Essay: American Physics, Policy, and Politics: An Uneasy Relationship

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This essay deals with the unique influence that physics and physicists have had on U. S. federal policy since World War II. I identify some ''lessons learned'' from the last six decades and speculate about the future of U. S. physics and physicists as advisors to future presidents.

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It is an honor to contribute to this year's celebration of the anniversary of *Physical Review Letters*. The goal of this essay is not to report particularly noteworthy original research results, the usual criterion for this distinguished journal, but rather to remind the reader of the unique influence that physics and physicists have had on U. S. federal policy since World War II, extract some ''lessons learned'' from the last six decades, and speculate about the future of U.S. physics and physicists as advisors to future presidents. In order to conserve space, references are kept to a minimum [1].

Physics and the war effort

The relevance of physics to vital national interests and federal policy making was made starkly clear during WW II, e.g., applications to radar, electronics, the proximity fuse, and nuclear weapons, and following WW II, through several decades of a cold-war nuclear standoff with the Soviet Union. WW II and the cold war also saw the establishment and growth of national laboratories—Los Alamos, Lawrence Livermore, Oak Ridge, Argonne, Brookhaven, and many others—most of them centers of physics, where many of the world's top researchers have worked. Those laboratories played vital roles during the cold war both by responding to evolving national priorities and advancing the frontiers of physics and other areas of science. Large industrial R&D laboratories, including Bell Labs, IBM, Xerox PARC, and Hewlett Packard, also flourished and made pathbreaking contributions in basic research, applied science, and engineering.

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In the early years of the cold war, robust federal funding flowed to support physics research in universities as well as the national laboratories. There has never been a single federal ''research budget'' or ''physics budget.'' Rather, research support for physics has been provided by several federal agencies, or parts of agencies, mainly the Department of Energy (DOE)—and its predecessors, the Atomic Energy Commission and the Energy Research and Development Administration (ERDA)—the National Science Foundation (NSF), the National Institute of Standards and Technology (intramural programs), and the defense agencies—Navy's ONR, Air Force's AFOSR, Army's ARO and DOD's DARPA (sometimes, ARPA).

Starting in the late 1950's, particularly after the launch of Sputnik I in 1957, the year before the launch of *Physical Review Letters*, until roughly the end of the millennium, U.S. physics experienced something of a ''golden age of discovery,'' capitalizing on earlier investments made in people and infrastructure, partly in response to the Soviet threat. But as the GDP of the nation grew, in large part due to inventions and technologies that came out of physics research—the transistor, integrated circuit, laser, fiber optics, computers, MRI imaging, CAT scans, to name a few—federal research funding for physics, indeed all the physical sciences, mathematics and engineering, has steadily lost ground [2].

The post-WW II era has also been a period during which scientists, particularly physicists, were called upon to advise presidents and other policymakers in the federal government on matters of science and technology policy. Most Presidential Science Advisors (by various titles) and the majority of members of the Presidential science advisory committees (particularly during the cold war) have been physicists. A brief history of this unique relationship between physicists and presidents can provide a useful context for looking forward. While the following history focuses on presidents' primary appointments as scientific advisors, it should be noted that many distinguished scientists and engineers have served as Acting Directors and as Associate Directors and professional staff of the White House Office of Science and Technology Policy (OSTP).

Later, I will discuss a number of questions that, given the special influence of physicists at the highest level of government, one might ask about possible conflicts of interest that, over time, could have affected physics research funding (up or down) and the objectivity and effectiveness of the Presidents' Science Advisors and advisory committees.

Brief history of physicists advising presidents

President Franklin D. Roosevelt recognized that scientific advice would be valuable in putting together his New Deal program and he appointed the first Scientific Advisory Board. But disagreements among the scientists and opposition by White House political staff insured the failure of the effort. The important role of science in WW II and, in particular, the Einstein-Szilard letter and the Manhattan Project changed all that. Vannevar Bush, MIT electrical engineer, became the wartime advisor to President Roosevelt and his successor, President Harry Truman. Bush had direct access to the President and, as head of the Office of Scientific Research and Development, controlled funding for military R&D, including the Manhattan Project. At the close of the war, his famous July 1945 report *Science: The Endless Frontier* established the notion of a government-university partnership, in which federal agencies would fund research in universities and faculty and students would carry out the research and make it freely available through publication; that notion has endured through decades of political storms and shifting agendas. But at the end of WW II, some questioned whether the President needed a Science Advisor. The question was answered in a memo written by William Golden, a New York investment banker and aide to AEC chairman Lewis Strauss, who, following the outbreak of the Korean War, had been asked to evaluate the effectiveness of military technology programs. Golden recommended both a Science Advisor and an external advisory committee. Truman accepted both recommendations but placed both at arms length, under the Office of Defense Mobilization (ODM). He made little use of the new advisory structure.

Eisenhower (34th).—With the cold war well underway, President Dwight D. Eisenhower saw the value of having confidential science advice on an array of technical and strategic matters. The ODM advisory committee, especially during the period when Columbia physicist I. I. Rabi (1956-57) served as ODM Science Advisor, took on issues such as military technical capabilities and missile defense and, in general, provided advice that Eisenhower found valuable. Thus, when the Soviets launched Sputnik I in 1957 Eisenhower immediately created the position of the President's Science Advisor and the President's Scientific Advisory Committee (PSAC), mainly physicists, and both reporting to him instead of ODM. The first Science Advisor, James R. Killian (1957-59), former President of MIT, and his successor, chemist George B. Kistiakowski (1959-61), continued to focus on national security, including air defense, atomic energy, and the military uses of space, and had easy access to the President. The success of this advisory arrangement can be attributed to three things: technical advice was crucial to policy during this period; the advice was entirely confidential; and PSAC did not make recommendations on research budgets of the agencies, hence avoiding any suspicion of conflicts of interest.

Kennedy (35th) and Johnson (36th).—President John F. Kennedy appointed MIT physicist Jerome Wiesner (1961-64) as his Science Advisor. A combination of early misunderstandings and growing discontent in the science community over the Vietnam War reduced Wiesner's effectiveness. Although Kennedy formally established the Office of Science and Technology (OST) in 1962, he made little use of it. On national security matters, OST became the junior partner of the National Security Council. After Kennedy was assassinated in November 1963, Lyndon B. Johnson became president. Wiesner resigned in 1964 and chemist Donald Hornig (1964-69) was appointed. Johnson was focused on the increasingly divisive Vietnam War and determined to try to show a unified front to the American people. Growing dissent among scientists—including some of his advisors on PSAC— over the nation's nuclear strategy and other politically contentious matters placed the President's Science Advisor in an awkward position, even if only by association, and weakened the influence of OST as well as PSAC. Johnson considered members of PSAC to be "disloyal;" they, in turn, felt they were being used to support a political agenda. Other changes were in the wind: it was a time when science and technology were being blamed for many of the ills of society.

Nixon (37th) and Ford (38th).—President Richard M. Nixon appointed physicist Lee DuBridge (1969-70), President of Caltech, and someone Nixon knew, as his Science Advisor. But, early on DuBridge was frozen out of national security matters. He also was not involved in budget issues because of opposition from the OMB Director after DuBridge argued for increases in NSF funding. Relations between DuBridge and the President soured as Nixon became increasingly irritated with criticism coming from the science community and PSAC members, some of them holdovers from the previous Administration. DuBridge stepped down in 1970 and was replaced by a Bell Labs electrical engineer, Edward David (1970- January, 1973). Disagreements with the physics community on two issues—antiballistic missile (ABM) defense and the supersonic transport (SST)—were particularly irksome to Henry Kissinger and others in the Nixon White House. The last straw was the Congressional testimony of IBM physicist Richard Garwin, a PSAC member, who, in response to questions, made public the technical arguments against the SST that PSAC had made to the President in an internal report. President Nixon then "accepted" resignations of PSAC and his Science Advisor, David, early in January 1973.

Some of the functions of the Science Advisor were transferred to NSF, whose Director (from 1972), physicist and former President of Carnegie-Mellon University, Guyford Stever (1973-77), found himself with two jobs, one at 18th and G Street (NSF) and another one block away, in the White House. I think it is worth noting that following the unfortunate episode during the Nixon Administration, several successive presidents chose not to appoint scientific advisory committees. Moreover, with the passage of the Federal Advisory Committee Act (FACA) in 1972, it became difficult for any federal advisory committees to provide confidential advice, thus reducing the value of a PSAC to the President.

After Nixon resigned in 1974 over the Watergate scandal, President Gerald Ford worked with Congress to establish OSTP, with a Senate-confirmed Director who also would serve as the President's Science Advisor. President Ford tapped Stever for that position. He was sworn in on August 12, 1976 and served until the end of Ford's term, January 20, 1977. Richard Atkinson succeeded him as NSF Director. Stever's offices at NSF and the White House focused on scientific collaboration with Soviet scientists and détente, issues of great importance to Nixon and Ford. After the OPEC oil embargo of October 1973, energy also became a major policy concern. ERDA was established in 1974, followed by DOE in 1977.

Carter (39th).—President Jimmy Carter chose MIT geophysicist Frank Press (1977-81) as his Science Advisor. Press felt it was important to emphasize, up front, that he was not there to represent the science community but to serve the President, a practice followed by each of his successors. He also began to develop rational approaches to setting priorities on the allocation of research funding. Energy received major White House attention; energy R&D efforts were increased, as some of the large energy technology demonstration projects, begun after the first oil shock during the previous Administration, were reined in. During the Carter Administration environmental concerns began to be addressed in connection with energy policy. Although a second oil shock occurred in 1978-79, R&D continued to be favored over large demonstration projects.

Reagan (40th).—President Ronald Reagan selected physicist George Keyworth (1981-85), a Los Alamos weapons scientist, as his Science Advisor but did not appoint an advisory committee. Keyworth appointed his own committee, which included Yale physicist D. Allan Bromley, later to become Science Advisor to President George H. W. Bush. The Reagan Administration sparked large-scale opposition from the science community when the President announced his Strategic Defense Initiative (SDI), commonly known as "star wars." Keyworth embraced SDI, but he was unable to generate support within the science community. He advocated increased support for research funding, particularly in the physical sciences, which grew some during that time. The troubled Isabelle accelerator project at Brookhaven was scrapped in favor of a bold new proton accelerator, the Superconducting Super Collider (SSC), which was to be built near Dallas, Texas. Many years later, in my conversations with OMB staff of that era, I was told that one reason for moving money to basic research in the physical sciences was the Reagan Administration's desire to cut programs favored by Democrats. William Graham (1986-89), former Deputy Administrator of NASA, was named Science Advisor following Keyworth's resignation in 1985. Graham continued the policies of the Administration and put in place the first interagency coordinated effort to study the effects of global warming and climate change. Following the election of 1988, Graham served under the new President, George H. W. Bush, until the confirmation of his nominee for Director of OSTP, who would also serve as his Science Advisor.

George H. W. Bush (41st).—President Bush appointed D. Allan Bromley (1989-1993), whom he knew, as his Science Advisor and gave him the title Assistant to the President for Science and Technology (the title of senior aides who report directly to the President), the first time that title had been used. Bromley also was confirmed as Director of OSTP. Bush also appointed an advisory committee with a new name—President's Council of Advisors on Science and Technology (PCAST), chaired by Bromley. With the fall of the Berlin Wall in 1989 and the collapse of the Soviet Union, the Bush Administration concentrated on the faltering economy and other domestic matters. Bromley, who had served on Keyworth's advisory committee, was well prepared to advise Bush on science and technology, including initiatives that were strategically important to the nation's ability to compete in a rapidly expanding global economy. In order to coordinate interagency initiatives, Bush upgraded the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) to cabinet level. Bush also signed the Global Change Research Act of 1990 as well as the 1992 UN Framework Convention on Climate Change, the foundation for the Kyoto Accord and other subsequent agreements. Bromley strongly supported the SSC against growing pressure in Congress to kill it and continuing criticism of its cost by individuals in the physics community. Funding for the SSC was finally eliminated by Congress in 1993.

Clinton (42nd).—President Bill Clinton appointed physicist John Gibbons (1993-1998), then Director of the congressional Office of Technology Assessment, as his Science Advisor, with the title Assistant to the President for Science and Technology, early in his Administration. He also was confirmed as Director of OSTP. Gibbons, an energy expert, was close to Vice President Al Gore, to whom the President deferred on science and technology matters. Clinton also appointed a new PCAST, cochaired by Gibbons and John Young, former President and CEO of Hewlett-Packard. In place of FCCSET, Clinton established the National Science and Technology Council (NSTC), a cabinet-level committee chaired by the President. The work of the Council was carried out by coordinating committees, several of which continued from the previous Administration. With the increasing importance of interdisciplinary research efforts, the NSTC continued to develop as an important policy coordination mechanism. Gibbons, one of America's longest serving Science Advisors, stepped down in 1998.

I had been appointed as NSF Director in 1993 and had intended to serve a full six-year term, having made that commitment to President Clinton and Vice President Gore. But when the President asked me to move over to OSTP as his Science Advisor, I moved. Both jobs are special and I feel privileged to have served. I was Science Advisor from August 1998 until Inauguration Day, Jan 20, 2001. The science and technology priorities toward the end of the Clinton Administration were climate change (particularly the follow-up to the Kyoto Accord and the first assessment of the possible impacts of climate change on the U.S.), energy R&D, national security, cyber-security, space policy, human genome (the first ''working draft'' of the human genome sequence was released in 2000), nanotechnology (the National Nanotechnology Initiative was established in 2001), and enhanced research funding, particularly for the physical sciences, mathematics and engineering. I had the benefit of an outstanding OSTP staff, most of whom were selected by Gibbons. I had a close working relationship with the President and Vice President and, I believe, very good rapport with other Assistants to the President and White House staff.

George W. Bush (43rd).—President George W. Bush was nine months into his first term before appointing his Science Advisor. He chose a distinguished physicist, John Marburger (2001-present), former Director of Brookhaven National Laboratory and past President of the State University of New York at Stony Brook. President Bush did not give his Science Advisor the title ''Assistant to the President'', which conveyed the impression that the Bush Administration did not place a high priority on science. Bush also appointed a PCAST, cochaired by Marburger and Floyd Kvamme, a California venture capitalist. The President reappointed two members of the Clinton PCAST, Norman Augustine, former CEO of Lockheed-Martin, and Charles Vest, then President of MIT and currently President of the National Academy of Engineering. The George W. Bush Administration has pushed for increased funding for the physical sciences in recent years but not for biomedical research, which has lost ground to inflation for the last six years of the Administration. The George W. Bush Administration has been criticized by members of the science community and by members of Congress for misrepresenting scientific findings in reports and on government web sites, overruling scientific advisory committees when considering policies related to the regulation of industry and other matters, attempting to silence government scientists, e.g., on climate change, and appointing members of scientific advisory committees for their political or ideological views rather than scientific expertise.

With this brief historical background as context, I will pose some questions that might help clarify the role and responsibilities of the President's Science Advisor, indeed all advisors to the President.

A few questions

Can scientists be expected to give objective advice without seeming to favor their own discipline, when budget issues are on the table? Does the fact that physicists have been disproportionately represented in the White House translate into bigger budgets for physics?

I am not aware of any evidence that Science Advisors have used their positions to increase funding for their field at the expense of others, although Daniel Kevles, in his book, *The Physicists,* has expressed the view that some loss of objectivity is likely to have occurred. I believe that even if a Science Advisor were inclined to push for more funding for physics, say, such a move would be seen as self-serving and quickly quashed, as has been pointed out by several past Science Advisors. It is understood that the Science Advisor likely will be an advocate for science and technology and for the federal support of science and engineering research. But that advocacy, to be effective at all, must be based on requests made by the various federal agencies, consistent with their priorities, as well as the potential relevance of research in meeting national needs and advancing the President's agenda.

Physics enjoyed a special position in 20th century America. The growth of physics research funding in universities and national laboratories following the end of World War II and during the early stages of the cold war undoubtedly was connected to physicists' contributions to the war effort. Physics remained strong in the major federal laboratories as well as several large industrial laboratories. Also, the cold-war momentum of nuclear, and later high-energy, physics—people, technology, laboratories and facilities—carried well into the following decades.

Have physicists tended to hold back their criticism of an administration out of fear that funding would be cut for their field? Alternatively, has such criticism hurt physics research funding?

It is clear that physicists did not hesitate to criticize presidents, the most prominent examples being the Administrations of Johnson, Nixon, Reagan, and more recently, George W. Bush. And, while physics funding has been flat or lost ground over several decades, there is no convincing evidence that criticism of a President by physicists has resulted in reduced funding for physics. Of course, many other scientists have also been critical of presidents over policies they disagree with. So one might broaden the question to apply to overall federal research funding. The facts are that *nondefense* R&D funding (which is 85% research and 15% development) has tracked overall *nondefense* federal discretionary spending, varying between 10% and 11% of the total, since the end of the Apollo program. The data suggest that when the federal government increases nondefense discretionary spending, research gets a share. Defense spending is another matter, where research, particularly basic research, has been a low priority for many decades.

The only field of science that has enjoyed significant steady growth for many decades is biomedical research, supported by the National Institutes of Health. It is not hard to explain the value of a "war on cancer." The NIH budget roughly doubled between 1998 and 2003, the result of an effective lobbying campaign and the leadership of the then Chair of the House Appropriations Subcommittee that had jurisdiction over NIH funding, Republican Congressman John Porter (retired 2001). Porter has said publicly that had he had jurisdiction over the budgets of other research agencies, he would have pushed for their doubling as well. The NIH budget is now about 50% of all nondefense federal spending on research, basic and applied. But, following the budget doubling period, NIH funding has been held roughly flat for six years in a row, creating something of a crisis, especially for early-career biomedical scientists.

In my opinion, physics funding has lost ground in recent decades, not because presidents and members of Congress have anything against physics—or physicists—but rather because the nation has many more priorities than it did during World War II and the early cold-war years, and most of them do not appear to relate directly to physics. Changing circumstances and priorities have meant that physics research has had to compete with other areas of science and engineering and with a long list of national needs that have little to do with science. (Recall that in the Congressional appropriations bills, DOE does not compete with NSF or NIH, rather with water projects.) As cold-war concerns diminished, so did physics funding, even though most Science Advisors have been physicists.

Some have suggested, however, that disagreements among members of the physics community about policy can impact physics funding, e.g., the matter of the SSC. I believe media coverage of physicists' criticisms of the SSC likely made the project harder to defend. However, George H. W. Bush's Science Advisor, Allan Bromley, believed that the two primary factors were the failure to secure significant foreign contributions (Japan had been expected to commit roughly $1 billion) and the escalation of the total project cost, largely due to changes in the machine design. During that period, there was considerable pressure to hold down spending and balance the federal budget: the Gramm-Rudman-Hollings deficit reduction bills were passed in 1985 and 1987. The SSC story is complicated and its tragic death had many causes and players.

Moving on to more recent times, although Science Advisor Jack Marburger was obliged to defend the George W. Bush Administration against a large number of well-publicized criticisms by scientists, there is no evidence that this dispute resulted in reduced budgets for research, at least in the physical sciences. Indeed, George W. Bush requested substantial increases for the physical sciences, mathematics and engineering at NSF, the DOE Office of Science, and NIST as part of his "American Competitiveness Initiative." And he signed the "America Competes Act" of 2007 into law, although continuing disputes with Congress have prevented the money from being appropriated.

Has public criticism of presidents by vocal members of the physics community influenced the judgment of Science Advisors in the past or affected their effectiveness in the White House?

I know of no evidence that physicists' criticisms have influenced the advice given to a President by his Science Advisor. But since such advice is confidential, it would be difficult to answer the question definitively. However, it is clear that public criticism of the President, especially if it comes from individuals serving on the President's advisory committee, as occurred during some earlier Administrations, can make the job of Science Advisor more difficult, even reducing his access to the President; the most extreme such example is the forced resignations of Nixon's Science Advisor and members of PSAC.

Lessons learned

With this abbreviated history and a few rhetorical questions as backdrop, I believe there are some lessons to be learned—from the experiences of previous Science Advisors—that may provide guidance for the future.

First, presidents must make decisions based on various kinds of often conflicting information—economic, strategic, political, as well as scientific—and they have to weigh that information in setting policy. Science is a special kind of information but, often, not the deciding factor. The value of advice given by a Science Advisor to a President depends on it being objective, based on the best current scientific understanding, and completely confidential. So, if one does not hear the Science Advisor taking a public position that we might consider appropriate but that goes against the Administration's policies, one must keep in mind that just goes with the job.

Second, the presidents' Science Advisors (by various titles) are not generally members of the inner circle of political advisors, most of whom are in the White House because of their personal relationships with the President or their political expertise or both. Indeed, only relatively recently, in the Administrations of George H. W. Bush and Bill Clinton, did the Science Advisor have the title Assistant to the President and report directly to him. Having that access to the President, using it judiciously, and *not* being in the inner circle of political advisors is the ideal situation. Guy Stever has said that it was a good thing that science was not in the White House during the Watergate disaster. I am inclined to agree with him, although I arrived in the White House shortly before the impeachment of President Clinton, and the work of the White House did not come to a halt. Had I been one of the President's close political advisors, it would have been difficult to focus on S&T policy.

Third, most of the President's time is taken up with things that relate to: national security (e.g., the Middle East), jobs and the economy (especially in down times), energy and environment, health and education, negotiations with Congress, political events around the country, scandals, bad press, national disasters (e.g., Katrina) and other crises. Rarely is science central to any of these, at least in the short term. Part of the job of the Science Advisor is to watch for opportunities to make science, mathematics, engineering and technology a significant part of the discussion and, in particular, make the important connections with high priority national needs.

Although there are many other lessons, these three are particularly important to keep in mind when thinking about how or whether science advice will be important to future presidents.

The future of physics and advice to presidents

Nothing about the three lessons implies that all or most future Science Advisors need to be, or will be physicists. What is most important is that the Science Advisor be respected by the broad science and technical R&D community—public and private sectors—understand how Washington works, possess the attitudes and personal skills that will allow him or her to establish good rapport with the other White House staff, and be seen as a team player with no agenda other than that of the President. The policy issues that the Science Advisor will deal with are likely to be highly interdisciplinary and coupled in complicated ways with issues that have little to do with science. Still, I believe that a career in physics provides an excellent background for a President's Science Advisor. Physicists deal with: the largest and smallest physical dimensions, time scales and levels of complexity; cover the spectrum from individual investigators to large collaborations; have a tradition of international cooperation (including the USSR during cold-war days); have been advisors on matters of national security for over four decades; and are increasingly involved in interdisciplinary research, e.g., with biology and medicine, astronomy, geosciences, computer sciences, and engineering. Most important, physics continues to attract many of the brightest women and men on the planet. I would argue that no other field of science has quite this reach.

I believe that the future of U.S. physics—indeed all of U.S. science, mathematics and engineering research—will depend on overcoming a number of high barriers. They largely have to do with changes in the world that have nothing directly to do with science. The outcome for our field will depend on how relevant physics—and physicists—seem to be in tackling the big issues that the public cares about, that affect the quality of life of Americans: the economy and quality jobs; health and safety; education, energy and environment; national and domestic security; and how effectively physicists can communicate that relevance to the public and political leaders. The latter is a role that, following the lead of former Democratic California Congressman, George Brown, I have called the "civic scientist"— someone who not only contributes to society through world class research and teaching of the next generation of scientists and other leaders, but as well, gives useful and honest advice to governments; reaches out to the public to speak and listen; and in other ways, helps to connect science with the things most people care about. Most societal needs require much more than science. Moreover, the relevance of science—particularly a field like physics—to such issues is not obvious to most people. So, physicists and other scientists and engineers will have to help translate the language, interpret the findings, explain the implications, speculate on possibilities, evaluate policy options, and, in some cases, get directly involved in the policy and political process. It is encouraging that we now have three Ph.D. physicists in Congress.

And they need our help. It is an uncertain and, to some extent, risky business to get close to the political process—but in my opinion, the cost of not doing so is likely to be high.

Note added in proof

On Saturday, December 20, 2008, President-elect Barack Obama announced the appointment of physicist John Holdren (Kennedy School of Government at Harvard) as his science advisor, and, following Senate confirmation, Director of the Office of Science and Technology Policy (OSTP). Holdren will report directly to the President, holding the title Assistant to the President for Science and Technology, as did science advisors for Presidents George H. W. Bush (41st) and Bill Clinton (42nd).

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[1] D. A. Bromley, *The President's Scientists: Reminiscences of a White House Science Adviser* (Yale University Press, New Haven and London, 1994); J. H. Gibbons, *This Gifted Age: Science and Technology at the Millennium* (Springer-Verlag, New York, 1997);V. Bush, *Science: The Endless Frontier*, 40th anniv. ed. (National Science Foundation, Washington, DC, 1990); *D. Allan Bromley: Nuclear Scientist and Policy Innovator*, edited by P. A. Fleury and F. Iachello (World Scientific, New Jersey and London, 2006); D. J. Kevles, *The Physicists* (Knopf, New York, 1978); J. R. Killian, Jr., *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology* (MIT Press, Cambridge, MA, and London, 1977); N. Lane, Social Research Report Series **73**, No. 3, 861 (2006). See also, "Threats to the Future of U.S. Science and Technology," in *Presidential Science Advisors: Perspectives and Reflections on Science, Policy and Politics*, edited by R. A. Pielke, Jr. and R. Klein (to be published); B. L. R. Smith, *The Advisers: Scientists in the Policy Process* (The Brookings Institution, Washington DC, 1992); G. Stever, *In War and Peace: My Life in Science and Technology* (Joseph Henry Press, Washington DC, 2001); G. P. Zachary, *Endless Frontier: Vannevar Bush, Engineer of the American Century* (The Free Press, New York and London, 1997).

[2] See 1972 Physics Survey Committee, National Research Council, D. A. Bromley (chair), *Physics in Perspective* (National Academies Press, Washington DC, 1972), Vol. 1, p. 2, and 1986 Physics Survey Committee, National Research Council, W. F. Brinkman (chair), *Physics Through the 1990's—An Overview* (National Academies Press, Washington DC, 1986), Suppl. 3, p. 115.