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Science and Technology Policymaking: A Primer

Deborah D. Stine, Resources, Science, and Industry Division

June 20, 2008

Abstract. This report provides a basic understanding of science and technology policy including the nature of S&T policy, how scientific and technical knowledge is useful for public policy decisionmaking, and an overview of the key stakeholders in science and technology policy. Note that the report places a greater emphasis on the executive branch science and technology policymaking as the federal government supports public policy decisionmaking as well as performing and funding research and development.

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Science and Technology Policymaking: A Primer

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Prepared for Members and Committees of Congress

Congressional Research Service

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Summary

Scientific and technical knowledge and guidance influences not just policy related to science and technology, but also many of today's public policies as policymakers seek knowledge to enhance the quality of their decisions. Science and technology policy is concerned with the allocation of resources for and encouragement of scientific and engineering research and development, the use of scientific and technical knowledge to enhance the nation's response to societal challenges, and the education of Americans in science, technology, engineering, and mathematics.

Science and engineering research and innovations are intricately linked to societal needs and the nation's economy in areas such as transportation, communication, agriculture, education, environment, health, defense, and jobs. As a result, policymakers are interested in almost every aspect of science and technology policy. The three branches of government — executive, congressional, and judiciary — depending on each branch's responsibility, use science and technology knowledge and guidance to frame policy issues, craft legislation, and govern.

The science and engineering community, however, is not represented by one individual or organization. On matters of scientific and technical knowledge and guidance, its opinions are consensus-based with groups of scientists and engineers coming together from different perspectives to debate an issue based on the available empirical evidence. In the end, consensus is achieved if there is widespread agreement on the evidence and its implications, which is conveyed to policymakers. Policymakers then determine, based on this knowledge and other factors, whether or not to take action and what actions to take. If there are major disagreements within large portions of the community, however, consensus is not yet achieved, and taking policy actions in response to a concern can be challenging.

Several organizations, when requested by the federal government or Congress, provide formal science and technology policy advice: federal advisory committees, congressionally chartered honorific organizations, and federally funded research and development corporations. In addition, many other organizations and individuals — international intergovernmental organizations, policy institutes/think tanks, the public, professional organizations, disciplinary societies, universities and colleges, advocacy, special interest, industry, trade associations, and labor — also provide their thoughts. These organizations may agree on the scientific and technical knowledge regarding an issue, but disagree on what actions to take in response, as their values on a proposed policy may differ. Policymakers may be overwhelmed with an abundance of information from these organizations.

Despite these challenges, scientific and technical knowledge and guidance can provide policymakers with an opportunity to make their decisions based on the best information available, along with other factors they might take into account, such as cultural, economic, and other values, so that societal and economic benefits are enhanced and losses are mitigated.

Contents

List of Figures

List of Tables

Science and Technology Policymaking: A Primer

Scientific and technical knowledge and guidance influences many of today's public policies. The following definition is used by some science and technology policy analysts as a cornerstone of thinking about science and technology (S&T) policy decisionmaking:

> [Science and technology policy] is concerned with the allocation of resources for scientific research and technical development. It includes government encouragement of science and technology as the roots of strategy for industrial development and in economic growth; but it also includes the use of science in connection with problems of the public sector. Because of the close association of basic research with higher education, this aspect of science [and technology] policy is difficult to separate from overall educational policy and from [scientific and] technical [workforce] policy.[1]

Because science and technical knowledge and guidance influences public policy decisionmaking on many other issues, some think that science and technology policy does not need to be a separate field of inquiry.[2] Others, however, view S&T policy as different from other public policy issue areas. These differences include the rapidity of change in science and technology; novelty of many issues in science and technology; scale, complexity, and interdependence among technologies; irreversibility of many scientific and technological effects; public worries about real or imagined threats to human health and safety; and the challenges to deeply held social values.[3]

This report will provide a basic understanding of science and technology policy including the nature of S&T policy, how scientific and technical knowledge is useful for public policy decisionmaking, and an overview of the key stakeholders in science and technology policy. Note that the report places a greater emphasis on the executive branch science and technology policymaking as the federal government

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[1] Organisation for Economic Cooperation and Development, *Science, Growth, and Society: A New Perspective*, Report of the Secretary-General's Ad Hoc Group on New Concepts of Science Policy. (Paris: Organisation for Economic Cooperation and Development (OECD), 1971), pp. 37-38. This report is called the "Brooks report" for the chair of the committee that developed the report, Harvey Brooks, then a well-known S&T policy scholar at Harvard University.

[2] Ibid.

[3] Guild K. Nichols, *Technology on Trial: Public Participation in Decisionmaking Related to Science and Technology*, (Paris: Organisation for Economic Cooperation and Development (OECD), 1979). The OECD analysis was based on a survey of developed nations.

supports public policy decisionmaking as well as performing and funding research and development.

Overview of U.S. Science and Technology Policy

The nation's first formal science and technology policy decision may well have been in the U.S. Constitution itself in 1787, when the Congress was given power

> To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.[4]

At the request of President Washington, Congress passed its first science and technology policy-related act, regarding patents, in 1790.[5] These actions led to today's Patent and Trademark Office (PTO).

The Constitution also identified the utility of scientific and technical policy guidance in the sense of congressional power "To coin Money, regulate the Value thereof, and of foreign Coin, and fix the Standard of Weights and Measures."[6] This is the origin of today's National Institutes of Standards and Technology (NIST). In addition, the Constitution stated that "No Capitation, or other direct, Tax shall be laid, unless in the Proportion to the Census of Enumeration herein before directed to be taken."[7] This is the origin of today's U.S. Census Bureau.

Other constitutional propositions,[8] not enacted, included the power of Congress to establish a university and seminaries for the promotion of the sciences, and encourage "by premiums & provisions, the advancement of useful knowledge and

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[4] U.S. Constitution, Article I, Section 8, Clause 8.

[5] Jeffrey K. Stine, *A History of Science Policy in the United States, 1940-1985* , Report for the House Committee on Science and Technology Task Force on Science Policy, 99th Cong., 2nd sess., Committee Print (Washington, DC: GPO, 1986) [http://ia341018.us.archive.org/2/items/historyofscience00unit/historyofscience00unit.pdf]. The report appendix provides a chronology of federal science policy developments from 1787 to 1985 prepared by Michael E. Davey of CRS.

[6] U.S. Constitution, Article I, Section 8, Clause 5.

[7] U.S. Constitution, Article I, Section 9, Clause 4.

[8] For more discussion of science and technology policy in the early days of the United States, see I. Bernard Cohen, *Science and the Founding Fathers: Science in the Political Thought of Jefferson, Franklin, Adams, and Madison* (New York: W. W. Norton & Company, 1995) and A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities* (Baltimore: Johns Hopkins University Press 1986).

discoveries."[9] Advancement of science was also used as part of the justification for freedom of speech.[10]

Prior to the Constitution, Congress requested a geological survey in the Land Ordinance of 1785 to classify lands west of the Allegheny mountains that had become a source of contention in writing the Articles of Confederation — the precursor of today's U.S. Geological Survey (USGS).

Science and Technology Policy Facets

As illustrated in **Table 1,** science and technology policy has four facets: *science for policy, technology for policy, policy for science*, and *policy for technology*.[11] These facets cannot be easily separated, but can help provide a framework to better understand the policy decisions that policymakers are addressing in a given situation. This, in turn, can reflect how policymakers consider the policy advice they are given by the scientific and technical community.

Science for policy and *technology for policy* are when scientists, engineers, and health professionals (see **Box 1**) provide analysis, knowledge, and data to inform policymakers with the goal of enhancing their ability to make wise decisions. This scientific and technical guidance is available for almost any public policy arena. A classic example is global climate change. Policymakers debate questions such as at what point actions, if any, should be taken to mitigate greenhouse gas emissions. If no action is taken, what are the possible impacts of global climate change on the United States and other countries? If policymakers decide to take action, what policy steps could the United States take to mitigate greenhouse gas emissions or to adapt to global climate change? Policymakers are the ones who decide what steps should be taken to manage these risks. They can base their decisions on the guidance provided to them by the science, engineering, and health communities.

In contrast, *policy for science* and *policy for technology* are when policymakers take actions that influence the S&T community or the actions in which they engage such as research[12] or S&T-business related activities (e.g., patent law). In the case

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[9] Max Farrand (ed.), *The Records of the Federal Convention of 1787*, Volume 2, Journal, August 18, 1787, p. 321-322 (New Haven: Yale University Press, 1911) at [http://memory.loc.gov/cgi-bin/ampage?collId=llfr&fileName=002/llfr002.db&recNum=327&itemLink=D?hlaw:30:./temp/~ammem_IMyH::%230020327&linkText=1].

[10] Journals of the Continental Congress, October 26, 1774, p. 108, available at [http://memory.loc.gov/cgi-bin/ampage?collId=lljc&fileName=001/lljc001.db&recNum=120&itemLink=D?hlaw:23:./temp/~ammem_IMyH::%230010121&linkText=1].

[11] See Christopher T. Hill, Where Does Science (and Technology) Fit in Public Policy?, AAAS Leadership Seminar in Science and Technology Policy, powerpoint presentation, November 14, 2006 at [http://www.aaas.org/programs/science_policy/leadership/hill1106.pdf] for a presentation on this topic.

[12] An example is discussed in CRS Report RL34497, *Advanced Research Projects Agency - Energy (ARPA-E): Background, Status, and Selected Issues for Congress*, (continued...)

of climate change, for example, these same policymakers make decisions such as the degree to which the federal government should invest in climate change related research, whether or not to establish programs and organizations that set priorities for this research, and what technologies federal agencies should investigate further as possible mechanisms to mitigate greenhouse gas emissions.

Table 1. The Relationship Between Science and Technology and Policymaking

	Policy *Influencing* Science and Technology	**Science and Technology *Informing* Policy**
Science	***Policy for Science*** e.g., Should the U.S. federal government support embryonic stem cell research?	***Science for Policy*** e.g., Should the United States take action on climate change?
Technology	***Policy for Technology*** e.g., Should the emerging field of nanotechnology be supported and regulated?	***Technology for Policy*** e.g., Should policy actions be taken to enhance the implementation of new vehicle technologies that might reduce the nation's fossil fuel consumption?

Source: Congressional Research Service.

Note: For information on the policy issues in the table, see the following: CRS Report RL33540, *Stem Cell Research: Federal Research Funding and Oversight*, by Judith A. Johnson and Erin D. Williams. CRS Report RL33849, *Climate Change: Science and Policy Implications*, by Jane A. Leggett. CRS Report RL34401, *The National Nanotechnology Initiative: Overview, Reauthorization, and Appropriations Issues,* by John F. Sargent. CRS Report RL30484, *Advanced Vehicle Technologies: Energy, Environment, and Development Issues*, by Brent D. Yacobucci. CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci.

[12] (...continued)
by Deborah D. Stine.

Box 1. Scientists, Engineers, and Health Professionals

Most universities consider the physical sciences, life sciences, social sciences, and economics to be "scientific." Engineering and the health professions, such as medicine, are considered by most universities as fields related to science that focus on the delivery of services.

Three common definitions used to determine who is a scientist, engineer, or health professional: (1) science, engineering, and health occupations; (2) science, engineering, and health degrees; or (3) self-identification of employment in a job that requires science and engineering knowledge. Estimates such as the number of scientists and engineers can vary among federal agencies based on which definition is used. For more discussion on this issue, see CRS Report RL34539, *The U.S. Science and Technology Workforce*, by Deborah D. Stine and Christine M. Matthews.

A related question is what fields are considered to be "scientific." Survey data indicate that the majority of Americans consider medicine to be the most "scientific" followed by biology, physics, and engineering. Economics and sociology, both social sciences, are not considered to be as scientific as these fields. Although about 50% of Americans consider these social sciences to be either "very scientific" or "pretty scientific," about 40% of Americans consider them "not too scientific" or "not at all scientific." The remainder do not know or have not heard of the fields.

Perceptions of what fields are considered to be "scientific," and who is considered to be a "scientist" can become an issue during discussions related to *policy for science*. This report uses the broadest definition and includes social scientists as science professionals.

Source: National Science Board, *Science and Engineering Indicators 2008* (Arlington, VA: National Science Foundation 2008), Chapters 3 and 7 at [http://www.nsf.gov/statistics/seind08/].

Historical Changes in U.S. Science and Technology Policy

In the early days of the United States, the focus of science and technology policy was on *science for policy* and *technology for policy*. Of particular importance was scientific and technical advice related to public health, agriculture, and geography. President Jefferson, for example, commissioned the Lewis and Clark expedition to explore the Western United States that opened trade in the far Northwest and made significant scientific findings in the life sciences.[13]

As the nation grew, scientific and technical knowledge became important for issues related to the military and issues related to the welfare state such as care for the needy and universal education and literacy. In general, research was supported primarily through the philanthropy of wealthy individuals.[14] During the Civil War, however, research became part of the military's mission, and the federal government

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[13] A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities* (Baltimore: Johns Hopkins University Press 1986).

[14] Bruce L.R. Smith, *American Science Policy Since World War II* (Washington, DC: Brookings Institution, 1990).

more actively engaged in *policy for science*, establishing the land-grant college system focusing on agricultural research (1862) and the Weather Bureau (1870), providing a telescope for the Naval Observatory, and supporting polar explorations and surveys of the Western United States.[15] Issues began to arise regarding how science should fit into the federal government's structure. As a result, in 1884, Congress set up a Joint Commission made up of three members each from the House and the Senate, chaired by Senator W. B. Allison. The Allison Commission discussed proposals for a Department of Science and a national university, as well as the need for the government to cooperate, not compete, with universities and concerns about duplication. In the end, the Allison Commission affirmed the utility of federal funding of science, but did not recommend a separate department or any other actions.[16]

At the beginning of the 20th century, prior to World War I, additional issues became the focus of the nation's science and technology policy including conservation, medicine, and public health; and a number of additional science organizations were established in the federal government (e.g., Food and Drug Administration). In addition, the first industrial research laboratories and large-scale mechanized industry were started. World War I brought about additional application of science and technology to weapon development.[17]

During the period between World War I and through World War II, the role of the application of research to provide technology for both military and economic purposes became evident. No longer were philanthropists the primary sources of funding for research and development (R&D); instead it was the federal government. This lead to a fundamental change in the relation between the federal government and the S&T community. This *policy for technology* focused on areas such as weaponry, communications, and medical needs such as surgical innovations. During this period, the capabilities of science and technology were widely recognized due to the use of chemicals, aircraft, mechanized weapons, radar, and other technological applications in World War II. As a result, President Franklin D. Roosevelt established the Office of Scientific Research and Development (1941). The Manhattan project also began its work at this time, managed by the Manhattan Engineer District of the Army Corps of Engineers, and tasked with the goal of building an atomic bomb prior to the Japanese or Germans.[18]

Following World War II, the utility of science and technology to society as exhibited during the War was crystallized in *Science, the Endless Frontier*, a 1945 report by Vannevar Bush, director of the White House Office of Scientific Research

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[15] A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities* (Baltimore: Johns Hopkins University Press 1986).

[16] Bruce L.R. Smith, *American Science Policy Since World War II* (Washington, DC: Brookings Institution, 1990).

[17] A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities* (Baltimore: Johns Hopkins University Press 1986).

[18] Bruce L.R. Smith, *American Science Policy Since World War II* (Washington, DC: Brookings Institution, 1990).

and Development, to President Franklin Roosevelt. This report, which proposed a "program for postwar scientific research," set the stage for today's view of the relationship between the federal government and the S&T community regarding *policy for science*.[19] In his report, Bush indicated that scientific progress was essential for the war against disease, for national security, and for the public welfare. The report also recommended that the federal government should undertake responsibility for renewing the nation's scientific talent. To respond to these needs, Bush proposed a new federal agency that would "accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent of our youth." This recommendation eventually led to the establishment of the National Science Foundation (NSF).

Today, science and engineering research and innovations are intricately linked to societal needs and the nation's economy in areas such as energy, transportation, communication, agriculture, education, environment, health, defense, and jobs. As a result, policymakers are interested in almost every aspect of science and technology policy.

Definition of Research and Development

The following definition of R&D, determined by international intergovernmental guidelines developed through the Organisation of Economic Cooperation and Development (OECD), is used by the National Science Board (NSB):

- **Research and Development (R&D):** Creative work undertaken on a systematic basis to increase the stock of knowledge — including knowledge of man, culture and society — and the use of this stock of knowledge to devise new applications.

- **Basic Research:** The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed in fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven agencies.

- **Applied Research:** The objective of applied research is to gain knowledge or understanding to meet a specific recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

- **Development:** Development is the systematic use of the knowledge or understanding gained from research directed toward the production of

[19] Vannevar Bush, *Science: The Endless Frontier* : *A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development*, July 1945 (United States Government Printing Office, Washington: 1945) at [http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm].

> useful materials, devices, systems, or methods, including the design and development of prototypes and processes.[20]

These definitions are based on the traditional linear model of innovation that some believe creates a false distinction between basic and applied research. Innovation, they believe, is instead more nuanced, and there is no need for a distinction between the two. (See later discussion on perspectives on innovation, particularly the section regarding the Pasteur's quadrant model.) These definitions are, however, the most commonly used in congressional and federal agency discussions regarding federal R&D activities.

Industries Linked to Science and Technology

Although most industries use science and technology to some degree, ten industries have been identified by the OECD as having a strong linkage to science and technology. OECD organizes these industries into two categories: knowledge-intensive service industries, which incorporate science, engineering, and technology in services or the delivery of services, and high-technology manufacturing industries, which spend a relatively high proportion of their revenues on R&D.

According to the OECD, knowledge-intensive service industries include

- communications services,
- financial services,
- business services (including computer software development),
- education services, and
- health services.

High-technology manufacturing industries include

- aerospace,
- pharmaceuticals,
- computers and office machinery,
- communications equipment, and
- scientific (medical, precision, and optical) instruments.[21]

What are Some Perspectives on Science and Technology Policy?

The encompassing nature of science and technology policy makes it challenging to provide the full range perspectives on science and technology policy. The purpose of this section is to highlight some of the most common differing perspectives that

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[20] National Science Board, *Science and Engineering Indicators 2008* (Arlington, VA: National Science Foundation 2008), Chapter 4 at [http://www.nsf.gov/statistics/seind08/].

[21] Organisation for Economic Co-operation and Development (OECD), *Knowledge-Based Industries* (Paris: OECD), 2001.

generate discussion regarding science and technology policy. They include the sometimes different perspectives of the science and technology community and policymakers regarding science and technology policy. This section also discusses different perspectives on federal funding of research; policy for science and science for policy; and policy for technology and technology for policy. The perspectives identified here may arise regardless of the issue being discussed, whether it be energy, transportation, agriculture, or science itself.

Science and Technology Community and Policymakers

A number of criteria may determine the utility of scientific and technical knowledge and advice to policymakers. These include whether or not this advice is relevant, disinterested, and credible.[22] Conflicts can occur if these criteria are not met.

Further, the S&T community and policymakers can, on occasion, view science and technology policymaking quite differently. For example, while the S&T community tends to have a long-time horizon, policymakers must often make decisions very quickly based on the available knowledge (see **Box 2**). Sometimes the reverse occurs. In these situations, the S&T community may believe a decision is needed quickly due to the nature of the risk involved, while the policymaker is concerned about the political and economic implications of taking the action recommended by the S&T community. The S&T community may also believe that the knowledge they communicate should be the primary factor influencing a policymaker's decision, while the policymaker believes they need to take into consideration other factors they believe are equally important.

One analyst identifies four different degrees of interaction between scientists and policymakers from no interaction to substantial interaction. These include:

- *The Pure Scientist* - seeks to focus only on facts and has no interaction with the decision maker.
- *The Science Arbiter* - answers specific factual questions posed by the decision maker.
- *The Issue Advocate* **-** seeks to reduce the scope of choice available to the decision maker.
- *The Honest Broker of Policy Options* **-** seeks to expand, or at least clarify, the scope of choice available to the decision maker.[23]

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[22] Bruce L.R. Smith and Jeffrey K. Stine, "Technical Advice for Congress: Past Trends and Present Obstacles," in M. Granger Morgan and Jon M. Peha (ed.), *Science and Technology Advice for Congress* (Washington, DC: Resources for the Future, 2003).

[23] Roger Pielke, "The Honest Broker," Bridges, Austrian Office of Science and Technology, April 2007 at [http://www.ostina.org/content/view/2027/699/]. This article is based on Roger Pielke, *The Honest Broker: Making Sense of Science in Policy and Politics* (Cambridge, U.K.: Cambridge University Press, 2007).

Many would contend, however, that the reality of S&T policymaking is such that there is no clear delineation as outlined here. Rather, the interaction of scientists, engineers, and health professionals with policymakers is a mix of each of these categories.

Scientists, engineers, and health professionals, like any other U.S. citizen, also advocate for action on policies related to the S&T community itself or promote their personal views. For example, members of the S&T community are recipients of federal funding for research, employed by universities or colleges impacted by higher education policy, work for industries influenced by tax policy, and often have a general interest in the quality of science, engineering, technology, and mathematics (STEM) education at the K-12 level relative to future education and workforce needs. Scientists and engineers may also have personal preferences with regard to public policies that may influence their political action on issues such as climate change, stem cell research, or others.

Box 2. Science: The Interaction with Policy

Scientific knowledge is dynamic, changing as new information becomes available. In this sense, science does not reveal "truth," so much as produce the best available or most likely explanation of natural phenomena, given the information available at the time; in many cases, analysis of data may give an estimate of the degree of confidence in the explanation. Moreover, scientific conclusions naturally depend on the questions that are asked.

The scientific method has, at its heart, two values that are strongly implied but not often stated: (1) a transparent approach in which both new and old data are available to all parties; and (2) a continuing effort to update data, and therefore modify, and even reject, previously accepted hypotheses in light of new information. Together, transparency and updating are the cleansing mechanisms that gradually sweep away scientific misunderstandings and errors — a sine qua non for scientific advancement.

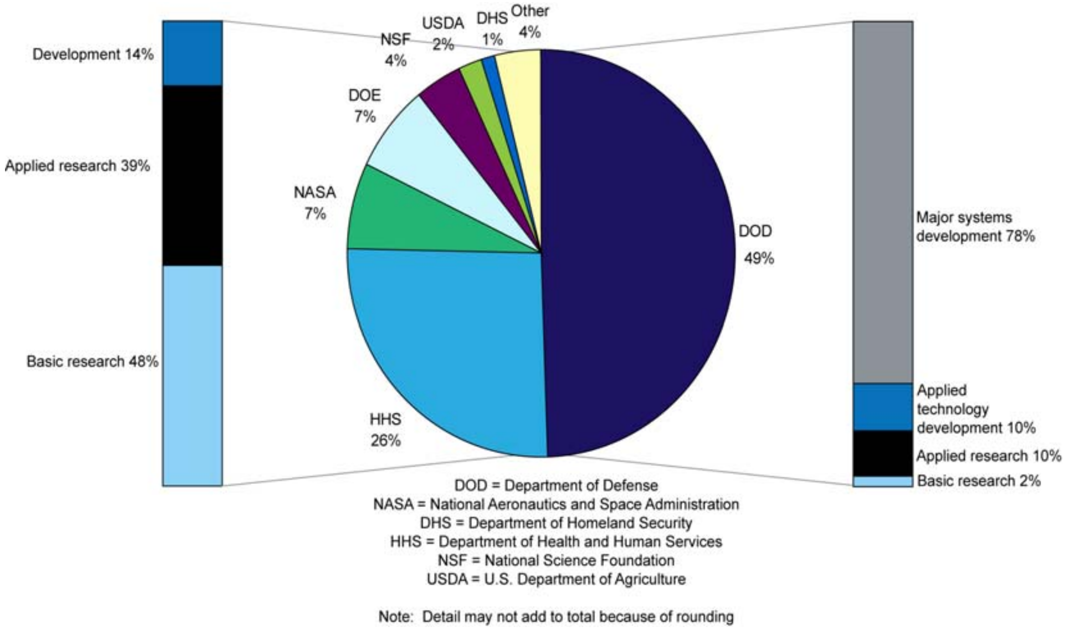
Decision-makers usually seek to affect how the world "ought to" or "should" be. Science provides one source of input for making policy decisions that balance diverse considerations.

Source: Excerpted from CRS Report RL32992, *The Endangered Species Act and "Sound Science,"* by Eugene H. Buck, M. Lynne Corn, Pamela Baldwin, and Kristina Alexander.

Federal Funding of Research

When discussing research and development (R&D), particularly in regard to funding, terminology can be important in understanding the premise of an issue. In discussing the federal funding of research, many analyses focus on R&D. Some, however, believe this provides a false impression of the degree of federal funding going toward research as it does not distinguish between federal funding devoted toward research and that focused on federal funding focused on non-research activities such as testing and evaluation of weapons. **Figure 1** illustrates the magnitude of federal funding in each of the R&D categories, by agency. As shown here, Department of Defense (DOD) R&D funding, which accounts for approximately half of all federal R&D funding, is focused on major systems development with approximately 11% for basic and applied research. The majority of non-DOD ("civilian") R&D funding, however, focuses on research, particularly basic research.

Figure 1. Projected Federal Obligations for Research and Development, by Agency and Character of Work: FY2007



Source: National Science Board, *Science and Engineering Indicators 2008* (Arlington, VA: National Science Foundation, 2008), Figure 4-6 at [http://www.nsf.gov/statistics/seind08/].

Another perspective to the R&D budget regarding federal funding of research is provided by the federal science and technology (FS&T) budget.[24] The White House Office of Management and Budget (OMB) includes both an R&D and FS&T budget analysis in the President's annual budget request to Congress. According to OMB, the FS&T budget "highlights the creation of new knowledge and technologies more consistently and accurately than the overall R&D data."[25] While the R&D budget includes funding for defense development, testing, and evaluation, the FS&T budget does not. As a result, the federal FS&T budget is generally less than half that of the federal R&D budget.

[24] National Academy of Sciences, *Allocating Federal Funds for Science and Technology* (Washington, DC: National Academy Press, 2005) at [http://www.nap.edu/catalog.php?record_id=5040#toc].

[25] Office of Management and Budget, "Research and Development," Chapter 5 in *Analytical Perspectives, Budget of the United States Government, Fiscal Year 2009*, available at [http://www.whitehouse.gov/omb/budget/fy2009/apers.html].

Policy for Science and Science for Policy

Two fundamental policy issues in *policy for science* include how much federal funding is sufficient to achieve national goals, and the degree to which the United States benefits primarily from its investment in research as opposed to the world at large.

The S&T community also sometimes has fundamentally different perspectives regarding *policy for science* issues (see **Figure 2**). The alternative perspectives shown in Figure 2 do not represent one side of the S&T community versus another. Rather, they represent views held by various entities in various ways. For example, junior researchers may favor risk-taking when it comes to research funding, while at the same time supporting set-aside programs designated for researchers at the beginning of their career that enhance their ability to obtain funding as opposed to competing with senior researchers who have already had the opportunity to receive federal research funding.

Figure 2. Major Alternative Perspectives in the Scientific and Technology Community on the Allocation of Resources for Research

Centralization of Federal research planning	⟷	Pluralistic, decentralized agencies
Concentrated excellence	⟷	Regional and institutional development (to enlarge capacity)
"Market" forces to determine the shape of the system	⟷	Political intervention (targeted by goal, agency, program, institution)
Continuity in funding of senior investigators	⟷	Provisions for young investigators
Peer review-based allocation	⟷	Other funding decision mechanisms (agency manager discretion, congressionally-directed funding)
Set-aside programs	⟷	Mainstreaming criteria in addition to scientific merit (e.g., race/ethnicity, gender, principal investigator age, geographic region)
Conservatism in funding allocation	⟷	Risk-taking
Perception of a "total research budget"	⟷	Reality of disaggregated funding decisions
Dollars for facilities or training	⟷	Dollars for research projects
Large-scale, multiyear, capital-intensive, high cost, per-investigator initiatives	⟷	Individual investigator and small-team, 1-5 year projects
Training more researchers and creating more competition for funds	⟷	Training fewer researchers and easing competition for funds
Emulating mentors' career paths	⟷	Encouraging a diversity of career paths
Relying on historic methods to build the research workforce	⟷	Broadening the participation of traditionally underrepresented groups

Source: U.S. Congress, Office of Technology Assessment, *Federally Funded Research: Decisions for a Decade*, OTA-SET-490 (Washington, DC: U.S. Government Printing Office, May 1991) at [http://govinfo.library.unt.edu/ota/Ota_2/DATA/1991/9121.PDF].

Science for policy can be contentious because it informs policy discussions, where there are sometimes disagreements as to what policy actions should be taken, if any, due to the societal and economic implications. The same scientific paper may be viewed in different ways depending on the perspectives of the advocate. Sometimes there are differing views as to the degree of consensus among the S&T community on a particular issue. Alternatively, a minority in the S&T community may have strong beliefs regarding the scientific and technical evidence on an issue that do not agree with the majority. As a result, when science for policy issues are discussed in a political setting, strong views can emerge on both sides of an issue.

Policy for Technology and Technology for Policy

The U.S. Bureau of Economic Analysis has estimated that if R&D were treated as investment, it would have accounted for 5% of real gross domestic product (GDP) growth between 1959 and 2004, and 7% between 1995 and 2004.[26] A Stanford University Hoover Institution study found that if U.S. students performed in science and mathematics education at a level comparable with the world's leaders, U.S. GDP would increase.[27] As a result, policymakers are often interested in the innovation process, both *policy for technology* and *technology for policy*, particularly the relationship between science, engineering, economics, education, and job creation.[28]

In the case of *policy for technology*, perspectives on a given policy may differ because of differing views of the innovation model. One perspective of innovation policy, based on the linear model of innovation,[29] leads some policymakers to believe that it is inappropriate to use federal resources to invest in technological development. Rather, private resources should be used to invest in this portion of the innovation process as private entities will receive the returns on investment. An alternative perspective is that research and innovation can be so interrelated that it is not possible to separate the two. Policymakers with this perspective on innovation

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[26] Bureau of Economic Analysis, "Research and Development Satellite Account 2007 Satellite Account Underscores Importance of R&D," press release, at [http://www.bea.gov/newsreleases/general/rd/2007/rdspend07.htm]. The press release also states: "To put the contribution of R&D in perspective, the business sector's investment in commercial and other types of structures accounted for just over 2 percent of real GDP growth between 1995 and 2004."

[27] Eric Hanushek, Dean T. Jamison, Eliot A. Jamison and Ludger Woessmann, "Education and Economic Growth,"*Education Next*, Spring 2008 at [http://www.hoover.org/publications/ednext/16110377.html].

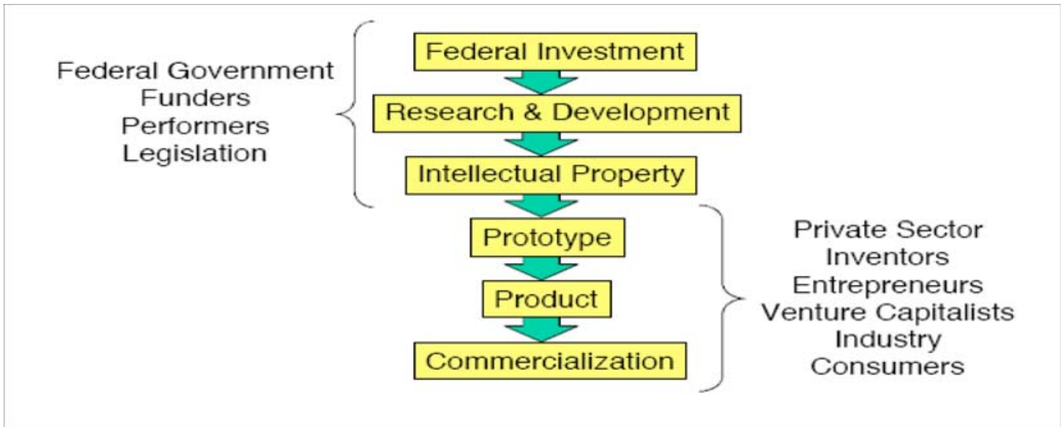
[28] For more information, see CRS Report RL34328, *America COMPETES Act: Programs, Funding, and Selected Issues*, and CRS Report RL34396, *The America COMPETES Act and the FY2009 Budget*, both by Deborah D. Stine.

[29] Benoit Godin, *The Linear Model of Innovation: The Historical Construction of an Analytical Framework*, Canadian Science and Innovations Consortium, Project on the History and Sociology of S&T Statistics, Working Paper No. 30, 2005 at [http://www.csiic.ca/PDF/Godin_30.pdf].

policy believe that investing federal resources to enhance technological innovation is appropriate and a wise use of federal funds.[30]

Figure 3 illustrates the linear model of innovation. As shown here, the federal government invests in research and development moving from basic research to applied research to development creating intellectual property. The responsibility then falls to the private sector including inventors, entrepreneurs, venture capitalists, and industry to use that intellectual property to capture that idea and translate it into technology, moving it through several stages: a prototype, then a product, and finally commercialized in such a way that consumers are interested in purchasing the result.

Figure 3. One Perspective on the Relationship of Federal Investment to Innovation



Source: Mark Y.D. Wang, Shari Lawrence Pfleeger, David Adamson, Gabrielle Bloom, William Butz, Donna Fossum, Mihal Gross, Aaron Kofner, Helga Rippen, Terrence K. Kelly, Charles T. Kelley, Jr., *Technology Transfer of Federally Funded R&D: Perspectives from a Forum*, prepared for the White House Office of Science and Technology Policy (Santa Monica, CA: Rand Science and Technology Policy Institute, 2003) at [http://rand.org/pubs/conf_proceedings/2006/CF187.pdf].

The gap between these two stages, however, is sometimes called the "valley of death," because of the challenges of taking the intellectual property and transferring that idea to private entities who may or may not be interested in turning that intellectual property into technology. As a result, some believe that the linear model is insufficient as a basis for S&T policy decisionmaking today — that the linkage between science and technological innovation is far more complex. One visual perspective on this theory of science and innovation, called the "Pasteur's Quadrant" model, describes a closer link between research and its intended outcome (see **Figure 4**).[31]

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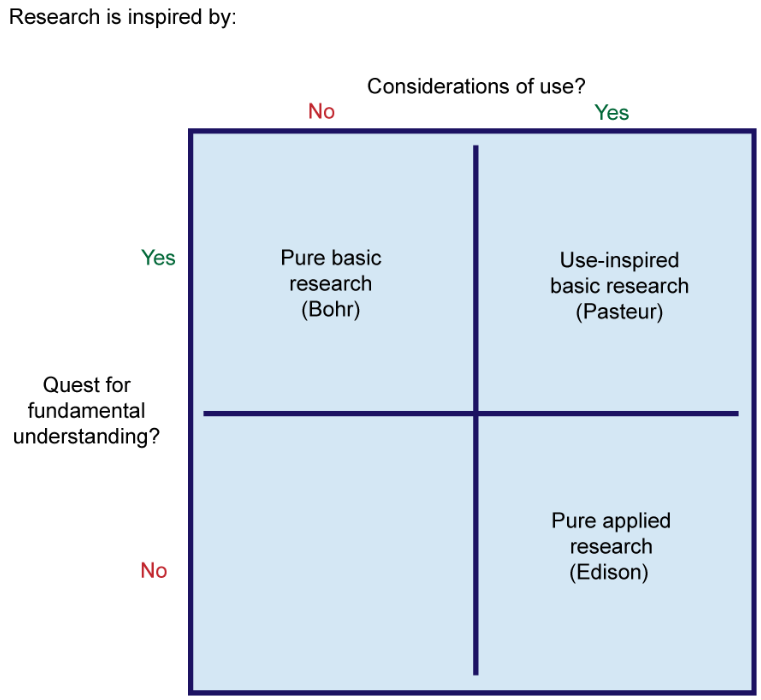
[30] For more information, see CRS Report RL33528, *Industrial Competitiveness and Technological Advancement: Debate Over Government Policy*, by Wendy H. Schacht.

[31] Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (Washington, DC: Brookings Institution Press, 1997).

Figure 4. Pasteur's Quadrant Model of Science and Engineering Research



Source: Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (Washington, DC: Brookings Institution Press, 1997).

As described by Stokes, there are four types of research:

- *Pure basic research*, pursued with the goal of fundamental understanding, without any consideration of the use (e.g., Niels Bohr, whose goal was to enhance our understanding of atomic structure);

- *Pure applied research*, pursued with the goal of use, without any consideration of fundamental understanding (e.g., Thomas Edison, whose goal was commercially profitable electric lighting);

- *Use-inspired basic research*, pursued with the dual goals of basic understanding and use (e.g., Louis Pasteur's use of his discovery of the process of disease at the microbiological level to develop mechanisms to combat anthrax in sheep and cattle, cholera in chickens, spoilage in milk, wine and vinegar, and rabies in people.)

- *Phenomena exploration*,[32] pursued due to research curiosity regarding particular phenomena, inspired by neither understanding nor use (e.g., the marking and incidence of bird species or why an

[32] This is represented by what appears to be an empty quadrant.

> apple falls from a tree). Such exploration might lead to the type of research represented by Bohr's quadrant or Edison's quadrant.[33]

As with previous models presented in this report, some would contend that the barriers illustrated in the model are not concrete, but porous. Research can easily move from one category to another as illustrated by the Pasteur example mentioned earlier. For example, there is little distinction sometimes between basic research, applied research, development, and commercialization. There may not be much difference, for example, in biotechnology research conducted at a university or at a small company funded by venture capital.

As a result, some policymakers believe that in a knowledge-based economy, federal investment in R&D should be inspired not only with the goal of fundamental understanding, but also, on occasion, with the goal of use. In addition, in order for the nation to obtain the return on federal investment in R&D and the related societal and economic goals, some contend that federal investment should not stop at the point just before prototype and product technological development.[34] This, some believe, is particularly important as, in a global economy, foreign firms are as easily able to capture the results of federal investment in research as U.S. firms.[35]

On the other hand, some policymakers express concerns that investing in R&D in a sector closely linked to industry — or, for that matter, at any stage of technology commercialization — may result in the federal government picking "winners and losers." For example, although some believe that federal investment in information technology R&D has resulted in benefits for the country and helps by setting industry standards, others believe that federal investment in information technology R&D is inappropriate because it is the federal government, not industry, who is determining the direction for research and determining technological "winners and losers."[36]

In terms of *technology for policy*, differing views regarding policy issues are not that dissimilar as those for *policy for technology*. Differing perspectives in *technology for policy* focus on the degree to which it is appropriate for the federal government to focus on a particular technology. Some believe it is important to undertake policies to encourage implementation of a technology. Others believe that such policy actions might inappropriately influence the market by supporting one technological option more than another. For example, some may question which is better, a hybrid electric vehicle, a plug-in electric vehicle, a fuel cell vehicle, or

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[33] Ibid., p. 73-75. Donald Stokes, "Completing the Bush Model: Pasteur's Quadrant," Paper presented at conference "Science the Endless Frontier 1945-1995: Learning from the Past, Designing for the Future," December 9, 1994 at [http://www.cspo.org/products/conferences/bush/Stokes.pdf].

[34] Ibid.

[35] CRS Report RL33528, *Industrial Competitiveness and Technological Advancement: Debate Over Government Policy*, by Wendy H. Schacht.

[36] CRS Report RL33586, *The Federal Networking and Information Technology Research and Development Program: Funding Issues and Activities*, by Patricia Moloney Figliola.

enhancing current vehicles?[37] Although there may be a common policy goal of reducing fossil fuel consumption, undertaking policies that may favor one of these technologies versus another creates "winners and losers," which some policymakers believe is inappropriate. Others, however, believe that unless the government does select a technology, there are insufficient incentives for companies to invest in technologies that would potentially reduce fossil fuel consumption.

Who Makes Decisions Regarding Science and Technology Policy in Congress?

Congress makes decisions regarding all four of the S&T policy facets described earlier: *science for policy*, *technology for policy*, *policy for science*, and *policy for technology*. Science and technology policy guidance can be used to frame policy issues, craft legislation, oversee federal activities, and govern. In addition, the decisions Congress makes influence S&T issues such as the funding of research and technological development, setting priorities for that funding, and supporting science, technology, engineering, and mathematics education. In making its decisions, Congress receives advice from both internal sources such as congressional staff, S&T policy fellows, hearings, and congressional support agencies (see **Box 3**) as well as external sources that will be described later in this report.

Committees[38]

Almost every congressional committee is in some way involved in S&T policy decisionmaking or uses the scientific and technical knowledge currently available to help them make decisions. Generally these issues fall into the category of *science for policy* and *technology for policy*. Examples include how to improve nutrition and food safety in the nation's schools, implement the Endangered Species Act, determine drinking water standards, respond to a bridge collapse, and create jobs.

The primary committees that focus on *policy for science* and *policy for technology* include the House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Transportation. The House Committee on Science and Technology jurisdiction includes many policy areas related to S&T policy including energy, astronautical and civil aviation, environmental, and marine research as well as the commercial application of technology, science scholarships, and a general category of scientific research, development, and demonstration.[39] As a result, the House Committee on Science and Technology is the authorizing

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[37] CRS Report RL30484, *Advanced Vehicle Technologies: Energy, Environment, and Development Issues*, by Brent D. Yacobucci.

[38] It is important to note that the House and Senate Parliamentarians are the sole definitive authorities on questions relating to the jurisdiction of congressional committees and should be consulted for a formal opinion on any specific jurisdictional question.

[39] House Rule X(1)(o), September 14, 2007.

committee for the non-defense research activities of many federal agencies.[40] In addition, the committee also has special authority to "review and study on a continuing basis laws, programs, and Government activities relating to nonmilitary research and development."[41] The Senate Committee on Commerce, Science, and Transportation jurisdiction is defined in the Senate rules more generally as "science, engineering, and technology research and development and policy." [42]

The jurisdiction of these committees, however, does not directly include biomedical research and development such as that supported by the National Institutes of Health (NIH), which is the federal agency that receives the majority of federal research funding. Biomedical research is under the jurisdiction of the House Committee on Energy and Commerce[43] and the Senate Committee on Health, Education, Labor, and Pensions.[44]

Defense research likewise falls under other committees' jurisdiction. The House Committee on Armed Services has jurisdiction over "scientific research and development in support of the armed services."[45] The Senate Committee on Armed Services jurisdiction includes "military research and development."[46]

The House and Senate Committees on Appropriations play an important role in S&T policy. Although the authorization of federal funding of research often has wide and bipartisan support, appropriated research funding faces a greater challenge when it competes for the limited amount of discretionary funding with other federal programs. In addition, not all research funding falls into the jurisdiction of the same committee. For example, the funding for NSF, NASA, NIST, and the White House Office of Science and Technology Policy (OSTP) falls under the jurisdiction of the House and Senate Committees on Appropriations' Subcommittee on Commerce, Justice, Science, and Related Agencies. Funding for energy research activities falls under the House and Senate Committees on Appropriations' Subcommittee on Energy and Water Development. For NIH, it is the House and Senate Committees on Appropriations Subcommittee on Labor, Health and Human Services, Education, and Related Agencies. For DOD, it is the House and Senate Committees on Appropriations Subcommittee on Defense.

All committees with legislative jurisdiction conduct oversight and investigations. In addition to the committees described above, the House Committee on Oversight and Government Reform and Senate Committee on Homeland Security

[40] House Committee on Science and Technology, "About the Committee on Science and Technology," website at [http://science.house.gov/about/default.htm#jurisdiction].

[41] House Rule X(3)(k), September 14, 2007.

[42] Standing Rules of the Senate, Rule XXV(1)(f)(1), September 14, 2007.

[43] House Rule X(1)(f), September 14, 2007.

[44] Standing Rules of the Senate, Rule XXV(1)(m)(1), September 14, 2007.

[45] House Rule X(1)(c), September 14, 2007.

[46] Standing Rules of the Senate, Rule XXV(1)(c)(1), September 14, 2007.

and Governmental Affairs also play an active role in S&T policy and use scientific and technical knowledge and information.

Caucuses

Science and technology policy related caucuses frequently organize symposia open to the public on topics of interest to their sponsoring Members. This provides a mechanism for congressional staff to gain a better understanding of a scientific or technical topic and provides a networking opportunity for staff who represent a Member interested in the topic. Because the jurisdiction of S&T policy is widespread throughout Congress, caucuses and other informal groups can bring together those Members who are interested in S&T policy issues.

Caucuses, coalitions, ad hoc task forces, or working groups are examples of the titles given to these voluntary alliances of Members of Congress that operate without direct recognition in chamber rules or line item appropriations (unlike formal leadership and party groups).[47] Financial support for the caucus events such as a luncheon symposium may be provided by interested groups. For example, a coalition of scientific and engineering disciplinary societies often sponsor the events of the Senate Science and Technology Caucus.

A list of the registered House caucuses, formally called "congressional Member organizations," can be found on the Committee on House Administration website.[48] Although there is not a similar website for Senate caucuses, some of those listed on the House website are bicameral, sponsored by both Senate and House Members. Some of the caucuses related to S&T policy include the

- Biomedical Research Caucus
- Congressional Competitiveness Caucus
- Congressional Diversity and Innovation Caucus
- Congressional High Technology Caucus
- Congressional Internet Caucus
- Congressional Research and Development Caucus
- Congressional Robotics Caucus
- Congressional Science Caucus
- House Aerospace Caucus
- House Biotechnology Caucus
- House Diversity and Innovation Caucus

[47] More information on these groups is available from CRS Report RL30301, *Informal Congressional Groups and Members Organizations: Selected Questions and Responses*, and CRS Report RL30288, *Informal Congressional Groups and Member Organizations, 106th Congress: An Informational Directory*, both by Sula P. Richardson.

[48] See [http://cha.house.gov/index.php?option=com_content&task=view&id=45&Itemid=37] for more information. The U.S. House of Representatives and the U.S. Senate telephone directories also provide a list of caucuses. Another source of information on caucuses including the membership of each caucus is available through the Leadership Library.

- House Science, Technology, Engineering, and Mathematics Education Caucus
- Senate Science and Technology Caucus
- Senate Science, Technology, Engineering, and Mathematics Education Caucus
- U.S. Senate Renewable Energy and Energy Efficiency Caucus

The list of caucuses changes constantly to reflect Member interest. The Members of Congress who host each of these caucuses is posted on the website.

Box 3. Congressional Support Agencies

Members of Congress may call upon three congressional support agencies: the Congressional Research Service (CRS), the Government Accountability Office (GAO), and the Congressional Budget Office (CBO) for information and advice. All of these offices include staff with expertise in science and technology policy.

CRS offers research and analysis to Congress on all current and emerging issues of national policy. Its staff of approximately 700 employees includes lawyers, economists, reference librarians, and social, natural, and physical scientists. Of the 450 analytic staff, approximately 70 analysts conduct research and analysis on S&T policy issues, about one-third of whom have Ph.D.s in science, engineering, or health. This estimate does not include economists, who often work on finance and other non-science and technology policy issues. One section is devoted toward *policy for science* and *policy for technology*; however, CRS science and technology policy analysts conduct analysis on all facets of S&T policy including *science for policy* and *technology for policy* on issues such as the environment, natural resources, energy, minerals, agriculture and food, transportation, industry, and health.

GAO — with more than 3,100 staff positions — is the largest of the support agencies and the only one with a nationwide field structure. GAO acts as an independent auditor of government agencies and activities. Sometimes called "Congress's watchdog" and its "investigative arm," GAO now provides a variety of services to Congress that extend beyond its original functions and duties, including oversight, investigation, review, and evaluation of executive programs, operations, and activities.

CBO's mission is to support the House and Senate in the federal budget process by providing budgetary analysis and information in an objective and nonpartisan manner. CBO's staff of 230 economists and public policy analysts prepare annual reports on the economic and budget outlook and on the President's budget proposals, cost estimates of legislation, scorekeeping reports, assessments of unfunded mandates, and products and testimony relating to other budgetary and policy matters.

Source: Some text includes excerpts from CRS Report RL33471, *The Congressional Research Service and the American Legislative Process*, by Ida A. Brudnick; CRS Report RL30349, *GAO: Government Accountability Office and General Accounting Office*, by Frederick M. Kaiser; and CRS Report RL31880, *Congressional Budget Office: Appointment and Tenure of the Director and Deputy Director*, by Robert Keith and Mary Frances Bley.

Who Makes Decisions Regarding Science and Technology Policy in the Executive Branch?

Key decisionmakers in the executive branch include those in White House offices such as the Office of Science and Technology Policy and the Office of Management and Budget. Presidential science and technology appointees also play a critical role along with federal agency staff. These organizations advise the President, the Vice-President, and other senior Administration officials, who take their views, along with others not involved in S&T policy, into consideration when making a decision.[49]

The President and the White House

The White House includes several S&T policy related organizations. These include the OSTP, the Council on Environmental Quality (CEQ), the Council of Economic Advisors (CEA), and the Office of Management and Budget (OMB). The role each of these organizations play in S&T policy decisionmaking changes with each President. Particularly for OSTP and CEQ, the influence of these organizations has been variable.

Office of Science and Technology Policy. The organization and institutional structure for S&T policy guidance has evolved over time. In addition, the influence of such organizations has varied among Presidential administrations. Prior to the 20th century, Presidents primarily obtained this guidance informally through friends, via referrals, or federal agency scientists and engineers.

The growing importance and influence of science and technology led President Franklin D. Roosevelt to establish the first formal Presidentially appointed science advisory mechanism, called the "Science Advisory Board," in 1933. The purpose of this board, in place until 1935, was to provide the President with recommendations and a central organization for federal government science policy. Prior to the United States entering World War II, the National Defense Research Committee (NDRC) coordinated research activities sponsored and conducted by the federal government. In 1941, President Roosevelt replaced the NDRC with the Office of Scientific Research and Development (OSRD) by executive order.[50]

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[49] For more information, see, *Science Advice to the President* (New York: Pergamon Press, 1980) and William T. Golden (ed.), Science and Technology Advice to the President, Congress, and Judiciary, (New York: Pergamon Press, 1988).

[50] Ibid.; Jeffrey K. Stine, *A History of Science Policy in the United States, 1940-1985* , Report for the House Committee on Science and Technology Task Force on Science Policy, 99th Cong., 2nd sess., Committee Print (Washington, DC: GPO, 1986), available at [http://ia341018.us.archive.org/2/items/historyofscience00unit/historyofscience00unit.pdf]. The report appendix provides a chronology of federal science policy developments from 1787 to 1985 prepared by Michael E. Davey of CRS.

President Harry S. Truman established a Science Advisory Committee in 1951 in the Office of Defense Mobilization within the executive office "to advise the President ... in matters related to scientific research and development for defense.[51] Following the launch of Sputnik,[52] President Eisenhower created the Office of Special Assistant to the President for Science and Technology in October 1957. Eisenhower transferred to this office an enlarged and reconstituted Science Advisory Committee, renamed the President's Science Advisory Committee (PSAC), in November 1957.[53]

In 1961, the Senate Committee on Government Operations Subcommittee on National Policy Machinery, following a series of hearings, recommended the creation of an Office of Science and Technology (OST) within the executive office of the President. President Kennedy established OST in 1962. When President Nixon was elected in 1973, he did not appoint members to PSAC and the OST was abolished. Later that same year, Nixon announced that the director of the NSF would also serve as the President's science advisor. There was no longer an S&T policy office in the White House; rather, a science policy analysis office was located within NSF. When Gerald Ford became President, he supported the return of a science advisory mechanism to the White House, but wished to establish it through legislation, not executive order.[54]

In the National Science and Technology Policy, Organization, and Priorities Act of 1976 (P.L. 94-282), signed into law by President Ford on May 11, 1976, Congress established OSTP within the Executive Office of the President. As a result, OSTP reports to both Congress and the White House. Further, from the Ford Administration until today, all Presidents have had an OSTP with a stable organizational structure and a director who also serves as the President's science advisor. The role and influence of this office, however, has varied among Administrations depending both on the President and the individual who undertakes the role of OSTP director.

OSTP serves as a "source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government."[55] OSTP defines its major objectives, based on the act, as follows:

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[51] Ibid.

[52] For more information, see CRS Report RL34263, *U.S. Civilian Space Policy Priorities: Reflections 50 Years After Sputnik*, by Deborah D. Stine.

[53] Dwight D. Eisenhower Library, U*.S. President's Science Advisory Committee: Records, 1957-61*, February 1975 at [http://www.eisenhower.utexas.edu/listofholdingshtml/listofholdingsU/uspresidentsscienceadvisorycommitteerecords195761.PDF].

[54] Jeffrey K. Stine, *A History of Science Policy in the United States, 1940-1985* , Report for the House Committee on Science and Technology Task Force on Science Policy, 99th Cong., 2nd sess., Committee Print (Washington, DC: GPO, 1986), available at [http://ia341018.us.archive.org/2/items/historyofscience00unit/historyofscience00unit.pdf].

[55] OSTP webpage at [http://www.ostp.gov/html/_whatwedo.html].

- Advise the President and others within the Executive Office of the President on the impacts of science and technology on domestic and international affairs;[56]
- Lead an interagency effort to develop and implement sound science and technology policies and budgets;
- Work with the private sector to ensure Federal investments in science and technology contribute to economic prosperity, environmental quality, and national security;
- Build strong partnerships among Federal, State, and local governments, other countries, and the scientific community; and
- Evaluate the scale, quality, and effectiveness of the Federal effort in science and technology.[57]

The Director of OSTP is appointed by the President and confirmed by the Senate along with up to four Associate Directors.[58] The OSTP Director co-chairs the President's Council of Advisors on Science and Technology (PCAST) and supports the President's National Science and Technology Council (NSTC). PCAST is a federal advisory committee and will be discussed in the section on Federal advisory committees later in this report. NSTC, a cabinet-level council within the executive branch, was established by Executive Order 12881 on November 23, 1993, to coordinate S&T policy across the federal government. OSTP staff manage NSTC activities in conjunction with federal agency staff. The NSTC establishes national goals for federal science and technology investments and prepares coordinated research and development strategies.[59]

The question of the appropriate status and role of OSTP and a science advisor to the President has been discussed at great length by the S&T community.[60] In particular, the role of the OSTP director and the science advisor to the President relative to Congress is a rather complicated one. If an individual serves only as an assistant to the President for science and technology (APST), then no Senate confirmation is required. Congress does, however, confirm the director of OSTP and

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[56] For more information on this topic, see CRS Report RL34503, *Science, Technology, and American Diplomacy: Background and Issues for Congress*, by Deborah D. Stine.

[57] This is the OSTP mission as described on its webpage at [http://www.ostp.gov/html/_whatwedo.html].

[58] The number of associate directors has varied. Currently there are two associate directors. One is focused on science and the other on technology.

[59] National Science and Technology Council, website at [http://www.ostp.gov/cs/nstc].

[60] See for example, National Academies, Committee on Science, Engineering, and Public Policy, *Science and Technology in the National Interest: Ensuring the Best Presidential and Federal Advisory Committee Science and Technology Appointments* (Washington, DC: National Academy Press, 2005); Henry Kelly, Ivan Oelrich, Steven Aftergood, and Benn H. Tannenbaum, *Flying Blind: The Rise, Fall and Possible Resurrection of Science Policy Advice in the United States* (Washington, DC: Federation of American Scientists, 2004) at [http://www.fas.org/pubs/_docs/flying_blind.pdf]; Jennifer Sue Bond, Mark Schaefer, David Rejeski, Rodney W. Nichols, *OSTP 2.0: Critical Upgrade: Enhancing Capacity for White House Science and Technology Policymaking: Recommendations for the Next President* (Washington, DC: Woodrow Wilson International Center for Scholars, June 2008) at [http://wilsoncenter.org/news/docs/OSTP%20Paper1.pdf].

that individual can be required to testify before Congress, unlike someone who is only appointed APST, whom Congress may not require to testify due to executive privilege.

Perhaps a more important distinction is whom the science advisor represents.[61] Is it the role of the science advisor to serve as an advocate and voice of the President? Or is the science advisor's role instead to make the President aware of the views of the S&T community in regards to national policy? Or is the science advisor to provide their personal views on an S&T policy issue to the President? Or is it a combination of the three? Past science advisors have undertaken all of these roles. For example, George Keyworth, who served during the Reagan Administration, is generally viewed as an advocate of that Administration's policies. On the other hand, Frank Press, who served during the Carter Administration, is generally viewed as representing the voice of the S&T community.[62]

Other issues discussed by the S&T community are the appropriate size, budget, organization, and staffing for OSTP. This includes the appropriate role and status of the existing advisory mechanisms managed by OSTP — the National Science and Technology and the President's Council of Advisors for Science and Technology — and the OSTP presidential appointees under the director, the assistant directors.[63] Some organizations have proposed that OSTP manage additional advisory mechanisms that focus on issues such as science, technology, engineering and mathematics education, and federal-state science and technology policy.[64]

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[61] A historical perspective is provided by H. Guyford Stever Presidential Science Advisor to Presidents Nixon and Ford and the first director of OSTP, in his book *In War and Peace: My Life in Science and Technology* (Washington, DC: Joseph Henry Press, 2002). The reflections of Allan Bromley, the first individual to hold the title of APST, are available in D. Allan Bromley, *The President's Scientists — Reminiscences of a White House Science Advisor* (Yale University Press: New Haven,1994). Other perspectives are offered by Frank Press, APST in the Carter Administration in "Science and Technology in the White House, 1977 to 1980: Part 1," *Science*, January 9, 1981 211:139-145 at [http://www.sciencemag.org/cgi/reprint/211/4478/139.pdf], and by the two APSTs during the Clinton Administration, John H. Gibbons, "Reflections of a Science Advisor: General Considerations, the Superconducting Supercollider (SSC), and the Space Station" and Neal Lane, "Personal observations on advice to the President," in the *Forum on Physics & Society of The American Physical Society*, October 2006, 35:4 at [http://units.aps.org/units/fps/newsletters/2006/october/articles-lane.cfm].

[62] A list of previous presidential science advisors is available at [http://www.ostp.gov/cs/about_ostp/previous_science_advisors]. An overview of the roles each science advisor played in the Administrations in which they served, from a personal perspective, is available in American Physical Society, *Science Advisors Past and Present Gather at APS Centennial* at [http://www.aps.org/publications/apsnews/199907/advisors.cfm].

[63] See, for example, National Science Board, *International Science and Engineering Partnerships: A Priority for U.S. Foreign Policy and Our Nation's Innovation Enterprise, NSB 08-4* (Arlington, VA: National Science Foundation, 2008), at [http://www.nsf.gov/nsb/publications/2008/nsb084.pdf].

[64] See, for example, National Science Board, *National Action Plan for Addressing the*
(continued...)

Office of Management and Budget. The Office of Management and Budget (OMB) assists the President in overseeing the preparation of the federal budget and supervises its administration in Executive Branch agencies.[65] Specific actions include formulating the President's spending plans, evaluating the effectiveness of agency programs, policies, and procedures, assessing competing funding demands among agencies, setting funding priorities, and ensuring that agency reports, rules, testimony, and proposed legislation are consistent with the President's Budget and with Administration policies.[66]

Each year, the directors of OSTP and OMB issue a joint memorandum outlining the President's priorities and the Research and Development Investment Criteria.[67] The OMB staff are often a key component in implementing the President's budgetary priorities including which federal science and technology programs are proposed for elimination as well as funding decreases or increases.

Other White House Science and Technology Policy Related Offices. Several other White House organizations play a role in science and technology policy. Three that fall into the "science for policy" facet are the National Security Council (NSC), the Council of Economic Advisors (CEA), and the Council on Environmental Quality (CEQ). The NSC provides the President with a forum for considering national security and foreign policy matters with his senior national security advisors and cabinet officials, advises and assists the President on national security and foreign policies, and coordinates these policies among various government agencies.[68] The CEA provides the President with "objective economic analysis and advice on the development and implementation of a wide range of domestic and international economic policy issues."[69] CEQ "coordinates federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives."[70] The President may also obtain advice from the President's cabinet (who may provide their advice based

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[64] (...continued)
Critical Needs of the U.S. Science, Technology, and Mathematics Education System (Ballston, VA: National Science Foundation, 2007) at [http://www.nsf.gov/nsb/documents/2007/stem_action.pdf]; Jennifer Sue Bond, Mark Schaefer, David Rejeski, Rodney W. Nichols, *OSTP 2.0: Critical Upgrade: Enhancing Capacity for White House Science and Technology Policymaking: Recommendations for the Next President* (Washington, DC: Woodrow Wilson International Center for Scholars, June 2008) at [http://wilsoncenter.org/news/docs/OSTP%20Paper1.pdf].

[65] For more details, see CRS Report RS20167, *The Role of the Office of Management and Budget in Budget Development,* by Bill Heniff Jr.

[66] Office of Management and Budget, webpage, at [http://www.whitehouse.gov/omb/organization/role.html].

[67] The evaluation criteria are indicated each year in a joint OSTP/OMB Memorandum. See [http://www.ostp.gov/html/FY2009FINALOMB-OSTPRDPriorityMemo.pdf].

[68] National Security Council, webpage at [http://www.whitehouse.gov/nsc/].

[69] Council of Economic Advisors, webpage at [http://www.whitehouse.gov/cea/].

[70] Council on Environmental Quality, webpage at [http://www.whitehouse.gov/ceq/aboutceq.html].

on federal scientists and engineers), White House staff, and Presidential appointees such as the director of the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration (see next section).

Agency Leadership

Fewer than 100 Presidential appointees and others hold leadership positions in science and technology-related agencies that support scientific, engineering, and industrial research and development; manage large-scale defense, space, energy, health research, and environment programs; and regulate activities that have large technology components.[71] These leaders play an important role in the S&T policy decisionmaking process. Many, though not all, of these individuals must undergo Senate confirmation before they can take office.[72] Some appointments, such as the director of the National Science Foundation, are "term appointments" so that an individual may serve across Administrations.

Executive branch positions are frequently retitled, eliminated, or added during each Administration. Just prior to each Presidential election, a list of all the presidentially-appointed positions with a list of the individuals holding the position is published, alternately, by the Senate Committee on Homeland Security and Governmental Affairs and the House Committee on Oversight and Government Reform in a document known as the "Plum Book," officially titled *United States Government Policy and Supporting Positions*.[73]

Federal Agencies

Federal agencies are generally broken up into two categories: agencies that conduct or sponsor research, and agencies whose mission is related to science and technology. Federal agencies whose major focus is conducting or funding research include the

- National Science Foundation (NSF),
- National Institutes of Health (NIH),
- National Aeronautics and Space Administration (NASA),
- National Institute of Standards and Technology (NIST),
- National Oceanic and Atmospheric Administration (NOAA), and
- U.S. Geological Survey (USGS).

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[71] National Academies, Committee on Science, Engineering, and Public Policy, *Science and Technology in the National Interest: Ensuring the Best Presidential and Federal Advisory Committee Science and Technology Appointments* (Washington, DC: National Academy Press, 2005) at [http://www.nap.edu/catalog.php?record_id=11152].

[72] For more details on which Senate committees have jurisdiction over which appointments, see CRS Report RL30959, *Presidential Appointee Positions Requiring Senate Confirmation and Committees Handling Nominations*, by Maureen Bearden, Henry B. Hogue, and Terrence L. Lisbeth.

[73] The following website provides access to both current and past Plum Books: [http://www.gpoaccess.gov/plumbook/index.html].

In addition, many important federal research agencies and major research activities are located within more general departments including

- Department of Defense (DOD),
- Department of Energy (DOE),
- Department of Health and Human Services (HHS),
- U.S. Department of Agriculture (USDA),
- Department of Homeland Security (DHS),
- Department of Transportation (DOT),
- Department of Veterans Affairs (VA),
- Department of Education (ED),
- Department of Justice (DOJ),
- Department of Interior (DOI), and
- Department of Labor (DOL).

For example, NIH, Food and Drug Administration (FDA), Centers for Disease Control and Prevention (CDC), Agency for Toxic Substances and Disease Registry (ATSDR), and Agency for Healthcare Research and Quality (AHRQ) are all part of the Department of Health and Human Services (HHS). Additional independent federal organizations that support research and development include

- Environmental Protection Agency (EPA),
- Social Security Administration (SSA),
- U.S. Agency for International Development (USAID),
- Consumer Product and Safety Commission (CPSC), and
- Smithsonian Institution.

In some cases, many federal agencies work together on an issue where a variety of scientific and technical expertise is needed. Examples include nanotechnology and climate change.[74] Science.gov is a search engine for government science information and research results.

Federal agencies can fund external, non-federal employee researchers who are generally, though not exclusively, at universities ("extramural"), and researchers within the agency or at national laboratories ("intramural"). The major federal laboratories are operated by DOE, DOD, NIH, NASA, and USDA.[75] (See later section on FFRDCs for more details on some of these laboratories.)

[74] For more information, see CRS Report RL34401, *The National Nanotechnology Initiative: Overview, Reauthorization, and Appropriations Issues*, by John F. Sargent and CRS Report RL32997, *Climate Change: Federal Expenditures for Science and Technology*, by Michael M. Simpson and John R. Justus.

[75] Federally funded research can also be conducted through a federally funded research and development corporation (FFRDC), a mix of the two approaches. FFRDCs are discussed later in this report.

Who Makes Decisions in the Judicial Branch Regarding Science and Technology Policy?

The judicial branch uses scientific and technical knowledge in making its decisions. The S&T community provides this knowledge to the judiciary through its writings and expert testimony. Examples of cases where scientific and technical knowledge can be useful include product liability, medical malpractice, and environmental litigation, as well as public policy debates such as differences of opinion between political parties regarding elections and voting that involve statistical analysis. While the science and engineering research community is constantly refining its theories through empirical testing, the judiciary must make decisions based on the scientific "facts" at a particular point in time. The judiciary also makes decisions that influence that same science and engineering community.[76] As Supreme Court Justice Stephen Breyer states:

> The practice of science depends on sound law — law that at a minimum supports science by offering the scientist breathing space, within which he or she may search freely for the truth on which all knowledge depends. It is equally true that the law itself increasingly requires access to sound science. This need arises because society is becoming more dependent for its well-being on scientifically complex technology, so, to an increasing degree, this technology underlies legal issues of importance to all of us. We see this conclusion illustrated throughout the legal system.[77]

The U.S. Supreme Court has determined when judges should assess the reliability of the scientific methodology and reasoning that supports expert testimony.[78] At a 2006 workshop, some experts expressed concerns regarding the judiciary's use of scientific evidence and expertise including whether courts

- sufficiently recognize minority views in science;
- appreciate differences among the sciences in collecting, validating, and synthesizing evidence;
- understand that much of the available research relates to populations rather than to individuals and that complex questions may arise in extrapolating data to a particular person;
- define validity in a way that corresponds with the scientific community's understanding of the term;

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[76] Carnegie Commission on Science, Technology, and Government, *Science and Technology in Judicial Decision Making: Creating Opportunities and Meeting Challenges* (New York: Carnegie Commission on Science, Technology, and Government, March 1993) at [http://www.carnegie.org/sub/pubs/science_tech/judicial.txt].

[77] Stephen Breyer, "The Interdependence of Science and Law," *Science*, 280(5363): 537-538, April 24, 1998 at [http://www.sciencemag.org/cgi/content/full/280/5363/537].

[78] For more information, see National Research Council, *Discussions of the Committee on Daubert Standards: Summary of Meetings* (Washington, DC: National Academy Press, 2006).

- provide an appropriate level of scrutiny to forensic evidence in criminal cases.[79]

The Federal Judicial Center provides a reference manual, training, and videos for judges on scientific topics such as management of expert evidence, statistics, economic estimation, DNA evidence, and engineering practices to help guide judges in managing cases centered around science and technology issues.[80] The American Association for the Advancement of Science (AAAS) provides a Court Appointed Scientific Experts (CASE) service to assist federal and state judges, administrative law judges and arbitrators in identifying highly qualified scientists, engineers, and healthcare professionals to serve as scientific experts.[81]

The judiciary system can also influence science and technology. In science, the courts are involved with two types of cases: those involving charges of scientific misconduct, such as research with human subjects; and those related to religious or moral opposition to particular kinds of scientific research or the teaching of science, such as biotechnology research or the teaching of evolution in schools.[82] Judiciary activities related to technology focus on issues such as patent policy, particularly for emerging technologies when a research discovery moves from the realm of basic research to something that can be patented. An example in this area is a Supreme Court decision to allow patenting of a genetically engineered microorganism.[83]

What Organizations Provide Science and Technology Advice to Policymakers?

The amount of scientific and technical knowledge and data produced by the S&T community can be sometimes be overwhelming given the nature of the scientific and engineering research enterprise which relies on a system of peer review and replication. Organizations that provide scientific and technical advice to policymakers can help provide an overview and synthesis of scientific and technical knowledge and data, and provide their view of a consensus of the S&T community.

The science and engineering community, however, is not represented by one individual or organization. On matters of scientific and technical knowledge and guidance, its opinions are consensus-based with groups of scientists and engineers coming together from different perspectives to debate an issue based on the available empirical evidence. In the end, consensus is achieved if there is widespread

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[79] Ibid.

[80] For more information, see [http://www.fjc.gov/public/home.nsf].

[81] For more information, see [http://www.aaas.org/spp/case/case.htm].

[82] Sheila Jasanoff, *Science at the Bar: Law, Science, and Technology in America* (Cambridge, MA: Harvard University Press, 1995).

[83] Mark Frankel and Brent Garland, "Law and Technology," in *Science, Technology, and Society: An Encyclopedia*, edited by Sal Restivo (New York: Oxford University Press, 2005).

agreement on the evidence and its implications. If this occurs, the knowledge is conveyed to policymakers so they can determine, among other factors, whether or not to take policy actions in response. If there are major disagreements within large portions of the community, however, the lack of consensus adds to the uncertainty facing policymakers responding to a concern.

Several organizations, when requested by the federal government or Congress, provide formal science and technology policy advice: federal advisory committees, congressionally chartered honorific organizations, and federally funded research and development corporations. These organizations are constantly changing (see **Box 4**). Federal advisory committees and the congressionally chartered honorific organizations described in this report are under the Federal Advisory Committee Act (P.L. 92-463).[84] FFRDCs are funded by the federal government. Federal government officials and members of the S&T community also participate in the activities of international organizations, which also provide a source of knowledge and advice to policymakers. Federal government officials and members of the S&T community also participate in the activities of international intergovernmental organizations, another source of knowledge and advice.

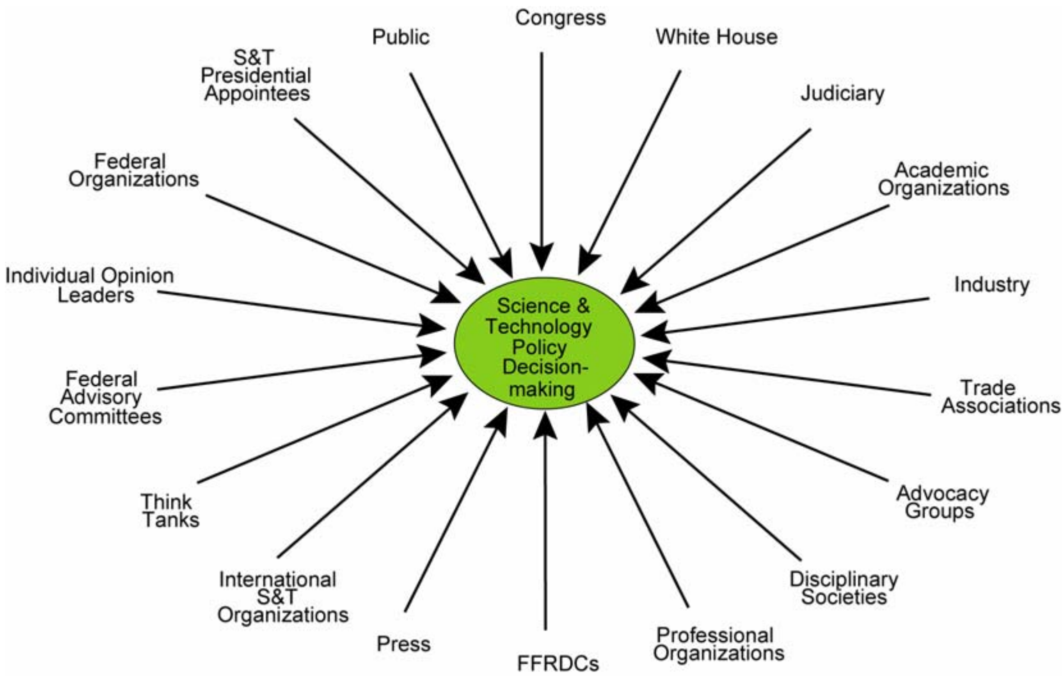
In addition, many other organizations and individuals — policy institutes, the public, professional organizations and disciplinary societies, universities and colleges, advocacy, special interest, industry, trade associations, and labor — also provide their thoughts (see **Figure 5**). These organizations may agree on the scientific and technical knowledge, but disagree on what actions to take in response on an S&T policy, as their values on a proposed policy may differ. For example, there may be agreement that action needs to be taken in response to concerns about climate change, but proposed policy responses may range from calls for additional research to emission reductions to a gasoline tax. If the groups agree on a general policy response, such as emission reduction, they may still disagree on the best way to achieve that goal. These organizations, described below, use a variety of mechanisms including papers, reports, and events to convey information to policymakers.

Federal Advisory Committees

Federal advisory committees, established by Congress, the President, a cabinet secretary, an independent agency administrator, or an agency executive, provide independent advice and recommendations to the nation. Many of these committees provide S&T policy related guidance. According to a National Academies report, S&T policy related advisory committees fall into five categories (see **Table 2**).

[84] For more information, see CRS Report RL30260, *Federal Advisory Committees: A Primer*, by Stephanie Smith.

Figure 5. Organizations and Individuals Who Influence Science and Technology Policy Decisionmaking



Source: Congressional Research Service

Table 2. Federal Science and Technology Policy-Related Advisory Committee Categories

Category	Example of Advisory Committee Created by Congress
Science for Policy	EPA Clean Air Act Advisory Committee
Policy for Science	DHS Science and Technical Advisory Committee
Program Evaluation and Direction	NRC Advisory Committee on Reactor Safeguards
Proposal Review	USDA Collaborative Forest Restoration Program Advisory Panel
Event Driven	National Commission on Terrorist Attacks Upon the United States — 9/11 Commission

Source: National Academies, *Science and Technology in the National Interest: Ensuring the Best Presidential and Federal Advisory Committee Science and Technology Appointments* (Washington, DC: National Academy Press, 2005) at [http://www.nap.edu/html/national-interest/index.html].

As previously noted, the two major overarching federal advisory committees are the President's Council of Advisors on Science and Technology (PCAST) and the National Science Board (NSB). The President appoints members of both PCAST and NSB. Both PCAST and NSB draw their members from industry, education, research institutions, and other nongovernmental organizations and issue reports on S&T policy.

Each President determines whether to have a science advisory council or committee, which generally focuses on policy for science issues. Beginning in the 20th century, many Presidents, but not all, have decided to do so. For example, President Theodore Roosevelt created a Committee on Organization of Scientific Work in 1903.[85] PCAST was originally established by President George H. W. Bush, and has been reestablished in subsequent Presidential Administrations, each time by an executive order. The current executive order indicates that PCAST is "to receive advice from the private sector and academic community on technology, scientific research priorities, and math and science education."[86]

Congress created NSB in the National Science Foundation Act of 1950 at the same time that it established NSF. According to the act, NSB's mission is to

[85] Jeffrey K. Stine, *A History of Science Policy in the United States, 1940-1985* , Report for the House Committee on Science and Technology Task Force on Science Policy, 99th Cong., 2nd sess., Committee Print (Washington, DC: GPO, 1986) [http://ia341018.us.archive.org/2/items/historyofscience00unit/historyofscience00unit.pdf].

[86] For more information on PCAST, see [http://www.ostp.gov/PCAST/pcast.html].

"recommend and encourage the pursuit of national policies for the promotion of research and education in science and engineering." NSB also provides oversight and establishes NSF policies within the framework established by the President and Congress and serves as an independent body of advisors to each on broad national policy issues related to science and engineering research and education.[87] Every two years, the NSB collects information and data from across the federal government to develop its *Science and Engineering Indicators*. This report serves as one of the primary resource guides for S&T policy.[88]

Many other federal departments and agencies also have overarching advisory committees that provide them with scientific and technical advice. Some examples include the NIH's Advisory Committee to the Director (ACD),[89] EPA's Science Advisory Board (SAB), and DOD's Defense Science Board (DSB).[90] Not all government executives, however, decide to have such advisory committees. For example, although the Secretary of Energy had a science advisory board for many years, it was disbanded in 2006.[91]

The General Services Administration (GSA) Committee Management Secretariat conducts an ongoing review to evaluate whether advisory committees are fulfilling the purpose for which they were established. The number of committees and committee members varies from year to year, but ranges from 900-1,100 committees with over 50,000 committee members that provide advice to over 50 departments and agencies. In almost all cases, committee members do not receive any Federal compensation for their advice other than their travel and per diem expenses.

Congressionally Chartered Honorific Organizations

Another source of S&T policy advice are honorific nonprofit organizations chartered by Congress.[92] The chief of these is the National Academy of Sciences (NAS), established by a congressional charter approved by Abraham Lincoln in 1863, to provide independent advice on science and technology matters.[93] The NAS is a private, nonprofit organization, whose new members are elected by current members

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[87] For more information about the NSB, see [http://www.nsf.gov/nsb/about/index.jsp].

[88] See the most recent edition at National Science Board, *Science and Engineering Indicators 2008* (Arlington, VA: National Science Foundation 2008) at [http://www.nsf.gov/statistics/seind08/].

[89] For more information about ACD, see [http://www.nih.gov/about/director/acd/index.htm].

[90] For more information about DSB, see [http://www.acq.osd.mil/dsb/].

[91] For more information about SEAB, see [http://www.seab.energy.gov/].

[92] For more information on such organizations, see CRS Report RL30340, *Congressionally Chartered Nonprofit Organizations ("Title 36 Corporations"): What They Are and How Congress Treats Them*, by Kevin Kosar.

[93] See this charter at [http://www.nasonline.org/site/PageServer?pagename=ABOUT_incorporation] and its amendments at [http://www.nasonline.org/site/PageServer?pagename=ABOUT_incorporation_amendment].

based on their research accomplishments. The NAS, along with its partner organizations, the National Academy of Engineering (NAE) and the Institute of Medicine, known collectively as "The National Academies," issue approximately 200 reports a year on a wide range of science and technology topics. Some of these reports are issued in response to congressional requests either in law, via letter, or through informal discussions through its operating arm, the National Research Council. The National Academies develop reports through a committee process that includes an extensive review process. All committee members serve on committees pro bono, but the Academy needs funding for staff and support before a congressionally-requested study can proceed. Reports requested by Congress are generally funded through a federal agency, but there is no requirement for them to do so unless funding is appropriated for this purpose.[94]

Another honorific organization that sometimes issues reports related to S&T policy is the National Academy of Public Administration (NAPA). NAPA is an independent, nonprofit organization established by congressional charter in 1984 (P.L. 98-257). Fellows are elected by their peers and include policy makers, public administrators, scholars of public policy and public administration, business executives, labor leaders, current and former cabinet officers, Members of Congress, governors, mayors, state legislators, and diplomats. NAPA's mission focuses on issues related to improving the effectiveness and administration of government, often in response to congressional request. For example, NAPA has examined the administration and performance of NASA in response to a congressional committee. The process and funding of congressionally requested studies is similar to that of the National Academies.[95]

Federally Funded Research and Development Corporations (FFRDCs)

FFRDCs are not-for-profit organizations, financed on a sole-source basis, exclusively or substantially by an agency of the federal government. Each Center is administered, through a contract with the sponsoring federal agency, by either an industrial firm, a university, or a nonprofit institution.[96] As of May 2007, there were 38 FFRDCs.[97] DOE sponsors the majority, followed by DOD. The other federal agencies sponsoring FFRDCS include HHS, DHS, NASA, NSF, Nuclear Regulatory

[94] For more information on the National Academies, see [http://www.national academies.org/]. Those interested in developing a congressional request for a National Academies study might wish to discuss it first with the National Academies congressional affairs office at [http://www7.nationalacademies.org/ocga/]. National Academies reports are also available at no cost to congressional staff through this office.

[95] For more information on NAPA, see [http://www.napawash.org/index.html].

[96] For more information on FFRDCs, see CRS Report RS21542, *Department of Homeland Security: Issues Concerning the Establishment of Federally Funded Research and Development Centers (FFRDCs)*, by Michael E. Davey.

[97] National Science Foundation, "Master Government List of Federally Funded R&D Centers," Special report NSF 06-316, May 2007 at [http://www.nsf.gov/statistics/nsf06316/].

Commission (NRC), Department of Transportation (DOT), and the Department of the Treasury. Examples of FFRDCs include Los Alamos National Laboratory (DOE), Lincoln Laboratory (DOD), Homeland Security Institute (DHS), Jet Propulsion Laboratory (NASA), and the National Center for Atmospheric Research (NSF).

Battelle, Mitre, the Aerospace Corporation, and the Institute for Defense Analysis (IDA) are examples of nonprofit independent research organizations who manage FFRDCs, including providing advice and analysis for the federal government. Much of Battelle's S&T policy analysis focuses on energy and national security issues. Mitre's focus is on defense, information technology, and aviation issues. The Aerospace Corporation focuses on space and launch systems. IDA manages an FFRDC called the Science and Technology Policy Institute (STPI). STPI provides advice and analysis for the White House Office of Science and Technology Policy and other government users. Congress created STPI, originally called the Critical Technologies Institute, in 1991. Rand managed STPI from 1993 until 2003 when IDA took over STPI.

International Intergovernmental Organizations

International intergovernmental organizations also provide S&T policy advice. The Organisation for Economic Cooperation and Development (OECD), established in 1961, "brings together the governments of countries committed to democracy and the market economy from around the world to support sustainable economic growth, boost employment, raise living standards, maintain financial stability, assist other countries' economic development, and contribute to growth in world trade."[98] Thirty countries, including the United States, are members of the OECD. OECD provides comparative data and policy analysis for its member countries.

Founded in 1945, the United Nations Educational, Scientific and Cultural Organization (UNESCO) "promotes international co-operation among its 193 Member States and six Associate Members in the fields of education, science, culture and communication."[99] UNESCO's S&T policy activities have two strategic objectives: "improving human security by better management of the environment and social change and, enhancing scientific, technical and human capacities to participate in the emerging knowledge societies."[100]

Another U.N. office involved in S&T policy is the United Nations Office for Outer Space Affairs (UNOOSA). This office provides a forum for intergovernmental discussions on space policy, primarily through the Committee on the Peaceful Uses of Outer Space (COPUOS), and manages discussions through its

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[98] OECD, "About the OECD," webpage at [http://www.oecd.org/pages/0,3417,en_36734052_36734103_1_1_1_1_1,00.html].

[99] For more information, see [http://portal.unesco.org/en/ev.php-URL_ID=3328&URL_DO=DO_TOPIC&URL_SECTION=201.html].

[100] UNESCO, webpage at [http://portal.unesco.org/science/en/ev.php-URL_ID=5572&URL_DO=DO_TOPIC&URL_SECTION=201.html].

Secretariat of international treaties related to outer space. UNOOSA also assists developing countries interested in using space technology for development.[101]

An organization active on a current issue with high science and technology salience is the Intergovernmental Panel on Climate Change (IPCC), which received a Nobel Prize in 2007 "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change."[102] The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the IPCC as a scientific intergovernmental body to provide an assessment of the causes of climate change, its potential environmental and socio-economic consequences, and the adaptation and mitigation options to respond to it.

Other Sources of Advice

Policy Institutes. A policy institute, sometimes referred to as a "think tank," is an organization that provides policy analysis and advice. Think tank reports may be authored by individual scholars, teams of scholars, or committees. Many think tanks are nonprofit organizations and some are funded by interest groups. Some are disciplinary focused; some promote a particular point of view on policies, while and others profess to be neutral. Some have a large staff and are well-funded, others consist of just a few staff members and have limited funding. Referring to a report from a particular think tank will often create an image in people's mind as to the policy perspective that may influence the analysis represented in that report.

Some think tanks that work to maintain a sustained expertise in S&T policy include Resources for the Future, the Center for Strategic and International Studies, Public Citizen, the World Resources Institute, Woodrow Wilson International Center for Scholars, Urban Institute, and the Council on Competitiveness. Examples of think tanks who comment on many policy areas and sometimes on S&T policy include the American Enterprise Institute, Center for American Progress, the Heritage Foundation, the Brookings Institution, Council on Foreign Relations, and the Cato Institute.

Public and Individual Opinion Leaders. Public opinion about science and technology influences S&T policy decisionmaking. The degree to which the public is willing to invest federal funds in research whose outcome is uncertain, but which has the potential of enhancing society or solving or ameliorating problems, reflects their trust in scientists, engineers, and health professionals. The public also influences whether or not research is conducted in certain fields of research, such as embryonic stem cell research; research methods, such as the use of animals in laboratory research; and STEM education. Public attitudes can also influence public

[101] For more information on UNOOSA, see [http://www.unoosa.org/oosa/en/OOSA/index.html].

[102] Norwegian Nobel Prize Institute, webpage at [http://nobelpeaceprize.org/eng_lau_list.html].

policies related to the application of a technology, such as the use of genetically-modified organisms as agricultural crops or irradiated foods.[103]

Based on NSF surveys, the majority of Americans believe

- the benefits of scientific research outweigh harmful results,
- science and technology makes our lives healthier, easier, and more comfortable,
- more opportunities will be available for the next generation due to science and technology,
- Americans depend too much on science and too little on faith, and
- the federal government should fund basic research.[104]

In 2006, the percentage of Americans who profess a great deal of confidence in the leaders of the scientific community was 41%, second only to military leaders at 47%.[105] On the other hand, many Americans do not give correct answers to basic factual questions about science and the scientific inquiry process, are skeptical of some established scientific ideas even when they have some basic familiarity with the idea, and are receptive to including nonscientific views in science classrooms.[106]

On occasion, individual opinion leaders become a major spokesperson on an S&T policy topic. Although they do not represent a particular organization, they have often held, in the past, leadership positions in government, business, industry, or nongovernmental organizations that have heightened their visibility and prominence on an issue. An example of such an individual is Colin Powell, former Secretary of State, who often speaks on behalf of himself rather than an organization.

Professional Organizations and Disciplinary Societies. Many scientific and engineering professional organizations and disciplinary societies are active in the S&T policy decisionmaking process. The goals of the organization or society are generally to advance and highlight research in their professions or fields. The nonprofit organizations and societies, in turn, represent the views of their Members in Congress amongst many other activities. According to one assessment, there are over 3,000 such organizations worldwide.[107] Although these groups do have a self-interest, this does not necessarily imply that their science and technology

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[103] National Science Board, *Science and Engineering Indicators 2008*, (Rosslyn, VA: National Science Foundation), Chapter 7 at [http://www.nsf.gov/statistics/seind08/].

[104] National Science Board, *Science and Engineering Indicators 2008*, (Rosslyn, VA: National Science Foundation, 2008), Appendix Tables 7-12, 7-13, and 7-16 at [http://www.nsf.gov/statistics/seind08/].

[105] National Science Board, *Science and Engineering Indicators 2008* (Rosslyn, VA: National Science Foundation), Appendix Table 7-20 at [http://www.nsf.gov/statistics/seind08/].

[106] National Science Board, *Science and Engineering Indicators 2008*, (Rosslyn, VA: National Science Foundation), Chapter 7 at [http://www.nsf.gov/statistics/seind08/].

[107] For a list of these organizations, see the following site developed by the Department of Energy at [http://eprints.osti.gov/cgi-bin/search_societies.pl#browse].

advice should be discounted or doubted. For example, the American Society of Civil Engineers (ASCE) warned well before the Minneapolis bridge collapse about the nation's deteriorating infrastructure.[108]

A professional organization is an organization whose goal is to advance a particular profession. Examples of professional organizations include the National Science Teachers Association (NSTA), the National Society of Teachers of Mathematics (NSTM), and the National Society of Professional Engineers (NSPE). Professional organizations conduct activities similar to disciplinary societies as well as, in some cases, offering professional certification activities.

The goal of a science and engineering disciplinary society is to advance that field of science, engineering, or a multidisciplinary field. For example, the mission of the American Physical Society (APS) is "to advance and diffuse the knowledge of physics."[109] The American Chemical Society (ACS) objective is to encourage the advancement of chemistry, promote research in chemical science and industry, improve the qualifications and usefulness of chemists, increase and diffuse chemical knowledge, promote scientific interests and inquiry, and foster public welfare and education. The mission of the American Association for the Advancement of Science (AAAS) is to represent the S&E community broadly and "advance science, engineering, and innovation throughout the world for the benefit of all people."[110] Examples of other disciplinary societies active in the Washington DC area include the Federation of Societies in Experimental Biology (FASEB), the American Mathematical Society (AMS), the American Geophysical Union (AGU), ASCE, the Institute of Electrical and Electronics Engineers (IEEE), and the American Society of Mechanical Engineers (ASME).

There are also organizations that represent S&T professionals, but which are not limited to particular disciplines. For example, some organizations focus on enhancing the status of women and underrepresented groups in science and engineering such as the Association of Women in Science (AWIS), the Society of Women Engineers (SWE), the National Action Council for Minorities in Engineering (NACME), and the Center for the Advancement of Hispanics in Science and Engineering Education (CAHSEE).

Many of the major science and engineering societies and professional organizations sponsor congressional fellowships where individuals with science and engineering backgrounds have an opportunity to spend time learning about congressional policymaking, while they in turn provide scientific and technical expertise and analysis for Members of Congress. In general, fellowships last for one year with the fellows acting as special assistants in legislative and policy areas that would benefit from scientific and engineering input. Any congressional office may

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[108] American Society of Civil Engineers, Report Card on America's Infrastructure at [http://www.asce.org/reportcard/2005/index.cfm].

[109] American Physical Society, "History and Vision," webpage at [http://www.aps.org/about/history/index.cfm].

[110] American Association for the Advancement of Science, "About AAAS," at [http://www.aaas.org/aboutaaas/].

request a fellow. The most prominent of the fellowship programs is that sponsored by AAAS in cooperation with approximately 30 national scientific and engineering societies.[111]

Universities and Colleges. Universities, colleges, and other post-secondary educational institutions are also active in science and technology policy. These organizations issue educational materials and position statements to support their points of view on a variety of issues. Some universities have Washington DC offices and others have Washington representatives who monitor the status of Congressional activities that might impact their institution. Examples include the University of California and the Massachusetts Institute of Technology.

In addition, there are about 50 organizations that represent post-secondary institutions.[112] These include the American Council on Education (ACE), the Association of American Universities (AAU), the National Association of State Universities and Land Grant Colleges (NASULGC), the Association of American Colleges and Universities (AAC&U), Council of Graduate Schools (CGS), and the Association of American Medical Colleges (AAMC).

ACE serves as the umbrella organization by developing consensus amongst all these organizations on higher education policy issues. AAU represents the major research universities and NASULGC represents state universities and land grant colleges. AAC&U focuses on liberal[113] undergraduate education, CGS on graduate education, and AAMC on medical education. In addition, some organizations may focus on a specific topic. For example, the Council on Government Relations (COGR) focuses on the financial and administrative aspects of federally funded research. Universities and colleges may be simultaneously active in many of these organizations.

Advocacy, Special Interest, or Action Groups. Advocacy, special interest, or action groups are individuals or organizations whose goal is to influence public policy or decisionmaking on an issue. One advocacy organization, the Pugwash Conferences on Science and World Affairs, received the Nobel Prize in 1995 "for their efforts to diminish the part played by nuclear arms in international politics."[114]

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[111] For more information, see [http://fellowships.aaas.org/02_Areas/02_Congressional.shtml] and Jeffrey K. Stine, *Twenty Years of Science in the Public Interest: A History of the Congressional Science & Engineering Fellowship Program* (Washington, DC: American Association for the Advancement of Science, 1994).

[112] For more information, see [http://www.whes.org/members.html].

[113] AAC&U defines liberal education as a "philosophy of education that empowers individuals with broad knowledge and transferable skills, and a strong sense of value, ethics, and civic engagement." For more information, see [http://www.aacu.org/resources/liberaleducation/index.cfm].

[114] Norwegian Nobel Prize Peace Prize, webpage at [http://nobelpeaceprize.org/eng_lau_list.html].

Examples of advocacy groups active in S&T policy are overarching groups such as the Union of Concerned Scientists, Federation of American Scientists, and the Center for Science in the Public Interest as well as issue-specific organizations such as Research! America that advocates for increased funding for health research, and the Natural Resources Defense Council that advocates on environmental policy issues. There are also coalitions where a number of organizations work together on a particular issue, such as the Task Force on the Future of American Innovation, where industry and academia advocate for increased federal support for research in the physical sciences and engineering.

Many of these organizations have scientists and engineers on their staff who help the organization base their positions on their views of scientific evidence as opposed to rhetoric. While some believe it is appropriate and critical for scientists and engineers to take positions on public policy issues, others believe it is inappropriate and that scientists and engineers should be careful to separate their personal viewpoints from their professional obligations so they remain neutral and do not influence their research activities. Some professional organizations and disciplinary societies may take a middle ground — taking positions on particular issues, but clearly separating their lobbying activities from their educational activities.

Industry and Trade Associations. To represent its point of view in Washington, DC, an industrial company has several options. It may represent its point of view individually, either through a Washington office or in its congressional district, or it may work with other industries in a trade association or other organization focused on business. A trade association is an association of people or companies in a particular business or trade or chamber of commerce organized to promote their common interests.[115] Examples of trade associations that may speak on S&T issues include the U.S. Chamber of Commerce, the National Association of Manufacturers, the Biotechnology Industry Organization, the Electronic Industries Alliance, the American Petroleum Institute, and the American Chemistry Council.

Labor. Labor groups may also influence S&T decisionmaking. A labor group may be a professional association (discussed above) or a labor union. Many of these groups are interested in safety issues — for example, how knowledge-intensive and manufacturing industries can enhance the safety of workers, what scientific and technical research can tell workers about their safety, and how science and technology can enhance worker safety. An example of a labor union active in this area is the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO), a voluntary federation of 55 national and international labor unions.

Labor groups are also interested in influencing decisions that impact their job market and their ability to compete for employment, such as immigration issues or

[115] For more information on trade associations and their political activities, see CRS Report RL33377, *Tax-Exempt Organizations: Political Activity Restrictions and Disclosure Requirements*, by Erika Lunder.

increasing the number of H-1B visas.[116] In addition to labor groups, some professional organizations (see earlier description) are also active on these issues. Examples include the Programmers Guild, the American Engineering Association, and the IEEE. Labor unions that are active include the Washington Alliance of Technology Workers and the Communication Workers of America.

Faculty, graduate students, and postdoctoral scholars also advocate for their views in Washington, DC, and on university campuses as part of labor groups or professional organizations. For example, the National Postdoctoral Association is a professional organization that represents postdoctoral scholars, and the American Association of University Professors represents faculty viewpoints. The graduate students at Columbia University are represented as a chapter of the UAW, the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America.

[116] For more information, see CRS Report 95-408, *Immigration: The Effects on Low-Skilled and High-Skilled Native-Born Workers*, by Linda Levine; CRS Report RL31973, *Programs Funded by the H-1B Visa Education and Training Fee, and Labor Market Conditions for Information Technology (IT) Workers*, by Linda Levine and Blake Alan Naughton; CRS Report RL30498, *Immigration: Legislative Issues on Nonimmigrant Professional Specialty (H-1B) Workers*, by Ruth Ellen Wasem and CRS Report RL34091, *Globalization, Worker Insecurity, and Policy Approaches*, by Raymond J. Ahearn.

Box 4. Congressional and Administration Interest in Science and Technology Policy Advice

The creation and long-term support of institutions whose mission is to provide science and technology knowledge and policy analysis for policymakers in Congress and the executive branch has not been a smooth progression. As noted earlier, the first executive-created organization, PSAC, was abolished, then statutorily resurrected. Similarly, the perceived need for technical assistance led to the statutory creation of two post-World War II agencies that were effectively closed down due to a lack of an appropriation for their operation in the 1990s: the Office of Technology Assessment (OTA), a congressional-support agency, and the Administrative Conference of the United States (ACUS), an independent agency of the federal government, also charged with providing advice to Congress.

Congress established OTA in 1972 to assess the consequences of applying technology by preparing comprehensive reports that discussed the pros and cons of policy options about an issue. The law created a support agency to provide objective and authoritative analysis of complex scientific and technical issues to aid in policymaking. It was intended to facilitate congressional access to expertise and permit legislators to consider objectively information presented by the executive branch, interest groups, and other stakeholders to controversial policy questions. OTA was effectively eliminated when Congress did not appropriate funds for FY1996 for its continued operation and appropriated funds to close down the office.

Congress established ACUS in 1964 to promote improvements in the efficiency, adequacy and fairness of procedures by which federal agencies conduct regulatory programs, administer grants and benefits, and perform related governmental functions. The Conference conducted research and issued reports on S&T policy issues such as making a statement on effective decisionmaking techniques for the evaluation of scientific studies based on an evaluation of the FDA's public board of inquiry procedures when there are disputes regarding scientific studies. As with OTA, the conference was terminated in FY1996 when funds were appropriated for its closure. Although reauthorized in 2004, no funds were appropriated, and this authorization expired on September 30, 2007.

There are recurring congressional discussions regarding the revival of these organizations. In the 110th Congress, S. 1602 proposes to authorize appropriations for OTA, and H.R. 3564 proposes to authorize appropriations for ACUS. H.R. 3564 passed the House in the 110th Congress, but it has not been voted upon by the Senate.

Source: Excerpt from CRS Report RS21586, *Technology Assessment in Congress: History and Legislative Options*, by Genevieve J. Knezo. U.S. Congress, House Committee on Science, *Scientific and Technical Advice for the U.S. Congress*, hearing, 109th Cong., 2nd Sess., July 25, 2006 (Washington, D.C.: GPO, 2006) at [http://frwebgate.access.gpo.gov/cgi-bin/useftp.cgi?IPaddress=162.140.64.181&filename=28757.wais&directory=/diska/wais/data/109_house_hearings]; U.S. Congress, House Committee on the Judiciary Subcommittee on Commercial and Administrative Law, *Reauthorization of the Administrative Conference of the United States*, hearings, 108th Cong., 2nd Sess., May 20 and June 24, 2004 (Washington, D.C.: GPO, 2004) at [http://frwebgate.access.gpo.gov/cgi-bin/useftp.cgi?IPaddress=162.140.64.183&filename=93774.pdf&directory=/diska/wais/data/108_house_hearings].

What are the Opportunities and Challenges of the Current Science and Technology Policy Decisionmaking Process?

This primer on S&T policy decisionmaking provides an overview how science and technology influences policy, and how policy influences S&T policy. The report also describes the major sources of knowledge and advice for policymakers. In surveying this landscape, it is perhaps worthwhile to also reflect on the opportunities and challenges facing the current S&T policy decisionmaking process.

Science and technology policy decisionmaking is both democratic and decentralized. In other words, many organizations and individuals representing a wide array of ideas and opinions participate in S&T policy decisionmaking. No one organization or individual is viewed as speaking on behalf of the entire scientific and technical community — either inside or outside the federal government. Each freely offers sources of knowledge and advice. This provides policymakers with an overwhelming amount of information, and it can be challenging to sort through it all to determine which information is the most germane to a particular issue or decision.

Communication between policymakers and the science and engineering community can also be a challenge due to fundamentally different perspectives, regardless of the issue. In addition, the science and engineering community may find it challenging to recognize that the information they provide is only one factor in a policymaker's decision process, which can include cultural, economic, and other values.

Another challenge is that many federal government agencies can simultaneously influence a S&T policy issue. Agencies often have overlapping roles that can influence assessments of risk, allocation of responsibility, problem-solving, and patterns of participation.[117] For example, federal decisionmaking regarding nuclear power includes

- Nuclear Regulatory Commission - Safety and design;
- Federal Power Commission - Rate bases and authority;
- Occupational Safety & Health Administration - Worker safety;
- Environmental Protection Agency - Environmental impact studies;
- Department of Energy - Nuclear power research and development;
- Federal Emergency Management Agency - Nuclear power plant emergency;
- Department of Homeland Security, Federal Bureau of Investigation, Federal Aviation Administration, U.S. Coast Guard, and others - Nuclear power plant security; and
- Department of Transportation - Shipment of radioactive materials.[118]

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[117] Richard Barke, *Science, Technology, and Public Policy* (Washington, DC: Congressional Quarterly, 1986).

[118] Ibid. Modified based on information at the Nuclear Regulatory Commission website at

(continued...)

Critics of the current S&T policy decisionmaking process say it can be challenging to make logical and consistent policies as each of these federal agencies may assess the risk of a given policy from a different perspective without a unified assessment.[119] There are many organizations and individuals in Congress, the judicial branch, state and local governments, and outside of government such as industry, advocacy groups, think tanks, and others who also offer their thoughts on any given S&T policy. As a result, this diversity leads some experts to believe that S&T policy decisions can not be made coherently and consistently.

Further, some critics say that public policies do not always reflect what is known about science and technology, and neither policymakers nor the public have sufficient understanding to make appropriate decisions.[120] A reliance on experts may help policymakers make decisions, but some express concerns that the experts themselves are unable to separate their personal biases sufficiently to provide an independent analysis of the situation. For example, on climate change, some have expressed concerns that some scientists are unable to separate their personal beliefs regarding public policy when providing the results of their research to policymakers.[121] In addition, experts do not always agree with one another due to the inherent uncertainty in science. As a result, policymakers may find it challenging to obtain a sufficiently clear answer for decisionmaking. Policymakers must often decide whether to make a choice on a current assessment of the costs and benefits of taking action based on imperfect information or to await additional scientific and technical information. Moreover, while scientific knowledge and technological development is changing constantly, the same is not always true of public policy. As a result, policies developed a number of years ago may not reflect the latest scientific and technological knowledge.

Finally, critics say that accountability for political decisions can also be a challenge.[122] The decentralized nature of S&T policy decisionmaking can make it challenging to separate sources of advice and make those providing advice accountable. For example, a Member of Congress may rely on a presidential appointee who in turn relies on his or her science and engineering staff. That staff may develop their opinion based on federal advisory committees, and experts outside the federal government, who in turn rely on peer reviews of the work of individual scientists and engineers, who are not able to be held accountable to the public for public policies based on their knowledge and guidance.

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[118] (...continued)
[http://www.nrc.gov/].

[119] Ibid.

[120] Ibid.

[121] See, for example, Edward J. Wegman, David W. Scott, and Yasmin H. Said, "Ad Hoc Committee Report on the 'Hockey Stick' Global Climate Reconstruction," at [http://www.climateaudit.org/pdf/others/07142006_Wegman_Report.pdf], p. 65.

[122] Richard Barke, *Science, Technology, and Public Policy* (Washington, DC: Congressional Quarterly, 1986).

Despite these challenges, scientific and technical knowledge and advice has the potential of being useful in making decisions related to public policy. Policymakers have an opportunity to make their decisions based on the best knowledge and guidance available, along with the other factors they must take into account. Perhaps one way to recognize the value of scientific and technical knowledge and guidance in the policymaking process is to think of the many countries in which policymakers must make decisions with limited scientific and technical advice. An intuitive sense can only go so far in such situations, while scientific and technical knowledge and guidance can help policymakers assess the potential risk and benefits of a decision they make so that societal and economic benefits are enhanced and losses are mitigated.