

PUBLIC SUPPORT OF SCIENCE: SEARCHING FOR HARMONY

Since the cold war ended, scientists and politicians seem increasingly at odds. Scientists need to address social concerns more squarely in their work.

Roland W. Schmitt

My subject is the rationale for public support of science in the post cold-war era. The first question is, Whose rationale? Congressman George Brown's or Senator Barbara Mikulski's or President Bill Clinton's or Phil Anderson's or Leon Lederman's? Everyone seems to be singing different tunes, and it is hard to hear any harmony in their voices. And yet with the profound changes in the forces that have driven our Federal science and technology policies, it is now more important than ever to find that harmony.

The rhetoric of today seems to signal a growing disagreement between the politicians and the scientific community. But I believe that schism is, to paraphrase Dorothy Parker, on the surface very profound but deep down quite shallow. I'd like to dig a little to see if we can find a harmony that is not just a compromise but rather is based on a valid synergy of interests.

Serendipity versus strategy

Let's start by looking at two representatives of the public, both of whom are influential in the life of US science today: Congressman Brown and Senator Mikulski.

Brown is urging a strategic approach to funding science, in place of reliance on serendipity—the approach he feels has characterized the past. As he puts it, “New directions must move us from the myriad serendipitous paths of where we are capable of going, to the strategic paths where we must go if the planet and its increasing population are to survive.”

Mikulski is also an advocate of a “strategic focus on basic research.” She warns scientists not to “shroud curiosity-driven activities under the rubric of strategic activities.” She warns that if the National Science Foundation can't set “specific performance milestones,” then some of its funding ought to go to other agencies that can set such milestones.

Now, you may be thinking, With friends like these,

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who needs enemies? Serendipity and curiosity have been the mantras of scientists seeking more funding for basic research. Indeed, the American Chemical Society has titled a glossy four-color booklet promoting the need for more pure research, “Science and Serendipity.”

Physicists, too, see serendipity and curiosity as virtues, and so it is disturbing to hear Brown and Mikulski describe them as vices. That emphasis on “strategy” also sounds worrisome, more appropriate for the battlefield or the boardroom than for the scientific laboratory. We may begin to wonder whether we have reached a time in which William Proxmire, the former Democratic Senator from Wisconsin, and his Golden Fleece Awards look like the good old days!

Reasons for science support

Searching for harmony between the science community and the politicians may seem like a stretch, but let's try. Let's start by looking at some of the fundamentals of why the public supports science.

I believe the reasons are at least fourfold. First is the desire to answer enduring, fundamental questions about the universe, nature and humankind, that is, the search for truth; second is the lure of a frontier to be conquered, the desire to be pioneers in keeping with our American ancestry; third is the utility of science, a feature that distinguishes the search for truth; and fourth is the immediate political appeal of many scientific projects and programs, having to do with the direct benefits to be obtained from executing them.

Let's look at these briefly, one by one.

Search for truth. First is the search for understanding, for underlying truths. The public does have an interest in uncovering truths about the universe: What are we made of? Where did we come from? Where are we going? At least since the Babylonians and Ionian Greeks, thousands of years ago, people have undertaken the quest for truth with support from the public. But if truth and understanding are the only motives, why support science any more lavishly than we support the humanities or the arts, which also provide a window on truth? Total funds available annually for the National Endowment for the Humanities and the National Endow-



Congressman Sherwood Louis Boehlert, the ranking Republican on the House science subcommittee, was a leader of House opposition to the SSC, which he considered too expensive and not top-priority science. Since 1982 Boehlert has represented Utica, New York.

ment for the Arts from the Federal government amount to a little over \$300 million, about four-thousandths of Federal expenditures on science and technology and less than 3% of Federal expenditures on basic research. One must conclude that much more is at stake than the search for truth and understanding.

The constricted frontier. The second rationale for public support of science in the US is that it is a pioneering activity. The pioneering urge is distinctly American, but only in the past half century has it been firmly linked to public support of research. The person most responsible for making the linkage was Vannevar Bush. At the end of World War II, Bush issued his famous report, *Science—the Endless Frontier*. In that simple title he made explicit that America's new frontier was science and technology. Bush's personal view, however, was that pioneering research included more than just the search for knowledge for its own sake. It also included "basic technology" or "engineering research," activities that generate "knowledge in order to do, not for knowing alone." He liked to illustrate this with the Wright brothers, who, in order to invent the wings for their airplane, first carried out engineering research using wind tunnels.

To encompass both scientific research and engineering research, Bush proposed a single Federal agency with responsibility across the whole scope of the science and technology frontier. Unfortunately, most of Bush's collaborators in writing *Science—the Endless Frontier* were professors who were not necessarily pioneers. When

Bush tried out his ideas about basic technology and the Wright brothers on them, they haughtily told him that they "did not think a couple of bicycle mechanics working on a flying machine would . . . be doing research."¹

So the consensus at the time was to keep the ennobling pursuit of knowledge free from the taint of the Wright brothers' bicycle shop. Rather than a single Federal agency with responsibility for the whole frontier, as Bush had wanted, there emerged a proposal for an agency responsible only for the science end—what became the National Science Foundation. And the American scientific community, though not the public, adopted this narrowed vision of the frontier. Since then, we in science have fallen into an even narrower self-image that equates the frontier with "curiosity-driven" research alone.

General utility. The third reason the public supports science has to do with its general utility—that is, the power of science to change the world. This goes back at least to the 16th century, when Francis Bacon argued explicitly that the support of science would be useful to society. In Bacon's words, "axioms rightly discovered and established supply practice with its instruments, not one by one, but in clusters, drawing after them trains and troops of works." His view has been abundantly confirmed; nobody disputes it today. The knowledgeable critics of science, such as Brown and Mikulski, argue not about the utility of science but about how to harvest that utility. They recognize that science is useful, and they recognize that to be useful, it must be done by talented scientists, not by political appointees. But they would like to influence what those talented scientists do.

Mikulski may have harsh words for curiosity-driven activities, but she has no problem with efforts to "bolster the research enterprise while creating jobs in the construction and manufacturing sector."

Special benefits. This brings us to our fourth and most politically appealing reason: The direct benefits science projects and programs bring to specific constituencies.

You may not like this factor and may agree with I. I. Rabi, who once said, "In science we can't let some guy from Podunk have the same vote as Fermi." But in fact those guys from Podunk do have the same vote as a Nobel laureate from Chicago in deciding whether or not to support science. And the specific appeal of a project to voters—is a legitimate reason for the public to support science.

Right now, the Superconducting Super Collider is the most interesting case in point. The research to have been done with the machine addressed questions that Western culture has been asking for over two millennia: What is the fundamental nature of matter and how did it originate? Moreover, the people who wanted to build it regarded themselves and presented themselves as pioneers and explorers.

In the end, however, the SSC stood or fell not because of its potential contributions to our understanding of the first picosecond of the big bang or the deepest structure of matter, but because of the political clout of the Texas Congressional delegation and its allies. That clout had been seriously weakened in the last few years with the ouster of Jim Wright as Speaker of the House, with the defeat of George Bush as President, and with the departure of Senator Lloyd Bentsen, who had been chairman of the Senate Finance Committee, to the Treasury Department. Moreover, Texas now has two minority-party senators. So the SSC has been lost. The vote of that "guy from Podunk"—New York Congressman Sherwood Boehlert,² if you like—does outweigh that of a Nobel laureate, Leon Lederman; physicists haven't learned that

Rabi got this one wrong! Meanwhile, the space station survives, probably because it is believed to be pioneering by the people from Podunk and because it keeps the Podunkers employed in the aerospace industry.

Inverted priorities

The order of these four motives for government support of research—understanding, pioneering, utility and specific political attractiveness—is the order of increasing appeal to politicians and administrators. Yet it is the order of decreasing appeal to most of the researchers who receive public support.

For scientists, understanding is at the top. The greatest heroes of science are the likes of Darwin and Einstein—individuals who brought new truth to the world. Second on the list is pioneering. Scientists like the idea that they are the frontier-persons of today, although they have forgotten Vannevar Bush's broader vision of it. Utility, important to many scientists, nevertheless typically comes in third. And of course special benefits to political constituents come in last. Scientists do not reject this last factor, but most find it either a necessary evil or a slight embarrassment.

For politicians, the order is exactly reversed. Political attractiveness comes out on top. Utility follows close behind. Pioneering comes third, and understanding comes last.

During the decades since Bush's report, this dichotomy was reconciled by the belief that satisfying the first two rationales—answering basic questions and pushing at frontiers—would act more or less automatically to produce the right outcome for the second two rationales—utility and political value. And that has been partly true. But today, too many things have gone wrong. Americans have dominated Nobel prizes while many of our industries have lost their competitiveness. Our nation is faced with too many urgent problems—disease, infrastructural decay, environmental blight, violent crime, drugs, homelessness—that have not yet found solutions; nor have scientists satisfied political interest through attacking basic questions or doing pioneering research.

Meanwhile we scientists insist on a rhetoric that talks about curiosity-driven research. We tend to assume that our own enthusiasm for what we do is shared by the public. But by and large it isn't. Instead, much of the public shares the view of the former Dutch Queen Juliana, who once exclaimed, "I don't understand computers: Why, I don't even understand the people who understand computers!"

Searching for harmony

So what do we do to reconcile these different priorities, to find a harmony that both parties hear? How do we define a new compact that will reinvigorate the scientific enterprise and all of the remarkable benefits it brings to our nation?

A recent report of the Committee on Science, Engineering and Public Policy of the National Academies of Science and Engineering suggests that the new compact should be based on goals of having the US "be among the world leaders in all major areas of science and of maintaining clear leadership in some major areas of science." While I believe that this is an important suggestion that has launched constructive debate within the scientific community, it is essentially a supply-side policy, an inward-looking policy; it only tells us how to set priorities within the scientific enterprise. And so, even if we agree on this particular suggestion, we will still not have responded adequately to public concerns.

So what do we do to find this new compact that



Leon Lederman, a former director of Fermilab, was a leading proponent of the Superconducting Super Collider. A Nobel prize winner recognized for several major contributions to particle physics, Lederman also has spearheaded science education reform efforts in Illinois, his adoptive state. He is currently professor of science at the Illinois Institute of Technology in Chicago.

everyone wants? To begin with, our four elements—understanding, pioneering, applications and local benefits—are not mutually exclusive. They have much common ground, much synergy, and it is precisely in this fact that we must find solutions. It is not just a matter of educating the public and the politicians about us. It is also a matter of educating ourselves about them and their needs.

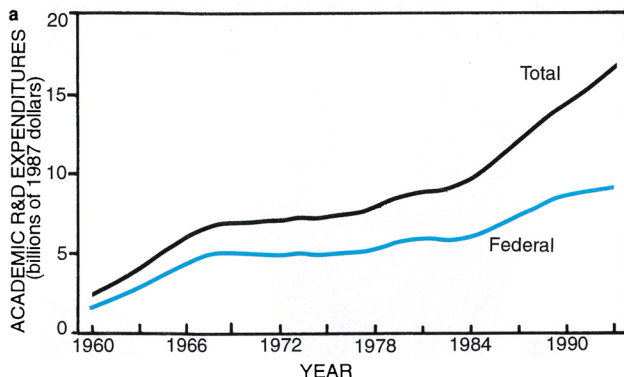
Let's begin with several observations of the scene today that are related to science and technology policy.

▷ American industry has lost competitiveness in a number of markets. This theme dominated policy in the 1980s, and we have just begun to turn things around.

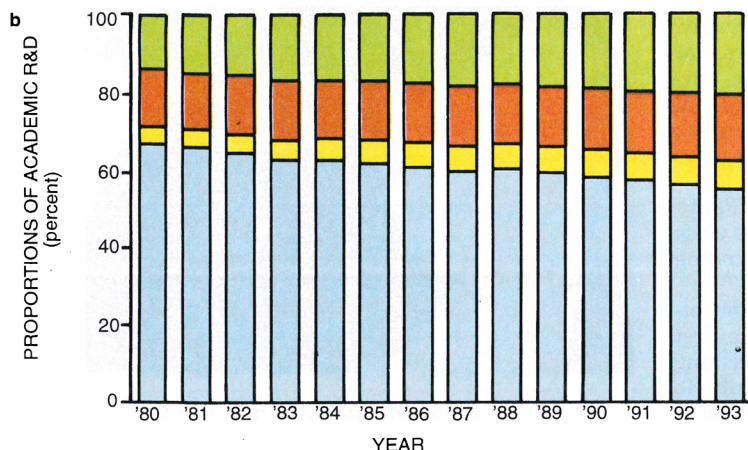
▷ About 5% of our gross national product has been in defense, but with the end of the cold war, this will decrease to something under 3% before the end of the decade. Because our economy grows a good deal more than 2% per year, this shift should be easily accommodated from a macroeconomic perspective. But, the industrial and commercial activity that will replace defense will probably be less technologically intensive, requiring a lower rate of investment in R&D than did defense.

▷ We need to create high-quality jobs—to accommodate population growth and to offset those jobs lost in established industries—in industries that are becoming more productive and competitive.

▷ We need to make better and more rapid progress in



Academic R&D expenditures. a. Real total and Federal academic R&D expenditures from 1960 to the present. b. Support of academic R&D from 1980 to the present. Federal support is shown in blue; industrial support in yellow; state, local and other support in orange, and self-funded in green. (Source: National Science Foundation.)



solving many economic and social problems, notably in the areas of the environment, infrastructure, health, energy, commerce and crime.

R&D—specific issues

In addition to these technologically relevant national issues, there are also a number of issues specific to the R&D system. Among the important ones are:

▷ **Decline in industrial research.** The growth rate of industrial R&D dropped significantly in the mid-1980s; since then, there also has been a shift of industrial R&D away from the pioneering work that has given rise to new industries, new businesses and new product lines.

▷ **Defense R&D conversion.** About one-third of the total US R&D expenditures, which amount to about \$150 billion annually, have been devoted to defense. Today, about 60% of the Federal government's yearly R&D expenditures of \$75 billion goes to defense. The administration has said it wants to change the Federal ratio to 50/50 by 1998, which means about \$7.5 billion should be shifted from defense to civilian R&D. The programs in place today—the Technology Reinvestment Program, CRADAs, the Advanced Technology Program, the Manufacturing Technology Centers—look like they will be funded at about \$2.5 billion within the next few years. This leaves a \$5 billion gap that we simply can't let become a \$5 billion cut!

▷ **Federal support for universities.** While academic R&D grew significantly during the 1980s, the Federal portion of that support shrank. Academic institutions provided rapidly growing support for their own R&D, but this trend cannot continue in light of the financial problems that most research universities are encountering (see charts, upper left).

▷ **Imperiled innovation.** Because of the trends in both

industrial and academic R&D, the nation's traditional strength in the kind of pioneering R&D that has led to new industries and job creation is threatened.

Thinking nationally

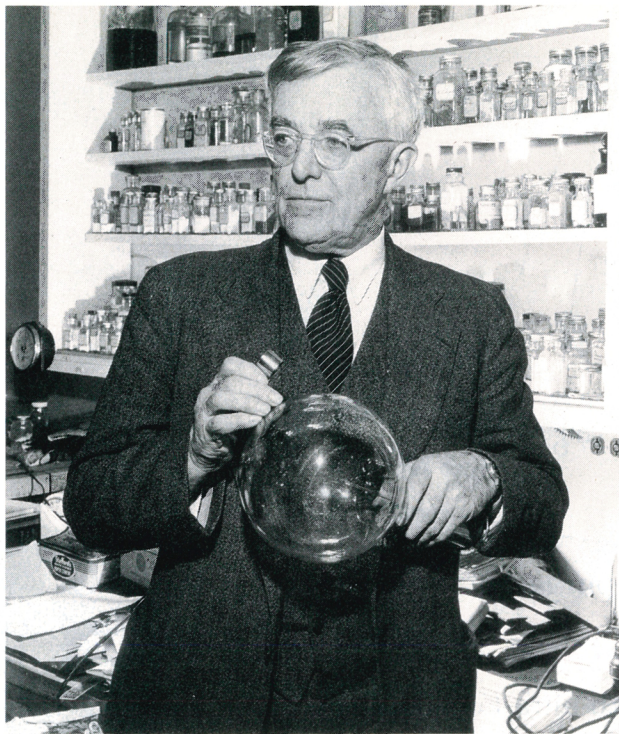
These problems of the national R&D system are serious. But if we are going to solve them, we need to make our solutions also be an important part of solving the nation's problems; we need to think that way, and we need to act that way.

As soon as one says this, however, people immediately think one is saying that basic scientists, exploratory scientists, pioneering scientists must append applied research and technology transfer to their curiosity-driven explorations. But I don't believe that is the answer. There is a better approach.

The answer, I believe, is to accept the responsibility of addressing issues of national importance, issues of strategic importance, issues of political importance, but to respond not by trying to do things we don't do well but by doing what we do do well—that is, pioneering, exploratory, basic work that is inspired by these tough problems. In the course of responding this way, we will enrich our own world; our curiosity will have an even broader, even more challenging terrain to explore.

Let's go back for a moment and look at what Congressman Brown and Senator Mikulski are really saying.

They are not saying that politicians should be looking over the shoulders of scientists and telling them what to do. They are merely saying that scientists are citizens. When scientists use public funds, they are citizens with special responsibilities, so they should be especially aware of the values of the society that is funding them, and in planning their research, they should give consideration to those values. As Brown puts it: Don't tell the biomedical researcher which experiments to perform, but tell her



Irving Langmuir looked into blackened light bulbs and created modern surface chemistry.

How can I create a biotechnology industry that will generate jobs? But in the end, he did help create that industry, and it is generating jobs.

Other examples

You're probably familiar with other examples. Louis Pasteur looked into problems of the French beer and wine industries, and came up with fundamental discoveries in biology. Irving Langmuir looked into blackened light bulbs and created modern surface chemistry. Karl Jansky listened to radio static and created radioastronomy. The research leading to the discovery of the transistor effect was undertaken at Bell Labs because of the explicit recognition that vacuum-tube technology would fall short of meeting the telephonic needs of the future.

Time and again, work undertaken in the search for utility has led to new understanding, just as work undertaken in the search for understanding has led to utility. The point is not which comes first. It's in the interconnection and positive feedback that is the basis for the social compact between science and politics.

We need to tell politicians that we share their constituents' concerns—creating jobs for their children and grandchildren, improving health, fighting crime, enhancing education. The best way we can do this is the way Avery and Pasteur and Langmuir did it: by recognizing, as only we can do, what new things we must learn about nature or what pioneering concepts need to be invented to address these concerns. We need to be responsive when we *begin* our research.

The technical barriers—like Langmuir's blackened light bulb—that practitioners encounter in their daily work can be just as rich a source of frontier research as what we learn from journals and scientific meetings. Embracing political, social and economic goals, far from being a hindrance to the science enterprise, will enrich it.

I believe there is an approach that is not only responsive to political and social concerns, that is not only consistent with the best values of science itself, but that can even enrich the scientific enterprise and make it more rewarding to the deepest interests of scientists.

Is this what George Brown and Barbara Mikulski have in mind? Probably not exactly. Is this what the scientific community has in mind? Not exactly. Is it an approach that both can understand, and in which both can see new opportunities? It will take discussion and an evolution in the quality and sophistication of the dialogue, but I believe the answer is, Yes. It can be a founding concept for the new compact that many now seek.

Notes

1. G. Wise, *Osiris* 1, 229 (1985).
2. Congressman Boehlert, a leader in the opposition to the SSC, is a good personal friend, and I'm sure he won't mind the literary license I've taken in this context. ■

that "moving from remediation to prevention is a primary national and international goal." Don't tell an agricultural researcher what crop varieties to test, but rather tell him that the goal is to "feed a burgeoning global population without stripping the land of topsoil and nutrients, or massive pesticide use."

An example: DNA discovery

Who discovered that DNA was the material that carries the hereditary message, and how did they do it? I suspect you're about to say, "James Watson and Francis Crick" and that they managed to squeeze in a bit of research at Cambridge University between tennis games and trips to the pub.

Actually what Watson and Crick discovered was the double-helix structure of DNA. The identification of DNA as the hereditary material was made by Oswald Avery and his colleagues at the Rockefeller Institute in the 1940s.

The reasons I bring up Avery's work are because it is one of the greatest truths discovered in the 20th century and because it was not undertaken as an unfettered, curiosity-driven search for truth. In fact, it was undertaken for a very utilitarian purpose, strategically guided by a national health-care need of the time: the battle against pneumonia. Avery was aware that the pneumococcus bacterium came in two varieties, one with a rough coat and the other with a smooth coat. Only one of them causes the disease. If you could transform the virulent form to the benign, you could perhaps prevent or cure pneumonia. So Avery had both a utilitarian purpose and a strategy.

But in the course of carrying out that strategy, he discovered a "transforming principle" that transcended his original aim—namely, that it was the nucleic acid DNA that determined whether the bacterium grew a rough or smooth coat. From that purposeful research program grew the focus on DNA that has proved so correct and fruitful.

Obviously Avery did not begin his work thinking,