Rethinking Science Policy

Frank Press

Something extraordinary happened at the recent summit conference at Versailles: science and technology were explicitly recognized as essential to the future welfare of the industrialized nations. Moreover, they are already on the agenda for the next meeting of the heads of state in 1983 in the United States. The large industrialized democracies now recognize that their economic future depends on new industries spawned or fed by high technology. That realization will surely affect attitudes—and hence policies—toward science and technology of the U.S. government, in its executive and congressional branches. Already a Cabinet report (*1*) notes that the United States has lost and may continue to lose competitiveness in high-technology industries. That declining position, it states, "has implications for the U.S. standard of living," adding that high-technology industry has "a ripple effect throughout the economy as other industries absorb the new technologies and create new jobs."

Summary. Industry is now investing heavily and at an increasing rate in research and development. The government's responsibility should be to assure that this industrial spending is paralleled by real growth in its support of basic research. Such growth is realistic, even in times of budgetary constraints, given a proposed compact between the scientific community and the government, in which, inter alia, a small percentage of the funds spent on development would be reprogrammed for basic research.

In rethinking the roles of science and technology in the nation's welfare, several elements need to be kept in mind:

First, it is the future that concerns us; specifically, maintaining scientific preeminence and transferring new scientific knowledge to industrial practice. It is in the latter art, encompassing development and production, that we are displaying evident weaknesses. The Japanese have certainly demonstrated their excellence in applying existing technology to the creation of innovative products and processes. Japanese managers continually examine the economic leverages possible with these new technologies, and continually strive to shape them for sale in a global market. We, demonstrably, are not doing as well in applying our own discoveries in fundamental science and technology. For example, until about 1975 research and development in robotics was done predominantly in the United States. Yet, the Japanese now lead in the application of robots, with Europe moving up.

Second, in the past few years there has been a major change in attitude by American industrial management in recognizing the importance of investment in long-term research and development and in allowing for significant real growth in industrial budgets, even in times of severe recession. I think that American management is increasingly aware that it has not done well in drawing from the deep well of technological knowledge available to it, and that a limited financial outlook has chilled commitment to R & D programs inevitably measured in years rather than in quarterly reports. However, the charge that American management has become risk averse is too categorical. Many of our companies—not coincidentally, dominantly our leading technological companies—do invest heavily, in proportion to their sales, in R & D; some managers invest such huge amounts that they are, in effect, "betting their companies."

Third, a parallel government program for real growth in basic research, coupled to the rising industrial investment already evident, could make the United States an even stronger competitor in the world market for high technology. I believe there are many opportunities for the reorganization and reprogramming of federal R & D funds that would allow for real growth in the support of basic research and would create an even more productive U.S. science. And that can be done, I believe, with minimum threats to the overall R & D budget. However, it would be a risky and hazardous operation, requiring an unprecedented process of evaluation, reorganization, and reallocation in the face of bureaucratic and, possibly, political opposition. It has not been done before, but the Reagan Administration seems willing to try and may bring it off.

Priorities: A Cabinet View

Why does scientific research deserve high priority support by government and industry? A few years ago, during my tenure as director of the Office of Science and Technology Policy (OSTP), I asked cabinet officers and agency heads to provide a list of science and technology questions, the answers to which they considered to be extremely important to the country. They responded with some 50 questions that were then, surprisingly, discussed at a meeting of the Cabinet. Some of the questions were as follows:

- Can we discover antiviral agents to combat viral diseases?
- What are the molecular mechanisms by which genes are regulated to produce specialized products? What new information is needed to exploit the new recombinant DNA technology?
- To what extent can laser-induced chemistry be used as a practical synthetic tool? This could open up new industrial practices, ones requiring little energy and producing few environmental problems.
- How do catalysts work?
- Can simple chemical reactions be discovered that will generate visible radiation?
- What is the nature of climate?
- What is the petroleum potential of the deep continental margin beyond the continental shelf?
- Can man-machine interfaces be made so simple as to allow real-time translation by untrained personnel? Certainly, such developments would provide not only improved communication between nations but also change our daily lives profoundly.

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- Can new materials be developed which would be less dependent on critical or strategic elements, noncorrosive, and very strong?
- How can the environmental stress tolerance of current crops and grasslands be improved by genetic manipulation? If we are able to solve that problem, some 40 percent of the world's uncultivated but potentially productive land can be brought into production.
- Can materials be found that superconduct at room temperature? That would revolutionize energy transmission and, with that, energy policy.
- What are the limits for communication of the channel capacity of the visible spectrum?

Some of these questions have already been answered, at least in part. If we could answer all of them in the next 10 to 20 years, we could transform industry, agriculture, health, defense, the use of energy, and other resources. The potential for new jobs and the growth of our gross national product is huge. The answers dealing with electronics have by themselves more potential for creating jobs than the automobile and steel sectors combined.

In short, in any national policy intended to assure the future welfare of our nation, science and technology deserve the same federal priorities as are given to defense, tax cuts, and deficit reductions.

An Industrial Renaissance

A recent McGraw-Hill survey (2) shows that firms intend to raise R & D spending in 1982 by 17 percent, to $59.7 billion, despite the recession. And that follows a 16 percent increase in 1981. Further, these companies as a group project that their expenditures on R & D will rise by 37 percent between 1982 and 1985. By contrast, from 1970 to 1975, real spending on industrial R & D declined by over a percentage point, but rose 5.8 percent between 1975 and 1980.

Thus the pattern of sacrificing long-term spending to protect short-term investments during hard times is, apparently, being broken. Even with reduced capital growth, companies intend to increase the amounts they spend on R & D. In 1970, another recession year, capital spending was up 6 percent, but R & D went down by 1 percent. In 1982, with a more severe recession, capital spending is down about 4 percent but spending on R & D will rise. In all, the survey suggests that "something of an R & D renaissance" is under way in the private sector, that U.S. industry is, once again, turning to R & D to protect, regain, or widen its lead in the technological marketplace.

Why the new attitudes by industry? One spur certainly is the Economic Recovery Tax Act, passed in August 1981. However, increases in R & D spending began before that act was in place. I think, rather, that given a melange of overlapping problems—intensified international competition, the energy crisis, technological challenges from Japan, and a slowly growing economy burdened by inflation—American industry has decided that increased investment in R & D is the key to reinvigorating itself.

A Federal Compact

Industry, in short, is doing its part: investing to assure that fundamental knowledge moves into products and processes. It is now incumbent upon the federal government, as the patron of fundamental science in the United States (as national governments are in all countries), to mirror the industrial investment by a parallel increase in its support of basic research. That can produce a powerful and autocatalytic enrichment of both science and technology, and will surely help assure the future economic and military security of the United States. Specifically, I suggest a *compact* between government, industry, and universities for the support of basic research (3). Such a compact would establish new national goals for the support of science, as follows:

1) A stable research budget. The basic research budget would increase each year at a rate that would cover inflation and permit a real growth of 2 percent. Such an annual increase would respond to the need for stability and predictability in establishing long-term planning goals. It would provide for the inflation intrinsic to the costs of doing science as new methods and techniques emerge. Such support would be the base program for all scientific fields.

2) Special support. An additional but smaller annual increase in real growth would support special targets of opportunity in particular fields, such as research related to particular national needs, or supplementary funding to assist with essential instrumentation and research facilities.

3) Increased productivity. The scientific community and the government would cooperate in transferring funds from less productive scientific and technological areas and institutions to more productive ones, within existing support levels. Productivity could be additionally enhanced by reducing indirect costs, reducing regulations that force indirect costs up, and improving research efficiency through longer-term awards. In this way, I believe that we can find a 2 percent real increase for basic research.

4) Industrial support. Industry would commit itself to a 1 percent real increase of the total amounts for R & D now going to American universities, amounting to an annual increase of about $50 million in the sum that industry is giving now.

5) Graduate education. A cooperative partnership of government, industry, and universities would ensure continuing and adequate support of graduate education. The National Science Foundation (NSF) and the mission agencies would support a coordinated program of national research fellowships and traineeships. NSF, itself, would support an overall program of merit; that is, provide funds to the best people, regardless of their fields—much as it is doing now. Mission agencies would provide fellowships appropriate for their own function; for example, the Environmental Protection Agency in toxicology, the Department of Energy in combustion science and engineering, and the Department of Defense (DOD) in computer sciences and integrated circuits. DOD has, in fact, already initiated such a program.

Industrial companies should be encouraged to establish named fellowships, perhaps in fields where their needs are greatest. If all of these funds could be pooled in a central depository, with a single agency perhaps making the selection, we could have, at relatively low cost for any one participant, a magnificent program to support graduate education.

Finding the Funds

How can the federal portion of this proposed compact, especially the proposed increase of 2 percent in real growth, be financed in an era of budgetary constraint? The government's basic research budget is $5.4 billion annually; the applied research budget is $7.2 billion; and the development budget is $26 billion, of which $19 billion is in defense. These categories flow into one another, and one can assume that about $7 billion annually is invested in basic science and engineering.

In that huge $26 billion development budget, it is surely possible to find each year $700 million that is not spent productively, and that by itself could provide the real growth of 3 or 4 percent above inflation vital to the compact.

To find those several hundred million dollars in the budget each year it will be necessary to make astute transfers on the basis of recurring evaluations of development projects and the institutions performing them. This means that the work of the national laboratories and universities, as well as sponsored research in industry, will require evaluation, as will developmental projects affecting many technological fields, such as energy, health, defense, agriculture, and environment. It will require cross-agency transfer within the Executive Branch, and cabinet secretaries and agency heads will resist. Such evaluation, and the resulting reorganization and reallocation, is unprecedented.

Risks and the Role of OSTP

Aside from these "turf" difficulties, the suggested reformation of federal policy for funding basic science is freighted by risks. If one identifies weak, unproductive areas, one may, instead of a budget transfer, see a budget cut. But against the risk is the rightness of what George Keyworth, the President's science advisor, has repeatedly said: that in this enormous R & D budget of some $40 billion a year, it is proper for the government to ask some fundamental questions. What is it appropriate for the government to do in supporting basic research? What is it appropriate for industry to do in the areas of development and demonstration? Might a portion of the government's huge investment in development be better spent on basic science and technology?

If, in fact, the science advisor can bring off a reallocation of R & D funds, shifting a very small portion from development to basic research, then I think the scientific and technological community—and, in time, the country—will be indebted to him.

If it cannot be done—and that is a possibility, given the bureaucratic and political inertial forces countering a reprogramming—then some $700 million dollars of additional funds will be needed each year to provide the real growth to support the quest for fundamental knowledge that is vital to this country's future. For perspective, $700 million can support the Clinch River Breeder Reactor for 3 to 4 years or pay for two B-1 bombers. Choices need to be made.

If it is done, it will be done by the science advisor, and it will be done quietly, without fanfare, without public pronouncements of successes, with the noises of bureaucratic battle muted, and often without responses to public criticisms of perceived damages to the R & D budget. A new science policy will be formed incrementally, through incessant and often interminable budget meetings and, most important, around a table in the Roosevelt Room of the White House, where the case will have to be made for the criticality of science to the nation's future.

It is difficult for the scientific community—understandably so, since it must rely on information that is inevitably imperfect—to see the gaps, particularly at budget time, between public perceptions and the private reality of governmental decision-making. For example, in the fall of 1981, during a budgetary crisis when many thought that science was going to suffer a 12 percent across-the-board cut, the science advisor counseled the scientific community that it was not going to be as bad as feared. And that is, indeed, how it turned out. There has been real growth in many areas of basic research. Against the largest federal deficit in history, science was relatively well treated.

The task before the science advisor, as outlined in the suggested compact, is even more awesome than his accomplishments in mitigating budget cuts in the Fiscal Year 1982 budget. His predecessors tried, with imperfect results. But, to reiterate, if it can be done, then, in concert with the intensified pace of industrial R & D, the United States will be assured of a vigorous scientific and technological base, one that will position it for international competition not only in this decade but also in the third millennium. The two decades ahead will be quite different from the postwar decades and, ultimately, our decisions as a society must reflect the new times. Certainly, the reformation of science policy that I have suggested strikes at a pluralistic cornerstone of postwar science policy—the belief that the role of government was to assure not only excellence in science but also breadth in the institutions of science, in and out of government. Such ubiquity of funding was possible in a time of general and real growth in federal expenditures. Now, given severe and perhaps secular budgetary constraints, a greater degree of evaluation and selectivity may be needed if American science is to remain vibrant and if it is to produce the knowledge essential to technological and economic growth.

I believe that priority support of U.S. science and technology by government and industry is justified, simply given the strong contribution that new knowledge and its application will make to the U.S. economy—industry, agriculture, health, employment, trade. American management appears to have recognized this, certainly in its increasing investments in long-term R & D. The government should complement that support with a healthy support of the science and technology base, and an economic and regulatory policy that fosters technological innovation and industrial development. And I believe that funds for the support of the basic sciences (including basic engineering) can be obtained from the development budget, particularly given that, because of the enormous differences in amounts spent, a 1 percent reduction in development support is equivalent to a 5 to 10 percent increase in basic research. That leveraging effect is seconded by the fact that, in sieving development projects for their unproductive components, the quality of both development programs and basic research will be enhanced.

Finally, if the reordering of federal support for science proves elusive, then the government must simply commit itself to providing the resources needed to assure that the nation's premier scientific status prevails. We cannot finesse budget constraints by choosing to be excellent in one field and not another. Our goal must be broad scientific excellence, in the belief that the rewards will be a stronger nation with better lives for its citizens.

References and Notes

1. *An Assessment of U.S. Competitiveness in High Technology Industries* (A study prepared for the Working Group on High-Technology Industries of the Cabinet Council on Commerce and Trade, final draft, 19 May 1982), pp. 1–3.
2. *27th Annual Mc-Graw Hill Survey of Business' Plans for Research and Development Expenditures, 1982–85* (Economics Department, McGraw-Hill, New York, May 1982). See also, C. Norman, "Industrial R & D rises," *Science* **217**, 427 (1982).
3. Testimony by Frank Press, Committee on Science and Technology, U.S. House of Representatives. (Hearings on U.S. Science and Technology under Budget Stress, 10 December 1981).