ment found in most of the courses which use computer programs. The faculty confirm the significance of this activity when they call computing integral to their courses.

Ten years' experience at Dartmouth demonstrates that an easy-to-use computer system open to the whole campus will be widely used in undergraduate instruction. It should be no surprise that a college full of this kind of computing activity comes to regard its computer center much the way it regards the library. To make use of its services is "no big deal," but to do without them would be "unthinkable."

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2. The President's Science Advisory Committee, *Computers in Higher Education* (The White House, Washington, D.C., February 1967).
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4. J. G. Kemeny and T. E. Kurtz, *Science* **162**, 223 (1968).
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6. The cost of computing per student per course was under $30 for the academic year 1974–1975.
7. Further details may be found in J. M. Nevison, *Computing as a Matter of Course: The Instructional Use of Computers at Dartmouth College* (Kiewit Computation Center, Dartmouth College, Hanover, N.H., 1976).
8. This is not unlike the growth recommended in R. Levien *et al.*, *The Emerging Technology, Instructional Uses of the Computers in Higher Education* (McGraw-Hill, New York, 1972).
9. *Biennial Report* (Kiewit Computation Center, Dartmouth College, Hanover, N.H., 1973), p. 12.
10. The distributions illustrated in Fig. 3 are the "yes" responses. Cross tabulations of "yes" and "no" responses against the respondents' ages (young, 25 to 39; old, 40 to 68) produced chi-square tests that support the claim that age is not significantly related to computer use. The idea for the box and whisker plots came from J. W. Tukey, *Exploratory Data Analysis* (Addison-Wesley, Reading, Mass., in press).
11. For an excellent introduction to the current variety of uses in higher education, see C. Mosmann, *Academic Computers in Service* (Jossey-Bass, San Francisco, 1973).
12. Masculine pronouns are used in this article only for convenience; the individuals referred to should be understood to be of either sex.
13. Figure 5 is based on data showing that the number of computing courses that students take obeys a Poisson probability law at a mean rate of 1.5 courses per student per year.
14. *Kiewit Comments* **7** (No. 11) (1974), pp. 1–3.
15. IMPRESS is an acronym for interdisciplinary machine processing for research and education in the social sciences. It is described in *The IMPRESS Primer* (Project IMPRESS, Dartmouth College, Hanover, N.H., 1971) and in *The IMPRESS Manual* (Project IMPRESS, Dartmouth College, Hanover, N.H., 1972).
16. A cross tabulation between whether or not some students in a course wrote their own computer programs and whether or not the instructor said the single most important benefit was a qualitative change in the course showed a chi-square value that was significant at the .001 level.
17. The most outstanding example of this reliance is the operating system itself, which was written largely by undergraduates. See Kemeny and Kurtz (*4*).


18. I thank R. Sokol for his essential advice on survey design.


# Science in a Political Context: One View by a Politician


James W. Symington


The December 1934 Pittsburgh meeting of the AAAS marked a significant change in the way many scientists looked at working with government. At that time, the prevailing attitudes among scientists about the relation of government to science were characterized by fears of political control, should government provide funding support. Nevertheless, the new AAAS president, Karl T. Compton, had proposed to President Roosevelt in 1934, a "Program for Putting Science to Work." The ultimate value of Compton's proposal and his advocacy role was the influence on two momentous political decisions made during the Roosevelt presidency: the extension of the government's responsibility for science beyond its own establishment and the coupling of science and government to serve national purposes. Several decades ago, both of these were revolutionary concepts.

Although Compton's *specific* proposal was not approved by President Roosevelt, federal science budgets were increased, universities began to receive government support, and there emerged a growing consensus in the 1930's among some scientists and politicians that they should work more closely together. This latter development was no small achievement—and I need not recount here how vital to our national security such relationships became as the clouds of World War II broke. President Roosevelt had already developed high respect for scientists, and he entrusted great responsibilities to them in the war effort after bringing them into the highest councils of government.

It is significant that the science and public policy questions that began to emerge in the 1930's have a very modern appearance. Several of these questions dealt with (i) recommendations to establish national policy with respect to science; (ii) suggestions that the United States participate more fully in the international scientific community and that it draw to a greater extent on the world reservoir of knowledge; (iii) attempts to counteract the frugality of Congress with respect to science; (iv) advice designed to eliminate duplication or improve intragovernmental coordination of scientific activities; and (v) suggestions intended to improve and increase the basic research activities of government agencies (*1, 2*).

For the past decade, the Committee on Science and Technology has devoted much of its attention to these kinds of questions. Thus, the pessimist would say that we have not made much progress in 40 years. However, I think that continuing consideration of these questions points to the enduring nature of a number of large issues in science policy. Some may never be settled. In each generation we must deal with these issues by taking actions that are appropriate to the special circumstances and problems of the times.

### Federal Role in Support of Science and Technology

Among the policy issues in a continual state of flux is the federal role in the support of science and technology. Some support has been provided since the beginning of our nation; however, the federal role changed dramatically as a result of World War II. For more than 25


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years—until the mid- to late-1960's—federal support grew rapidly. In varying degrees, R & D became an integral part of virtually every federal agency and came within the province of amost every committee of Congress.

Although the magnitude of support has become large, its nature and emphasis have gradually changed; examples of such change are the following.

1) Just prior to 1940, nearly 90 percent of all federally supported research was performed in-house (that is, in government owned and operated facilities), whereas for fiscal year 1976 the percentage for in-house R & D and management of extramural work was 27 percent. Thus, despite the fears of the 1930's, the federal government has become the major provider of money for R & D for some industries and for most university research. Whether or not this kind of support has brought political control is a topic that I discuss below.

2) In 1938, nearly 40 percent of all federally supported research was provided by the Department of Agriculture. For 1976 the USDA share is 2 percent, and there is a growing consensus among the Congress, the Administration, and the scientific community that this is not enough. This consensus has emerged from a debate on the current and long-range prospects for worldwide food and nutrition—and on the role that science and technology should play. I might add that the House has passed the National Agricultural Research Policy Act of 1976; this act will greatly increase the emphasis on agricultural research in relation to worldwide food problems. There is a chance that this act will become law if an agreement can be reached with the Senate.

3) In 1960, about 91 percent of the total federal support of R & D went to the defense, aerospace, and atomic energy complex. The comparable amount for 1976 is about 72 percent and reflects a greater share of federal support of R & D for such organizations as the Department of Health, Education, and Welfare, the Department of Transportation, the Energy Research and Development Administration's nonnuclear programs, the Department of Commerce, the National Science Foundation, and the Environmental Protection Agency. These trends reflect growing concern and debate over critical social problems including environmental quality, the cost and quality of health care delivery, efficient transportation, the availability of energy, and the serious problems of urban decay and suburban sprawl.

## The Allocation Problem for R & D

These changes and trends reflect a multitude of *political* decisions that are related to the fundamental problem of how best to determine who should spend how much R & D money for what purposes. Willis Shapley (*3*) points out that one form of the debate on this problem has centered on whether or not there is or should be an "R & D Budget" for the United States. I agree with the view that there is no "R & D Budget" as such, and that agency heads should be responsible for formulating their budgets, including such R & D as considered necessary to perform their missions. However, I believe there is a reasonably strong case for going beyond the Office of Management and Budget's "cross-cut" analysis of R & D and introducing a stronger central function for analysis and some control at the top. Why?

1) I agree with Harvey Brooks (*4*) that the root of resource allocation problems is that science and technology really form a single strongly interacting system that is not well understood. Most of the theories on planning and allocation proposed and used in actual decision-making emphasize only some aspect of the system, such as basic research or applied technology. However, as Brooks says, "we have to develop a much more sophisticated understanding of how the existing system works before we can control it." I think this calls for a strong overview—without giving up pluralism of performance and the majority of individual decentralized decisions.

2) An added dimension of complexity has been noted by Edward Shils (*5*). He suggests that from the long philosophical debate on the allocation of resources for scientific research has come the acceptance of two independent criteria: scientific value and practical value. These distinctions correspond roughly to the divergent views of those who argue, respectively, for the autonomy of science and the comprehensive direction of science toward technological applications.

That there is tension and conflict between these differing views has been well established. However, what is new within the past decade or so is increasing presidential and congressional insistence that R & D and its uses be more closely linked. In short, there has been an increasing tendency of many in politics to seek greater and faster "payoffs" from the nation's investment in R & D. In a very real sense, the past successes of scientists and engineers have led to rising expectations on the part of politicians. This takes us back to the point raised earlier that scientists fear political control of science.

Care is needed to ensure that we engage in debate with a minimum of acrimony and mutual suspicion. Together, scientists and politicians must struggle to achieve the kind of understanding called for by Brooks (*4*). I believe that it is as wrong for scientists always to demand complete freedom in conducting research as it is for Presidents and the Congress always to specify in elaborate detail what scientific work shall be done to achieve "quick payoffs"—particularly for unrealistic political purposes—such as energy independence by 1980. I think, too, that it is incorrect for the Congress to legislate detailed research programs for specific problems, as has been the tradition in agricultural research for a century or more—unless there is a strongly demonstrated need for such action in a few limited areas.

I do not wish to minimize the importance of the political "control" concern. Federal support of science is an element of the larger issue of federal support of numerous societal functions, from education to welfare. Political requirements are placed on all institutions and activities receiving federal funds. Probably all institutions, including state and local governments, would prefer "no strings" money; but other forces call for accountability in the use of public money. Inevitably, these requirements have some impact on those who receive support from public funds. All this leads to the need for an intricate balance of interests; but I am optimistic because solving such problems of balance is the genius of our political system.

We in Congress must guard against the tendencies of some who would interpose Congress into the detailed procedures for selection of research projects and the determination of who should perform them. Yet, it is entirely proper for the Congress to act on broad policy matters, such as whether to embark on a manned lunar program or on the development of a multibillion-dollar weapons system or the construction of a large radio-astronomy project. Further, in carrying out its responsibilities, the Congress should examine the performances of agencies, render evaluations on management effectiveness, and determine whether policy guidance of the Congress is being followed.

I also think that it is an appropriate function of the Congress to originate and to establish new programs and new organizations when an important need is perceived, such as the National Agricultural Research Policy Act of 1976, which I mentioned earlier, and the National Science and Technology Policy, Organization, and Priorities Act of 1976, which was recently enacted into law. The latter statute leads to the next point.

## A New Organization: Office of Science and Technology Policy

In addition to the issue of a total R & D budget, there is the set of policy decisions and problems related to allocation of research and development resources to and for the various departments of government. There is also the long-standing problem of "coordination." How best to perform this elusive and complicated process has been debated since at least the 1880's when the National Academy of Sciences first proposed a Department of Science or a broad Science Advisory Committee. Other, more general issues include scientific and technological transfer and interchange with other nations—for example, the Soviet Union—and the relation of federal R & D to that supported by industry. A prime example of the latter is the burgeoning importance of energy R & D.

Such issues are commanding the attention of the Executive Branch. Jerome Wiesner has argued that, as federal support and programs have grown, there have been steadily increasing "efforts toward coherence and integration at the Presidential level to make more productive and effective use of scarce manpower, facilities and fiscal resources" (*6*).

Wiesner's point of view is similar to that adopted by the House Committee on Science and Technology when it began a series of hearings 3 years ago on "Federal Policy, Plans, and Organization for Science and Technology." These hearings were prompted by the abolishment, in 1973, of the Office of Science and Technology in the Executive Office and the designation of the director of the National Science Foundation as a part-time science adviser. Three years and another President later the position of Science Adviser and a new Office of Science and Technology Policy (OSTP) have been restored to the White House.

We see this new office as the realization that "science permeates all important national issues" (*7*). Lest there be some who still do not understand the basic rationale for the OSTP, let me state it in this way: it is designed to facilitate the use of contributions of science and technology in national decision processes; it is not to be a spokesman or advocate for science and technology.

## Support of Basic Research

There will be occasions when it may appear that the OSTP is performing the role of science advocate; but even then it will be, as it must be, acting in the context of larger national purposes. An example from the fiscal year 1977 budget should illustrate my point: in the final stages of the budget formulation, as I understand it, the President added $50 million for basic research to the National Science Foundation's (NSF) budget, on the basis of analyses provided by the Office of Management and Budget (OMB) and his science adviser, H. Guyford Stever.

As his reason, President Ford referred to the high value placed by "our Founding Fathers" on the pursuit of knowledge and its application and said, "I fully recognize that this country's future—and that of civilization as well—depends on nuturing and drawing on the creativity of men and women in our scientific and engineering community" (*8*). I agree with this view and, after making certain adjustments for greater emphasis on science education, I have supported the NSF budget request.

We were not of one mind in the Congress on this increase for basic research. I have no wish to criticize the members of the Appropriations Committees for their position in opposing the increase. They believe firmly in their case, as do we in ours. Our differences are a reflection of the difficulties that face us, as a nation, in setting "proper" levels for basic research. Our committee has placed extensive reliance on the economic fact that, as measured by constant dollars, financial commitment to basic research has decreased since 1967 by about 20 percent. The Appropriations Committees do not believe this measure is a reliable indicator of decreasing "real" research. This is a difference that is not easily resolved, and it takes me to my next major observation.

## Science Indicators

In May 1976, Congressman Ray Thornton's Subcommittee on Domestic and International Scientific Planning and Analysis began hearings on the "Science Indicators 1974" report which was recently issued by the National Science Board (*9*). These hearings arose from our concern about how to do a better job of measuring and evaluating the results of federally supported research and development. In the past, "inputs" have been the primary science indicators; in contrast, a noteworthy feature of the new report by the National Science Board is the inclusion of a number of "output" indicators.

In his testimony, James H. Zumberge of the National Science Board said that the further development of "output" indicators "will require even more determined and creative efforts, as we attempt to uncover the complex interactions of science, technology, and society. These efforts will involve . . . an expansion into previously uncharted areas" (*9*). These laudable activities of the National Science Board represent the type of analysis that will be of enormous value to the President and the Congress as we struggle collectively to make better decisions in a world that grows more complex, not less.

## Public Attitudes about Science and Technology

Apart from, but related to, the attitudes of those in government and in science is this salient feature of modern society: public attitudes toward the value of scientific research seem to be changing. For example, La Porte and Metlay have reported that "supportive of science yet guarded about technology, the public is uneasy about future technological developments" (*10*). Also, such individuals as former science adviser Edward E. David believe that public attitudes are going to influence increasingly the directions and content of scientific and technological programs in the future (*11*).

An important example of David's view is that controversial subjects within the social sciences have aroused emotional debate on the content, validity, and ultimate ends of social science research. The development and implementation of science curriculums, particularly social science projects, by federal agencies have led to a serious reexamination of such projects in relation to our philosophy of public education. The recent debate in California over the issue of nuclear power provides another example of growing public interaction with scientific and technological programs.

Taken together, these views and examples lead me to conclude that ways must be found to provide for an informed electorate to deal with the increasing number of complex problems. The NSF has developed a "Public Understanding of Science" program to enhance science literacy. The Congress is working on a new aspect of this problem which is a "Science for Citizens" program; this Senate proposal would provide for NSF funding of groups involved with public issues that require scientific and technological expertise. It is not that we in the House shy away from controversy, nor should the NSF and the scientific community remain aloof from subjects simply because they are controversial, but that we have a genuine concern as to whether the funding of public advocacy groups is a proper function of the NSF. The entire subject requires a great deal of careful analysis.

Another concept that has received some public attention but has been only briefly considered by the Congress is the "science court." I understand that it has been discussed by the President's two new advisory groups—appointed last November as a precursor to the Office of Science and Technology Policy—in this form: Is it possible to set up a group of scientists or others who actually receive a scientifically controversial subject and try to resolve the controversy so that the outcome would be generally beneficial to society? Perhaps my political bias comes through too strongly, but my instinct tells me that science will have its primary effects on public policy as a result of political debate rather than in judicial opinion.

Indeed, I should like to encourage the organizations of professional scientists to engage in the debate on how best to increase public understanding of science and of issues having significant scientific and technological content. Another challenge for such organizations and for those of us in government is to bring about a better understanding of the essential role of industrial research as part of our total national effort. I believe that too little attention is devoted to this aspect of R & D. As Sarett testified before our committee last year, "recognition should be given to industry's special role in the effective development of products that serve a useful public purpose" (*7*).

It is evident that government and science are closely intertwined. Each affects the other, and, while the potential for "control" is present—of science by government *and* of government by science—I do not think such a simplistic reflects the realities. At times, arrogance and foolishness afflict individual politicians and scientists; petty concerns may occasionally distort the debate. Yet we seem to be devising a relationship of enduring workability for the benefit of our society. A needed element in this relationship is a continuing sensitivity to the pressures affecting the work of those in science and of those in government.

In concluding, I have the feeling that I have raised far more problems than solutions. But if I do not bring specific solutions, let me share with you a belief of my old friend and colleague, Charles Mosher, who surely is one of the wisest men ever to grace the halls of Congress. He said recently: "I could hardly think of anything more fundamental than the fact that the scientific community must no longer be timid politically in asserting what they or any individual scientist believes is important to the national interest and the interest of mankind. It will take a lot of political courage to do this." It will indeed take courage, but I find that commodity in ample supply in the scientific community.

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**NEWS AND COMMENT**

# 94th Congress: In an Election Year, Budget Process Makes an Impression

The closing out of a Congress in a presidential election year is usually a time when partisan one-upmanship prevails, and the 94th Congress, which adjourned on 2 October, proved no exception. Most observers, however, identified no clear winner in the contest between the Democratically controlled Congress and the Republican-tenanted White House, either on the legislative scoreboard or in terms of political points made with the voters. In areas where science and technology are important, Congress and the Administration generally collaborated or compromised, although on some significant environmental issues (see p. 406) President Ford and his allies in Congress nullified or delayed Democratic initiatives.

Any assessment of a 2-year Congress should look beyond the tally of new legislation to the record on appropriations and to the legislators' performance in dealing with issues that will determine how Congress will conduct its business and how it will be perceived by the public.

With respect to funding what the scientific community regards as the two bellwether federal agencies, the National Science Foundation (NSF) and the National Institutes of Health (NIH), the 94th Congress, on balance, improved slightly on the performance of its predecessor. But science, at best, barely held its own. NSF did come out of the budget battle this year with a significant boost in funds for basic research. And at NIH, where in recent years the cancer institute and, to a lesser extent, the heart and lung institute have claimed the major share of new funds, steps toward redressing the balance in favor of the other institutes were taken.

In general terms, the 94th Congress was self-consciously a post-Watergate Congress seeking to regain prerogatives lost to the Executive and to refurbish the image of the institution. The most important effort at reasserting its initiative was the experiment of the new congressional budget process, which completed a first