PEER REVIEW AND THE PUBLIC INTEREST

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PROLOGUE: *The unique contract between science and government that has existed in the United States since the end of World War II rests on the assumption that science must remain autonomous but that the public interest will best be served if scientists play a decisive role in determining how public funds are spent to support scientific research. The notion that the government can delegate authority over the distribution of public money to the beneficiaries of that largess is remarkable. That it can do so without the intrusion of corrupting influences and without threatening the autonomy of science is due largely to the principle of peer review.*

Here, Richard C. Atkinson, former director of the National Science Foundation, and William A. Blanpied, currently international studies specialist at the National Science Foundation, warn that the peer review principle is in jeopardy. By using "pork barrel" tactics to obtain funds for research facilities, bypassing the traditional process of consultation and peer review, a number of universities threaten to reduce science to just another special interest lobby. Defense of the peer review principle is essential, the authors argue, to restore a healthy relationship between science and government and to ensure the continued effectiveness of our national scientific research effort.

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Reprinted from ISSUES IN SCIENCE AND TECHNOLOGY,
Volume I, Number 4.

The present relationship between science and government in the United States is remarkable.[1] It would have taken a particularly reckless prophet to predict, even 50 years ago, that the scientific community could convince a succession of administrations and Congresses that support for basic research in universities is not only a legitimate role for government, but a responsibility. Today most U.S. scientists probably do not find anything out of the ordinary in a policy that delegates to the scientific community decisions about the expenditure of funds appropriated by Congress for scientific research. But 40 years ago influential people in the White House and Congress were asking whether the public interest could be served if decisions about research priorities were left in the hands of scientists.[2] At the same time a few conservative leaders within the scientific community were expressing skepticism that any system of safeguards could guarantee that federal support for science would not lead to federal control and the inevitable corruption of fundamental scientific values.[3]

We now have reason to believe that these concerns should not be dismissed as alarmist. For example, in 1983 a Senate floor amendment to a supplemental appropriations bill for the Department of Education earmarked $15 million for construction of a space and marine science building at the University of New Hampshire, a step that heralded what was soon to be labeled scientific pork barreling. This is a tactic used to obtain funds for research facilities from Congress through last-minute floor amendments to government agency funding bills, thus circumventing project evaluation by the broader scientific community, by the agency, or by a designated congressional committee.[4]

The Office of Management and Budget's (OMB) characterization of scientists as "the quintessential special interest group"[5] is certainly exaggerated. Yet pork barreling is not in the overall interests of science or society and may reinforce the view, apparent in some quarters, that scientists are in fact just another special interest lobby. Certainly pork barreling and OMB's apparent contempt for the scientific community's pleas for increased research support are indicative of strains in the relationship between science and government. We will argue in this paper that these strains are due, in part, to both parties' partial abrogation of the explicit contract they concluded in the aftermath of World War II. The burden of our argument is that both science and society will be better served if the scientific community recognizes that it must assume a strong, coherent negotiating stance in its relationship with government, as it did 40 years ago. Defense of the peer review principle is essential to the achievement of that stance.

II

By 1943 a consensus was emerging within the scientific community, the then Bureau of the Budget, and Congress that the close working relations established between science and government during the wartime emergency should be sustained. Yet questions about the character of that relationship remained. For example, would the public interest be served by a policy of establishing closer links between science and government? Who should define the public interest? How would it be guarded? What would constitute an intrusion on scientific autonomy? Finally, since the principle (dating from the seventeenth century) that scientists alone are qualified to determine research priorities—the peer review principle—was conceded to be central to the preservation of autonomy, how should the relevant peer group be selected and what scope of authority should government delegate to it?

In May 1950 the creation of the National Science Foundation ended five years of negotiation between the scientific community and the government. Although many questions were still incompletely resolved, it was assumed, at least by the key parties in government, that future disagreements could be settled by good-faith negotiations.[6] Viewed from that perspective, the apparent belief among much of the scientific community that government support for research is a virtual entitlement abrogates the post-World War II contract.

The post-World War II agreement between science and government was—and is— a political contract negotiated in the political arena according to political rules by a broad spectrum of scientists who exhibited considerable skill in the process. They succeeded in large measure because they were able to elevate issues important to science to the status of important national issues. One such issue was direct federal support for research and science education in universities. But the five-year debate on that issue was linked with, and conditioned by, negotiations over the relationship between science and the military,[7] civilian versus military control of atomic energy,[8] and the terms under which the scientific community could accept direct support from government and provide policy advice in return.[9]

The unique feature of that contract was the assumption that science would best serve the public interest if scientists, as private citizens, retained decisive influence over how public funds were spent to support scientific activities. The integrity of peer review was regarded as essential in making that part of the contract workable. Erosion of the principle of peer review by tampering with the normal appropriations process not only undermines quality control, but threatens to reduce the scientific community, in the eyes of Congress and the White House, to " . . . just another set of hands being held out for a share of the Federal pie."[10]

III

Although peer review is usually understood as a recently developed process for allocating government research funds to individuals working in nongovernment institutions, the principle actually emerged in the seventeenth century. By the end of the eighteenth century, there existed a federation of self-governing learned societies dedicated to the disciplined search for useful knowledge that included, for example, the Royal Society of London (chartered in 1660),[11] the American Philosophical Society (1743),[12] and the Asiatic Society of Bengal (1784).[13] The proceedings of these societies provided the principal mode of communication among their members. Significantly, proceedings also served as a means for new societies to establish their credentials among their peers.[14] The integrity of the proceedings of each society was ensured, in turn, by an editor who relied on an advisory board—in effect, a peer review panel—to review prior to publication all members' contributions. That precedent was established in 1664 when the Council of the Royal Society licensed the publication of a regular proceedings and took upon itself what was to become, within a century, an editorial control role.[15]

As peer review was emerging as a means of ensuring quality control, the learned societies were also attempting to define their relationship with the larger society. Almost from the outset a dichotomy existed between what Stephen Toulmin has referred to as the Newtonian ideal of science as a worthwhile end in itself and the Baconian ideal of science as a means of achieving social benefits. That is, the societies, while asserting their autonomy, also compromised it by seeking official sanction for their activities as well as continuing reassurance about the social value of the activities. Resolution of the dichotomy between autonomy and accountability has required that science continually reexamine and negotiate its relationship with government, no matter how reluctantly it has done so, and no matter how often it has denied doing so.

Thomas Jefferson understood that while the interests of science and government may overlap, they are rarely congruent.

The idea that scientific rationality could provide the basis for an enlightened political system was central to the thinking of the founders of the American Republic. In particular, as Don K. Price argues, they subscribed to the conviction that "truth," as exemplified by science, would provide an effective counterbalance to the potential excess of political power.[16]

The convergence of science and government during the 50 years following American independence was epitomized by Thomas Jefferson, who simultaneously served as president of the American Philosophical Society and president of the United States. Yet, as his initiative in connection with the 1804-06 Lewis and Clark Expedition suggests, Jefferson understood that while the interests of science and government may overlap, they are rarely congruent. In 1803 he convinced Congress to appropriate $2,500 " . . . for the purpose of extending the external commerce of the United States. . . . "[17] To ensure that the expedition would serve the needs of government, Jefferson groomed his personal secretary, Captain Meriwether Lewis, as its leader. Mindful of his desire that the expedition also serve science, Jefferson established what was, in effect, a peer advisory committee by dispatching Lewis to Philadelphia to receive instruction from members of the American Philosophical Society on celestial observations, on the collection of botanical and zoological specimens, and the study of the customs of American Indians.

In applying what can be called peer review or peer monitoring to a scientific project that had significant policy implications, Jefferson extended the principle beyond its original quality-control function. In addition, the peer review principle came to serve as a buffer against external, nonscientific interests, and as a means for forging an alliance between scientific interests and other interests—in this case, commerce. In fact, Jefferson had already established a closely related precedent when, as the nation's first patent officer, he turned for advice to an expert panel from the University of Pennsylvania, and in that way extended peer review to an external government advisory function.[18]

The importance of peer review for the scientific community—both to ensure quality control and to define an internal governance framework for science—became increasingly significant from the late nineteenth century onward as science emerged as a full-time profession centered in universities and industrial laboratories.[19] The internal governance function is evident, for example, in the establishment of quasi-official institutions such as the National Academy of Sciences in 1863, and the National Research Council as an adjunct to the National Academy of Sciences in 1916, and also official bodies such as the National Advisory Committee for Aeronautics (which was established in 1915 and was to serve in World War II as the model for the Office of Scientific Research and Development),[20] or the ill-fated Science Advisory Board experiment of the early New Deal era.[21] In all these cases government sought to institutionalize science policy advice, and in all cases scientists were able to maintain control over the conditions for providing that advice. These pre–World War II institutions had a mixed record of success in fulfilling the objective of providing useful policy advice to government. However, the autonomy maintained through peer control remained intact and was respected by government.

IV

Viewed against this historical background, the postwar science-government contract that attempted to bring science into the political system while at the same time preserving its autonomy was a truly daring innovation. No arrangement of comparable importance exists in other countries, and there was never any assurance that the peer review system in the United States would remain vigorous enough to protect science from the corrosive influences of politics. It is in that context that scientific pork barreling must be examined. For nothing in the contract required one party to defend the values of the other in the event that the party should default, as scientists and administrators in at least 15 universities have done in recent years.

A February 1985 report of the National Science Board's ad hoc Committee on Excellence in Science and Engineering documents these largely successful attempts by universities to obtain authorizations and appropriations for facilities (valued at over $100 million) by taking their claims directly to Congress. Often the universities retained professional lobbying firms to assist them.[22] These incidents include the following:

- A total of $13.9 million in fiscal years 1984 and 1985 appropriations for the Department of Energy for construction of a vitreous state laboratory at Catholic University.
- A total of $8.0 million in the Department of Energy's appropriations for the same two years for construction of a chemical research laboratory at Columbia University.
- A $7 million appropriation added to the Department of Energy's fiscal year 1985 budget to permit Florida State University to construct a supercomputer center and acquire instrumentation.
- A $4.5 million add-on to the National Institutes of Health's fiscal year 1985 appropriation to facilitate the development of a cancer research center at West Virginia University.

- An $800,000 add-on to the appropriation for the National Oceanic and Atmospheric Administration's fiscal year 1984 budget to enhance the University of North Carolina's undersea research program.

Of the 15 pork barrel incidents documented in the National Science Board committee report, five were add-ons to Department of Energy appropriations bills, four to appropriations bills for units within the Department of Health and Human Services, and one to a National Oceanic and Atmospheric Administration appropriations bill. The remaining five incidents involved agencies that are not major supporters of basic research; namely, the Department of Education (four incidents) and the Economic Development Administration (one incident). All 15 actions involved construction of facilities for the conduct of research rather than funds for research itself. But the committee report suggests that a next logical step would be to use pork barreling to seek funds for such research support.

Pork barrel tactics violate the understanding that available resources are to be allocated in the best interests of science—and the public. . . .

As more than one critic has suggested, the point at issue is not whether meritorious research will be carried out in facilities obtained through pork barrel tactics.[23] Rather, those tactics violate the understanding that available resources are to be allocated in the best overall interests of science—and the public—rather than in the interests of individual claimants, no matter how qualified or deserving they may be. At another level pork barreling underlines the dependence of research universities on federal largess and suggests that the potential for the corruption of scientific values by access to political power that was feared by conservative scientific critics of the post-World War II contract is a legitimate concern.

Yet thus far the peer review principle has preserved considerably more autonomy for science in the United States than anywhere else in the world. Translated into practice, the central tenet of the earlier, implicit agreement between science and government—that truth should be kept separate from power—has meant that the U.S. government has provided support to universities by means of research grants to individuals distributed on a competitive basis according to criteria and procedures largely controlled by the scientific community. One disadvantage of this system is that the uncertainties and instabilities inherent in two- or three-year funding cycles make long-term planning by universities difficult.

The situation in Western Europe, Japan, and particularly Eastern Europe is quite different.[24] In other countries universities receive stable, baseline operating support from the central and sometimes state or provincial governments and, with a very few exceptions, are firmly controlled by government. Additionally, almost all national governments except the United States provide baseline support to a parallel basic research system separate from the university system. (These nonuniversity research systems differ from U.S. government laboratories, which are either managed by universities or consortia of universities or managed directly by a federal agency for specific, mission-oriented purposes.) Many governments also provide some research funds on a competitive basis to scientists working within the university and national research systems. However, the magnitude of the support available for this purpose is small relative to the continuing baseline support.

American scientists clearly pay a price for trying to preserve the indirect, pluralistic support system based on peer review. But they also acquire benefits. Most other countries provide stable support to universities. But they do not recognize universities as the principal sites for the conduct of basic research. Informed observers in both the United States and Western Europe (as well as some from other countries, including the People's Republic of China[25]) agree that whereas the system in effect elsewhere is more stable, it is also much less effective in encouraging competition among the most innovative ideas, particularly those of young scientists. University scientists, as government employees, also cannot claim the same degree of autonomy they can in the United States.

V

Conceivably those scientists who have convinced their universities to compromise their values so blatantly would not have done so had they believed that they could obtain resources in some more legitimate fashion—or if they had believed that they would be effectively censured by their colleagues for their tactics. Have those scientists lost confidence in peer review? How fair and effective is the process as presently implemented?

Peer review operates most directly and successfully when experts from the same discipline or related sets of disciplines make priority rankings of research proposals within established programs. Similar procedures are frequently followed in competitions for special types of facilities, although in these cases the reviews are usually more extensive, require approvals at more levels within an agency, and may involve criteria, such as geographical balance, in addition to scientific and technical merit.

Broadly analogous implementation procedures are followed at the project level at many of the principal agencies that support basic research in universities—e.g., the National Institutes of Health, the National Science Foundation, and those units with the National Aeronautics and Space Administration, the Department of Defense, and the Department of Energy that support external research and fund special research facilities. The most significant procedural differences relate to the discretion of agency program officers with respect to the judgments of external peer reviewers and panelists. At the National Institutes of Health, for example, priority rankings of review panels (known as study groups) are binding. At the National Science Foundation, where these judgments are advisory, program officers are at liberty to make a case to the agency to modify external peer rankings for good and sufficient reason.

Questions about the fairness of peer review are almost inevitable, particularly since, in most cases, programs do not have sufficient funds to support all proposals that are judged as meritorious by external peers. However, independent assessments have concluded that at the project level peer review generally operates to distribute funds on the basis of merit in the context of criteria established by the agencies themselves—usually in consultation with external advisory panels.[26] But the issue of the effectiveness of peer review as opposed to its fairness is more germane to the science–government relationship.

For example, should priorities within a program be established strictly on the basis of intrinsic merit, or should added weight be given to meritorious projects that promise rapid advances in understanding in a particularly critical area—even at the expense of equally meritorious work in other less dynamic areas? In other words, should peer review operate only to evaluate merit or should it also help establish priorities? Can it or should it be effective in changing the direction of a program, in allocating resources among programs within agencies, or in changing the scientific directions of the agencies themselves? These questions are significant because they challenge the assumption that peer review is the best possible way to allocate resources in the best overall interests of both science and society.

Peer review operates less directly and less effectively at the program than at the project level. Each government agency negotiates the details of its annual budget first with the Office of Management and Budget and then with a set of congressional committees. External advisory bodies can often help an agency define appropriate and feasible program directions. They can and are effective in marshaling the support of the scientific community to save programs threatened with extinction by the Office of Management and Budget. But with one notable exception, those bodies have almost never had to make priority judgments that are almost certain to distress respected colleagues and institutions. That exception is the Department of Energy's High Energy Physics Advisory Panel, which formerly served as an external advisory body to the Atomic Energy Commisson and the Energy Research and Development Administration. Members of that advisory panel recognized in the early 1960s that support would not be forthcoming for the construction and operation of new particle accelerators required for frontier research unless older facilities (many still capable of useful research) were shut down. The fact that this advisory panel has been able to reach and generally enforce consensus on priorities to optimize the overall health of the field may be one important reason for the ability of high-energy physics to continue to garner substantial financial resources from government.

Quasi-official peer advisory panels have demonstrated the potential to deal more effectively with the painful decisions inherent in the resource allocation problem—at least on the disciplinary or program level—than most official panels, with the notable exception of the High Energy Physics Advisory Panel. Beginning in 1962, the Committee on Science and Public Policy of the National Research Council, with the support and encouragement of the National Science Foundation and other agencies, has convened successions of panels for particular scientific disciplines to make recommendations concerning the most fruitful long-term research directions.[27] Within the last five years these panels have begun to face up to the priorities question, which they had largely avoided. For example, the centerpiece of the 1982 report on astronomy and astrophysics was a listing by priority of facilities required to exploit opportunities for the balance of the century.[28] The highest priority was assigned to construction of the Very Long Baseline Array radio telescope, and that priority is reflected in the National Science Foundation's long-range-planning document for fiscal years 1986–90. Currently, the Committee to Survey Opportunities in the Chemical Sciences has reportedly reached consensus on three priority areas in the field.[29] A comparison of skillfully staged previews of this committee's report with the report of another National Research Council committee on chemistry published 20 years ago, which emphatically refused to refer to priorities, suggests that the scientific community's attitude toward its responsibility for making difficult decisions in the long-range interests of science may be changing.[30]

The problem of establishing priorities across rather than within disciplines has yet to be clearly faced, although attempts in that direction have been made. The Office of Science and Technology Policy, which from 1976 to 1982 was required by law to prepare for Congress a *Five-Year Outlook* on science and technology, agreed with the National Science Foundation that the National Research Council should be asked to convene representatives from a range of scientific fields to examine their own and related disciplines and to identify research areas of particular importance both to science and to the resolution of important national issues.[31] More recently, the Committee on Science, Engineering and Public Policy has, at the request of the president's science adviser, prepared a series of annual research briefings that address these issues.[32] Although these devices have been useful for information exchange and for helping the separate disciplines sort out their own priorities, there is no evidence that they have had any appreciable effect in determining resource allocation across disciplines or among agency programs.

The rapid growth of the defense-related components of the R&D budget since 1981 has occurred with little effective input from the scientific community.

VI

There is the larger problem of whether peer review can or should operate at an even higher level of aggregation to allocate resources *among* federal R&D agencies, or even help determine the overall size of the federal R&D budget. Because policy considerations other than scientific and technical excellence and promise are involved at this level, it is tempting to conclude that scientific peer review has no applicability whatsoever. Recent experience appears to bear out this conclusion. For example, the rapid growth of the defense-related components of the R&D budget since 1981—coupled with the decline, in real dollars, of the civilian components—has occurred with little effective input from the scientific community.[33] On the contrary, until well into the 1960s, government actually expected scientists to provide substantial advice not only about levels and allocations of research support, but also about other important science-related policy matters. Until 1957, however, official spokesmen for science rebuffed government's repeated offers to give the scientific community a voice in resolving such issues.

In February 1951 the newly organized National Science Board (the legislated policymaking body of the National Science Foundation) rejected the Bureau of the Budget's request that it play a major role in planning and coordinating federal research allocations; for the next five years the National Science Foundation rejected similar appeals by the bureau.[34] But the psychological crisis occasioned by the Soviet Union's launching of Sputnik in 1957 finally brought science, for about a decade, firmly into the political system very much as the Bureau of the Budget had envisioned and on terms that largely preserved scientific autonomy. The President's Science Advisory

Committee, created late that year by President Eisenhower, was a prestigious scientific peer group expected to provide independent advice at the highest levels of government on issues important to both science and society, including R&D budget allocations.[35] Significantly, government implicitly accepted the claims of science to a particular level of autonomous disinterest by conceding that (unlike the Council of Economic Advisers, for example) scientific competence alone, rather than competence and approved political leanings, should serve as a basis for membership on the President's Science Advisory Committee.

No doubt the waning and eventual extinction of this peer committee during the Vietnam era was due in large measure to the fact that its members often assumed positions that were inconsistent with the policies of the Johnson and, later, the Nixon, administrations.[36] But as the fate of many individuals in the White House during those years attests, it is unlikely that preoccupation with its own survival would have spared the committee. On the contrary, such a course might have damaged science's reputation for disinterest and integrity. In any event, the lesson that some scientists seem to have learned from the demise of the President's Science Advisory Committee—that science can be badly burned if it approaches government too closely—may be the wrong one. Rather, the continued waning of science's influence with government during the past decade—as suggested by the current imbalance between the military and civilian components of the federal R&D budget or the impasse that has apparently developed on the issue of open scientific communication—suggests a different lesson; namely, that science should discipline itself to speak out strongly and coherently on important policy issues even though it may, on occasion, suffer setbacks as a consequence.

VII

Science and government both assumed in the late 1940s that a coherent set of strategies was required to bring scientific resources and capabilities to bear on important national issues. Science policy was implicitly defined as the sum total of those strategies. During its first decade the President's Science Advisory Committee came close to defining and implementing such a national science policy. Viewed in that context, support for university research was regarded as being in the public interest because such support would amplify resources critical to the nation.

Today many scientists tend to regard research support as an end in itself and entanglement with other issues as either unnecessary, dangerous, or both. The National Science Board seems to have taken such an attitude when it rebuffed the Bureau of the Budget in the early 1950s. But in doing so it also abdicated a good deal of the political authority it might have had to negotiate on behalf of the scientific community. At any rate, the assumption that research is a sacrosanct activity that government must continue to support adequately has lulled much of the scientific community into a state of political apathy and has allowed government to treat science as if it were, in fact, just another special interest. Even the informed public, if it comes to regard science in that way, will have difficulty understanding why scientists become upset because some of their colleagues claim a piece of the federal budget through the same pork barrel tactics that other special interest groups have traditionally used.

Scientific pork barreling probably cannot be completely halted unless the scientific community severely disciplines those who engage in it, or unless its root cause—the deterioration of university science facilities—receives national attention. Precedent suggests that the viability of the universities can, in fact, become a national issue. During the 1960s the President's Science Advisory Committee was able to convince the Kennedy and Johnson administrations that it was in the national interest to increase the number of first-rate research universities in the country, and to award "centers-of-excellence" grants competitively to do so.[37] But that occurred only because science was in a strong position to negotiate from a perspective of national rather than parochial interests.

It is, of course, unlikely that the resources required to conduct all potentially meritorious research, or to plan, construct, and operate all special scientific facilities that could be used to good advantage, will be forthcoming from the government in the near future. Recognition of that state of affairs has, as already noted, led several scientific disciplines to face the difficult problem of forging a consensus about their priorities. By doing so they have acquired the strength and cohesion required to negotiate with individual government agencies for the resources they need, at least for the most essential elements of their programs. While this trend is promising, it also represents a piecemeal approach to the problem of allocating resources. It does not address the problem of the overall size of the federal R&D budget nor its distribution among agencies and programs. Nor does it address the problem of maintaining the country's broad scientific infrastructure. At its extreme the disciplinary approach concedes, in effect, that the scientific community cannot have any significant influence on the overall R&D budget, and reluctantly blesses efforts of the separate disciplines to press their independent cases for marginal budget increments or even larger pieces of a fixed pie.

Scientific pork barreling cannot be halted unless the scientific community disciplines those who engage in it or the deterioration of university science facilities receives national attention.

Could peer review processes be extended to yield a broad consensus not only about research priorities within disciplines but also about priorities across disciplines and priorities for both moderately expensive research facilities and very expensive programs? Could the scientific community arrive at such a broad consensus even if some institutions and some disciplines were to suffer as a consequence? Could a sufficiently strong consensus be reached about the fairness and effectiveness of procedures for establishing priorities so that individuals and institutions that attempted to circumvent those decisions could be effectively censured by the rest of the community—for example, by being threatened with denial of subsequent support by official peer panels?

Two decided advantages might accrue to science if it could, at the very least, move in these directions. First, by presenting a more united front, the community could lay claim to a stronger voice not only in allocating existing resources but also with respect to other important science-related policy issues—including the overall size and distribution of the federal R&D budget. Second, an effective demonstration that science is not just another special interest lobby would legitimize the importance of preserving scientific autonomy not only for science but for society. And it would give to the scientific community a good deal of the political and moral authority required to negotiate issues of genuine national importance.

Several recent cases illustrate the effectiveness with which high-level, semi-independent advisory bodies that enjoy the confidence of the scientific community can elevate issues of interest to science to the status of national issues. The Defense Science Board, by questioning whether the use of export control regulations to restrict international scientific communication is in the national interest, expanded the constituency with a stake in that issue and probably forestalled even heavier-handed attempts to limit such communication than are now being suggested. Doing so ensured that the issue would be resolved at the highest levels of government and with the participation of the scientific community.[38] The National Science Board, by invoking a little-used authority granted it by the National Science Foundation Act of 1950, established a distinguished, broadly representative Commission on Precollege Education in Mathematics, Science and Technology, and thereby allied the scientific community with other groups concerned with the deterioration of precollege education.[39] As a final example, even the moderate success of university scientists from agriculture-related fields in establishing a competitive grant program occurred because those scientists allied themselves with other groups, including scientists in other fields who correctly saw the issue as important to ensure the viability of peer review, and with private interests that have a stake in the quality of basic research in agriculture.[40]

Of course these examples can also be taken as illustrations of the limits of science's current influence with government and the need for it to develop stronger political alliances. The full objectives of science have not been attained in any of the cases cited above. However, the fact that the scientific community has managed to speak with a strong, coherent, and largely disinterested voice and to gain substantial public attention in these matters should not be overlooked.

Can the scientific community speak with the same strength, coherence, and relative disinterest on the single issue that it is most qualified to address? A strong science and technology infrastructure and maintenance of the viability of the universities as the basis for that infrastructure are at least as important to the nation now as they were 40 years ago. But establishing such an infrastructure requires more than just adequate support for research and research facilities. It also requires that science preserve a large measure of autonomy for detailed decisions about overall directions for research. However, as we have argued here, scientific autonomy has always been negotiated within a political framework—with the expectation that its protection serves the public interest. Perhaps, as some critics suggest, a new science-government contract is needed to suit current realities. Perhaps modification of the present contract will be sufficient. In neither case is the outcome likely to be in the best long-term interests of either science or the public unless science is able to deal with government from a position of strength and to recognize that support for research is linked with other important policy problems.

The central issue to be addressed is not whether the scientific community should enter the political arena; science is in that arena whether or not scientists speak there effectively on its behalf. Rather, the issue is whether the community will enter that arena from a position of strength and thus have a reasonable chance of affecting policy decisions, or whether it will decline to play the political game and be forced to live with decisions that it has, at best, a small voice in determining.

The paradoxical claim that society will obtain maximum benefits from science if scientists are allowed to pursue their work free from intervention is as old as Bacon, and it is unlikely that challenges to that assumption will cease in the near future. If so, the best safeguard that science has against unwarranted intrusions is its long-standing reputation for integrity—a reputation based on public confidence in the ability of scientists to govern themselves in the best interests of the larger society. Rigorous application of peer review as a means for self-governance has been a critical factor in maintaining science's autonomy in the changing circumstances of the past three centuries. A continued defense of that principle and a continued demonstration of its viability, even at the risk of considerable distress to some members of the community, is the best course available to science to serve both its own best interests and the best interests of the larger society. ■

NOTES:

1. The opinions of the authors are their own and do not necessarily reflect the policies of their institutions.
2. Daniel J. Kevles, "The National Science Foundation and the Debate Over Postwar Research Policy, 1942–1945: a Political Interpretation of Science—the Endless Frontier," *Isis* 68 (1977): 5–26. J. Merton England, *A Patron for Pure Science: The National Science Foundation's Formative Years, 1945–57* (Washington, D.C.: National Science Foundation, 1982), 9–107.
3. England, *Patron for Pure Science.* One of the principal skeptics was Frank Jewett, president of the National Academy of Sciences, whose skepticism regarding the dangers of overly intimate links with government dates at least from World War I; (cf. A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge: The Belknap Press of Harvard University Press, 1957) 324 and 337.
4. *Science* 222 (1983): 592; *Science* 223 (1984): 27; *Science* 226 (1984): 519; *Congressional Record* (Sept. 25, 1984): E 4002–4003. For a political analysis of the origins of the pork barrel phenomenon see Philip M. Smith and Albert H. Teich, "University Research Facilties and Pork Barrel Politics" (in press).
5. In *Science and Government Report* Daniel Greenberg attributed this remark to an unidentified OMB official; George Keyworth II, President Reagan's science adviser, quoted it in an address delivered at the AAAS Colloquium on R&D in the Federal Budget, April 3, 1985.
6. William D. Carey, "Science and Public Policy," *Science, Technology and Human Values* 10, no. 1 (Winter 1985): 7–16.
7. cf. Daniel J. Kevles, "Scientists, the Military, and the Control of Postwar Defense Research: The Case of the Research Board for National Security, 1944–46," *Technology and Culture* 16 (Jan. 1975): 20–47.
8. Alice Kimball Smith, *A Peril and a Hope: The Scientists' Movement in America, 1945–47* (Chicago: University of Chicago Press, 1965).
9. Vannevar Bush, *Science—The Endless Frontier.* First issued as a report to the president of the United States, July 5, 1945. Reprinted in 1980 by the National Science Foundation, Washington, D.C.: Detlev W. Bronk, "Science Advice in the White House: The Genesis of the President's Science Advisers and the National Science Foundation," in *Science Advice to the President,* ed. William T. Golden (New York: Pergamon Press, 1980) 245–256.
10. George A. Keyworth II, *C&EN News* 63, no. 5 (April 15, 1985): 5.
11. Thomas Sprat, *History of the Royal Society* (London, 1667). Reprinted by Routledge and Kegan Paul, Ltd. (London), 1958, ed. Jackson Cope and Harold Jones.
12. Alexandra Oleson and Sanborn C. Brown, eds., *The Pursuit of Knowledge in the Early American Republic* (Baltimore: Johns Hopkins University Press, 1976), xvi.
13. William A. Blanpied, "Notes for a Study of the Early Scientific Work of the Asiatic Society of Bengal," *Japanese Studies in the History of Science* 12 (1973): 122–44.

14. A. Hunter Dupree, "The National Pattern of American Learned Societies, 1769–1863," in *Pursuit of Knowledge*, ed. Oleson and Brown, 21–32.
15. Harriet Zuckerman and Robert K. Merton, "Patterns of Evaluation in Science: Institutionalization, Structure and Functions of the Referee System," *Minerva* IX, no. 1 (Jan. 1971): 68–69.
16. Don K. Price, *America's Unwritten Constitution: Science, Religion, and Political Responsibility* (Baton Rouge: Louisiana State University Press, 1983).
17. Dupree, *Science in the Federal Government*, 31–36.
18. Dupree, *Science in the Federal Government*, 26–28.
19. Dupree, *Science in the Federal Government*, 120–48, 289–325.
20. Dupree, *Science in the Federal Government*, 283–87.
21. Dupree, *Science in the Federal Government*, 350–58. Daniel J. Kevles, *The Physicists* (New York: Alfred A. Knopf, 1978), 252–58.
22. "Report of the NSB Committee on Excellence in Science and Engineering" (NSB–85–50. Available from the National Science Board, National Science Foundation, Washington, D.C. 20550).
23. Smith and Teich, *University Research Facilities*, Norman Hackerman and Warren D. Niederhauser, *C&EN News* 63, no. 16 (April 22, 1985): 31.
24. cf. "Research in Europe and the United States," in *The Five–Year Outlook on Science and Technology, 1981*, vol. 1 (Washington, D.C.: National Science Foundation, 1981), 255–84.
25. A small competitive grant system has been established within the research system of the Academia Sinica. (cf. William A. Blanpied, *Science, Technology and Human Values* 9, no. 2 (Spring 1984): 67–72.) More recently, the state Science and Technology Commission of the People's Republic of China has announced its intention to establish a national science foundation to support research on a competitive, peer-reviewed basis, and Chinese officials visited the National Science Foundation in Washington during the spring of 1985 for intensive discussions on details.
26. cf. S. Cole, J.R. Cole, and G.A. Simon, *Science* 214 (1981): 881–86.
27. William W. Lowrance, *Science* 197 (1977): 1254–60.
28. Astronomy Survey Committee of the National Academy of Sciences (George Field, chairman), *Astronomy and Astrophysics for the 1980s* (Washington, D.C.: National Academy Press, 1982).
29. National Research Council, *Report of the Committee to Survey Opportunities in the Chemical Sciences* (Washington, D.C.: National Academy Press, due 1985). For a preliminary indication of the tenor of the committee's report see Committee on Science, Engineering and Public Policy, "Report of the Research Briefing Panel on Selected Opportunities in Chemistry," *Research Briefings 1983* (Washington, D.C.: National Academy Press, 1983) 65–92.
30. Committee on Science and Public Policy, *Chemistry: Opportunities and Needs* (Washington, D.C.: National Academy Press, 1965).
31. Three successive editions of the *Five-Year Outlook* were prepared by the National Science Foundation under the guidance of the Office of Science and Technology Policy and with substantial input from the National Research Council and the American Association for the Advancement of Science. These were published by the National Science Foundation in May 1980, January 1982, and September 1983, respectively. The legislated requirement for a *Five-Year Outlook* was eliminated by the omnibus Reports Elimination Act of 1982.
32. Committee on Science, Engineering and Public Policy, *Research Briefings 1983* and *Research Briefings 1984* (Washington, D.C.: National Academy Press, 1983, 1984).
33. American Association for the Advancement of Science, *Research and Development in the Federal Budget*, volumes for fiscal years 1982 through 1986 (Washington, D.C.: American Association for the Advancement of Science).
34. England, *Patron for Pure Science*, 131–210. Milton Lomask, *A Minor Miracle: An Informal History of the National Science Foundation* (Washington, D.C.: National Science Foundation, 1976), 91–110.
35. Golden, *Science Advice to the President*.
36. David Z. Beckler, "The Precarious Life of Science in the White House," in *Science and its Public: The Changing Relationship*, ed. Gerald Holton and William A. Blanpied (Boston: D. Reidel Publishing Co., 1976), 114–34.
37. cf. President's Science Advisory Committee, *The Universities and the Federal Government* ("The Seaborg Report"), Nov. 1960.
38. cf. National Academy of Sciences, *Scientific Communication and National Security* (Washington, D.C.: National Academy Press, 1982).
39. National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century* (Washington, D.C.: National Science Foundation, 1983).
40. cf. Don F. Hadwiger, *The Politics of Agricultural Research* (Lincoln, Neb.: University of Nebraska Press, 1982).