and presenting their results as well as familiarity with the funding system. In some university research programs and industrial labs there are certainly funds available for such positions. However, this is not the case with most universities. Therefore, during the present period of tight funding (one of the reasons for which, ironically, is our own "*perestroika*" in DOD funding), the government can be looked to for help and leadership in the problem. My proposal is that any principal investigator who already has research funding from any government agency be allowed to submit a very brief addendum proposal to the same agency asking for 50%, but not exceeding a certain amount, of the support (basically, for salary, publications and travel) for an immigrant scientist doing research on the same project under the general supervision of the principal investigator, provided that the immigrant has at least a PhD (or equivalent degree) and appropriate credentials. The rest of the support as well as all the major equipment, space, computer time and so on would be provided by the university. The support would typically be granted for one year, with an extension of one or two more years based on performance and funding availability.

The proposed arrangement would not require a new administrative structure and would secure a proper scientific level of research and proper academic and financial control by the university. Money for this project could be earmarked and allocated among participating agencies in proportion to their funding for fundamental research. This way, the main purposes of the program would be served: It would involve some of the best active researchers in this country, benefit already existing research programs and help to orient the newcomers toward the problems regarded as most significant here. It would also provide them with state-of-the-art equipment, computers and firsthand experience in the organization of research, as well as direct their efforts toward the (mostly) fundamental research in which they seem to be strong.

The current quota for immigration from Russia is some 50 000 each year. Assuming the number of eligible candidates to be around 2% of this amount[1] (with say, about half of those meeting the academic credential requirements) and the average cost per person to be $55 000–60 000 (including an average salary of $30 000 a year, fringe benefits and indirect costs), the extra funding would come to $14–15 million annually. Furthermore, the government could stipulate that the universities waive their indirect-cost charges for the addendum grants (but not for the 50% costs charged to the main grants), which would put the total cost below $10 million for the first year. Such a national-scale investment with a very short expected period of recovery does not look terribly expensive or risky. A joint effort by our professional societies in lobbying Capitol Hill could secure the necessary funding for such a program.

Lastly, I think it would be appropriate to make the proposed program available not only to Russian emigrés but to any other refugee or immigrant research scientists (such as those from Eastern Europe or China) legally residing in this country.

At the end of this century this country will be about 9000 short of PhD-level researchers and faculty members in the "hard" sciences and engineering.[1] The proposed program could be a significant part of the solution to that problem. A mind is a terrible thing to waste, especially that of an active, accomplished researcher. By helping these professionals to reestablish themselves in this country, we can help ourselves and give American science and industry an extra push to become more vigorous and competitive in this rapidly changing world.

Reference

1. C. Holden, Science **248**, 1068 (1990).

ALEXANDER E. KAPLAN
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8/90

Physics Career Advice—and Dissent

Leon Lederman's column "Low Pay and Long Hours" (January 1990, page 9) is at odds with my experiences and those of my contemporaries. (I got my PhD in 1981.) Lederman's very successful career was built in an era of growth in science funding. The success is atypical; today, growth is an exception.

I have been involved with many technical organizations, including huge corporations, academia, government laboratories and several small technology companies, including a very successful technology startup that was actually engaged in securities fraud. Projects I have been involved in have covered the spectrum from wild successes to dogs with fleas. Herewith is my response to Leder-

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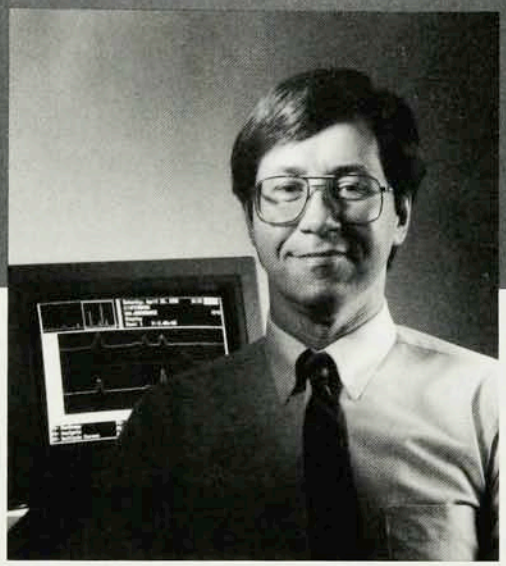

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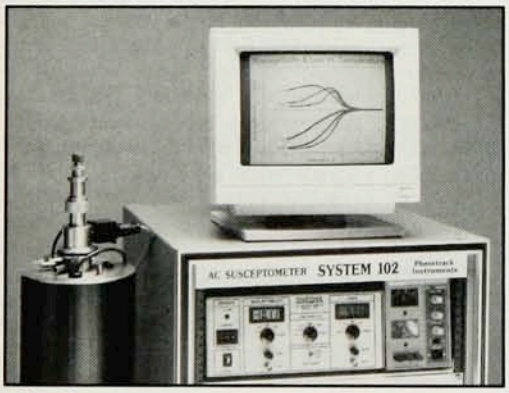

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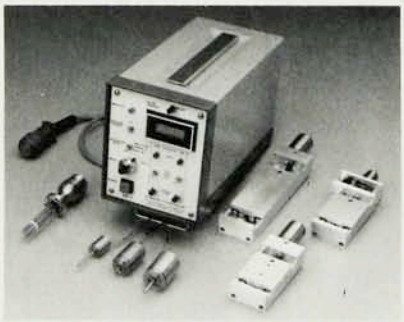

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man, addressed to the same "Young Undergrad" he wrote to:

Dear Young Undergrad,
The career issues that you so thoughtfully raise are indeed important, but I can't give you the assurances Leon Lederman gave. My advice: If you aren't crazy about science and technology, and very good at it, stay out of it as a career.

▷ *Is science good?* Why do you think science "actively promotes the welfare of humanity"? Is designing a cigarette factory good for people? Suppose you choose your alternate career, as an actuary, and in that role you help keep an insurance company profitable, thereby protecting the assets of retirees. Isn't this "good"? Maybe your real issue here is *significance* rather than goodness. Science contains the possibility of doing something significant for humanity. But really significant discoveries are very rare, and it's not wise or realistic to bet your career on one, regardless of your level of talent.

▷ *Finding support.* You have not yet had to find funding. You may think because science is important, there will be funding. This just ain't so. You will have to get financing for your research, regardless of where you work. Managements operate from a financial paradigm, not a technical one; few managers have much understanding of technical issues. The currency of management is schedules and budgets, not scientific merit. Even technical successes are frequently viewed as a credit to management, for "having made technical resources productive." Technically challenging (interesting) projects are usually perceived by managers as dangerous and risky—something to be avoided.

▷ *Federal funding.* In the last decade, it has become much more difficult for individuals to obtain Federal funding. Government research funds, traditionally allocated by peer review, have often become oriented to big projects and highly politicized: What congressman's district gets the supercomputer center? Scientists are not exempt from these demands: If you see stories in the press about a Federal research area—the achievement of high temperatures in fusion, global warming, first views of the Stealth bomber, a successful "Star Wars" test—you can be pretty sure the funding is up for review.

▷ *Industry and finance.* In commercial organizations, research has not been in vogue since the 1960s. It is expensive and uncertain, and there are surer ways to make money. To draw an analogy to architecture: Most architects would probably like to design buildings of originality, beauty and enduring value. Reality is perhaps a shopping mall, where the only language for measuring value is a discounted cash-flow analysis of lease payments. Pitching for funds in industry, you will face one manager after another who will want to know a little about your ideas and a lot about your costs, schedules and returns—the last being the only acceptable criterion for funding decisions.

It is seldom understood by scientists that the financial community values technological prowess primarily because it can enhance the perceived value (price) of securities. The *appearance* of prowess does the trick, since most stock analysts and buyers aren't technically trained. How many Nobelists sit on the boards of startup companies? I promise you the prospectuses of such companies (written by investment bankers) mention these affiliations prominently. At a Fortune 500 company where I worked, less than a week after an expensive ion implanter arrived, the company photographer arrived to take pictures for the annual report. Five years later the machine had barely been used—this just wasn't where the emphasis was.

One businessman I know commented that in the world of finance, the function of PhDs is to "speak when spoken to." In commerce, the value of a scientific degree is often unrelated to science: It serves as a credible endorsement of financial transactions, be they stock sales or R&D allocations. Research has a role that is inevitably secondary to this marketing function. Is posturing for Wall Street what you had in mind for a science career?

▷ *Drawbacks to a technical career.* There are significant rewards that go with technical careers—intellectual stimulation, the company of well-educated people, the parade of nature's marvels, the limousines and groupies. There are also big drawbacks. The training is as long and difficult as that for medicine or law, without yielding the financial and professional status attendant to those fields. I have twice been offered the "opportunity" to work without pay; I have been told on three interviews that "the only way we can hire you is if you have your own funding." This is tantamount to paying for the privilege of working, since employers usually charge overhead to research contracts. In short, you will have to save your efforts for funded activities or the search for them: *This should not*

be confused with scientific research.

Further, in organizations where work is supported by outside contracts (common in engineering and research), the professional staff lives from contract to contract. Layoffs are the remedy of choice when these expire. Success in business will give you money; in science, you get to keep your job for another year (unless someone annexes your funding first). Secretaries and bureaucrats, who charge to overhead, actually have more secure jobs (and didn't endure grad school to get them). Lederman cites contact with professional colleagues, but this costs travel money—by now you should know what that means. In one lab, management sent the scientific staff a fiat that actually said "the only acceptable reason for requesting conference travel is if attendance will attract funding"; *specifically excluded* were "the scientist has a paper to present" or "the scientist wants to go."

In many creative fields, such as music or acting, there are established channels, like residuals, that pass some of the income to the artist. Not so in technology: Financial rights inevitably accrue to the organization and not the individual.

Your scientific reputation depends on the quality of your ideas. But idea theft occurs in all scientific fields. There are no laws against stealing ideas unless there is clear financial damage. Time and again I have seen unscrupulous office politicians strip inventors of credit for their work. Few organizations have any means of adjudicating scientific ownership. (If there's no court, there are no crimes.)

If you're still with me, Young Undergrad, please note that *all* fields of endeavor have their drawbacks; I have tried to warn you of the problems with technical careers. Science really isn't different from any other human activity. It isn't better for mankind; the timeless failings of greed, ego, incompetence and folly are very much a part of the technical milieu. The only valid reason for going into it is if you enjoy it enough to outweigh the negatives.

2/90 NAME WITHHELD BY REQUEST

In a way, Leon Lederman must have led a very sheltered life. Perhaps professional success and prominence have blinded him to the restriction of opportunities that life offers to other scientists and engineers.

In his Reference Frame column "Low Pay and Long Hours" Lederman states, "Today any trained scientist or engineer who is average (B) is assured employment at reasonable

wages." This is plain out not the case, and in making such an inaccurate statement in the context of his letter to an anonymous "Young Undergrad," Lederman has presented career information for students that will undoubtedly be taken as authoritative but is potentially seriously misleading.

Employment at reasonable wages is not assured to anyone in the contemporary American market economy, and unemployment or underemployment is a fact of life for many scientists and engineers.

Furthermore, scientists and engineers are a heterogeneous bunch, and unemployment hits some groups harder than others. Aeronautical engineering is famous for its boom-and-bust cycles, with engineers earning great salaries one year and finding themselves out on the street the next. And where are all those terrific high-paying jobs for geologists, geophysicists and petroleum engineers that we heard about a few years ago? What happened to the demand for reactor engineers and reactor physicists? Many corporations are downsizing, and right now defense electronics, for example, is not a very comfortable place to be. Another, related example in physics is that the weapons laboratories are not in the exuberant hiring mode they have been in on occasion in the past.

Being one of only a few individuals in a particular research field can also lead to employment problems if you want to remain in your field of specialization: Even if you are an outstanding student, you can still be in trouble when it comes to job hunting if there isn't a coincidence in time between an opening in one of the very limited number of positions in your field and the time interval during which you are conducting your job search (as a superbly qualified young physicist of my acquaintance found out to his dismay last year). So even if you are a top-notch student, you can make the mistake of picking the "wrong" field and find it hard to get a job doing anything like what you want to do. Other factors can play a role too: If you aspire to a career in science but were born female, you will find yourself up against the fact that you are job hunting as a member of a group characterized by a higher unemployment rate. The unemployment rates of women doctoral scientists and engineers, for example, are two to five times those of men in the same field.[1]

As Americans, we live and work in a society in which employment is not an entitlement. A student doesn't earn a job by getting good grades, and even if he or she finds a position in science or engineering, it will not necessarily be well paid, at least in comparison with jobs in some other fields that are more highly regarded and more highly valued in our society.

As a physicist, I personally enjoy science immensely, and I would encourage any student who shares my enthusiasm to go all out for a career in science or engineering. But it's not all a bed of roses. For a distinguished physicist like Lederman to write that today any average trained scientist or engineer is assured employment at reasonable wages is in my opinion irresponsible and a disservice to students who may read his letter to the Young Undergrad and believe it.

Reference

1. B. Vetter, in *Contributions to the GASAT-5 Fifth International Gender and Science and Technology Conference*, vol. 1, I. Ravina, Y. Rom, eds., Technion—Israel Institute of Technology, Haifa (1989), p. 5.

CAROLINE L. HERZENBERG
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1/90

The exchange of letters between Leon Lederman and a "Young Undergrad" touched on problems that are rather painful for any scientist.

"Why should we bother to pursue careers in science?" asked the Young Undergrad. Certainly we remember times when physics was in fashion owing to the sensational promises of nuclear energy and spaceflight. However, I believe most undergraduate physics majors come to study science, not for a career. Curiosity and the desire for a permanent feeling of being in touch with mystery are the main stimuli for students, and only those who are able to maintain these all their lives have made the right choice.

Why do we feel that it is physics that we must pursue? I belong to the generation of Soviet physicists who graduated about 15 years ago. Some of us could not get places at the universities or Soviet Academy institutes because we were of Jewish origin or held dissident views. What forced us to engage in physics secretly while at our workplaces, and on evenings and weekends? (Certainly the theoreticians did this.) Recently some of this group emigrated to the US. What forced many of them to start from the postgraduate level, even though they might become applied programmers and have no financial problems? Do we explain why we love a certain woman? No, we

seek meetings with her.

Well, once we have declared love, two problems arise immediately: reward and jealousy. I think the Young Undergrad's questions are connected with just these companions of our feeling.

"Why should I bother to work hard?" the Young Undergrad asked.

"You have to give 100% of what you've got. If you give less, you have no talent." This challenge posed by the artist Marc Chagall may be the best answer. But the sense of the question is, "Why do others work less and get the same or even greater rewards?"

What is the real reward for a person? How far can we move if our motivation is jealousy of others? These problems don't exist for scientists alone. Sport, business, . . . any mode of self-expression evokes such problems. We know scholars who are sincerely happy every time they have a note published. Nevertheless, the biographies of many prominent scientists convince us that your most severe judge may be yourself.

So, dear Young Undergrad, if such "damned questions" appear in your mind, they will worry you all your life. Be courageous and don't hope that routine business (you mentioned becoming an actuary) will save you. Frankly speaking, sometimes I want to remain a database manager only (my official job is connected with such duties). Nevertheless I always remember a parable:

A sinner died and went to Hell. He was surprised to find himself in a splendid apartment. He got a delicious supper. Then he spent the night with a nice woman.

"Is this really Hell?" the sinner asked a servant the next morning.

"Yes, sir. You will live here eternally—in this apartment, with the same supper as last night, the same woman and me" was the answer.

ANATOLY B. SCHMIDT
5/90 *Riga, USSR*

LEDERMAN REPLIES: Name Withheld's lengthy advice has lots of relevant detail, and I have very little quarrel with most of this except for the tone of aggrievement at the fact that the world is a far from perfect place. Yes, business puts profits above support of pure science; yes, someone may steal your ideas; yes, the cultural norm of modern America is far from what we would like; yes, not all technological work benefits mankind. So what's new?

This shy respondent insists on adding the small print to my somewhat romantic pitch. Long before Galileo's

difficulties, scientists were embroiled (in the case of Giordano Bruno, literally!) in real-world brouhaha. As professionals, scientists are given very little absolution from the earthly burdens that bankers, lawyers, policemen and schoolteachers carry. My point was simple: "To thine own self be true." That is, find out what it is that turns you on, and if it's science, go for it! But by all means don't send money until you read the prospectus.

Caroline Herzenberg complains about the accuracy of my assertion that "today any trained scientist or engineer who is average (B) is assured employment at reasonable wages." Let's see where I get this: In the NSF's *Science and Engineering Indicators—1989* we read: "Science employment [in the science and engineering work force] nearly doubled [in the 1980–88 period]; employment of engineers increased by 75 percent. Overall S/E work force grew by 7.8 percent per year during this period. In comparison total US employment increased by only 1.8 percent per year."

Then later: "In 1980 the unemployment rates for scientists and engineers were 1.6 percent and 1.0 percent, respectively, compared to 2.5 percent for all technical and professional workers and 7.1 percent for the entire US work force."

The number of scientists and engineers employed in jobs outside science and engineering is admittedly more significant. We'd need more data to know how much of this is voluntary—more money, more socially redeeming and so on—but in any case I don't believe it is a big factor.

Still later in the *Indicators* we see: "The experience of recent S/E graduates is another indicator of the degree of market balance. In general, the demand for scientists and engineers is greater than the supply at existing salary levels, and the proportions of recent graduates who obtain jobs in science or engineering will be relatively high."

I have also been impressed by the projections, most recently summarized by Richard Atkinson in *Science*.[1] The NSF, using economic data from the Bureau of Labor Statistics, estimates the supply–demand ratio based on plausible indicators, retirements and demographics. These analyses concentrate on PhDs and project an annual shortfall of 7500 PhDs *per year* in the first decade of the 21st century. Although these projections may have errors, they simply use present activity as a base. Clearly, transients such as the welcome conversion of military to civilian R&D will be present. I personally believe the shortages are vastly underestimated because they do not include the tremendous scientific and technical burden of three major global problems: the need for environmental improvement, materials shortages and the north–south gap between the hemispheres in standard of living. How can we reverse the ecological degradation of the planet; design around the shortages of such materials as oil, high-grade iron ores, vanadium and cobalt; and raise the quality of life for the impoverished 70–80% of the world's population without further environmental degradation?

Summarizing, I believe there are reasonable data to support the sense of optimism that triggered Herzenberg's ire. However, the preferential unemployment that she asserts women suffer doesn't show up in my dry numbers and is, if real, not only intolerable but stupid.

Anatoly Schmidt gives us an interesting and poetic glimpse of the life of a Soviet physicist and says it all much better than I did. It is heartwarming to encounter a PHYSICS TODAY letter on my side!

Having said all this, I would like to agree with the respondents on one important issue, and that has to do with the current health of the academic science enterprise. There is no question that science in our universities is in very poor shape and that this can be traced to an underinvestment by the Federal government in basic and applied research. If not soon reversed, this policy could have devastating consequences for science in the US. I believe solving this problem requires concerted political action on the part of (older!) scientists. A continuation of this academic malaise will certainly make the life of science less appealing. However, I made my own decision to go into science during the Great Depression, when, to first order, there was 100% unemployment. I would have given the same "advice to an undergraduate" then as I did in January.

Reference

1. R. Atkinson, Science **248**, 425 (1990).

LEON M. LEDERMAN
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8/90

Mitogenetic Radiation: Pathology, or Biology?

The inclusion of "mitogenetic radiation" as an example of "pathological science" in Irving Langmuir's 1953 talk on that topic (October 1989, page 36) may or may not have been appropriate at the time he delivered his speech. The references cited by Robert Hall, who edited the talk for publication, are quite old. Several more modern citations should bring Hall up to date on mitogenetic radiation.[1]

The gist of these articles is that many cell systems emit ultraviolet light during or immediately before cell division and that the total effect of this emission on neighboring cells is still not known. The 1985 article has many recent references on mitogenetic radiation in yeast cell strains. Giuseppe Cilento has written an excellent overview of ultraweak bioluminescence.[2]

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1. T. I. Quickenden, S. S. Que Hee, Biochem. Biophys. Res. Commun. **60**, 764 (1974); Photochem. Photobiol. **23**, 201 (1976); Radiat. Res. **46**, 28 (1971). T. I.