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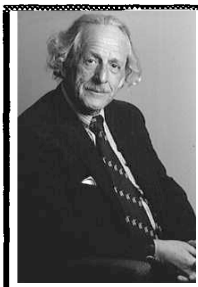

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Science/Technology Policy. Part 1. Will the Real Science Policy Please Stand Up? Forays into the History and Realm of Science Decision Making

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The topic of science policy is discussed. Part 1, an overview, examines the problem of defining terms, as well as detailing a short history of US science policy. Five science-policy scholars are queried on various aspects, including why science policy is an important subject and the influence of science policy on the academic research system.

Probably everyone who is a *Current Contents*® reader is familiar with the phrase "science policy." We all have, no doubt, some vague notions about what it is and what it does. But what, precisely, is science policy, and how does it influence the conduct of science?

Recently, we spoke with five eminent scholars on this broad topic and asked them their views on various issues concerning science policy: Harvey Brooks, J.F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts; Maurice Goldsmith, International Science Policy Foundation, London, UK; Jurgen Schmandt, LBJ School of Public Affairs, University of Texas, Austin; Craig Sinclair, Advanced Studies Institute, North Atlantic Treaty Organization, Brussels, Belgium; and John Gibbons, congressional Office of Technology Assessment, Washington, DC.

Science Policy: Definition, Importance

To begin with, the term "science policy" is not easy to define. Indeed, in *Webster's*, the word "policy" has 16 definitions. The most applicable definitions are "prudence or wisdom in the management of public and private affairs...; a definite course or method of action selected (as by a government, institution, group, or individual) from among alternatives and in the light of given conditions to guide and usually determine present and future decisions...; a projected program consisting of desired objectives and the means to achieve them...."[1]

The definitions seem simple enough, and if you add the word *science* to the last one, it would be "a projected *science* program consisting of desired objectives and the means to achieve them." But it doesn't quite work out that way.

Many publications combine "science policy" with "technology policy." (Because of the widespread usage that includes technology with science policy, we follow this practice here.) What is more, some interpret the phrase as being more encompassing—including innovation and productivity. Others see the term as describing the activity of legislating science and technology. We went through many journals and books on science policy, and most authors have their own, singular interpretations of the subject. For example, according to Richard Barke, Department of Political Science, University of Houston, Texas, one definition of science and technology policy is "a governmental course of action intended to support, apply, or regulate scientific knowledge or technological innovation."[2]

However, as we found out from discussing the topic with our five experts, science policy is interpreted differently by each authority—demonstrating the breadth of opinion as well as the descriptive difficulties of the subject. Their comments are interspersed throughout the two parts of this essay.

Q: What, in your view, constitutes science/technology policy? Why is it an important subject?

Brooks: I interpret science policy broadly to include both the "planning and programming of public science and technology investment" and the use of scientific information and knowledge for the formation of public policy which is not in the first instance scientific. That's a fairly broad definition, but I think both aspects are equally important. Of course, there's a certain amount of overlap between them, because the programming of public science and technology is certainly influenced by public-policy requirements, as in the regulation of toxic chemicals, and so on.... There is hardly a public-policy issue today that doesn't involve at least some dimension of science and technology.[3]

Goldsmith: What we've got to understand is that science policy is what the government of the day wants science and technology to do. If one doesn't grasp that, one is really spreading an illusion because there's no such thing as science policy in the abstract. Science and technology policy is important because no country—whether First, Second, or Third World—can envisage any development without the wise application of science and technology. We've reached the stage at which the word "industry" needs to be added to the phrase "science and technology policy".... This indicates clearly what has happened within the past two decades—that is, a more obvious link between science and technology and industrial development.... I don't know [of] any country that has a clearly defined science-policy system.[4]

Schmandt: Science/technology policy considers the various impacts of science and technology on traditional as well as new policy issues. It's important because the contribution of science and technology to all spheres of life is so central. In a narrower sense, science policy deals with public support of science and technology.[5]

Sinclair: Science policy effectively came about when scientific research particularly, but scientific education as well, started to cost appreciable sums of money. And that was just after World War II.... Science policy was, pretty well, decisions about how government should fund science in general and in what terms. The first stage...was maybe 10 years, longer for some countries, less for others, after the war, when science policy was about building up the infrastructure for science—education, building and equipping laboratories, and so on. The second stage was in the mid-1950s, early 1960s, when science, having established itself as a relatively costly part of government activities and becoming of more importance to industry, started widening out to include decisions that were made for science but were affecting other decisions in other areas of government concern, such as defense and the environment. I think we are in a third phase where...expansion in funds for science has stopped, and we're entering a kind of steady state. Also, the edges between science, applied science, and technology are becoming quite blurred.[6]

Gibbons: I believe science policy reflects a national conviction that science and its products so insure our economic future and our security, as well as the further enlightenment of the human adventure, that they merit development of national goals and commitment to long-term sustained support. Science policy derives from a historical, cultural viewpoint—a national commitment established by our forefathers: science is something we should do, and support, and enjoy as a people.[7]

Science/technology policy may make the most sense if you think in terms of the advisory process to those in charge of national governments, specifically, the president in the US. Most discussions of science/technology policies take place in national capitals—they deal with how much money various sectors of the science community should have. As with all things on the federal level, you have the long-range view (decades hence) in conflict with the here-and-now reality. This is well expressed by Rodney W. Nichols, executive vice president, The Rockefeller University, New York. "Paradoxically, science policy is often long range in outlook and yet oriented toward year-to-year progress in the sciences themselves. Science policy often lacks the muscle that grows from exercises in political and economic reality.... Improved technology policies are crucial for the nation's economic future."[8]

US Science/Technology Policy: A Synoptic History

Perhaps one of the reasons a definition of science policy is so hard to pin down is that it is a relatively recent phenomenon in decision making. According to Schmandt, science policy became an important responsibility of the federal government during World War II.[9] This is not to say there was not some form of science policy before the war;[10] rather, the 1940s were the watershed of a focused, massive mobilization of science and technology, as well as the coming together of two pluralistic institutions—governmental agencies and universities—for a common goal. Some illuminating statistics concerning prewar federal research mentioned by Brooks are that

> in 1938 about 40 percent of all federally supported research was provided by the Department of Agriculture, while by 1962, agricultural research constituted only 1.6 percent [in 1988, the figure has not changed much—see Figure 1].... In the late 1930s substantially all federally supported research was performed "in-house." Even the NACA (National Advisory Committee on Aeronautics) [established in 1915], which in many ways represented a foretaste of the postwar pattern of research, was about 98 percent intramural. By the 1960s only 14 percent of federally supported research was performed in-house....[11]

A pivotal event in US science/technology policy was the now-classic report on science in the postwar world, delivered in July 1945 to President Franklin D. Roosevelt, *Science: The Endless Frontier*.[12] The report was authored by Vannevar Bush, then director of the Office of Scientific Research and Development, Washington, DC, and head of the wartime scientific effort. The report argued that organized exploration of the unknown, if supported by the federal government, could bring both intellectual adventure and rich economic rewards to the nation.[13]

The gearing-up resulting from US involvement in the war effort took the form of the government contracting for brainpower, knowledge, and know-how from universities and industry, thus establishing a productive division of labor between public and private institutions. The results were profound: weapons, military strategy, and the conduct of foreign relations were radically altered. Decision making at high levels of the federal government became dependent on scientific information, and the methods of science, in turn, began to be applied to the process of decision making itself.[9] During the war era and immediately afterward, several science-policy-oriented institutions were chartered, among them the National Defense Research Committee (1940), the Office of Scientific Research and Development (1941), and the Atomic Energy Commission (1947). Table 1 is a selected chronology of events and science-policy organizations.

The next phase of US science policy, during the 1950s, was largely influenced by American perceptions of the USSR. In the early part of the decade, a large "cold war" arms buildup was initiated to guard against the spread of Soviet-style socialism. To achieve this, science was given new status as an attribute of world power—a sign of the nation's international standing (most visibly through military hardware, but also in biomedical research and improved innovation and growth in the production sector of the economy). The effect of Bush's report had by this time been assimilated—according

Table 1: Institutions and events in the recent history of US science policy.

war mobilization	National Defense Research Committee (1940) Office of Scientific Research and Development (1941) Vannevar Bush—*Science: The Endless Frontier* (1945) Office of Naval Research (1946) Atomic Energy Commission (1947) Interdepartmental Committee on Scientific Research and Development (1947) National Institutes of Health (ca. 1950)
cold war arms buildup	National Science Foundation (1950) Special Assistant to the President for Science and Technology (1957) President's Science Advisory Committee (1957-1973) (1976-)
Sputnik (1957)	National Aeronautics and Space Administration (1958) Office of Science and Technology (1962) Office of Technology Assessment (1972) Office of the Presidential Science Advisor abolished (1973)
antitechnology movement	Office of Science and Technology Policy (1975) National Science and Technology Policy, Organization, and Priorities Act (1976)
push to private funding of nondefense research; emphasis on military strength and international competitiveness	Committee on International Science, Engineering and Technology (1985)

to Schmandt, "Federal support for research and development was now accepted policy."[9]

The USSR's launching of the first artificial satellite in 1957 was a shock, and the perception that highly showcased prowess of American science was shaken. From then on, the level and quality of the nation's scientific and technological efforts were seen by both policymakers and taxpaying citizens as the advance-guard response to the perceived Soviet superiority. As a result there was an influx of federal dollars for the education of future scientists. Scientific advice was presented at the presidential level by the Special Assistant to the President for Science and Technology (1957), the President's Science Advisory Committee (established in 1951 but given access to the Oval Office in 1957), the National Aeronautics and Space Administration (1958), and the Office of Science and Technology (1962).

Three major events of the 1960s and early 1970s that had an effect on science policy were *Apollo 11*, the Vietnam conflict, and acrimonious debates about antiballistic missiles and the supersonic transport during Richard M. Nixon's administration. The myth of Soviet technical and scientific superiority was exploded. The very frontier of American technology was perceived as a large, negative force of social change. Shortly before the Watergate political scandal became public, and responding to what he perceived as unacceptable leaks, President Nixon abolished the science-policy machinery in the White House and terminated the post of Presidential Science Advisor.

Once Watergate faded from the headlines, science policy gradually reemerged as a concern of the federal government. At first, attention focused on an energy crisis, increasing dependence on imported raw materials, and deteriorating economic performance at home and abroad. The Office of Technology Assessment (created in 1972) became fully utilized by the Congress; the Office of Science and Technology, abolished under Nixon, was reestablished in 1975 (and renamed the Office of Science and Technology Policy). This reestablishment was concomitant with the passing by Congress of the National Science and Technology Policy, Organization, and Priorities Act, in 1976.

In the 1980s, under the influence of Ronald Reagan's administration, funding for science and technology was increased, chiefly in the military R&D sector (especially the Strategic Defense Initiative [SDI]). There was a modest increase in basic research, but a cutback of publicly supported applied R&D related to civilian technology, especially demonstration programs in the Department of Energy.[3] Such civilian-oriented funding was largely taken up by the states (42 states have projects involving university-industry collaboration, with emphasis on applied science[14]).

During the last year, there has been a proliferation of proposals for major governmental initiatives in science and technology. However, due largely to the federal deficit, the fiscal base for such initiatives is steadily shrinking, and, as a result, there is a polarization and politicizing of the scientific community.

Gibbons: Science, after the successes in World War II, became the Holy Grail—it was going to provide the way out of all our social dilemmas. We experienced an unhealthful optimism in the 1950s and 1960s but eventually came to an understanding that, while science has a lot to offer, it can't provide everything.

Now there is a fight between "big science"—the large-capital items—and "little science." "Big science"—the superconducting supercollider, the mapping of the human genome, the Hubble Space Telescope for space science—requires big funds. On top of all the so-called "little science" (e.g., solid-state physics, basic chemistry, and biology) that we're doing, the total bill comes to more than we can afford to pay. In order to do the big science, which garners the popularity of large constituencies, we tend to rob little science. We're finding fights even within the scientific community on account of it.... Resolving this dilemma will require close cooperation between the executive and legislative branches; we have to pare our shopping list, but that means that something—and probably something important—gets left off. That's the essence of the big debate about science [that is] now occurring between the Congress and the administration.... Each branch wants to hold some science projects hostage to a balanced budget. Science policy has been swept up into our problem of deficit spending.[7]

During the Reagan administration, with all the emphasis on cutting deficits, technology policy commonly has been connected with science policy. Discussed by itself, technology policy is widely interpreted as innovation and productivity—aspects influencing the economy. During the Reagan administration, the emphasis has been on "strategic" projects: large, multifaceted efforts such as superconductivity, SDI, and spaceflight. Other aspects of technology policy that are no less important have not been implemented. An example is the 1980 Stevenson-Wydler Technology Innovation Act that was passed by Congress. Its purpose was to enhance further industrial innovation by stimulating technology transfer and the diffusion of industrial technologies.[15] The act's nonimplementation left the states to attempt something on their own.

Recent emphasis has been on high technology. According to J. Rees, Department of Geography, University of North Carolina, Greensboro, and R. Bradley, Florida Advisory Council on Intergovernmental Relations, Tallahassee:

> Because the goal of further economic growth was to be achieved largely by encouraging the development of high-technology complexes, the new initiatives by state and local governments could be interpreted as a grass roots industrial policy with a strong bias towards sectors possessing a high science and technology content. What this amounted to at the state level was a marriage of *science policy to industrial policy*, directly encouraging research activities related to the goal of increased productivity-growth, and regarding economic development as a precondition for social progress.[15]

These efforts resulted in the National Science Foundation (NSF) Engineering Research Centers, as well as indigenous programs, including the Advanced Technology Development Center, Atlanta, Georgia (instituted in 1981); and the Metropolitan Center for High Technology, Detroit, Michigan (1982).

How has this 40-year period of evolving concepts of science policy and changing attitudes about the role of government in funding research affected scientists?

Influence of Science Policy on Academic Research, and the Role of the Scientist

Science/technology policy, when implemented, directly or indirectly affects researchers and science administrators in academia. I believe that these very same people should be able to affect science policy as well. According to Nichols, "Power over resources entails responsibility and public accountability. Influential advisers have superior knowledge about only the technical components of a policy issue. An open advisory process must tolerate, nay, encourage, dissent, and then ultimately give way to political resolution about policy and resources."[8]

As a general rule, those in the science profession are apolitical. However, scientists—whether researchers or administrators—have an obligation, as members of the public, to exercise their right to affect the policy-making process. We discussed this and related topics with our five experts.

Q: What are your major concerns about the influence of science policy on the academic research system? What part does the academic scientist play in defining science policy today?

Schmandt: Let me talk to the middle part of the question. I'm not so sure that the academic segment of the science-policy system is really that important in setting the science-policy agenda, except for the advisory role that some prominent members of the academic community have played and are likely to play in the future. I don't see that the academic community should play a large role in the future. This is because science policy has become a part of what you might call mainstream policy rather than a sideline, which it was for a good number of decades when it first came to the forefront after World War II. Now that has changed—it is part of mainstream policies. The first part of the question.... What I see right now is the possibly negative impact of science policy developments on the academic sectors of the commercialization of some of the applied research within the universities.[5]

Brooks: I think there is always the danger that short-term social and economic goals will tend to drive the system to a degree which prevents it from really advancing in an optimum manner. The analogy I like to use is climbing a mountain—that going up the face of the cliff may not always be the best way to get to the top of the mountain most efficiently and rapidly.... The academic research system is primarily an opportunity-driven system. And it *should* be.... I think it's really a distortion of priorities towards short-term goals as defined by the currently fashionable formulation of social problems that is of concern.... The most important part the academic scientists play—as well as other scientists, but principally academic scientists—is in the peer evaluation of research proposals in the project grant system and in helping to define the priorities of the overall system. Sitting in on National Institutes of Health study groups, NSF advisory panels, refereeing papers and journals, and so on all contribute to this ongoing agenda-setting process. I think that is the most important role of the academic scientist.[3]

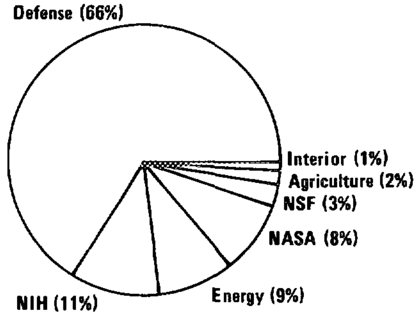
Sinclair: To put it in a nutshell, the fact that politicians have relatively short horizons and academic research has relatively long ones means that there's a kind of tension between the scientist in the university who wants to follow a long-term, basic-science strategy and the government, who has to fund it and wonders why it should fund a lot of academics who are sitting around drinking tea or, in America, coffee. I think the second thing that affects science in the universities is this whole business between defense spending and secret work, if you like, and the whole notion of the open, normal academic science.

Another aspect that is relevant to the scientist is that science is in transition now—physics, chemistry, math. All the old divisions are now breaking up and you're having biochemistry, biophysics, molecular biology, biotechnology.... So the old funding categories and old teaching categories are not so applicable to the main thrusts in basic science or in applied science at the moment, and I think that is causing some readjustment within the universities.... In Europe at least, the role of the academic scientist is less than I would think it is in the States. But I think some of the American mechanisms, such as the National Research Council [and the] NSF, are stronger than [those] in the UK, in Europe.... I think that, if academic scientists want to play a role, they are going to have to learn to be politicians a bit and enter into the hurly-burly of the political system. That's hard—to remain an academic and do that.[6]

Gibbons: Until 1980-1981, the federal government divided its research dollars pretty evenly between projects rationalized for defense reasons and other projects—the pure science and nondefense opportunities. Now, two-thirds or more of our federal research dollars flow into defense areas [see Figure 1]. My concern for the academic enterprise is that we may be unduly influencing students and professors to work on essentially defense-related projects.... I think the shifting ratio of defense versus civilian sector research inescapably is going to impact to some degree on the academic enterprise. And I say unduly influencing. Because that old saw—that defense R&D spending spins out and feeds the civilian economy—is definitely debatable. Nowadays, many reputable experts argue the reverse.

Should academics help define the policy and the research agenda? They certainly have a role to play, but I don't think they're the only actors. People in not-for-profit research institutions and people in the commercial and industrial sectors should certainly have some voice.... Yes, academics constitute very important committees in the National Academy of Sciences, for instance, and they testify on the Hill, they go in and out of government, but a much broader set of participants now defines and shapes science and technology policy than perhaps we had 10 or 20 years ago.[7]

Figure 1: Estimated 1988 US obligations for R&D, by major departments and agencies. Figures are from the Office of Management and Budget.



Goldsmith: Science policy has two aspects: one, as understood by politicians in government; two, as understood by their scientists and representative organizations. Government in the Western world today is concerned with ensuring a return on investment. Which means, in effect, that although everyone recognizes that basic research is important—it's regarded as the seed corn from which all future growth must come—governments insist on the influence of the market-led economic system. What that means for the way in which the scientific community can influence science policy is a difficult question because this situation is now posing basic problems to the scientific community on how it must act in the future to survive. I mean literally to survive. For example, I believe scientists must now take into account the cost-effectiveness of their work. In the health services, cost-effectiveness is accepted as a valid management tool. The underlying fact is that as demands continue to be made by the scientific community for more resources, it becomes essential for scientists to develop the necessary techniques and new institutions without which the excellence of science will come to be in danger.

So, the answer to this question about influencing science policy will come to be based upon a recognition of the fact that we're beginning to live in a new era for science, and this new era demands new thinking.... When you ask the scientific community about the allocations, you find that "for every PhD there is an equal and contending PhD," so that you get, even among the physicists, a violent discussion on whether high-energy [physics] shouldn't receive more money, as against another field of physics research. Or, you will get the biologists as a group, screaming their heads off that too much money is devoted to, say, high-energy particle physics. The politician cannot intervene because he just really doesn't understand what is going on, and his role is to ensure that there is a payoff for the monies that are invested—the payoff being either in new applications or in the production of the appropriate new scientists and technologists, who are regarded as being important for future development. It's not a direct opposition, but it's the politician who is the key person. And the scientific community is divided.[4]

As I stated previously, science policy is concerned with advice to the chief executive: who gives it, whether the president listens to it, and how it is implemented. Even with all the anecdotes and divergent viewpoints of those involved in science policy in the last 40 years, one observation of mine is worth noting. For any policy to work, it needs input from those it will affect: scientists and all citizens.

Conclusion

This necessarily brief overview of some of the issues of science/technology policy displays a maddening characteristic of the subject—it eludes a unifying framework. There is a chronology of events and institutions, but the science policy of an era depends on the quality of scientific advice and the willingness of the administration to act. Besides that, the field is almost anecdotal. According to Joseph Haberer, Department of Political Science, Purdue University, West Lafayette, Indiana, "To a considerable degree, we still have a body of literature in search of a field."[16] Haberer wrote that in 1977, and it's just as true today.

Next, in Part 2, we'll look at topics concerning international science policy. Some of the issues to be covered include the effects of US science/technology policy on the rest of the world, US policy versus Soviet policy, and today's most important science-policy questions worldwide.

* * * * *

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