The Expanding Role of Peer Review Processes in the United States

David H. Guston
Bloustein School of Planning & Public Policy, Rutgers, The State University of New Jersey, USA
Email: guston@rci.rutgers.edu

Introduction

The diverse processes of peer review are familiar to science policy. Peer review processes serve a critical role in the allocation of such scarce resources as research funds and journal space, as well as in helping to produce knowledge on which researchers rely (Chubin and Hackett 1990). In part because of the perceived success of peer review in these roles, reformers have sought to harness peer review to help produce knowledge on which policy makers can rely, for the ultimate purposes of improving decisions, reducing the occurrence of legal challenges and other procedural obstacles, and achieving other political goals (Jasanoff 1990).

This paper will explore what appears to be the increasing domain of peer review processes in science policy. It is an early portion of a two-pronged research agenda that seeks to elaborate both the logical structure and the detailed procedures of peer review and the use of scientific expertise in the policy process. In elaborating peer review's logical structure, the project builds on previous work on the logical structure of science policy more generally. Following the traditional between "policy for science" and "science in policy" (Brooks 1968), this earlier work applies a principal-agent perspective to focus exclusively on the delegation inherent in funding research (Braun 1993; Guston 1996b; van der Meulen 1998; Caswill 1998). Applying the same principal-agent perspective to "science in policy," the agenda seeks to articulate a more sophisticated analytical framework for peer review (and other uses of expertise) that both scholars in several disciplines and practitioners in advice-producing and -consuming arenas can appreciate.

In elaborating the detailed procedures of peer review, the agenda extends an approach to studying science and scientists by following them out of the laboratory (Latour 1987) and into arenas in which they are called upon to come to judgments in a more public and accountable way. It also extends an approach to studying science and scientists that emphasizes observing how, through their rhetoric as well as the establishment of policies and procedures, scientists attempt to demarcate their vision of scientific from non-scientific activities (Gieryn 1995; Jasanoff 1990).

Such detailed scrutiny, for example, can yield a more complete, scholarly understanding of consensus and consensus formation in science (Kim 1994), as well as create precise, policy-relevant knowledge about the decision making of expert advisory committees (Guston 1999). Ultimately, the project will synthesize both perspectives in a way that has been done for "policy for science" (Guston 2000a).

This paper provides preliminary descriptive work for the agenda. It begins by defining peer review and recounting a very brief history of its use by the federal government of the United States. It then describes the expansion of its domain in several areas: the allocation of federal funds, the evaluation of research programs, the evaluation of knowledge inputs to policy, the admission of expert testimony in federal courts, and in state science policy. The paper concludes with a brief evaluation of these trends.

Definition and History of Peer Review

As the General Accounting Office (GAO 1999) has found, there is no single definition of peer review used across government agencies in the United States. Consequently, the practice of peer review varies within certain wide parameters (Guston 2000c). GAO (1999:3) found, however, that "all of the agencies' definitions or descriptions of peer review contained the fundamental concept of a review of technical or scientific merit by individuals with sufficient technical competence and no unresolved conflict of interest." This definition is sufficient for the purposes of this paper, but key to its further usefulness is the specification of exactly what constitutes technical or scientific merit, who the competent persons are and how are they selected, what conflicts of interest need to be resolved in which ways, and how the process of review itself relates to actual outcomes. I take up some of these questions elsewhere (e.g., Guston 2000b).

Over the long span of history, peer review as a method of evaluation has clearly expanded its domain. Among the earliest examples of peer review for proposed research projects in the United States include the Smithsonian Institution, which created an advisory committee for reviewing and recommending funding proposals in the 1840s; the Navy Consulting Board, which in 1915 began reviewing requests for funding from inventors (Savage 1999); and the Hygienic Laboratory, predecessor to the National Institutes of Health (NIH), which pioneered peer review in 1902 with a congressionally mandated advisory committee (Smith 1990).[18] The National Cancer Act of 1937 and the Public Health Service Act of 1944 legitimated the use of advisory councils to award grants to extramural researchers, and NIH fully established its peer review system with the creation of its Division of Research Grants (now the Center for Scientific Review) and the original review groups after World

[18] An early example of peer review for publication occurred when President Thomas Jefferson, who commissioned the Lewis and Clark expedition, requested the American Philosophical Society to review the expedition's report prior to its publication (Savage 1999:5).

War II (Smith 1990). At the National Science Foundation (NSF), peer review was only implicit at the start, although NSF's governing body, the National Science Board (NSB), understood that after staff members evaluated proposals, they would send them to advisory bodies before presenting them to NSB for statutory approval (England 1982).

Expansion of Peer Review in the Allocation of Federal Funds

One of the critical conflicts in science policy at the time of the founding of NSF was between different schemes for allocating federal research and development (R&D) dollars: Would the wartime practice of distributing funds only to the elite universities continue, or would there be some geographic formula (as had been the mode with agricultural research) that might redress some of the distributional inequities? Although the former model triumphed, and was buttressed by the peer review system, the political demand for the redress of geographic inequities did not disappear. Instead, it manifested itself, in part, in the earmarking of federal appropriations to specific projects. Thus, earmarking (or porkbarreling) is seen as competitive with peer review, and the level of earmarks are anxiously traced in the science policy community. Journalists from *The Chronicle of Higher Education* conduct an annual survey of earmarks to academic institutions. In recent years, the amount of those earmarks identified by *The Chronicle* have totaled in the upwards of $500 million, showing a generally increasing trend (Savage 1999:3). The latest figure for fiscal year (FY) 2000 is slightly over $1 billion (Brainard and Southwick 2000). This figure represents only about 3% of federal R&D spending at colleges and universities, but it is widely agreed to be an underestimate.[19]

Identifying the amount of peer reviewed research within total R&D is difficult (Smith 1990). A generation ago, Harvey Brooks (1982) estimated the fraction of peer-reviewed research in total national R&D expenditures at about 5%. This figure assumes that no peer review occurs in the large fraction (then about two-fifths; now, about two-thirds) of R&D funded and performed in-house by corporations – a notion disputed by Lewis Branscomb (1982). Whereas, Brooks lamented the small fraction; Rustum Roy (1985:73), a critic of peer review, estimated with some satisfaction that "at least 90% of the total money spent on research and development in the United States" is allocated by mechanisms other than peer review.

Since FY 1996, the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) "have jointly provided annual direction to agencies encouraging them to emphasize the funding of peer-reviewed research over non-peer-reviewed research" (GAO 1994:4), but there is no direct way of judging whether or not this directive has had any impact. The Clinton Administration's FY 2001 budget proposal reports that $26 billion of the nearly $83 billion

[19] See Intersociety Working Group (1999:68) for expenditures at colleges and universities.

total federal R&D (31.4%) was peer reviewed in FY 2000, and that this share is proposed to increase to 33% in FY 2001. This level of peer reviewed R&D corresponds to about 10% of national expenditures. Again assuming that no private funds are peer reviewed,[20] this rate is double what Brooks estimated, despite the nearly two-fold increase in the relative share of private funds in the national account. There has thus likely been a significant increase in the share of federal R&D funds that are subject to peer review.[21]

Such changes, however, may occur as a side effect of the changing composition of total R&D, rather than as a first-order effect of emphasizing peer review. For example, in the early 1990s, the composition of federal R&D spending was approximately 60% defense, 40% civilian. Currently, the composition is closer to parity between defense and civilian accounts, and as civilian R&D is more likely to be peer reviewed than defense R&D, this relative transfer can account for some of the growth in the share of peer reviewed research. Within the civilian account, the recent growth of NIH's share has expanded the influence of peer review as well.

Nevertheless, some recently established federal funding programs tout peer review as an important and novel component:

- In 1991, the U.S. Department of Agriculture created the National Research Initiative as a competitive, peer reviewed grant program to complement its intramural research and its formula funding to land-grant colleges. The National Academy of Sciences has praised the program for producing high-quality science, but Congress has appropriated only about one quarter of its annual $500 million authorization and the number of applications has fallen 25% off of its 1994 peak (Southwick 2000).

- In 1995, the Environmental Protection Agency created the Science to Achieve Results (STAR) program, which has been funded at $100 million. STAR uses peer review to allocate funds among responses to requests for proposals in EPA's mission-related research, and highly rated proposals are "subjected to a programmatic review within EPA to ensure a balanced research portfolio" (GAO 1999).

- The Advanced Technology Program (ATP) of the Department of Commerce makes use of independent external review as well. ATP reviewers rank proposals based on scientific/technical merit and on the potential for broad-based eco-

[20] Sapolsky (1990:95n29) suggests that NIH found a model for peer review in the private Rockefeller Fund, which began the practice in 1930 (but Rockefeller's reasons for doing so are obscure). Today, a few private foundations use peer review to allocate funds, but review by program officers and boards seems to be the norm (Guston 2000c). Such funds, however, are still a small fraction of private industry's support of R&D.

[21] This increase has not resulted in a concomitant increase the number of grant review committees which, according to reports by the General Services Administration, have actually shown a decrease in numbers over the last five years.

nomic impacts. Since it received its first appropriations in 1990, ATP has funded more than $1.5 billion in R&D (see Hill 1998).

Expansion of Peer Review in the Evaluation of Research Programs

The jurisdiction of peer review may be further increasing among agencies that sponsor research with the increasing importance of the Government Performance and Results Act (GPRA), which requires federal agencies to engage in program and performance assessment. Because the results of research funding are hard to quantify, research agencies rely on peer assessments (either prospectively or retrospectively) to justify and evaluate their performance (NAS 1999). The National Science and Technology Council (NSTC 1996) finds that "[f]or evaluating current programs in *individual agencies*, merit review based on peer evaluation will continue to be the primary vehicle for assessing the excellence and conduct of science at the cutting edge" (emphasis in the original). Such review can occur not only prospectively, as with current peer review for funding allocations, but "[a] form of merit review with peer evaluation can also be used for retrospective evaluation of an agency's fundamental science program or programs." NSTC recommends that assessors performing this evaluation should include "input from stakeholders, next-stage users, and/or customers who will use or have a stake in the results of the research being done," in addition to those with "relevant scientific expertise and experience in the type of research being done."[22]

Expansion of Peer Review in the Evaluation of Knowledge Inputs to Regulation

Congress has recently sought to expand the application of peer review to the knowledge inputs to regulatory policy making. Bills introduced in the 106th Congress (1999-2000) include: S. 746, to peer review cost-benefit and risk analyses of major rules, among other purposes; H.R. 574, to peer review all regulations supported by scientific data; and H.R. 2639, to peer review the data used in standards promulgated by the Occupational Safety and Health Administration.

Many federal agencies, however, already practice forms of peer review in their regulatory, evaluative, or assessment missions (Guston 2000b; 2000c; Jasanoff 1990; Smith 1992).[23] Some of these mechanisms, such as the Science Advisory Board of the Environmental Protection Agency (EPA), are decades old. Others, such as the Board of Scientific Counselors of the National Toxicology Program (NTP), are recent innovations.

---

[22] NSTC's recommendation for this kind of input seems to foreshadow what NIH has done in establishing a Council for Public Representation to advise the NIH director.

[23] The General Services Administration reports that approximately 25% of all federal advisory committees are "scientific/technical" in nature (excluding grant review committees); this percentage has held roughly constant since GSA began the categorization for fiscal year 1985.

EPA has made the most intensive effort to expand the application of peer review to the use of science in its own decision making. A set of documents published over the last decade has:

- Emphasized the importance of external peer review for EPA scientific and technical products, contact between EPA and external scientists, and the use of the best science in decisions – thus setting the agenda for regulatory peer review (EPA 1992);
- Attempted to set standard operating procedures among various EPA divisions by creating a Science Policy Council (SPC) to "expand and improve peer review in all EPA offices" (Browner 1994);
- Articulated the new policy for "peer review and peer involvement" in EPA (1997)[24] that anticipates the peer review of "major work products that are primarily scientific and technical in nature and may contribute to the basis for policy or regulatory decisions;" and
- Primed EPA staff and managers on the "organization and conduct of peer review," (EPA 1998), including specific criteria of when to apply and not apply it.

NTP is an agency of the Department of Health and Human Services, created in 1978 with the mission to "evaluate agents of public health concern by developing and applying the tools of modern toxicology and molecular biology" (NTP 1999:2).

NTP uses a Board of Scientific Counselors (BSC) to provide peer review for a number of agency activities, including oversight of research conducted in NTP centers and review of nominations for substances to be included in the congressionally mandated *Report on Carcinogens*.

In this latter role, BSC demonstrates another aspect of the expanding jurisdiction of peer review: the requirement that all information considered in the decision to list (or delist) a substance in the *Report on Carcinogens* be from the publicly available, peer reviewed literature. Further research intends to document the extent to which other federal agencies apply such a stricture in their regulatory, evaluative, or assessment missions (but see below as well).

[24] A more complete chronology exists in Powell (1999), which also describes a 1996 GAO report that found uneven progress on implementing peer review and an internal study conducted by EPA's Office of Research and Development that reported few deviations from peer review requirements except in the area of models.). One of SPC's early products was "Guidance for Conducting External Peer Review of Environmental Regulatory Models" (Sussman 1994).

Expansion of Peer Review in State Policy

There is no systematic information about the use of peer review in the states, but ad hoc information suggests that it is taking root and expanding there, too, in both roles of allocating funding and evaluating knowledge inputs.

State agencies support modest amounts of research closely related to missions in, for example, environmental protection, health and human services, or housing, planning and development. They also support R&D programs aimed specifically at economic development. NSF (1999) reports that states fund about $3 billion in R&D annually.[25]

Many state agencies provide small grants and contracts to academic and other researchers in pursuit of their missions. The New Jersey Department of Environmental Protection, for example, is one of the few such departments in the nation with a separate and highly professionalized Division of Science, Research, and Technology (DSRT). For its extramural research, DSRT conducts a peer review, using three reviewers, two of whom are outside DSRT. The reasons for not using external review include the problem of competitors for the funding reviewing proposals and the problem of quicker turnaround needed by the agency than external reviewers normally provide.[26]

The State Science and Technology Institute (SSTI) is a clearinghouse for information about R&D at the state level. Searching its summaries of state programs in R&D for economic development for "peer review" yielded hits at eleven states (AK, AR, CA, CO, KS, MI, ND, NJ, NY, OK, PA) and the following details:[27]

- Some states use visiting committees to review major investments in R&D centers; such review may occur annually or biennially and is important in decisions to renew or extend funding.
- More states use peer review, in either an ad hoc or panel fashion, for allocating small grants.
- For technology programs, states review both technical elements of proposals and business plans, as ATP does.

[25] This figure presumably encompasses both types of funding and is likely an underestimate.

[26] In his proposal for post-war federal support of research, Vannevar Bush implicitly compared the federal government to state governments, finding that the latter lack the institutional means and talent to provide the necessary administrative support for research funding. Many states have improved their capacities since 1945, but it is not clear whether the new capacity is sufficient (See Guston 1996a).

[27] See www.ssti.org/states.htm. Minnesota, which did not appear in the SSTI search, has mandated peer review in the authorizing statute for Minnesota Technology, Inc. (MN Statutes 116O.071, subd. 2).

It is possible that many of these peer review activities did not commence until after the programs were established. In New Jersey, for example, several programs initially implemented in a non-competitive fashion were replaced by competitive, peer-reviewed programs over the first decade of their operation.

California has recently offered $300 million in matching funds to the University of California (UC) system to establish new collaborative research centers. The choice of the centers will depend on the results of two rounds of peer review: the first stage, conducted by technical experts chosen by the UC system; and the second stage by technical experts selected by the governor from a slate proposed by UC.

There is similarly no systematic information about the use of peer review in state regulatory decisions, although there is evidence of interest among the states in science in policy (Andersen 2000; CGS 1999). California has implemented this interest the furthest. In 1997, Governor Pete Wilson signed SB 1320, which contained a peer review mandate.[28] Also in 1997, a Risk Assessment Advisory Committee issued a final report that asked for peer review to be applied more consistently throughout the state's Environmental Protection Agency (Cal/EPA). Cal/EPA (1998) has begun to implement the request in its strategic planning and the publication of policy and principles for peer review. California's Proposition 65 also mandates a peer function to list chemicals shown to cause cancer, birth defects, or reproductive harm.

There are likely a wide array of uses of peer advisory committees in support of policy or regulatory decision making in other states, including:

- The Michigan Environmental Science Board, established by Governor John Engler by executive order in 1992, which answers referrals from the Governor, who asks specific questions regarding, for example, the review of environmental impact statements or proposed environmental standards for permits or operating licenses. A subcommittee of the Board, with guests added as needed for their expertise, then provide answers.[29]

- North Carolina's Scientific Advisory Board on Toxic Air Pollutants, composed of five scientists who review new or revised acceptable ambient level guidelines for air toxics and who conduct risk assessments.[30] A broader Environmental Management Commission adds economic and feasibility concerns, and an Environmental Review Commission serves as gatekeeper to the legislative process.

Expansion of Peer Review in the Evaluation of Courtroom Expertise

---

[28] See www.calepa.ca.gov/publications/factsheets/1997/prop65fs.htm.

[29] See www.mesb.org.

[30] See daq.state.nc.us//offices/technical/toxics/risk/.

In its 1993 *Daubert v. Merrell Dow* decision, the Supreme Court articulated an important but not dispositive role for peer review in the certification by judges of expert witnesses. *Daubert* also prompted judges to appoint their own experts to review scientific findings and offer analysis not based on advocacy. The Court elaborated its view in such subsequent decisions as *GE v. Joiner* and *Kumho v. Carmichael*.[31]

In *Daubert*, the Supreme Court ruled that the Federal Rules of Evidence, and not the 1923 *Frye* rule, govern the admission of expert testimony.[32] Passed by Congress in 1975, the Federal Rules hold that all expert testimony that is "relevant and reliable" is admissible, and they place the responsibility of determining relevance and reliability in the hands of the trial judge – whom the Court felt was competent to make that judgment.[33] The Court also identified four points that judges could take into account when determining admissibility: 1) Is the theory or technique testable? 2) Has the theory or technique been subjected to peer review and publication?[34] 3) Is the error rate known or potentially known? and 4) Is the theory or technique generally accepted within the particular scientific community? The Court specified that judges should consider these questions for the principles and methods of experts, and not their conclusions. It further directed that this list was neither definitive nor dispositive.

General Electric v. Joiner was the first case implementing the *Daubert* decision that percolated back to the Supreme Court. Associate Justice Breyer separately concurred with Chief Justice Renquist's opinion in *Joiner*, citing several of the *amici* that judges' lack of scientific training does not relieve them of the role of gatekeeper that *Daubert* casts them in. Breyer therefore concluded that judges should make greater use of court-appointed experts, as the Federal Rules allow them to do.

A high profile instance of court-appointed experts occurred in the issue of systemic illness from silicone breast implants.[35] Judge Sam C. Pointer, Jr. appointed a panel of four scientists to assist him in a class action suit. After reviewing the published research and questioning the experts offered by both sides, the panel found no clear

---

31 A helpful summary of the cases appears in Berger (2000).

32 In its 1923 *Frye* decision, the Supreme Court found the use of a primitive lie detector to be inadmissible because the machine did not work on a principle "generally accepted" within the relevant community.

33 The Federal Rules of Evidence hold sway in all Federal courts, and most states have adopted them voluntarily.

34 In their *amicus* brief, *The New England Journal of Medicine* and *The Annals of Internal Medicine* argued that peer reviewed publication should have a stronger role in determining what information is admissible, as peer review is the mark of "good science." Other briefs, for example that submitted by Chubin, Hackett, Ozoroff and Clapp, disputed this gatekeeper role for peer review, arguing that peer review is more a tool of editing than a guarantor of reliability.

35 Breyer (2000; 1998) speaks favorably of such a solution elsewhere.

evidence that silicone breast implants cause immune disorders (Kaiser 1998). Although the panel was widely heralded as bringing clarity to the issue, some disputed the idea that the experts were, in fact, independent, and delimiting the evidence to published research may have pre-ordained the conclusion in any event.[36]

Conclusion

A review of the use of peer review by the U.S. Federal government suggests that its role and jurisdiction has continued to expand. Not only is a greater share of federally funded R&D (and national R&D) peer reviewed than in the past, but peer review is taking hold as a means of evaluating larger aspects of the R&D system and of producing “relevant and reliable” knowledge in the regulatory process, in the Federal court system, and even in R&D funding and regulation by states.

The expansion of peer review in this manner is not, however, easy to evaluate. Functions of peer review beyond the allocation of funds are based on an analogy to the success of peer review there; yet many criticisms of funding peer review exist, and the analogy between it and regulatory peer review is not exact (Jasanoff 1990; Powell 1999). Moreover, despite the attempts of many in Congress to quell controversy in regulatory science by adding peer review, the addition of peer review in funding programs does not seem to serve the same purpose, as several of the new peer reviewed funding programs remain politically vulnerable.

The increased instance of peer review is reason enough for increased scholarly attention: Can we further quantify and qualify the ways in which the Federal government invokes peer review? Can we specify more completely what political and policy problems are supposed to be resolved by peer review? Can we understand in both a more comprehensive and more detailed fashion the relationship between the processes of peer review and the supposed outputs of relevance, reliability, quality, and consensus? The answers to these questions may lead to a more complete and nuanced understanding of the relationship between politics and science.

Acknowledgements

The research included in this paper was supported in part by a contract from American Chemistry Council (formerly, Chemical Manufacturers Association). The conclusions are solely the author’s and in no way represent the views of ACC. The author thanks Margaret Brennan, Christine Krupka, Pamela LeBeaux, Elizabeth Nasi, and Veronica Rowan for their research assistance. The author also thanks Bernard D. Goldstein, Lewis M. Branscomb, Neal F. Johnson, Diana Hicks, Caron Chess, and Clinton Andrews for their advice on the report on which this paper is partially based.

---

[36] To help support judges in finding experts, , the American Association for the Advancement of Science (AAAS) started the Court Appointed Scientific Experts (CASE) project to will help identify, contact, and vet potential experts. See AAAS (1998), Kiernan (1999), and Runkle 1999).

References

American Association for the Advancement of Science (AAAS). 1998. "Court appointed scientific experts: A demonstration project of the AAAS." Available at www.aaas.org/spp/case/case.htm.

Andersen, Glen. 2000. "Science and politics: A balancing act for environmental health policy." *State Health Notes* (28 February):3-6.

Berger, Margaret A. 2000. "Expert testimony: The Supreme Court's rules." *Issues in Science and Technology* 16(4):57-63.

Brainard, Jeffrey and Southwick, Ron. 2000. "Congress gives colleges a billion-dollar bonanza." *The Chronicle of Higher Education* (28 July):A29-31.

Branscomb, Lewis M. 1982. "Industry evaluation of research." Pp. 68-81 in *Quality in Science,* edited by M.C. La Follette. Cambridge: MIT Press.

Braun, Dietmar. 1993. Who governs intermediary organizations? Principal-agent relations in research policy-making. *Journal of Public Policy* 13 (2): 135-62.

Breyer, Stephen G. 2000. "Science in the courtroom." *Issues in Science and Technology* 16(4):52-56.

______. 1998. "The interdependence of science and law." *Science* 280(5363):537-38.

Brooks, Harvey. 1982. "Science indicators and science priorities." Pp. 1-32 in *Quality in Science,* edited by M.C. La Follette. Cambridge: MIT Press.

______. 1968.

Browner, Carol M. 1994. Memorandum on Peer Review to Assistant Administrators, General Counsel, Inspector General, Associate Administrators, Regional Administrators, and Staff Office Directors. 7 June. Mimeo. Available at http://www.epa.gov/ordntrnt/ord/spc/memo0607.htm.

Cal/EPA. 1998, March. "Policy and Guiding Principles for External Scientific Peer Review."

Carnegie Commission on Science, Technology, and Government. *Science and Technology in Judicial Decision Making: Creating Opportunities and Meeting Challenges*. New York: Carnegie Commission.

Caswill, Chris. 1998. Social science policy: Challenges, interactions, principals, agents. *Science and Public Policy* 25(5)286-86.

Chubin, Daryl and Hackett, Edward. 1990. *Peerless Science: Peer Review and US Science Policy*. Albany: SUNY Press.

Council of State Governments (CSG). 1999. *A State Official's Guide to Sound Science*. Lexington, KY: CSG.

England, J. Merton. 1982. *A Patron for Pure Science: The National Science Foundation's Formative Years, 1945-57*. Washington, DC: National Science Foundation.

Environmental Protection Agency (EPA). 1998. *Science Policy Council Peer Review Handbook.* Office of Science Policy. EPA 100-B-98-00. Washington, DC: EPA.

______. 1997. "Peer Review and Peer Involvement at the U.S. Environmental Protection Agency." Available at http://www.epa.gov/ordntrnt/ord/spc/perevmem.htm.

______. 1992. *Safeguarding the Future: Credible Science, Credible Decisions*. EPA/600/9-91/050. Washington, DC: EPA.

General Accounting Office (GAO). 1999. *Federal Research: Peer Review Practices at Federal Science Agencies Vary,* GAO/RCED-99-99.

______. 1994. *Peer Review: Reforms Needed to Ensure Fairness in Federal Agency Grant Selection*, GAO/PEMD-94-1.

Gieryn, Thomas F. 1995. "Boundaries of Science." Pp. 393-443 in Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, eds., *Handbook of Science and Technology Studies*. Thousand Oaks, CA: Sage Publications.

Guston, David H. 2000a. *Between Politics and Science: Assuring the Integrity and Productivity of Research*. New York: Cambridge University Press.

______. 2000b. "Regulatory peer review." Paper presented at the annual meeting of the American Political Science Association, Washington, DC, 2 September.

______. 2000c. *What is Peer Review?* Report submitted to the American Chemistry Council, May.

______. 1999. "Constructing Consensus in Food Safety Science: The National Toxicology Program's *Report on Carcinogens*." Paper presented at the annual meeting of the American Association for the Advancement of Science, Anaheim, CA, 22 January.

______. 1996a. "New Technology Role for the States." *Forum for Applied Research and Public Policy* 11(3):38-44.

______. 1996b. Principal-agent theory and the structure of science policy. *Science and Public Policy* 23 (4): 229-40.

Hill, Christopher T. 1998. "The Advanced Technology Program: Opportunities for enhancement." Pp. 143-73 in Lewis M. Branscomb and James H. Keller, eds., *Investing in Innovation: Creating a Research and Innovation Policy That Works*. Cambridge: MIT Press.

Intersociety Working Group. 1999. *AAAS Report XXIV: Research & Development, FY 2000*. Washington, DC: American Association for the Advancement of Science.

Jasanoff, Sheila. 1990. *The Fifth Branch: Science Advisers as Policy Makers*. Cambridge: Harvard University Press.

Kaiser, Jocelyn. "Scientific panel clears breast implants." *Science* (11 December 1998):1963-65.

Kiernan, Vincent. "Project will supply 'independent' experts for suits involving scientific issues." *The Chronicle of Higher Education* (11 June 1999):A20-21.

Kim, Kyung-Man. 1994. *Explaining Scientific Consensus: The Case of Mendelian Genetics*. New York: The Guilford Press.

Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge: Harvard University Press.

National Academy of Sciences (NAS). 1999. *Evaluating Federal Research Programs: Research on the Government Performance and Results Act*. Committee on Science, Engineering, and Public Policy. Washington, DC: National Academy Press.

National Science Foundation (NSF). 1999. *What Is the State Government Role in the R&D Enterprise?* Division of Science Resources Studies. 99-348. Arlington, VA: NSF.

National Science and Technology Council (NSTC). 1996. *Assessing Fundamental Research*. Committee on Fundamental Science, Subcommittee on Research. Accessed online at http://www.nsf.gov/sbe/srs/ostp/assess/start.htm.

National Toxicology Program (NTP). 1999. "[What is the] *Report on Carcinogens*?" Research Triangle Park: NTP.

Powell, Mark. 1999. *Science at EPA: Information in the Regulatory Process*. Baltimore: The Johns Hopkins University Press.

Rip, Arie. 1994. The republic of science in the 1990s. *Higher Education* 28: 3-23.

Roy, Rustum. 1985. "Funding science: The *real* defects of peer review and an alternative to it." *Science, Technology, & Human Values* 10(3):73-81.

Runkle, Deborah. 1999. "Court appointed scientific experts: A demonstration project of the American Association for the Advancement of Science." *Federal Discovery News* (December):3-4.

Sapolsky, Harvey. 1990. *Science and the Navy: The History of the Office of Naval Research*. Princeton: Princeton University Press.

Savage, James D. 1999. *Funding Science in America: Congress, Universities, and the Politics of the Academic Pork Barrel*. New York: Cambridge University Press.

Smith, Bruce L.R. 1992. *The Advisers: Scientists in the Policy Process*. Washington, DC: The Brookings Institution.

______. 1990. *American Science Policy Since World War II*. Washington, DC: The Brookings Institution.

Southwick, Ron. 2000. "Is an Agriculture-Research Effort Dying on the Vine?" *The Chronicle of Higher Education*(18 August):A23-24.

Sussman, Robert M. 1994. Memorandum on Establishment of Agency-wide Guidance for Conducting External Peer Review of Environmental Regulatory Models to Assistant Administrators, General Counsel, Inspector General, Associate Administrators, Regional Administrators, Deputy Assistant Administrators, and Deputy Regional Administrators (with attachment). Available http://www.epa.gov/ord/spc/regmod1.htm.

van der Meulen, Barend. 1998. Science policies as principal-agent games: Institutionalization and path dependency in the relation between government and science. *Research Policy* 27 (4): 397-414.

Discussion of David Guston's paper

Peter Blair (Sigma Xi, USA). What about the good old boy network of peer review?

David Guston. We don't have much information on changes in the peer review process. The literature does suggest a modest old boy network and gender effect in evaluation of proposals. There seems to be an indication that panel review is preferable to ad hoc review.

Irwin Feller (Pennsylvania State University, USA). We should reconcile the rise of earmarking of billions of dollars to the rise of peer review. The NSF EPSCoR program is peer reviewed, but it is a set aside. Another example is the T21 Transportation bill. The NSF and NIH models are symbolic of peer review.

David Guston. We need to figure out more where numbers are coming from. Symbolism of peer review is important, but it does solve the problem of who to give the money to. It is a fair option when political controversy is too high for distributing resources in other manners. If the political environment changes, then there may be other ways to solve the problem. For more of the controversial issues such as EPA research, peer review may resolve controversies associated with these types of activities.

Peter Blair. Scientists may not be best people to solve problem of evaluating the societal issues of projects.

David Guston. NSF is just at the beginning stage of evaluating using a two criteria model. The NIH attempted to stay in touch with the social relevance by having a committee structure for the technical/scientific merit and another committee comprised of more public people to look at the broader societal issues. This committee may also have lay people who have some technical credentials but who may not be scientists, etc.

Stefan Kuhlmann (Fraunhofer Institute for Systems and Innovations Research). ATP has a technical review panel and another review panel so that even if the scientists love the "whizbang" technology, this can be balanced by an educated layperson review panel that looks at its overall impacts. These two panels have separate review processes that are then brought together. A project can lose if it doesn't meet both areas.

David Guston. The NSF review forms do not include an area for societal impacts.

Maryelle Kelley (National Institute of Standards and Technology, USA). Define what you mean by peers. In European programs, more and more assessment panels are represented by the public as well as scientists. This reflects a growing trend to fund generally societal-beneficial programs, but it is difficult to find appropriate peers in this realm.

David Guston. My paper doesn't deal with who these people should be but it is not difficult to address. It may answer the question of what the jurisdiction is by defining who the peers are. Evaluative committees are set up to judge proposals in some service programs which is not very different from what's going on in science review. Both are based on communal merit review. This can expand into societal merit review.

Commentary on the Session and Additional Discussion

Arie Rip (Twente University, The Netherlands). The title of this section suggests that a framework could be an articulation of a theory. Here are my comments on the papers:

Kelley's paper creates a picture of the ATP program. The program has been pushed toward specific questions to justify its existence. The pressure to show success has been important, but also shows some very interesting findings including the problem of skewed distributions in the capabilities of firms to do something meaningful with the money received.

Dietz's paper could be linked with other work such as SRI studies to give more insight into its results. Another suggestion is to look at larger populations and possibly case studies as these can convince sponsors/critics by providing more details about the program. It is not enough to have just a few interesting case studies. Using multi-modal evaluation methods is important.

Guston's paper looks at the expansion of peer review into a new jurisdiction. Peer review can be mobilized for certain resources but it's difficult to get a handle on what peer review does for you as an evaluator. Why is peer review expanding in the US? The shift from responsibility for decisions (by courts, regulatory environment) has been seen in Europe less visibly because Europe has never been very clear about responsibilities for decisions. The US starts in a different vein. It does imply that some things happening in Europe could be interesting in US. For instance, as soon as a proposal is made, it is immediately fragmented. There is a danger in evaluation, though, by copying what others are doing abroad.

Barry Bozeman (Georgia Institute of Technology, USA). On several occasions, I have conducted reviews for the EPSCoR program. The program is designed to give money to the research “have-nots.” There is recognition of social and economic impacts of research programs. He has been invited to review proposals in other areas but not in his area of specialty. What is EPSCoR’s peer review process?

Irwin Feller. Because EPSCoR is a NSF program, peer review is a way to fundamentally legitimize the program within NSF because it is not a very popular program. Peer review should also select the best programs for funding. This holds true for the NSF. EPSCoR has spread to 6-7 other agencies. The objective of other agencies in this program is not necessarily the same, but is directed by Congress.

David Guston. This is reflective of the way these agencies operate.

Liam O'Sullivan (European Commission). In reference to Kelley's account of NIST, the focus on control groups has an appeal for economic evaluation, but there's a difficulty with control groups. He can't think of a European parallel where there is a significant focus on outcomes. Notions of additionality that have been developed in EU may be useful in the US. A project has a different quality (not just whether the project would have taken place without funding). Projects have other values such as training and dissemination of results yet the ATP seems to be focused only on the direct economic benefits without considering other impacts.

Maryellen Kelley. After the mad cow disease situation, there was a feeling that scientific advice itself should be put out to peer review. Many peer reviewers say they are not sufficiently equipped to evaluate socio-economic impacts.

Terttu Luukkonen (VTT Technology Group, Finland). Looking at socio-economic impacts can also have negative impacts. People use phrases from other projects just to get funded. There is a type of hypocrisy in evaluating proposals.

Maryellen Kelley. Additionality of behavior is something that I would like to push because product development is perhaps too far afield. The importance of collaboration and willingness of firms to share information and form partnerships are types of additionalities that they should consider more in-depth. Yet they have the problem of what to look at. For the R&D tax credit question, the real answer is that they are not really supporting research with the credit, but are instead supporting pre-competition, which has a benefit to other firms.