Science, technology, and the federal government: comments on a recent NAS report

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Science, Technology, and the Federal Government: National Goals for a New Era (1), a report issued by the Committee on Science, Engineering, and Public Policy (COSEPUP)[1] of the National Academy of Sciences (NAS), proposes a "renewed and strengthened covenant between science, technology, and society." Because national security can no longer provide the justification for maintaining a large program of fundamental scientific research, the NAS report advocates a new rationale for supporting science. This rationale, based on the linkage of science to techology policy and national goals, reflects themes expressed in recent months by Congress, the Clinton administration, and various national policy organizations (2–4). While providing a new justification for research funding, there is the concomitant requirement that the benefits of fundamental scientific research be made explicit.

In this report the biomedical sciences are frequently cited in examples of how fundamental research has aided society in the past, and as examples of the potential for future benefits. Proposals for stable research support, multiyear funding, and reduced administrative burdens should receive widespread support from the research community. Recommendations for removal or reduction of institutional and disciplinary boundaries in the performance of research will also be welcomed.

Although many recommendations advanced in this report are likely to be viewed positively by investigators in the biomedical sciences, some proposals could have detrimental consequences and need to be examined critically before they become part of the "conventional wisdom." One of the most problematic features of the report is the acceptance of the current federal R&D budget as adequate, in contrast to other studies that call for greater investment. Another potential problem is the linkage of fundamental science to strategic objectives.

GENERAL PREMISES

In the era after World War II, U.S. science policies were guided by the demands of the cold war and the promise of basic scientific research. Now, according to the NAS report, major changes in international political and economic conditions call for a new framework for science and technology policy. The relationship between research and the public interest is more complex than at any time in history. Support for science can no longer be justified by an external military threat alone. Science and technology issues affect the nation's economy, health, and environment, and as necessary conditions for social and economic progress, science and technology have become essential aspects of public policy. Science and technology are also changing, and research in many areas requires substantial resource allocations.

The importance of science and technology for national goals, the increased scale of research projects, and the competition for limited federal resources provide the rationale for integrating science and technology policy into discussions of national goals. Although recognition of the importance of science and technology should be gratifying to the research community, the integration of science policy into public policy carries with it a reduction in autonomy. This linkage of science and the public interest raises issues of objectives and accountability, redefines the roles of scientists and other stakeholders, and puts science funding in direct competition with other priorities for government spending.

GOALS FOR SCIENCE

The linkage of science and technology to national policy objectives (economic growth, improved health, national security, and environmental protection) is the rationale for setting national goals for science and technology. There are two national goals for science proposed in the NAS report: *1*) the U.S. should be among the world leaders in all areas of science, and *2*) the U.S. should maintain clear leadership in some areas of science.

The NAS committee believes that these goals can be met within the existing overall federal R&D budget, and criteria are established for determining those fields in which the U.S. should be a world leader. Fields chosen would be those with close relationships to national objectives, the ability to capture the imagination of society, and multiplicative effects on other areas of science.

Once goals are established, assessment of performance becomes a key policy concern. The NAS report calls for better ways to gauge the overall health of research, and to determine whether it is adequately supporting broad national objectives. One of the most striking proposals for departure from current practice is the suggestion to monitor performance across fields of science using panels of experts. Comparative international assessments would be made by panels from within and outside the various fields, and would include nonscientist "research users." The NAS report concludes that . . . "assessments of fields will prove useful in the allocation of resources both within and among fields" (1).

In addition to goals and assessment mechanisms, the NAS report also proposes a series of principles to be followed in achieving the goals. These principles include an emphasis on quality, adequate and stable funding, removal of institutional and disciplinary barriers to research, and a greater synergy between research and education (1).

[1]Abbreviation: NAS, National Academy of Sciences.

GOALS FOR TECHNOLOGY POLICY

Rejecting the position that the development and adoption of technology are largely functions of the private sector, the committee calls for the federal government to adopt a leadership role in those technologies that promise to have a major effect on industrial and economic performance. Like science, the report argues that the U.S. does not need to be preeminent in all technologies. Guidelines are suggested for identifying key technologies in which this nation must establish or maintain world leadership. The principal difference between the goals for technology and those for science is the belief that the technology goals cannot be achieved by federal government policies alone.

IMPLICATIONS FOR FUNDAMENTAL RESEARCH IN THE BIOMEDICAL SCIENCES

Many parts of the NAS report will be appreciated by researchers in the biomedical sciences. The report affirms the linkage between science and technology capabilities and national well-being. Scientific research carried out in government, industry, and university laboratories is considered essential. "This country therefore needs to explore how to ensure the progress of science and how to use new knowledge most effectively to meet human needs" (1). The contribution of fundamental biomedical science to the national is clearly acknowledged. Stable, multiyear funding for research will allow researchers to plan more effectively and enable them to devote a greater percentage of their time to research rather than to the search for resources. Removal of institutional barriers to research—if it results in the freer flow of resources, personnel and ideas among government, university, and industry laboratories—would also prove beneficial.

Although the NAS report carries no official status, many recommendations are shared by key players in the policymaking process. Many of the principal themes of the NAS report—setting science priorities, linkage to national goals and assessment of outcomes—have been expressed recently by the Congress (2), the administration (3), and public policy groups (4). Several topics raised in the NAS report (criteria and measures of world leadership in science, priority setting, and incorporation of research users into the planning process) were agenda items for the *Forum on Science in the National Interest* recently convened by the Office of Science and Technology Policy (5). In some cases, initiatives have moved beyond the discussion stage and important changes have already taken place. The creation of the President's Committee of Advisors on Science and Technology and the National Science and Technology Council — the latter with the mandate to establish national goals for federal science and technology investments—represent major steps in the development of a new system to formulate science policy.

Some elements of the NAS report, however, need to be given close scrutiny by the research community before they become part of a "renewed and strengthened covenant." Of chief interest to researchers in the biomedical sciences are:

- The belief in the adequacy of the current federal R&D budget; and
- The consequences of linking of scientific research to specific technology goals.

Adequacy of current R&D levels

The NAS report concludes that its goals can be met within the existing overall federal R&D budget (6). Reallocation and prioritization can provide the needed resources, and a higher level of investment in R&D is not required. No evidence, however, is provided for the adequacy of current levels of R&D spending, and no sources of reallocated funds are identified. By at least one standard, the U.S. rate of investment could be improved. Two of our key economic competitors, Japan and Germany, exceed the U.S. in the percentage of their gross domestic product spent on R&D (7).

Other reviews of R&D in the United States have reached different conclusions regarding the need for additional investment. A recent report by the Council on Competitiveness, a nonpartisan organization of chief executives from business, education, and labor, concludes that the U.S. needs to increase support for R&D (8). The Competitiveness Policy Council, a federal advisory committee whose members are drawn from business, labor, government, and the public interest, recently called for more investment in civilian technology programs (9).

More important, however, than general assessments of investment needs are the research opportunities before us. Potential breakthroughs should be the basis for funding, and science policy decisions should revolve around analyses of these scientific opportunities. The recent FASEB consensus conference on federal research funding, for example, identified opportunities in the biomedical sciences and proposed increases in federal R&D funding to support them (9). Statements about the adequacy of current R&D levels are premature at best, and potentially limiting to scientific progress.

Linking scientific research to technology and policy objectives

The role of fundamental scientific research in the development of new technologies is undeniable, but anticipating the direction of future relationships is difficult. The NAS report concedes that "it has proved impossible to predict reliably which areas of science will ultimately contribute to important new technologies" (1). Examples abound of important innovations that could not have been predicted from the initial direction of the fundamental research (10, 11). The attempt to tie fundamental research to the support of technology has the potential danger of diverting resources from fundamental science, and it will impede progress toward other discoveries. As the NAS report acknowledges, "[a] substantial redirection of such fundamental research toward goal-directed work would reduce the potential for advances of economic and social importance without necessarily leading to solutions for the problems being addressed" (1).

Linking scientific research to technology goals and national objectives may have two important benefits: it could help justify major investment in fundamental research to the public and Congress and speed up the effort to solve important social problems. On the other hand, linkage calls for a policy and decision-making structure that is new and untried. Gone is the faith in basic research expressed by Vannevar Bush, who postulated that "the simplest and most effective way in which the government can strengthen industrial research is to support basic research and develop scientific talent" (12). The new mechanisms developed for establishing priorities, assessing outcomes, and allocating funds could become major forces in shaping the future of scientific research. These procedures could increase the role of political criteria over scientific criteria in targeting fundamental research, drawing resources away from areas of greater scientific opportunity, and hindering long-term scientific and technological innovation.

Proposals for goals, priorities, and targets are being made with increased frequency. The dangers inherent in such suggestions need to be addressed directly, especially when they appear to limit opportunities for investigator-initiated research. Should these proposals become the basis for policy-making, we must ensure that biomedical scientists are active participants in all strategic planning exercises. The expertise of researchers must be considered, and biomedical scientists must be adequately represented in all science policy deliberations. FJ

The author wishes to thank Samuel H. Herman for his constructive comments on an earlier draft of this paper.

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COMMUNICATIONS CAPSULES

The following are capsule summaries of research communications appearing in this issue.

BCL-2 INTERFERES WITH SIGNAL TRANSDUCTION

Apoptosis is a form of cell death responsible for the deletion of specific cells within a population. Overexpression of the Bcl-2 protein in cells has been demonstrated to be able to suppress apoptosis induced by a variety of agents in many cell types. **Caron-Leslie et al. (pages 639-645)** demonstrate that cells expressing Bcl-2 are resistant to glucocorticoid-induced cell death but retain the potential to undergo apoptosis in response to other signals, and that growth inhibition can be dissociated from apoptosis when Bcl-2 is present. **Thus, Bcl-2 interferes with signal transduction leading to apoptosis but not with the final steps of programmed cell death.**

PKC IN THE DEVELOPING MESANGIUM

In the pre- and postnatal period of kidney development, proliferation with subsequent functional maturation of intrinsic glomerular mesangial cells (MCs) continues within the existing framework. Recent work has suggested that one of the protein kinase C (PKC) isoforms, PKC β is responsible for the proliferation observed during maturation. **Saxena et al. (pages 646-653)** sought to ascertain whether PKC β expression is altered during the development of the mesangium and observed that neonatal and adult MC express β_1 PKC. Unlike adult MCs, however, neonatal MC express β_{II} in postnatal days 1-4 and none thereafter. In adult kidneys, there was only PKC β_{II} staining of the parietal epithelial cells. Thus, differential expression of PKC β_{II} closely parallels the proliferative behavior of the MCs of the maturing glomerulus. **Therefore, PKC β_{II} expression and activation may play a critical role in development.**

TUMOR PROMOTERS INHIBIT APOPTOSIS

Tumor growth in vivo may depend on evasion of normal homeostatic control mechanisms that operate through induction of physiological cell death by apoptosis. Individuals may be exposed to agents in the environment that suppress the normal process of apoptosis, thus promoting neoplastic cell survival. **Wright et al. (pages 654-660)** report that 10 known or suspected tumor promoters were all found to inhibit apoptotic DNA fragmentation and cell death of 7 different cell lines triggered into apoptosis by diverse agents. These findings provide new insight into the mechanism of tumor promotion and **suggest that screening compounds for inhibition of DNA fragmentation during apoptosis may be useful to detect new tumor-promoting agents in the environment.**

FUNCTION OF THE CARBOHYDRATE MOIETY OF γ-GLUTAMYL TRANSPEPTIDASE

γ-Glutamyl transpeptidase is an enzyme of major importance in glutathione metabolism. Transpeptidase isolated from animals contains as much as 30% carbohydrate, whereas *Escherichia coli* transpeptidase contains no carbohydrate, and is only about 0.1% as active as the animal enzymes. **Smith and Meister (pages 661-664)** accomplished the complete removal of carbohydrate from kidney transpeptidase and obtained fractions that were fully active. **The carbohydrate seems to protect the enzyme against protease action.**