, culminated by preparing a 20-page life-view paper. The student told me that his girlfriend was an extremely good writer, and he asked if she could help him by editing this important paper. I said it would be okay, but the content had to be all his: This life-view paper was too personal for any plagiarism (and I was sure he wouldn't show it to his buddies). He said okay. It turned out to be one of the best papers submitted, and there were no grammar errors (she must have eliminated a lot of them)!

Perhaps there is a lesson here for all of us. We sometimes need a little help from our friends. It has been my experience that many people are not objective about their writing skills. This came up particularly when I worked at the Du Pont Experimental Station.

All new research chemists were required to take a well-known (and excellent) writing course taught by R. S. Burger (a former writing professor and newspaper editor). Some chemists were irate when they were challenged to change some parts of their writing. It couldn't be better: Just ask the writer! It was fortunate that Burger had seen this attitude enough to deal with it successfully.

A graduate school professor of mine said that the reason a fellow professor did not emerge as a prominent researcher was because he didn't like to write. That can be a serious limitation. I had a high regard for this person's scientific expertise, and had often asked him questions about chemistry: He was the first person I approached. A very well-known chemist once commented on what a good graduate student this person had been when they were both at a high-quality university. The research he did was excellent, and a few publications did emerge, but it was not sustained for a long period of time. Not liking to write took its toll.

Research requires money, and usually the funds are obtained through formal, written grants.

Fortunately, undergraduate research is not always very expensive. It can be, but that is not necessarily the case. Perhaps another person in the same department can write a joint proposal such as an **RUI** program grant through the **NSF**, for example. These programs allow support for undergraduate researchers and minor equipment or chemicals. The options are well covered in the Council on Undergraduate Research (**CUR**) publications. Refer to them. They provide excellent resources.

If someone doesn't like to write, most schools have good support systems to teach improved writing for faculty members. Colleagues should also be of help, especially in undergraduate settings where contact with fellow professors (e.g., in the English Department) happens more readily than in a large university. **Many people don't ask for help, and that is why they don't get it**. It can take guts to ask for help, but ask the right people, and you can get it. Whether it takes guts or humility, seek assistance.

Chapter 12
Statesman

When I visited prominent **PUI** chemistry departments, there often seemed to be someone who was not necessarily the most research-productive person there, but who was deeply respected and appreciated by most of the department members. I don't want someone like this to be missed in the analysis of productive programs. Although the focus of this manuscript is on those who publish regularly, this type of person seemed to emerge as an important part of the department's success.

When I visited Harvey Mudd and Occidental Colleges, there clearly was someone who was almost a statesman **within the department.** It was never stated in an obvious way who that was, but the sentiment was definitely there, with one person emerging as the center of it and representing the spirit of the department. The person may or may not publish regularly, but his or her contribution was pivotal. The members of the department strongly identified with the person I also know who that person is at Hope College.

There are times when a department needs a reconciler or peacemaker. It may not seem like it, because the department runs smoothly, but this type of person can have a real impact through his or her quiet assertiveness.

Furthermore, a person may be a statesman **within the school**, and that can be important, too. Budgets can be indirectly affected, and influence can increase with the right leader. As was said earlier, there are many ways to contribute to a chemistry department.

In earlier years, Gene and Elaine Jekel had summer workshops for high school teachers, ands these had a major impact on the department and its morale. Often we would later get a student from one of the high schools participating in the program. Many colleges have programs that involve high school and college students in environmental projects, and these are very popular. Such applied programs have a special appeal, and they are "Green Friendly." What could be more "politically correct?"

CHAPTER 13

Ambition for Teaching and Research

We won't get rich teaching at a **PUI**, at least not on the typical wage paid at these institutions. The love of money doesn't drive us. What drives us to push beyond the minimum of teaching only, and do research and publish it?

People typically want to be recognized in an area they value. What do you prize most? Can you value two things: teaching and research? Is your heart big enough?

In a major university, publication and recognition for outstanding research may take precedence: Teaching may take a back seat, but not necessarily. However, at a **PUI** teaching is usually a high or top priority.

Before I came to Hope College, I had heard about Gerrit Van Zyl, because he was one of the first successful undergraduate researchers. It was probably when I was serving on the **CUR** council that his name came up. My undergraduate advisor had done undergraduate research with him, and had a publication in the process.

When I came to Hope College, I asked Irwin Brink, a current dean, and earlier a chemistry student at Hope College, about Dr. Van Zyl's teaching. He gave me a skeptical look, and I inferred that the man was not an inspiring teacher/lecturer. But it was also made clear to me that Van Zyl made you learn, and he kept track of all of his students.

However, when I asked Brink about his associate, J. Harvey Kleinheksel, whom I had not heard of prior to coming to Hope College, he said Kleinheksel was a **master teacher**. It was clear that there was great appreciation behind the response. Recently, I heard the same thing from a former student at a 1959 class reunion: "He was my favorite teacher of all time in all fields." The alum had a Ph.D. in physics, so this was not an uninformed opinion. Clearly, from this and other compliments I've heard, Kleinheksel was an inspiring teacher.

To be recognized as a master teacher was not Van Zyl's priority, but he was able to forego that reputation and establish himself as a leading undergraduate researcher: and he was.

The master teacher was deeply appreciated and recognized locally, or within the college itself. The researcher received national attention. **This discussion has been made into a study in contrasts, and it is dramatized for clarity**. But I believe it took both an inspiring teacher and a solid researcher to establish Hope College's excellent chemistry program.

Can one person excel at both? Could a department attract students if it had only unimpressive teachers, even if they were outstanding at undergraduate research? What if the department had only inspiring teachers, but no researchers? Doesn't it take some of both?

There are only two bronze plaques in Hope's Schaap Science Center atrium that have faces on them. The first one is of Dr. Kleinheksel, and the prominent words under it say, "Master Teacher." The second is of Dr. Van Zyl, and its first words are, "Inspirational Leader": Great heritage from both of them. What would you want your plaque (if any) to say?

The inscriptions say that they both insisted on the highest standards of student performance—that has to be another key to the legacy.

CHAPTER 14

Conclusions

When I started this book, I asked professors from productive undergraduate schools and even some professors from a few top-notch universities what it took to succeed in research (and publish too). The most common answer was, "It takes a fire in the belly." After my study, I believe that is a **necessary but not sufficient quality** to have to succeed in research. It is necessary, especially for long-term success.

I spent a long time evaluating what psychologists call "achievement motivation" because it involved studies of what led to achievement. It seemed the closest thing to what we were looking at, and from perspectives (psychology) that are more into behavioral studies than chemists and other scientists are.

I also asked the question about a person's academic pedigree, or what school the person got a Ph.D. from, and the emphasis was on success in undergraduate research. There was **no** consideration of what leads to the success of a graduate school professor. That is someone else's worry. We extracted data from the most recent **CUR** *Directory of Undergraduate Research* (not very current, but the data should still have relevance), and reported on those who had more than the "average" publication rate for **PUI**s. That was the threshold chosen, but many professors had far more than the average. That also was a debatable standard, but a line had to be drawn. For those who had more than a threshold publication rate, graduate school quality did not appear to be critical. Iowa State University was an "outlier" that produced several productive undergraduate researchers. Again, no attempt was made to draw correlations of what schools productive graduate school mentors came from. That story could be significantly different.

The impact of a "publish or perish" mentality was assessed. The idea of "multitasking" abilities was discussed, and a misperception of the idea was pointed out.

Many people choose to teach at a **PUI**, and some of them could succeed in a school with a graduate or Ph.D. program. Why do people choose to teach at a **PUI**, and what factors do improved relationships among faculty-faculty and faculty-student interactions play? A personal testimonial from a Hope professor is included. A balance in teaching and research in professional life can play an important role.

A high level of creativity can improve a person's future in research. Ways to enhance this attribute are given. It apparently takes some inherent amount of it to begin with (there is a debate in the field on this), but many references suggest ways to improve it. This subject is tied in with the reality of "multiple, interacting factors." This is a hard subject to write about because we don't write or even think that way: We typically divide up the topics and write about them one issue at a time. However, we have a comment that suggests that determined effort over a long period of time in an area of personal strength improves a person's creativity (note the three factors: expertise, extended effort, and creativity). Other interactions can play a role, too. On the negative side, I have seen personal or family matters spoil a person's career. Again, on the interaction of factors side, how much does having good or positive family matters help careers? In what ways? We ought to think about that, even though we can't quantify it.

We can't cover all the bases, so often we need collaborators. Sometimes, we need to search them out and approach them for assistance. It may be intangible, or it may be equipment needs or expertise. Chemists are good at helping other chemists. We chemists started **CUR**, and now it has spread to many other professions. We were the first to reach out. Someone can help you, but you need to seek out that person or persons.

Sometimes it may seem that we need to stop working so hard, and that we need to slow down. It may just be that our attitude toward work makes it seem worse than it really is. As a productive friend says, "My research is my hobby." We need to take the research seriously and do it right. It can be deeply fulfilling if we do it with the right attitude.

There are many ways to contribute to a chemistry program, and research is not the only one. Some people represent the department, almost as statesmen, and they can have the respect of the entire department and beyond. The tasks that face chemistry departments are legion, and accomplishing them can be intimidating. The contributions of everyone should be acknowledged.

Ambition is related to what a person values. If research is a treasure of one's heart, it should show up. It will bring fulfillment, particularly if one does not **worry** about the sentiment of "Publish or perish."

CHAPTER 15

The Future

In a Bill Moyers' interview, Harvard sociologist Sara Lawrence-Lightfoot was questioned about the current financial insecurity, and what it will cause in the future. She mentioned that when there was significant financial stress in the past, these were also times of significant creativity. Our private schools are highly dependent on student enrollment, and this may force some real changes. I'll assume most schools will survive the economic downturn, but it may take more than wage freezes, cuts, and so on. Creativity will be more than a catchword, and we need to center on **something outside ourselves** and departmental matters. Think that over.

We won't need people who loudly and obnoxiously assert themselves in an attempt to appear to have a fire in the belly. We will need the real thing.

I don't have a crystal ball, but in a book that attempts to predict the future (*Generations: The History of America's Future. 1584 to 2069,* by William Strauss and Neil Howe), the authors say that the current generation, or those born from 1982 to 2000, will have several important characteristics. The generation, often called "The Millennials/Generation Y," is predicted to embrace diversity and enjoy working collaboratively in teams. They will also favor civic involvement and multiple involvements, or multitasking. They will place a high value on relationships, but will want specific instructions or guidelines for how their performance will be evaluated.

If these predictions come true, the attributes may help students to adjust to their changing world. Some of these characteristics may help research output, especially in the interdisciplinary areas. However, we must maintain our established culture of research and emphasize that it is an important characteristic of the mission of our **PUI**.

I'll conclude with an idea from the book with the special title used in Chapter 1. Author Sam Keen emphasizes that a new kind of leader needs to emerge, one who seeks to empower others (p. 153). A great attribute would be to **empower other students to outdo us**. May we all work hard to do just that!

Appendix

Statistics of Ph.D.s in Chemistry: The University of California at Berkeley graduated the most Ph.D.s in chemistry, with 173 students earning their doctorates from 1996-1999 (see **Table 1**); 14 of the graduates (not necessarily from the same group of 173) during 1993-1996 went on to produce five or more papers. Similarly, 128 students earned their Ph.D. from the University of Wisconsin-Madison, and seven of the graduates became professors at **PUIs** who published five or more papers in this time frame.

The data were then sorted by various methods to attempt valid correlations. **Table 1** lists the schools by the number of Ph.D.s produced in descending order (Total). After that, the number of productive **UG** research professors produced by the schools is listed.

Table 1: Total number of Ph.D.s and an attempt to correlate their productivity at PUIs.

1996-1999 Ph.D.s	'96-'97	'97-'98	'98-'99	Total	Ave	#Productive At PUIs
University of California, Berkeley	51	56	66	173	57.67	14
Purdue University	41	52	39	132	44	3
University of Wisconsin-Madison	49	41	38	128	42.67	7
Massachusetts Institute of Technology	39	44	42	125	41.67	6
University of Illinois, at Urbana-Champaign	46	43	33	122	40.67	5
University of Texas, at Austin	32	47	34	113	37.67	5
University of Florida	28	57	28	113	37.67	3
University of Minnesota-Twin Cities	48	33	29	110	36.67	6
Texas A&M University	30	39	41	110	36.67	3
University of North Carolina, at Chapel Hill	34	47	25	106	35.33	3
California Institute of Technology	33	36	35	104	34.67	2
University of California, Los Angeles	29	35	35	99	33	1
Harvard University	28	38	32	98	32.67	9
Stanford University	29	40	25	94	31.33	2
Iowa State University	27	31	34	92	30.67	11
University of California, San Diego	32	30	27	89	29.67	2
Ohio State University	36	33	19	88	29.33	8
Pennsylvania State University	33	32	23	88	29.33	2
Cornell University	28	24	30	82	27.33	5
University of Michigan, Ann Arbor	21	30	31	82	27.33	6
Yale University	24	26	28	78	26	3
University of Colorado, at Boulder	18	30	30	78	26	1
Michigan State University	24	30	21	75	25	5
Indiana University	30	27	17	74	24.67	5
University of Pennsylvania	24	22	21	67	22.33	0
Wayne State University	21	22	22	65	21.67	0
University of Maryland	26	22	16	64	21.33	1
Northwestern University	23	19	22	64	21.33	4
University of Pittsburgh	16	22	26	64	21.33	4
University of Washington	25	20	16	61	20.33	5
University of Arizona	22	16	22	60	20	1
Princeton University	21	14	22	57	19	3
Columbia University	19	17	21	57	19	0
State University of New York at Stony Brook	21	18	17	56	18.67	2

The data in **Table 1** were taken from American Chemical Society (ACS) tables that are readily available online, and the sums of those are in the **Total** column. These data should be reliable.

Table 2 is analogous to **Table 1** (and is derived from it), but the sorting is made according to number of productive undergraduate researchers produced by each school. Again, the threshold used was an attempt to list the professors who published at or above our threshold number of publications (five in four years).

It is interesting that UC Berkeley was first in both listings. Some schools improved in their rankings. Some graduate schools were not listed, because zeros began to come up in the productivity column that are misleading. These schools and their professors may have done well in other ways that are significant, because there are many ways to contribute to a chemistry program (development of a new course, improvement of an existing one, student recruiting, school and educational contributions).

Table 2: Schools ranked by number of productive professors produced for PUIs.

School	Total # of Ph.D.s	# Productive	% Productive based on 137 (total of all productive schools)
University of California, Berkeley	173	14	10%
Iowa State University	92	11	8%
Harvard University	98	9	7%
Ohio State University	88	8	6%
University of Wisconsin-Madison	128	7	5%
Massachusetts Institute of Technology	125	6	4%
University of Minnesota-Twin Cities	110	6	4%
University of Michigan, Ann Arbor	82	6	4%
University of Illinois, at Urbana-Champaign	122	5	4%
University of Texas, at Austin	113	5	4%
Cornell University	82	5	4%
Michigan State University	75	5	4%
Indiana University	74	5	4%
University of Washington	61	5	4%
Northwestern University	64	4	3%
University of Pittsburgh	64	4	3%
Purdue University	132	3	2%
University of Florida	113	3	2%
Texas A&M University	110	3	2%
University of North Carolina, at Chapel Hill	106	3	2%
Yale University	78	3	2%
Princeton University	57	3	2%
California Institute of Technology	104	2	1%
Stanford University	94	2	1%
University of California, San Diego	89	2	1%
Pennsylvania State University	88	2	1%
State University of New York at Stony Brook	56	2	1%
University of California, Los Angeles	99	1	1%
University of Colorado, at Boulder	78	1	1%
University of Maryland	64	1	1%
University of Arizona	60	1	1%

The last column is an attempt to express as a percentage an individual school's Ph.D.s that have become productive **PUI** researchers. It is a "percent" resulting from a total of the individual school's number in the preceding column divided by the total of the productive **PUI** professors produced by all the schools (137, or the total number of all productive **PUI** researchers estimated by these methods).

Some small graduate schools did not survive some key cut-offs, typically because they produced fewer Ph.D.s. Yet, some of these produced one or two productive **PUI** professors (more than some well-recognized institutions). This should alert the academic community that it is **not just** the quality of the graduate school that produces good **PUI** researchers. Other factors need to be taken into account. Yet each person should seek the best training possible. It is hoped that this book will bring out other factors that are important.

Table 3: Schools ranked by the % of their Ph.D.s that became productive researchers at PUI's.

School	Total # Ph.D.s	# Productive	%Productive
Iowa State University	92	11	12.0%
Harvard University	98	9	9.2%
Ohio State University	88	8	9.1%
University of Washington	61	5	8.2%
University of California, Berkeley	173	14	8.1%
University of Michigan, Ann Arbor	82	6	7.3%
Indiana University	74	5	6.8%
Michigan State University	75	5	6.7%
Northwestern University	64	4	6.3%
University of Pittsburgh	64	4	6.3%
Cornell University	82	5	6.1%
University of Wisconsin-Madison	128	7	5.5%
University of Minnesota-Twin Cities	110	6	5.5%
Princeton University	57	3	5.3%
Massachusetts Institute of Technology	125	6	4.8%
University of Texas, at Austin	113	5	4.4%
University of Illinois, at Urbana-Champaign	122	5	4.1%
Yale University	78	3	3.8%
State University of New York at Stony Brook	56	2	3.6%
University of North Carolina, at Chapel Hill	106	3	2.8%
Texas A&M University	110	3	2.7%
University of Florida	113	3	2.7%
Purdue University	132	3	2.3%
Pennsylvania State University	88	2	2.3%
University of California, San Diego	89	2	2.2%
Stanford University	94	2	2.1%
California Institute of Technology	104	2	1.9%
University of Arizona	60	1	1.7%
University of Maryland	64	1	1.6%
University of Colorado, at Boulder	78	1	1.3%
University of California, Los Angeles	99	1	1.0%

Data in the far-right columns on the previous page were derived from the 7th edition of the CUR Directory of Research in Chemistry at Primarily Undergraduate Institutions as described above. I thank Nancy Hensel for helpful telephone conversations on the use of the data. Data in the other columns were taken from tables compiled by the ACS Committee on Professional Training, and I thank Cathy Nelson for her assistance with the use of the ACS data.

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Dr. Taylor with Matt Ryzenga, Julie Pollock, and Matt Pridgeon.

About the Author

Stephen Taylor has taught at Hope since 1985. His primary teaching focus through the years has been on organic chemistry with a secondary focus on introductory chemistry; he most recently taught the capstone Senior Seminar course, "Science and Christian Perspectives." He retired from Hope College in 2009.

Dr. Taylor has mentored many students in collaborative faculty-student research, and is the author of 34 articles published in research journals. Through the years he has received multiple grants in support of his research from external agencies, including the Petroleum Research Fund, National Institutes of Health, the National Science Foundation and Research Corporation. His most recent scholarship, included research for this book.

From 1993 to 1995 he was a member of the advisory board of the Petroleum Research Fund, and in 1995 he received one of only eight "Camille and Henry Dreyfus Scholar/Fellow Awards for Undergraduate Institutions" nationwide.

Taylor earned his bachelor's degree in 1969 from Pasadena College (now Point Loma Nazarene University), where his undergraduate advisor was a Hope alumnus, Victor Heasley '59, who involved him in undergraduate research. He subsequently completed his doctorate from the University of Nevada, Reno in 1974, after which he worked at Du Pont Experimental Station as a research chemist for five years. Following his time at Du Pont he taught at Olivet Nazarene University for seven years before coming to Hope College.

he "fire in the belly"? Psychologists have studied achievement-oriented behavior (similar to what is described in this book), and they surpris
s call it "Achievement Motivation," or something very similar. Some of their findings and conclusions are very pertinent and enlightening. They
to say about what leads to achievement, and their perspective is a good one with which to view the subject. Psychologists also focus in on a
e of motivation, and use a single phrase or term that is analogous to Fire in the Belly, and it is grit. This essential quality is defined
erance and passion for long-term goals. Most of the time, it is discussed as relevant to ambitious clear-cut goals, not just any goal. A key wo
e area even made the far-reaching comment that, "one personal quality is shared by the most prominent leaders in every field: grit." This grit m
g strenuously toward goals despite failure, adversity, and slowdowns in progress: You need to persist despite obstacles toward major achieveme
ologists Martin Seligman and Angela Duckworth at the University of Pennsylvania have popularized the term and the ideas behind it. One Psycho

"It takes a 'fire in the belly.'"

At primarily undergraduate institutions (PUIs), teaching is usually the primary responsibility, and many PUI professors do not regularly produce publications, even if they were hired to include research as an important responsibility. Most instructors at these schools are busy enough with just teaching and other academic responsibilities. It can seem intimidating to think also of doing research, writing a research proposal, then a publication, and so on. Perhaps the sum of these duties may seem like a daunting set of tasks, and a "fear factor," consciously or subconsciously, may slow or even stop the research initiative. But at PUIs, it is not just "publish or perish," and how much of that representation exists depends on the undergraduate institution: The best schools may push publication performance, and the weakest may ignore it. Either way, this book provides a new and more positive emphasis—"Publish and Fourish."

"Pursuing authentic, publishable research through faculty-student collaboration is now well established as one of the best learning practices in undergraduate science education; thus, colleges and universities strive to identify and recruit faculty members who demonstrate the strongest promise to become successful as teacher-scholars. For this reason, the book by Dr. Taylor, emeritus professor of chemistry at Hope College, a revered teacher, and a highly published researcher, is a must read for faculty and administrators who are engaged in hiring new faculty."

- Moses Lee Ph.D., Professor of Chemistry and Dean for the Natural and Applied Sciences, Hope College, Holland, Michigan

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