The Physical Sciences in a Changing Environment

William C. Harris

In December 1994, the Swedish Natural Science Research Council organized a one-day symposium on the subject "Natural Sciences in Society" to be held April 3, 1995, in Stockholm, Sweden. The letter of invitation stated: "After the breakdown of the cold war, it is clear that the situation for natural science has changed internationally and we may also foresee substantial changes in the years to come. Research that before was taken for granted must be motivated in a context that the society of course understands. This trend is now clearly seen internationally, and Sweden is no exception. It is important for the scientific community now to bring up these matters, discuss them, and formulate as clearly as possible why natural science is important and how it relates to various aspects of society and mankind."

Invited speakers were: Professor Jan Borgman, Holland, chair of the European Science and Technology Assembly (ESTA); Dr. Peter Morand, president of NSERC of Canada; Professor Jurgen Mittelstrass, Universitat Konstanz, vice president of the Academia Europea; Professor Dervilla Donnelly, University College Dublin, vice chair of ESTA; Dr. William C. Harris, NSF; Professor Jens Fenstad, Oslo University, Institute of Mathematics.

This article is abstracted from the lecture presented by William C. Harris at the symposium.

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Overview

A goal for this symposium, I believe, is to ensure we all understand that one consequence of the ending of the cold war is a major restructuring of each nation's economic priorities. The citizens in each of our countries are asking similar questions, and we are all facing budgetary short falls. In fact, I am sure that many of us in this room today have been asked, in some form, how we would handle possible reductions in public funding for research. And we have probably been questioned about the value of the research investment relative to other priorities for public funds. Let me share with you my personal views on the issues associated with this symposium.

Before focusing on the budget issues that have helped to give rise to the above questions, I believe it would be useful to pause for a moment to recognize that the most important consequence of the cold war ending is the reduction in East-West tensions. The end of the cold war permits us all to move beyond a world motivated by the military-industry complex to a world that is driven by innovation, knowledge, and ideas. Each country can now place greater emphasis on economic growth and the quality of life for all citizens; that is important for all of our futures. In the post-cold war world, all sectors/countries must learn to compete and to cooperate.

Figure 1 displays the FY96 U.S. federal budget in broad categories to help make clear the nature of the problem—that is, the size of the deficit relative to the total federal budget. It now appears the entire budget is going to be examined for possible reductions, since there is a

growing recognition that it is not in the nation's interest to eliminate the deficit by focusing the reductions on the portion labeled as "discretionary" funding. The "discretionary" category of the budget contains a variety of investments

PostScript Picture
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important to our nation's future, including research and development—that is, investments like the National Science Foundation (NSF).

I believe a discussion on the changing environment for research support is particularly important, since a number of independent economic studies demonstrate research is essential to wealth generation and the improvement of the quality of life for all of mankind (see, e.g., Edwin Mansfield, *The Review of Economic Statistics*, February 1995, page 55). And, importantly, basic research is also a pure form of knowledge advancement, which is a key to our future. NSF leadership in this dialogue in the U.S. is particularly important because our research institutions are all under enormous stress. To emerge stronger and more effective for the long term, in my view, we must end the simple focus on a single budget year or a single discipline. We must take a longer and broader view and, also, reestablish the rationale for public support of the sciences as we approach the twenty-first century. Perhaps we need to focus on the following questions, in order to set our goals and priorities: Where do we want to be by the year 2000 or 2010, and how do we get there? Let's agree that we need to control our own destiny.

Background

For decades following World War II, U.S. Government science and technology policy was focused on support for basic science and government-mission R&D—predominantly defense, followed by health, aerospace, and energy. New discoveries in science laboratories were assumed to move more or less automatically through a pipeline of applied research, development, design, and commercialization. R&D and procurements for defense and other government missions were assumed to spin off into commercial products and services. That approach worked well at a time when our nation's top priority was winning the cold war and when U.S. companies dominated world markets. It does not answer our nation's needs today.

The physical sciences continue to be an essential fuel for a successful free-market economy. As important as research investments in the physical sciences were in the cold war era, they will be even more important in the post-cold war era, in my opinion. But one of the challenges physical scientists now face is making sure the public understands the value and purpose of this research investment in a contemporary society which has "down-sized" its private sector investment in the physical sciences. Together, we must help the public understand that this is an investment in their future; otherwise, the public may down-size its investment in the physical sciences and shift the resources to other things. To ensure the public understands the central role mathematics, physics, and chemistry continue to offer for economic and intellectual leadership, we must all participate constructively in the process of priority setting.

U.S. Congressman George Brown, a strong supporter of science and technology, has warned scientists that without a strong economy, there cannot be continuing growth of funding for research. In fact, he has predicted that U.S. R&D funding will be reduced by more than 25 percent (see June issue of *Notices* for details). We must understand that there are limited funds in all national treasuries and many calls upon those funds. No component of research, including fundamental science, can claim the entire budget or a disproportionate share. Thus, we should not be infuriated when asked by those who provide the resources for research: What good is it? Or, how much public support is enough? Rather, we should seize the opportunity such questions provide to explain clearly the value of the investment for the long and short term.

There is currently an intense national debate about the appropriate level of R&D investments for all sectors. Unfortunately, the discussion of R&D budgets, in my view, has been complicated by our vocabulary. Words are used that carry different meanings, based upon your respective experience. For example, budgetary arguments for science, in recent years, have been cast in terms of research that is: "curiosity driven", "need driven", "useful", "strategic", "basic", "fundamental", "applied"; and in the Department of Defense, we use numbers or codes like: "6.1",

"6.2", and so forth. I could confuse the debate further by suggesting terms equally descriptive, such as "knowledge driven" or "pioneering research". It is important, I believe, that we help others understand that science and its applications are complex, interrelated activities. Clearly, we have a shared responsibility to ensure the public understands, trusts, and believes in the purpose and value of our research investment portfolio.

We must simplify the vocabulary and make sure the purpose of this public investment is clearly articulated. My bias, of course, is to develop a highly understandable framework that does not promise to do things that are simply impossible or not credible. And I prefer to develop a framework for our rationale built upon an investment in people and their ideas. Innovation comes from people—and we can surely do a better job making our case by collectively communicating advances that originate from real people and that connect to the broader society paying for these investments.

The history of science is very clear. Namely, there has been fundamental science that has been pursued to understand natural phenomena whose relevance and potential impact were unknown at the time of the work. And there has been fundamental science pursued with a clear vision of how the knowledge gained would be important to others or what impact it would have on society. Throughout history both types have flourished. In fact, it is a relatively recent phenomenon which has tended to have the former become synonymous with fundamental or basic research. The irony is that more than ever today, science drives technology and technology creates new opportunities for science.

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Challenges and Opportunities

Each nation is facing many challenges—economic competitiveness, improving the environment, health care, defense conversion, the safety and security of our homes. It is a long and still-growing list. Virtually all of these challenges share one important ingredient. Each requires a major contribution from the talents and capabilities of the scientists and engineers from each of our countries. The magnitude of the challenge we in the U.S. face is made even greater by the overriding need to reduce the federal budget deficit. The very existence of the deficit casts a cloud over our ability to invest in the future well-being of our children and grandchildren.

The research universities in the United States remain a unique asset—really treasures—of our nation, but they are facing serious financial challenges that, ultimately, will lead to a restructuring. We at the NSF are concerned that the restructuring of academe be purposeful and strengthening—preserving excellence, innovation, and risk taking—qualities important to the country and its people.

Not one of us will receive a "blank check" for the sciences. And, in my view, it is fair for the public to ask: How much is enough? Or, if we are given $X annually (where X is multi billions of dollars of public support), how will the society benefit in both the long and short term? If we do not or cannot answer these questions, others will do so for us. And we will have failed to control our own destiny.

There is, however, one very positive side effect of this constrained budget environment. It places a premium on developing new approaches to research and education that work to the mutual benefit of government, industry, and universities. Cooperation can no longer be considered a luxury or a tangential part of science and engineering. It is a necessity and will be a central part of both the support and the conduct of research and education in science and engineering, in my opinion. There will continue to be significant research opportunities in the U.S. for those prepared to address the current challenges responsibly.

Although some of the long-standing barriers between the industrial sector and universities are

beginning to fall, there are still many challenges and issues. We want to encourage "appropriate" interactions driven by fundamental science, engineering, and education. The NSF is prepared to support appropriate interactions involving academe and industry—to experiment with what is needed in specific areas. For example, the NSF will support opportunities for: (1) faculty, students, and postdoctoral fellows to conduct research and gain experience in an industrial setting; (2) industry scientists and engineers to bring industry's perspective and integrative skills to academe; and (3) interdisciplinary industry-university teams to conduct long-term projects. Support for such industry-university partnerships will be merit based.

When I talk to people from industry, they regularly tell me that one mechanism is more effective than any other for knowledge transfer—supporting substantive interactions among people in the different sectors. In addition, industrial scientists and VPs for research strongly support the federal government's role in the U.S. in supporting basic research in universities. This way you get both new knowledge as well as educated and skilled scientists. Industry agrees the NSF emphasis should be on people.

When students who have participated in joint research activities move to jobs in industry, they bring with them an understanding of industry and a respect for careers in industry that often in the past had been missing from the academic experience. This last point is undoubtedly the most important for ensuring the rapid transfer of knowledge and technology between universities and industry. It brings students and their new ideas from their classrooms and campus laboratories to their first jobs in industry and elsewhere. But these students need to come with the knowledge, skills, and attitudes industry needs.

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Conclusion

Despite the serious resource challenges, research continues to stand out as the ultimate multipurpose activity. It is a great vehicle for education and training, particularly in the U.S. Research is also a unique test-bed for new techniques and technologies as it generates new knowledge that can help solve important problems. But we need to identify these benefits more explicitly and to tell the broader public about them. No one else can communicate on these topics as effectively as active scientists, and we must ensure that the value of the public investment is understood now and in the future by participating more completely in the public dialogue. Clearly, our colleagues in industry must be our partners in this discussion with respect to research being viewed as an investment in our respective futures.

As we move forward to a new equilibrium point with respect to public trust and support, I believe it will also be important for us to move beyond the artificial barriers that tend to separate disciplines and sectors. We will continue to be expected to make choices so that excellence and unique ideas are supported on the basis of merit, not entitlement or history. Let's make sensible arguments for the support of research and anchor them firmly in excellence and openness. Let's work together in science and share the costs appropriately. And let's ensure that our young scientists meet, visit, and work together—compete and cooperate at the frontiers so that all citizens benefit.

Finally, let's make sure we recall that universities are really about education, knowledge, and, most importantly, people. If the focus is on the rich diversity of our people—particularly our students—it is my belief that the U.S. research and education enterprise will be uniquely positioned to respond to the challenges and the new opportunities.