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Ten Mistakes for Physicists to Avoid

by James D. Patterson

Ed. Note: *In 2004, James D. Patterson wrote an open letter to* Physics Today[1] *containing advice to the next generation of physicists. With several more years of accumulated wisdom, he presents some further ruminations in the article below.*

James D. Patterson

Montaigne said "... you never talk about yourself without loss: condemn yourself and you are always believed: praise yourself and you never are."[2] Nevertheless here is an update of a paper in which I discuss mistakes I have made. I suspect Montaigne is right, but I have long been retired so my loss is minimal, and is possibly compensated by gains of those who will consequently avoid my errors.

My main reason for writing another article is that I have new reflections on mistakes already considered as well as some new ones to discuss. I will get to all those in a moment, but first some preliminary observations.

What is judged a mistake depends on objectives.
A dean once told me he wanted me to be a success. That sounded good. Of course his definition of success was different from mine, so there remained an unresolved conflict. I think for him it meant more and larger grants. For me success meant time to do and teach the physics that I found interesting. Naively, I thought this would lead to a better world. However, I am not sure the current culture of seeking more (of something, I am not sure what) is an improvement. Being stubborn, by refusing to go in the direction you are pushed, may not always be wrong. You may be happier. There is nothing wrong with loving your field and making personal sacrifices to stay true to it. Fairly late in my career, I was a department head and was not aggressively pushing the department to seek as many outside funds as was desired by the university. An official in charge of university research wanted to get me fired, but I felt there was an imbalance in the emphasis on grants and I opposed him. I did endure a couple of very uncomfortable years in consequence.

An academic career is no longer necessarily the path of many physics majors.
Most current PhD graduate students will not go on to become university professors. There are not that many available positions. Many don't want to anyway. There are other alternatives. I spent several summers in industry and national labs. In some cases I applied for more permanent positions outside academia. One mistake I made was in my résumé. I would list degrees earned, papers published, positions held and very little else. I don't think I even listed grants awarded. For industrial résumés you should list the assignments you have had and what you achieved with them. Another aspect was pointed out to me by Jim Fergason, an inventor of the twisted nematic liquid crystal display. He was irritated by scientists who never gave any thought to possible uses of their ideas. Obviously this mindset is not attractive to industry.

Now for my list of mistakes. Most of my career was in colleges and universities; nevertheless many of the mistakes are universal. (Parenthetically I note two other short papers about universities and teaching.[3])

1. Moving Ahead Before Being Ready
At the University of Missouri-Columbia, where I got my bachelor's degree, I was more interested in getting good grades than in mastering the subject. I did not understand, as colleague Lyle Feisel advised, that my job (to learn

the subject matter) was more than my assignment (to get good grades). When I went to the University of Chicago to start graduate school, I was advised to take some senior undergraduate level courses first. I refused and went ahead with the regular graduate program. This was ill-advised. When I took the feared “basic” exam at the end of the second year I failed, partly because my grounding in fundamentals was insufficient. For example in the oral part, I could not give an adequate definition of what it meant to say that two waves were spatially coherent.

Some failing students (including me) were recommended to try again the following year, but I elected to finish my PhD studies at the University of Kansas. Perhaps another mistake was I was not willing to gamble that I would pass on the next attempt.

I also tried to do too much too soon as a teaching assistant at Chicago. When I was assigned to conduct a recitation section for the quarter on optics (using Sears’ optics book) I quickly became bored and tried introducing material from Sommerfeld’s optics book. Not only did this not help the students, I doubt that I understood what I was doing. Towards the end of the quarter the attendance in my section dropped to zero. This episode still haunts me.

2. Losing Focus
In my formative years. I should have practiced solving problems efficiently. I spent more time reading than working problems. I “knew a little bit about a lot of things,” but I didn’t know enough about how to apply the fundamental ideas of physics. A friend studiously worked every problem in Kittel’s solid state book, and passed the basic exam the first time. He focused on the physics, what it really meant, and how to use it to analyze phenomena.

3. Not Making Fundamentals a Working Part of Memory
I began to understand the importance of memorization when I took a group theory course taught by Prof. William Scott at the University of Kansas. A myriad of definitions were used in the derivation of results. The math graduate students knew these definitions and followed the lectures with ease. I didn’t and struggled. On a more elementary level, it bothers me when students don’t know simple things like the value of the sine of 30 degrees. The point of physics is not memorization, but knowing the fundamentals without constantly looking them up greatly facilitates communication.

4. Not Focusing on Physical Ideas While Obsessing Over the Mathematics
Experiment is the heart of physics. Many feel if you can’t measure something, the concept has no meaning. Connecting ideas with experiment, and reducing them to their essential physical core is hard, it takes time, and for this it is often useful to talk to people and gather essential crumbs, one by one. In courses and even in research (for example on the statistical mechanics of magnetic systems described by the simple Heisenberg Hamiltonian) I tended to avoid experimental results. This once cost me a job when in the interview I was asked how I had interacted with experimentalists. I had no answer. It was a mistake for me not to consider realistic materials upon which experiments could be done and ideas could be tested.

5. Not Fitting Goals to Abilities
We all would have liked to be Feynman, but there was only one. I wanted to work on advanced problems in theoretical physics before I was ready. I finally settled on more applied problems in solid state physics, but for a while I felt I was demeaning myself. I fluffed an opportunity to establish myself in semiconductors in the early days at Hughes Products, where I worked two summers in the fifties. The first summer I followed directions and wrote a report on crystal growth, but the second summer I tried to go my own way into more basic (I thought) areas. The report I produced was good neither by my standards nor by theirs. It was too early in my career and very unrealistic to go off on my own. As I matured, I realized I would be lucky to find problems in solid state that I could help with, and that all physics is intriguing when you begin to really understand it. Even today, despite the fact that I have written texts on solid state physics,[4] I cannot say I have mastered anywhere near all the important ideas in that field.

6. Ignoring Personal Life
Like many physicists, I was shy around people. This caused difficulties, even in physics. A physics meeting in Rolla, Missouri began with a social gathering for the attendees. For reasons of insecurity I didn’t go. The next day when I gave my talk its validity was questioned. There was a good rebuttal, but I was too nervous to think of it. The chances are if I had attended the social gathering, in the course of informally talking about my work, the same question would have arisen and I would have dealt with it better. After I got married, at the relatively late age of 38, my wife helped me immeasurably in feeling comfortable in a social setting, whether related to physics or not. I should have sought more balance in my personal life at an earlier stage.

7. Using Secondary Sources
It takes work to track down results in professional journals, but looking things up only in texts often results in less complete and sometimes less clear answers. Of course the scientific literature is consulted for research, but it is also useful for classroom lectures. For example, the Quantum Hall Effect originally was hard for me to understand. Then, I discovered a review paper [5] and was able, after digesting it, to read the original literature. Texts may be

handy, but shortcuts to grasping physics are few.

8. Always Rejecting Authority
I have a problem accepting authority. Perhaps I cannot easily put myself in others' shoes. This trait has led me to cause trouble often for no real reason. I constantly interrupted a lecturer (who in fact was a good scientist) in my junior electricity and magnetism course, using the excuse that the text or his lectures or both had errors. Maybe they did, but that hardly made either unique. In any case, I was arrogant about it. Once he got so irritated he threw down the chalk and left the room. I shamefully admit now, I felt victorious. Later in my career, a college president encouraged the faculty to learn about computers. It was the early days, and he was leading us in the right direction. I wrote the few programs he required, but without enthusiasm, and with minimal effort. By resisting direction, I lost a chance to mature and be guided by someone with superior experience and knowledge.

9. Letting Anger Rule Behavior
In mid-career, I went to Florida Institute of Technology and was assigned to teach a class in advanced undergraduate mechanics. Because of my predilections the class tended to be rather mathematical. At Florida Tech there were both physics and space sciences students. My lectures seemed to be appropriate for the former but the latter were used to a more qualitative approach. One student began coming late. I lost my temper with him and started to lose control of the class. Later I became department head there. There was one faculty member who did not publish much and was stuck at the associate professor level. He began to blame me and verbally attacked me in one department meeting. Again I lost my temper. This led to problems in the department which eventually reached the Dean's ears. I had a rocky path for a while. In both cases when I lost control of myself, I lost some control over others and more importantly, some of their respect. Being strong seldom means being angry.

10. Not Keeping in Physical Shape
In the late 70's I got invited by Prof. Gerald Jones to Notre Dame for a year as a visiting professor. I arrived fat and tired. I had wanted a dog for some time and got one. I began taking him for walks and also watching my diet. Physical discipline led to losing weight and also helped increase my mental organization. The year went quite well in research, teaching, and life. I discovered that letting things go slack in one area often leads to slackness in other areas including physics.

So there you have a representative, if not exhaustive, set of suggestions. If you are a young person, just getting started, I hope they prove to be of some use.

1. James D. Patterson is Professor Emeritus, Florida Institute of Technology, Melbourne, FL.
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3. Michel de Montaigne, *Four Essays*, Translated by M. A. Screech, Penguin Books, New York, 1991. From "On the Art of Conversation."
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5. James Patterson, Bernard Bailey, *Solid-State Physics Introduction to the Theory, Second Edition*, Springer-Verlag, Berlin Heidelberg, 2010.
6. H. Stormer, *Rev. Mod. Phys*. 71, 875 (1998).

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An Open Letter to the Next Generation

James D. Patterson

Starting as an undergraduate student and ending as a department head, I had a career in physics that spanned approximately a half century. While, on the whole, I enjoyed my various roles as student, professor, and department head, I suppose a reviewer of a proposal I wrote got it right when he said I had had a relatively undistinguished career. Then why you may wonder, should you listen to me? For one thing, I think my career was fun. Physics is so interesting that I believe it is rewarding at whatever level you can perform. My teaching often energized me; I wrote papers that interested me, if few others; and I met many interesting people. However, I wish I had maximized my opportunities. Obviously, because I had a long, uninterrupted physics career, I must have done a few things right. But that is another story.

Retirement has given me time for introspection, and I think I have figured out a few reasons why I was not more successful. Such insights are of little use to me now, but perhaps they may be helpful to some of the younger generation.

Doing too much too soon

When I arrived at the University of Chicago in the fall of 1956, I had just graduated from the University of Missouri–Columbia, where I had been more interested in getting good grades than gaining understanding. I was advised that perhaps I should take some senior courses before venturing into the graduate ones. I refused, and consequently never really caught up with the graduate level at Chicago. When I began teaching, I still had trouble with the basics and related details. It wasn't until I was doing research on my own that I realized I needed to understand the basics before delving into the unknown.

We have to learn basics first, because we need them for all that follows. If we do not learn the basics, we are disadvantaged. A related sin is skipping essential details. Then we do not get to the bottom of things and are not well grounded.

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Disrespecting superiors

When I headed the physics and space sciences department at the Florida Institute of Technology, the dean was younger than I, and I thought his philosophy was wrong headed. So I tended to oppose him head on. Whether he was right or not really misses the issue. My job was to move the department ahead as best I could, given the boundary conditions I was working under. Obviously, my technique was not optimal. Later, I observed a more effective department head who approached the same dean about an issue by saying, "How do you see this?" Then the department head skillfully guided the conversation until he ended up with at least part of what he wanted.

Regarding superiors with ill-conceived contempt often comes from a false arrogance that may arise from insecurity. It can lead us to rebel and become isolated from the very ones who can help us. Courtesy is not insincere nor is networking with those who are helpful or whom we can help.

Not controlling temper

While I was serving as the department head at Florida Tech a few faculty members thought I was doing a poor job. I lost my temper with them more than once in departmental meetings and privately. As a consequence, I probably had less support from the department than I could have had, and also lost influence with the dean, who I am sure heard about my lack of support.

Losing one's temper often comes from frustration, which in turn may come from poor performance. If we lose our temper we let the situation control us rather than the converse.

Being inefficient

As a second-year graduate student at Chicago, I resolved to spend most of my time studying for the dreaded "basic" exam. So I took few courses, and it was up to me to organize my time. I did not have a focus to my work, but instead read a lot and worked few problems. Chicago itself also provided distractions. One student I knew resolved to work every problem in Charles Kittel's *Introduction to Solid State Physics*. He passed the basic. I did not, although many students did take the exam again. Instead, I transferred to the University of Kansas, where I eventually earned my PhD.

In graduate school, time may be your most valuable asset. Even impractical goals, which some people would say included my goal of becoming a theoretical physicist, need a practical, organized approach for accomplishment.

Being a desk potato

After several years as professor at the South Dakota School of Mines and Technology, my friend Gerald L. Jones invited me to spend a sabbatical year at the University of Notre Dame. I arrived tired and fat. However, I resolved to change. I got a dog, took him for walks, dieted, and worked hard in between. Compared to my previous achievements, the year was productive and fulfilling. I actually solved more problems—some while walking—than I ever would have done otherwise.

Sometimes our problems are so vexing we feel we cannot leave our desk or we will never find the solutions. However, we often need a rested body and a fresh approach to generate new ideas. Staying in condition, taking walks, and doing other sorts of exercise are important. Fatigue arising from lack of conditioning can cause errors and inhibit inspiration.

Using math without experiment

My PhD research at Kansas was on the theoretical interpretation of color centers, crystalline defects that absorb visible light. Although this area was clearly linked to experiment, I found it very frustrating because the calculations that could be done at that time were rudimentary. When I started my career, I looked for an area that had few directly relevant experimental results. For a while I settled on applying statistical mechanics to finite Heisenberg magnetic systems. During a job interview, I was asked why I did not work on problems that

connected easily with experiment. I had no answer. I did not get the job. Incidentally, for a role model in the opposite direction, I recommend Marvin L. Cohen and his calculations; he has used pseudopotential and other techniques on real materials with strong connections to experiment.

When we begin learning about something, it is comforting to be able to "surround" it—to achieve a concrete understanding of what we are dealing with and thereby have a precise understanding of what we need to know. Mathematical problems that are easy to surround are said to be well posed, but just because they are well defined does not mean they relate to reality. An intuitive feel for reality is necessary for doing physics. Mathematics is essential, but so are the measurements and their meaning.

Having unrealistic goals

Early on, I somehow got the idea that being a theorist was the only truly prestigious objective in physics. In my heart, I felt that nuclear or high-energy physics was the most noble. Despite my eventually settling on solid-state, I thought for a long time that the subject was not important enough. Maybe I bought into some precursor of the idea, often attributed to Murray Gell-Mann, that solid-state physics was really squalid-state physics. I finally came to see that every physics subfield has many fascinating, rewarding, and useful problems. The trick is to find an area you can handle. And today, even though I have written a text on solid-state physics, I would not say I have mastered the topic to the extent that it deserves.

In my early teaching, I often tried to do too much, either to learn something new or to impress the students. It wasn't until I figured out that my job was to teach the students in my class, rather than to make a splash, that I began to succeed as an instructor.

Our goals should fit our interests and aptitude. It is all very well to attempt solving the most fundamental problems, but not all of us can make headway on them. Sometimes other problems, perhaps less fundamental, offer us rich opportunities for making contributions. We need to think carefully before doing our work. Of course, if we are excited and interested in it, we will have fun. Otherwise, work may seem like total drudgery.

Not referring to original literature

Scientific papers are almost always more complete and understandable than their digested versions in books. A recent example for me involved the half-integer quantum Hall effect. I never seemed to get the point of it from texts. Then I ran into Horst Stormer's Nobel Prize address.[1] Somehow that paper, involving both theoretical ideas and experiment, clicked with me. After digesting it, I was able to read the original papers.

When we want to know something, there is a tendency to seek a quick answer in a textbook. This often works, but we need to get in the habit of looking at original papers. Textbooks are often abbreviated second- or third-hand distortions of the facts, and they usually do not convey the flavor of scientific research.

Never memorizing basic facts

Graduate students at Kansas needed to take some courses outside their major. I chose to take a couple of courses involving group theory with William R. Scott. I could not follow him, even though he was a renowned expert in the field. He expected that after he defined something, we would remember the definition and he could then use the term without elaboration. I was lost because of my faulty memory. I had a similar problem while attending American Physical Society meetings.

Although memorization is not the goal of physics, when we listen to presentations, we need to know what the speaker is referring to without looking everything up. Some physicists may automatically remember what they need, but for the rest of us, memorizing is an often overlooked tool.

I do not claim this list exhausts all of the missteps I have made. But these are the ones that occur to me as perhaps being common to many other physicists. And although I cannot claim expertise in many areas, I do think I know something about my own shortcomings. At this stage of the game, I have nothing to gain by hiding from the truth.

Reference

1. H. Stormer, *Rev. Mod. Phys.* **71**, 875 (1998). ■

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