Perspective

Science: The Best and Worst of Times

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"IT WAS THE BEST OF TIMES; IT WAS THE WORST OF TIMES." Charles Dickens's opening lines to *A Tale of Two Cities* capture the dilemma of the American scientific community: while contemporary research continues to be exuberant and richly fertile, it faces damaging losses in federal funding owing to unprecedented federal budget deficits.

Fundamental research (*1*) has been spared much of the budgetary pain suffered by other sectors, in both the fiscal 1986 cuts mandated by the Gramm-Rudman-Hollings legislation and the Administration's proposed budget for fiscal 1987. Thus, one sees for 1987 about a 13 percent increase for basic research in the physical sciences and engineering, but virtually no increase in the biomedical sciences. One can take some comfort in those numbers, especially given Congress' past history of raising the Administration's proposals for biomedical research support. But I think that comfort may be illusory. Although Gramm-Rudman-Hollings has been declared unconstitutional, it does remain in effect until the Supreme Court rules later this spring; and the forces which created Gramm-Rudman-Hollings—the desperation to reduce the massive deficit—endure; the courts cannot quash the deficit.

In short, I think the scientific community, rather than think that the budgetary crisis was short-lived, must operate on the assumption that it will endure for years, perhaps to the end of the century. I think we must assume in our planning that past real growths in basic research budgets are now history and that future growth is likely to be almost flat or, in some areas, negative.

In the face of that, we have two major obligations. One is to remind our political leaders of the contradiction between the acceptance of science as essential to economic and social well-being and the prospective cuts in federal support.

Our second obligation—the focus of this article—is to ensure the optimal use of limited funds. We already do that, principally through evaluation and competition—the peer review system. And new suggestions are emerging—for example, reallocating the distribution of research and development funds, prompted by the enormous size of the development budget relative to basic research funding (*2, 3*). Thus, the director of the National Science Foundation, Erich Bloch, in asking for a major shift of resources toward the nation's universities, argued that "the funding should come from a reallocation from applied research and development accounts, without any overall increase in the federal budget. Something like a 2 percent reduction in those accounts would make $1 billion available for the purpose, and the result would be an overwhelming improvement in our overall rate of technological progress" (*4*).

I support that proposal. However, I would like to suggest that we reform not only the distribution of federal research and development funding, but also widen its availability on a competitive basis. My proposal rests on the simple fact that one-quarter of federal support for basic research in fiscal 1986 is intramural funding, and that it is over one-third if one includes the federally funded Research and Development Centers (FFRDC's) (Table 1) (*5, 6*). I suggest that, as is already the case with academic research, intramural and FFRDC research be opened to a common peer-reviewed, national competition. That is, fundamental research programs be "pooled" and made accessible to proposals from the general scientific community—from the universities, from national laboratories, and from agency laboratories. Actual funding decisions would be made through a common peer-review system, perhaps embodying the models of the National Science Foundation or National Institutes of Health.

This proposal raises a niagara of questions, many of which can be answered only if and when its detailed implications are debated. However, let me try to address some of the more obvious concerns and questions.

The differences among agencies are too great. My proposal certainly glosses over daunting "cultural" differences among agencies. Thus, there are wide swings among departments and agencies in the amounts and distribution of basic research support (Table 1). The Department of Energy has very little intramural research, and 71 percent of its funds go to the national laboratories; the Department of Defense spends a substantial fraction of its basic research money intramurally, but very little in the federal laboratories.

At the same time, all agencies engage in fundamental research. Each may define it differently, but the refrain is unclassified, fundamental research of the sort that is communicated openly and is acceptable to scientific journals of established repute. Table 2 lists examples of basic research projects done within federal departments, agencies, and FFRDC's. Further, all agencies already use some form of evaluation to review their internal research (*7*). Overall, the underlying similarities among agencies dominate, to the extent that open competition would in practice not significantly affect the ability of an agency to fulfill its mission, although it may affect the sites where the work is done and the population of research performers.

How can the proposal be implemented? Each department and agency differs in its budget processes, in its evaluation procedures, and in its goals. Some agencies are comfortable with open competition; others are not. As with university faculty, some measure of job security albeit not project security has to be granted to governmental researchers, should a particular proposal not survive the competition.

These and other elements have to be factored into implementing the proposal. There is no government-wide mechanism for doing it, but I believe that a coherent implementation mechanism can be created. It would have to be top-down, and involve presidential offices, including the Office of Management and Budget and the Office of Science and Technology Policy, as well as the senior research officials from each of the departments and agencies. Bureaucratic and political impediments would normally make this proposal difficult to achieve—except in a time of budgetary crisis when many unprecedented changes in government functions are being proposed and implemented.

Open competition would damage the federal laboratories. Again, the peer-review process of the sort I am suggesting would be for fundamental research in the same fields and not for mission-oriented research. Thus, there might be competition among investigators in federal laboratories and the universities working in relativistic astrophysics or physical oceanography, but there would be no such competition for work being done within federal laboratories on, for example, energy and environmental technologies.

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Table 1. Federal obligations for basic research: intramural and federally funded research and development centers (FFRDC's) during fiscal year 1986. Source: National Science Foundation.

Agency	Total (thousands of dollars)	Intramural (6)		FFRDC total (thousands of dollars)	Intramural and FFRDC (percentage)
		Total (thousands of dollars)	Percentage		
All agencies	7,875,126	1,969,165	25	852,433	36
Departments					
Agriculture	418,510	285,859	68	120	68
Commerce	17,521	16,113	92	112	93
Defense	964,446	342,750	36	13,390	37
Education	11,409	1,823	16	0	16
Energy	937,849	17,704	2	670,343	73
Health and Human Services	3,055,583	594,391	19	23,327	20
Interior	117,734	112,033	95	0	95
Justice	2,520	25	1	0	1
Labor	4,701	1,171	25	0	25
Transportation	3,300	300	9	0	9
Treasury	5,460	4,197	77	0	77
Other agencies					
Agency for International Development	2,941	78	3	0	3
Environmental Protection Agency	40,187	6,887	17	250	18
Federal Trade Commission	1,511	1,511	100	0	100
Library of Congress	288	288	100	0	100
National Aeronautics and Space Administration	835,000	347,703	42	34,644	46
National Science Foundation	1,364,865	145,031	11	110,247	19
Smithsonian Institution	71,001	71,001	100	0	100
Tennessee Valley Authority	4,700	4,700	100	0	100
Veterans Administration	15,600	15,600	100	0	100

Table 2. Examples of basic research projects conducted within federal agencies and FFRDC's.

Department or agency	Research area
Department of Energy	Atomic physics Heavy element chemistry Polymer science Radiation biology Climatology
Department of Defense	X-ray crystallography Geophysics Computer science Physical oceanography Astronomy and astrophysics Laser chemistry Operations research Mathematics Tribology
Department of Commerce	Meteorology Computer science Thermodynamics Fluid mechanics
National Aeronautics and Space Administration	Solar-terrestrial physics Cosmology Comparative planetology Astrophysics
Environmental Protection Agency	Photochemistry Separation science Atmospheric modeling Reproductive biology
Department of the Interior	Geology Geophysics Metallurgy Aquatic biology Ecology

Second, federal laboratories provide absolutely indispensable instruments, facilities, and services to both intramural and extramural researchers; these resources must be maintained. In any case, competitive evaluation procedures already exist for granting access times to the facilities of the federal laboratories.

Why do it? What's to be gained? The potential gains can be considerable. Diligently done, an open competition of this sort would assure that each agency would support the best possible scientific work, whatever its origin and whoever the performer. The funding pool for competitive research proposals would be increased substantially; however, the proposal does not imply a simple zero-sum game with predictable results. In many instances agency scientists will prevail in open competition with university researchers.

Agency research programs would remain stable and strongly related to missions. Congressional committees would maintain their responsibilities for oversight, authorization, and appropriation. The Office of Management and Budget would gain greater assurance that federal research funds are well spent. Overall, changes in the budgetary process would be minimized, and current agency oversight by the Executive Branch and Congress would continue.

Crisis and Opportunity

This proposal has its flaws. But I believe that these are mooted by some elemental facts: (i) the power and drive of the American research system, which more than in any other country flows from open competition and peer review; (ii) unprecedented scientific opportunities; (iii) the likelihood of no growth, or even contraction in federal research support, owing to the massive deficits and the imposition of automatic budget reductions; and (iv) the opportunity to improve research productivity by improved resource allocation.

We face both crisis and opportunity. But in reality we face as a nation only a single choice: To assure that the best science is done. To paraphrase that notable philosopher, Damon Runyon, the race is not always to the swift nor the contest to the strong. But that's the way to bet.

REFERENCES AND NOTES

1. One can argue endlessly about the definition of "fundamental research." For the purposes of this article, I shall use the definition provided in the President's National Security Directive 189, *National Policy on the Transfer of Scientific, Technical, and Engineering Information*: "Fundamental research" means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.
2. F. Press, *Science* **218**, 28 (1982).
3. E. Bloch, "Basic research and economic health: the coming challenge," 53rd Steinmetz Memorial Lecture, Schenectady, NY, 7 November 1985.
4. ———, *ibid.*, p. 16.
5. National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1984, 1985, and 1986* (September 1985), vol. 34, p. 54.
6. Intramural funds include costs associated with the administration of intramural and extramural programs, as well as actual intramural performance. Federal laboratories in this context are the FFRDC's administered by industrial firms, universities and colleges, and other nonprofit sectors.
7. J. M. Logsdon and C. B. Rubin, "An overview of federal research evaluation activities" (Program of Policy Studies in Science and Technology, George Washington University, Washington, DC, 1985), p. 28.
8. The views expressed in this article are those of the author and not necessarily those of the National Academy of Sciences or the National Research Council.