LETTERS

More on 'Why Do They Leave Physics?': Money Matters, Research and Job Opportunities

I enjoyed reading Philip Anderson's "Reference Frame" column in your September 1999 issue (page 11). The situation facing young scientists needs continuing attention if we are to keep the best and brightest of them in the field.

I agree wholeheartedly with Anderson's answers to the column's title question: "Why Do They Leave Physics?": Horganism (that is, the belief propagated by science writer John Horgan that there are no new scientific laws to discover) is a dangerous recurring infection in the scientific community, one that most certainly predates Horgan himself. And it is undoubtedly true that the current funding paradigm does little to promote creative, curiosity-driven research.

However, I believe there is also another causal factor that has led to the relative ease with which the young, talented members of our community leave, a sociological one that emerged with the end of the cold war. Government funding cuts, industry downsizing, the influx of talented foreign scientists, and other contemporaneous events led to irreversible changes throughout science in the early 1990s and shattered the dreams of many young scientists who had promising scientific careers ahead of them. Not only could they not get the kinds of jobs they wanted, they could barely find any jobs for which they were appropriately qualified. Many left physics with remorse and reluctance to take jobs on Wall Street, in management consulting, or with what would now be called Internet start-ups.

Although those employment difficulties have eased considerably, the sociological paradigm shift (to abuse a Kuhnian term) that resulted remains with us. Graduate students who began their studies in the 1990s came to physics with their eyes wide open about their job prospects. No longer did they dream of eventually walking in the shoes of their thesis advisers. They were content with the idea of doing some interesting research for a few years and then moving on to careers elsewhere. The recruiting of graduate students also changed gears: Aware that applications for admission were falling, especially from Americans, many departments began trying to sell graduate physics education as good training for many nonscientific careers. Consequently, graduate education has shifted from a kind of guild/apprenticeship model to something more akin to preprofessional training. In many graduate programs, students are offered noncredit courses to enhance their communications skills. Many of them step out of the lab a couple of nights a week to take computer science or marketing classes. Few are still dead set on the idea of a career in physics.

I do not view this shift as a bad thing. It was necessary, given the circumstances, and the apprenticeship model was doomed to implode, a Ponzi scheme that presupposed sustained exponential growth in research. But perhaps we as a community have not fully made the transition. Graduate students in many departments and research groups are still often treated as second-class citizens, as cheap labor whose every waking hour should be devoted to research. But in the cynical and savvy 1990s and in the midst of a record economic boom, that is a surefire way to drive away our most talented students.

So, although I agree with Anderson that we need to provide creative opportunities for young physicists as an incentive for them to stay in the field, we also need to address the culture of physics (and of all of science), to create a community in which they can feel welcome, encouraged, and respected.

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Philip Anderson's essay contains the seeds of the exact problem that he is concerned about—namely, that too many of the best and brightest are leaving physics. In fact, he assumes that physics is currently being practiced mostly within the confines of academia and government laboratories, and presumably within only a few narrow specialties. Unfortunately, the same attitude seemed prevalent last March at the American Physical Society's centennial meeting, where there were virtually no symposia covering such topics as fluid dynamics or optics. Recently, though, the special everyday-physics issue of PHYSICS TODAY (November 1999) has served as a welcome tonic in this regard.

The fact is, physics is where you find it, be it in academia, industry, or a government lab. It is unfortunate that there are people who would segregate physics and have it be a small, parochial, and inapplicable branch of science. If the goal of physics is truly to explain how and why the world (or entire universe) is what it is, then it is a fool's game to restrict physics to a vanishingly small subset of subjects to study.

Anderson and I agree on two points—that financial compensation in science is significantly higher outside of academia, and that industry is hiring young people while academia is not. Where we disagree is on whether this situation adversely affects the advance of physics (or of all science). In a free market, talent goes where the money is. Society has progressed to the point where the continuing advancement of technology is crucial to future development, and thus there are commercial research programs willing to pay a high price to bring in good talent. Therefore, it is ludicrous to claim that commercially funded work in, say, the semiconductor industry, the oil industry, or the telecommunications industry is detracting from the advancement of physics. It may be satisfying to blame others—namely, those with responsibility for hiring and for funding research—but that begs the question as to how many

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young researchers the physics department at, say, Princeton University has recently hired (on a tenure-track level) and how much funding the department receives from, say, the National Science Foundation.

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Although I enjoy well-taken (and well-deserved) jabs at National Science Foundation funding procedures and computational physics, I happen to think that Philip Anderson has missed the core issue in today's physics (and science in general): money.

Overhead, as a form of virtually unrestricted funds, is an object highly coveted by university administrations. Consequently, the entire research infrastructure has been overhauled to suit the purpose of securing it. As a result, the ambiance of physics has changed such that, in lieu of scholarship, scientific achievement, and reputation, we are now assessed in terms of four so-called objective criteria: number of papers published, prestige of the journals involved, number of invited talks given, and amount of grant monies received. (One of the symptoms of this shift is the explosion in the number of papers that get into print—as reflected in the fact that the heft of *Physics Review Letters* is now approaching that of *Physical Review* as it was a few years back, and yet, in condensed matter theory, which happens to be Anderson's field, progress in the last 15 years or so hardly deserves such a voluminous output.)

In short, one shouldn't expect adventurous talent to be enamored of and stay in a system run by bureaucrats and dominated by what I'll call operators. The underlying problem is not in our minds and attitudes, as Anderson seems to believe. Rather, it is the corruptive influence of federal funding, and it is very real.

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Philip Anderson's essay is a good commentary that outlines a real problem, but I think the answer is clear. Twenty years ago, physics was exciting, but now—largely as a result of all the work that has been done using government funding to address many first-order questions—it isn't. Thus the reason for studying physics today shouldn't be mainly preparation for doing physics research (that is, for learning more about nature), but rather it should be in furtherance of acquiring a modern general, or liberal arts, education. So the sensible thing to do after getting a physics PhD is to go on to systems analysis or the world of finance or some other segment of industry or commerce. After all, as Anderson points out, the better students do leave the academic world! Granted, one spell as a postdoc may be necessary to convince the graduate that it's time to move on, but it's best not to linger. (Some 20 years ago, as a physicist working for a major think tank in the Washington, DC, area, I got a call from a professor in a first-rate physics department: They were getting a student out with a PhD after 11 years, and would we be interested in interviewing him? I said no; if this man was willing to work for starvation wages as a graduate student for that long, he surely didn't have the attitude we were looking for—one conducive to grappling with real-world problems under the inevitable time constraints.)

When a British acquaintance of mine got a classics degree from the University of Oxford some 30 years ago, he became a civil servant, knowing that nobody was going to pay him to write classical Greek poetry. One of his first assignments was to lay out and oversee land purchases for a superhighway linking the London area with Cambridge. That meant having to tackle an array of complex problems and also cope with serious constraints of time, money, and so forth. In other words, he had to climb out of his professional sandbox and find ways of putting his education to work in dealing with some large-scale practical challenges. He looked to specialists, such as surveyors and purchasing agents, and his function was to integrate their work so as to provide an acceptable overall solution. He succeeded.

Similarly, I suggest, the present function of a physics PhD should be to obtain a thorough general education and manifest a willingness to tackle societal problems, rather than continue to play in the government-funded research sandbox.

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PHILIP ANDERSON REPLIES: I appreciate these letters and also the many thoughtful ones that were sent to me directly, some of which contained positive proposals for dealing with the situation and most of which were surprisingly (to me) supportive. But I would like to say a few words in response to the letters chosen for publication.

I agree with Jonathan Friedman that the "cloning" sociology that grew up in the time of expansion was unfortunate in many ways. I never caught it since my apprenticeship was served in England, where most of my first students went on to jobs like road research or Israeli intelligence; academic or real research jobs were very scarce. Neither the students nor I seemed bitter, since we felt our time together had been well spent, and when I got a few genuinely original and imaginative students, there was not much difficulty in placing them even in those scarce jobs, since there were people around the world who were willing, even eager, to take a risk with them. Such risk taking, in my diagnosis, is what is now missing.

I find it strange to be accused by Andrew Resnick of academic snobbery when I have been such an advocate of "the opening to complexity" (to quote the title of a symposium I organized) and of the "relevance," at least intellectual, of science. I am aware of much good science done for practical ends, and I think the record of Bell Laboratories, where I spent a 35-year career, abounds with examples. But in the end there are subjects in which the open-endedness of academic research is essential. The companies, for instance, that stand to gain the most from breakthroughs in cuprate superconductors are the least willing to sustain the long-term effort necessary for understanding them—but perhaps that is a proper function of government (after all, our basic understanding of the strength of materials did not come from US Steel). Of course, the young men and women who join entrepreneurial companies are not wasting their lives, but we need to keep enough of them in pure research and teaching to allow for renewal—and I will not give up the principle that they should be the best and most creative.

Again, with Rostislav Serota I have a lot in common. Far be it for me to defend the overhead system or university administrations. But I don't see them as quite as greedy as he does. Perhaps he doesn't know

that university overheads are less than half of those in industry. Government agencies, particularly the National Science Foundation, try very hard with minimal resources. Otherwise, I think he is simply reinforcing my point.

Ernest Bauer seems to have caught the Horgan infection. Of course the questions that were current when we were in graduate school have been mostly answered—as have, in my case, the ones after those. But science keeps throwing up new questions, and it takes imagination to see they *are* questions. I'm also a little tired of those British classics students—they got the UK into two world wars, messed up the Balkans permanently, and left the British people with four or five different kinds of electric light plugs. At least physicists might have done better with the light plugs. Physics—unlike the classics—is a good education for such jobs as management consulting, and I don't want to discourage those who take naturally to such careers. However, I deplore leaving only the least-imaginative individuals in physics to teach future generations.

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Fubini and Salam Inspired Plans for Mideast Synchrotron

The lead story of your "Physics Community" section in the August issue (page 54) is Toni Feder's account of new and hope-filled initiatives for peace in the Middle East, based on scientific collaboration. Specifically, she tells of the plan for the region to be given a decommissioned German synchrotron light source that would become the centerpiece of a major international research facility—site still to be determined—that would function as a center where scientists from previously hostile countries would interact, much as CERN brought together former enemies after World War II.

Although Feder does discuss the vital role played in this plan by the Middle East Science Collaboration (MESC), as well as by various individuals, she makes no mention of Sergio Fubini, who conceived the first Sinai Meeting on Physics, held in Dahab, Egypt, in November 1995 (see PHYSICS TODAY, February 1996, page 11), which led directly to the founding of MESC in 1997. Fubini has remained an active and essential participant in MESC and its push for more science in the Middle East, as reflected in what happened at the Paris meeting hosted by the United Nations Educational, Scientific and Cultural Organization last summer. UNESCO's director general Federico Mayor stated, "I wish to pay tribute to a group of scientists from the Middle East and Europe who have worked together for five years now in order to promote scientific cooperation in the Middle East and the Mediterranean region. . . . We are fortunate to have with us today the person who initiated this movement of scientists and did more than anyone else to make it the success it now is. He is Professor Sergio Fubini from the University of Turin and CERN."

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One of the key individuals who laid the groundwork for what may turn out to be the Middle East's first synchrotron light source and a major international scientific research center was Abdus Salam, a cowinner of the 1979 Nobel Prize in Physics, the founder and long-time director of the International Centre for Theoretical Physics (recently renamed in his honor), and "a humanitarian who devoted much of his life to uplifting the status of science and technology in the third world" (PHYSICS TODAY, August 1997, page 75).

As noted in *PT*, Salam, born in what was then part of British-ruled India and is now Pakistan, "dreamed of creating 20 international centers like the ICTP, spread throughout the world." As part of that vision, he actively promoted the idea of advancing the cause of science and technology in the Middle East, not only by having researchers from the region work with their colleagues in the developed world, but also by having the region develop its own facilities—including a synchrotron laboratory.

In May 1983, at the Symposium on the Future Outlook of the Arabian Gulf University held in Bahrain, Salam delivered a paper entitled "The Gulf University and Science in the Arab-Islamic Commonwealth," in which he reminded his listeners that "We forget that an accelerator like the one at CERN develops sophisticated modern technology at its furthest limit. I am not advocating that we should build a CERN for Islamic countries. However, I cannot but feel envious that a relatively poor country like Greece has joined CERN, paying a subscription according to the standard GNP formula. I cannot rejoice that Turkey, or the Gulf countries, or Iran, or Pakistan seem to show no ambition to join this fount of science and get their men catapulted into the forefront of the latest technological expertise. Working with CERN accelerators brings at the least this reward to a nation, as Greece has had the perception to realise. . . ." [1]

He then went on to make the following points: "I have mentioned an international laboratory in material sciences for Bahrain, with specialisation in microelectronics and modern electronic communications, including space satellite communication, to help also with the banking communications needed at Bahrain. Such a laboratory was in fact proposed for the University of Jeddah. The idea was to emphasise science transfer in addition to technology transfer and to create international laboratories in the fields of materials sciences, including surface physics and a laboratory with a synchrotron radiation light source. The facilities created would have been of the highest possible international order; the laboratories would have been opened to teams of international researchers, who would congregate and work at Jeddah, just as they congregate now at the great laboratories in Hamburg, Geneva or Paris. . . ." [2]

Perhaps, in memory of Salam, Jeddah (Jidda) in Saudi Arabia or a suitable location in Bahrain should be added to the list of possible sites for the relocated German synchrotron.

References

1. A. Salam, in *Renaissance of Sciences in Islamic Countries—Muhammad Abdus Salam*, H. R. Dalafi, M. H. A. Hassan, eds., World Scientific, Singapore (1994), p. 45.
2. Salam, p. 53.

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Correction

November 1999, page 83—In Piotr Wasiolek's letter, a minus sign was omitted from the conversion sequence for the average indoor level of radon. The correct sequence is 1.3 pCi/L = 1.3×10^{-12} Ci/L = 0.048 Bq/L = 0.048 Bq/(0.001 m^3) = 48 Bq/m^3.

December 1999, page 59—Charles Townes's book is $29.95, not $49.95.■