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It's probably not relevant, but I was talking to someone the other day about the VCR as an example of Japanese initiative, and their comment to me was, "It's better than having us build the VCR's while they make the movies."

It is a distinct pleasure to be here this afternoon. I especially want to thank Leon Lederman for inviting me to my first visit to this fabulous laboratory. I was gratified to get Leon's invitation, because at the time he called, I wasn't all that sure that someone from the NSF would be welcome here. That's because my boss, the Director of NSF, Erich Bloch, not too long ago suggested that maybe the National Science Foundation should no longer support high-energy physics. As you can imagine, that's created a certain amount of distress among the high-energy physics community. Erich Bloch is more provocative than I'm going to be. Recently, he was quoted as saying that the national laboratories ought to be required to get 30% of their funding from industry and if they can't do it, then shut them down. Industrialists who read this monograph are in for a really big surprise when Lederman sends an invoice in a few weeks.

When I approached the subject of spirals and technology transfer I had a sinking feeling. I decided that, even though I know nothing about technology transfer (I work for the government, after all), I could talk about that, because the National Science Foundation has an increasing number of programs that have some kind of technology transfer as one of their goals due to the growing concern about competitiveness.

Because technology transfer is one of the mechanisms proposed for improving the competitive posture of the country, it is useful to discuss the connection between economic competitiveness and the National Science Foundation, because NSF has claimed that it has a role to play. Many academic scientists view

saying NSF and competitiveness in the same sentence as a non sequitur, or at least they hope it is. It scares academics, because they think NSF is really changing its mission. In what follows I want to explain to you how we see that connection from the NSF vantage point.

Why should scientists worry about economic competitiveness in the first place? The most obvious reason is that, unless our country has a healthy economy with increasing productivity, there's not going to be enough money to invest in scientific research. We're already seeing examples of that. In fact, the deficit and the recent stock market crash led directly to the demise of President Reagan's request to double the budget of the National Science Foundation.

Another manifestation of this problem we have with competitiveness, and the trade deficit, and the budget deficit, is the increasing number of calls one hears for prioritizing in science. All of a sudden, we're hearing the statement, "You've got to set your priorities in science because the country cannot afford everything anymore, and we're not going to be able to do everything." We hear that all the time now, at least in Washington. Another reason for talking about competitiveness is that, as Steve Lazarus noted, it's *the* issue in Washington. It has been for awhile. It is a buzz word. In fact, I heard a congressman say it's a buzz word squared the other day. On the other hand, most serious people regard it not as a fad, but as a truly serious problem for the future of this country. It's not something that's going to go away and it will be a serious issue when the next administration comes into office.

I want to say something about competitiveness at the national level and then try to explain the role that NSF has claimed in this area. Someone recently said that if the Seventies in this country were the decade of inflation, then the Eighties are the decade of debt. Some people call it the decade of conspicuous consumption in this country. Simply put, for too long a time we as a nation have been living beyond our means at a standard of living that's not sustained by our productivity. We've been doing that with a very simple expedient - we've been borrowing. Borrowing on a really big scale. The total national debt is now approaching $3 trillion, an incomprehensible number even to high-energy physicists. A little more comprehensible, when you think about it, is the interest we pay every single year to service that debt: $150 billion a year. One hundred and fifty billion dollars that doesn't buy a Superconducting Super Collider, that

doesn't pave any roads, that doesn't double the NSF budget, $150 billion just to service that $3 trillion debt. Much of the borrowing that we've done has come from foreign investors, to the point where we now are the largest debtor in the world. We achieved that distinction in 1985. Our foreign debt now totals about $400 billion, almost 10% of the annual income of our country. It's interesting to ask how these debts are going to be repaid or who is going to pay them. I'm not an economist and I don't understand these things all the time, but I'm pretty sure I know the answer. The answer is that our children are somehow going to have to pay. In that context, it's sobering to realize that, because of demographics, never before and probably never again will this country have as many people working and paying taxes as it has right now.

What does all this have to do with NSF? After all, solutions to the trade deficit and these things are very complicated and controversial issues. What could NSF possibly contribute? There are two things that nearly everyone on both sides of the political aisle agree are necessary, if not sufficient. These are things that the nation has to do if it's going to remain competitive or be competitive in a strategic sense in the long-term future.

First of all, the United States must invest aggressively in basic scientific research to create new knowledge. Everybody agrees that's important. Second, the United States needs to continue to invest in the education and training of future generations of scientists and engineers so that we continue to have a skilled work force. Everybody agrees that those two things are important.

Bingo! That's a definition of the National Science Foundation to a first approximation. That's exactly what the National Science Foundation does and has really always done. In fact, those are the only two things that Erich Bloch or any of us has ever claimed NSF has to contribute to improving the competitive posture of the country. We have not said that we're going to do more applied research. We have not said we're going to do research for industry. We've not said a lot of the other things that I've heard us accused of, either.

Suppose you're sitting there in the Roosevelt Room in the White House, and you're making this argument to the President, and the President says, "Well, okay, I agree. Those two things are really important. But, after all, aren't we doing enough right now as a nation? I mean, aren't we okay when it comes to those two things?" I think the answer you'd have to give is that it's true. We

invest an incredible sum of tax money into R&D, $65 billion. But if you look at basic research, at the creation of new knowledge through scientific research, if you look at education and training, then I think the answer you have to give the President is that we're not doing very well as a nation.

In terms of investments in R&D, the picture is not a particularly reassuring one. In fact, it's been greatly exacerbated just in the last seven years by the rather dramatic shift, at the federal level, in the balance between civilian and defense research. For a long, long time in this country, defense was about 50 cents of the R&D dollar. In the space of seven years, defense expenditures have grown to about 75 cents on the federal R&D dollar. Moreover, the fraction of defense-research expenditures devoted to basic research has declined.

What about the other NSF role, that of educating and training future scientists? I think you probably know the answer from your own experience in terms of education or from things you read in the newspaper or from some of the studies funded by the National Science Foundation. Instead of trying to give you all those statistics, I thought I would just relate a couple of personal anecdotes to illustrate the situation.

My wife is a high school chemistry teacher in one of the suburbs of Washington, D.C. Recently, a student came in after class for help. At one point he said to my wife, "Mrs. Nicholson, I ain't never had a course as hard as chemistry." She looked up at him and in all innocence said, "Oh, really? How are you doing in English?" And the student said, "Oh, I done real good there. I got an A." That is a true story. Or how about this answer that another teacher got on an examination question: "The pistil of a flower is it's only protection against insects." "It's," of course, is spelled with an apostrophe-s. And here is one student's attempt to explain the tides: "The tides are a fight between the earth and the moon. All water tends toward the moon because there's no water in the moon and nature abhors a vacuum. I forget where the sun joins in this fight." That's the situation at the front end of the education pipeline in this country.

What does it look like at the output end of that pipeline? How does the future look in terms of the supply of scientists and engineers? Again the news isn't very good. The 22-year-old cohort in the United States is now dropping like a rock and it's going to continue to do so late into the next decade. I'm talking about immutable demographic data. Even if all of us decided to start working

on it tonight, we couldn't change that number. Moreover, Congress can't pass a law to change it. I suppose I shouldn't say the Congress can't do something. I do recall once that a state passed a law which made pi a rational number. The sharp decline in the number of 22-year-olds in this country surely portends a future sharp decline in the production of Ph.D.'s in this country. That trend will reach a low point at about the same time that, due to bad luck as much as anything, a lot of retirements will be taking place in all of our universities.

What's the solution? One thing we could do is try to get better representation from under-represented groups in science and engineering - women, minorities, and the like. For example, in the year 2000, 29% of the births in the United States are projected to be black. That's a significant resource for the future. But historically, blacks have shown very little interest in science, and the current trends are in the wrong direction. Another solution is to make up the difference with foreign Ph.D. students. In fact, that's how we're dealing with the problem right now, but in a certain sense, I think it's probably akin to the borrowing that I mentioned earlier. I think it's questionable whether it is good public policy for us to be so dependent on a critical resource that we don't control. I think that was illustrated very nicely just recently when we read that China, which has been the source of some of our most gifted students in this country, is going to turn off the valve. The number of Chinese students coming to this country will drop from 8000 to 600.

To make a long story short, I've just recited the basic arguments - improving investments in research education and training to underpin future competitiveness - that Erich Bloch made when he convinced the President to propose doubling NSF's budget a little over a year ago. I want you to know that we did everything we could to get that budget through Congress. Our astronomer friends arranged to have a little star they didn't need anymore, in the large Magellanic cloud, explode just a month after the State of the Union Address. That made the cover of *Time* magazine. And just for good measure, we had one of our program officers, a fellow named Paul Chu, publish a paper about high-temperature superconductivity in *Physical Review of Letters* just a week after the supernova. There's been all sorts of excitement about science this past year that we arranged in order to get the budget increase for the National Science Foundation.

As I said earlier, the stock market crashed and we lost everything when that happened. In fact, it was a double whammy, because the resulting budget summit also set limits on 1989 budgets with very little growth in domestic spending and no possibility to trade off domestic and defense spending. As a friend of mine says, support for science on Capitol Hill is a mile wide, but it's only an inch deep. I think that's really the state of affairs. Everybody's for science until a crunch comes. It's very frustrating, because I think all of us really do believe that the country, if it's going to be competitive in the future, does need to make these kinds of investments. But I don't think the prospects look very good, to be honest with you. We have these big debts and our country's now saying it can't afford all of these expensive things. The space station alone will cost more than the combined cost of all the big science facilities built in this country since 1945.

This leads to statements like the one that appeared in *Business Week* a few months ago: "The problem is that no one is setting priorities for increasingly costly science and technology projects. Scientists are asking for too much." More recently, *Business Week* said, "Lobbying efforts on big ticket projects have put the once lofty science community in the same league as other special pleaders seeking legislative pork." *Newsweek* puts it this way: "Suddenly, science is competing for scarce funding, not only against other national needs but against itself." And later *Newsweek* says, in an editorial, "Scientists need to curb their own excessive appetites. In an age of ever more costly science projects, everyone must accept the need for setting intelligent priorities." These are comments that I think we as scientists are not accustomed to hearing from the public in this country. I don't think they bode well for the future.

On this regrettably gloomy note, I'm going to stop. But I feel that this is a situation that all of us in the science community need to take seriously and think about, because something fundamental is changing now in the public attitude toward the support of scientific research.