

REQUIREMENT FOR MANAGING AN
UNKNOWN FUTURE:
A SCIENCE-INFORMED, TECHNOLOGY-
STRENGTHENED GOVERNMENT

**The Strengthening America's Future Initiative
Issue Paper**

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The views expressed in this report do not necessarily reflect the views of the individual members of this issue team or their institutions. In some cases issue team members have offered dissents to specific sections of the issue paper.

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*Requirement for Managing an Unknown Future:
A Science-Informed, Technology-Strengthened Government*

Summary

Most all of the great challenges of the day—jobs, energy, health care, education, terrorism—have substantial science and technology content. Managing such problems—both those we perceive now and those over the horizon—demands bringing to bear the best scientific knowledge and the most advanced technologies. Yet the federal government does not have in place the requisite capacity to do so.

To be certain that science and technology-informed governance is equal to the challenges at hand, the President and the Congress must provide:

- An overarching national strategy to ensure the strength of the nation's innovative capacity and global competitiveness;
- Policy debate informed by credible and balanced science and technology-related data, information, and analysis;
- New information and communication technology tools for networking and mobilizing collective intelligence to address complex, intractable problems;
- A federal workforce strengthened by the hiring of a new generation of scientists and engineers and by continuing STEM education¹ opportunities for all federal employees;
- Increased collaboration with advanced technology companies and relevant international partners.

Cohesive Research and Innovation-related Policies, Programs, and Budgets

- Key Issue: An overarching strategy is necessary to ensure national innovative capacity and competitiveness by guiding federal policies, programs, and budgets and by countering chronic organizational stovepiping throughout the federal government.
- Recommendation: The President should initiate a *New Era of Discovery and Innovation* aimed at ensuring the nation's preeminence in technological innovation and advanced technology global competitiveness and trade. The initiative would comprise a biennial Cabinet-level review of the nation's "innovation ecology"—the intellectual, economic, and societal environment shaped in significant part by federal funding for research and education and a plethora of federal policies and practices related to such matters as intellectual property rights; export control; environmental, health, and safety regulations; government procurement; and visa policy.

A Science and Technology-Knowledgeable Federal Workforce

- Key Issue: Science and engineering expertise and basic STEM (science, technology, engineering, and mathematics) knowledge are essential for a federal workforce confronting a range of science and technology-intensive problems ranging from the nuclear fuel cycle to cyber-security to the H1N1 pandemic threat.
- Recommendation 1: Efforts to recruit and retain scientists and engineers in the federal workforce should be increased through such means as scholarships to science and engineering graduate students who are committed to government service.

- Recommendation 2: Opportunities should be provided for continuing education and training for workers in mission-critical fields and for career employees who increasingly are required to manage science and technology-laden issues.

New Data and Analytical Tools Required

- Key Issue: Challenges we face as a nation are so complex and their time constants are so protracted that analytical instruments are inadequate.
- Recommendation: New tools made possible by the Internet and the information and communication revolution—wikis, blogs, and new tools on the drawing boards that aim to exploit the Internet’s potential for enabling collective intelligence—should be engaged and explored.

Policy Debate Informed by Credible, Balanced Data, Information, and Analysis

- Key Issue: The Congress needs credible, balanced information and analysis related to the range of problems for which it has major legislative and budgetary responsibilities.
- Recommendation: A Congressional entity should be created with responsibilities to provide science and technology-related education and training for new Congressional members and staff and to shepherd a new Congressional science and technology wiki that would provide policy-relevant data and information, as well as horizontal networks with federal, corporate, and academic science and technology enterprises.

Introduction

Consider President Obama's 2010 State of the Union address and the staggering range of challenges we face:

- “China is not waiting to revamp its economy. Germany is not waiting. India is not waiting. These nations—they’re not standing still. These nations aren’t playing for second place. They’re putting more emphasis on math and science. They’re rebuilding their infrastructure. They’re making serious investments in clean energy because they want those jobs.”
- “We need to export more of our goods. Because the more products we make and sell to other countries, the more jobs we support right here in America.”
- “We need to encourage American innovation.”
- “To create more of these clean energy jobs, we need more production, more efficiency, more incentives. And that means building a new generation of safe, clean nuclear power plants in this country.”
- “We’re also confronting perhaps the greatest danger to the American people—the threat of nuclear weapons.”
- “We have gone from a bystander to a leader in the fight against climate change. We’re helping developing countries to feed themselves, and continuing the fight against HIV/AIDS. And we are launching a new initiative that will give us the capacity to respond faster and more effectively to bioterrorism or an infectious disease—a plan that will counter threats at home and strengthen public health abroad.”

The problems to which the President referred are comparable in nature to most all of the great global challenges of the twenty-first century. They have substantial science and technology content and are characterized by vast complexity, time constants that span decades or more, and a multitude of actors outside government. These are the issues of which we are now aware, but as we know well, from 9/11, Katrina, and the financial crises, the great challenges that engage us now may at any moment be surpassed by the unforeseen. Thus, we also must be prepared to meet the unknown.

Managing complex problems, both those we perceive now and those over the horizon, requires bringing to bear multidisciplinary knowledge, new ideas, and frontier innovations, including the best scientific assessments and the most advanced technologies available. But to do so requires assets that are lacking in Washington and capabilities—perhaps taken for granted—that are threatened throughout the nation.

Historically the foundation of American scientific achievements and innovative capacity has been the passion to explore, to discover, and to invent—desires that have been nurtured within a national policy environment distinguished by rule of law, intellectual property rights protection, controls on corruption, an abundance of venture capital, and such intangibles as acceptance of failure, openness to radical ideas, and freedom to challenge accepted practices.

Based in great measure on those national assets as well as our immigrant forefathers’ courage to take risks, dedication to hard work, and capability to imagine a better future for their children and their new country, the United States has been the global leader in science, technology, and innovation for more than a half of century. Now, however, our relative lead is narrowing. This is due in part to the admirable progress of others, but the loss in standing also reflects a weakening of our national research and development infrastructure.

Consider the following:

- The U.S. Patent and Trademark Office reports that the number of patent filings by U.S. inventors and businesses fell for the first time in thirteen years (by 2.3 percent) in 2009, while those by foreign entities increased by 6.3 percent during the same period. Certainly the recession is a primary factor in slowing down business introduction of new products to markets. The antiquated U.S. patent system and complex intellectual property disputes, however, also are significant inhibiting factors.
- Fifty percent of the U.S. science and engineering workforce is older than 40, according to National Science Board reports, and barring changes in retirement patterns, significant numbers will retire in the next two decades.ⁱⁱ No new generation of scientists and engineers to take their pace is apparent, however. American young people show little interest in science and engineering careers, and foreign young people—put off by tough U.S. visa policies—are beginning to look elsewhere for science and engineering training and employment.
- Although President Obama’s budget for FY 2010 includes significant increases for basic research from the 2009 budget, the total federal support of basic and applied research (including both defense and nondefense) *in inflation-adjusted dollars* will continue a significant downward trend, now down 6.8 percent from 2004. As a result, federal support for research in nearly all disciplines is in decline.ⁱⁱⁱ
- The American Association for the Advancement of Science (AAAS) forecast for future science funding prospects is dire as the coming year’s efforts to reduce budget deficits gather steam. Guidance from the Office of Management and Budget (OMB) to agencies for the FY 2011 budget is to develop two alternatives: a freeze at the FY 2010 level or a 5 percent reduction from that level.^{iv}

Federal Role in the Nation’s Research and Innovation Capabilities

The federal government provides direct support of research and innovation through funding of basic research, training of young scientists, and procurement of advanced technologies to meet government missions. Indirectly, government tax, regulatory, patent, and export controls and a range of other policies and practices help shape the intellectual, social, and economic environment within which science advances and technologies are developed and used throughout the economy.

There is growing concern, however, that the federal government lacks the requisite expertise and organizational capacity to address the range of science and technology-laden problems now and into the future. This will hamper informed government policy formulation and implementation in areas relevant to the nation’s innovative capacity, as well as in the range of security and economic challenges for which scientific knowledge and technological capabilities are central.

Consider the following examples:

- On Export Controls: Over the past two decades, the National Academies^v repeatedly have declared that the current system of export controls—designed for the Cold War era, when the United States had global dominance in most areas of science and technology—now harms our national and homeland security, as well as our ability to compete economically.^{vi} In August 2009, President Obama directed federal agencies to review and update the overall U.S. export control system “to address the threats we face today and the changing economic and technological landscape.” An effective new export control

structure will require extensive science and engineering expertise across the technological spectrum.

- On Nuclear Power and Proliferation: Plans for new nuclear power plant construction are under way globally, including in the United States. How individual countries and the international community manage nuclear fuel cycle services, requirements for safeguards and security, and related technological advance over time will help determine the security of the global nuclear environment. There is a need in the United States and worldwide for well educated personnel to support the formulation and implementation of the whole nuclear fuel cycle and related policy.^{vii}
- On Cyber Threats: President Obama has deemed cybersecurity to be “one of the most serious economic and national security challenges we face as a nation.”^{viii} A recent assessment by the Partnership for Public Service and Booz Allen Hamilton concluded that acute problems within the federal cybersecurity workforce—difficulty in recruiting and retaining highly skilled workers, reliance on contractors to fill talent gaps, poor management and arcane processes that undermine employee performance, and lack of coordination that results in agencies competing against one another for talent—are creating the potential for major vulnerabilities in our national security.^{ix}

These and similar problems indicate systemic weaknesses in the management and oversight of science and technology policies and practices that have developed over time as Washington has failed to adjust to the changing global technological, security, and economic environment. As a noted government scholar explained, “The structure of the federal government was largely crafted in the 1930s with additional jerry-built entities added for World War II and the Cold War. Little if anything has changed even as the economy globalized and we moved headlong into the Information Age.”^x

The nation needs a renewed focus and a comprehensive strategy to assure the vitality of the nation’s capacity for innovation. Significant weaknesses in the current federal system include:

- A paucity of scientists and engineers in Executive Branch agencies and the Congress and the challenge of maintaining a science and technology-literate federal workforce in the face of rapid technology advance;
- Chronic organizational stovepiping within the federal structure, both Executive Branch and Congress, that inhibits cohesive science and technology-related policies, programs, and budgets in support of national objectives;
- Inadequate sources of timely, usable, and credible science and technology-related data, information, and analysis, especially in the Congress; and
- Insufficient dialogue and partnerships with science and technology-relevant actors beyond the federal system—the private sector, nongovernmental organizations, state and local governments, international organizations, and governments globally.

Presidential Leadership for a New Era of Discovery and Innovation

Federal policies and practices have been slow to evolve in response to change—whether in the geopolitical, security, or broad global technology arenas. This stasis has been especially detrimental to the U.S. “innovation ecology” that is shaped in part by federal laws, regulations, and policies—tax policy, antitrust laws, patent law, intellectual property rights, export controls. It is within this “innovation ecology” that the nation’s capability to discover, invent, and compete globally—our innovative capacity—thrives or withers. The problem now is that many federal

policies and practices that shape that ecology were created in the context of old technologies and prior geopolitical and economic eras and have not adapted adequately to ensure future technological progress.^{xi}

Upon taking office, President Obama moved quickly to provide White House leadership to address these problems. He appointed a Senior Advisor to the President for Science and Technology, established a President's Council of Advisors on Science and Technology, and appointed scientists to top posts throughout the federal system. The President stated firmly that policy in his administration would be guided by the best science available. In the first year of his Presidency, he launched programs aimed at strengthening the nation's schools, especially in the areas of science and mathematics education and announced a major review of export control policies and practices.

All these are encouraging steps. There is concern, however, that for the United States to remain at the forefront of global science and technology progress—a position essential in meeting the challenges of technologically advanced adversaries and competitors—a comprehensive national research and innovation strategy is required.

There is a need for an overarching strategy to ensure national innovative capacity and competitiveness and to counter chronic organizational stove-piping throughout the Executive Branch and the Congress that inhibits cohesive policies, programs, and budgets. A White House-led *New Era of Discovery and Innovation* would aim to ensure the nation's preeminence in technological innovation and advanced technology global competitiveness and trade in the new century.

The initiative would comprise a biennial Cabinet-level review of the nation's research, innovation, and competitiveness. The aim would not be to construct an "industrial policy" or to "pick winners"—approaches reminiscent of Japan in the 1980s—but to assess the range of variables that affect the nation's capacity to innovate. Such a comprehensive analysis would consider the health of key technological sectors and government instruments—both direct and indirect—that have an impact on each sector's innovative vitality and global competitiveness.

A Science and Technology-Knowledgeable Federal Workforce

Parallel to an assessment of the "innovation ecology" shaped by the federal government is the question of the capabilities of the federal workforce to operate effectively in an increasingly advanced technology environment that requires policy formulation and implementation for science and technology-intensive problems ranging from the nuclear fuel cycle to cyber-security to the H1N1 pandemic threat. There is concern that there are not enough scientists and engineers in the federal workforce in such areas as cyber-security. There also is concern that technological advance is so rapid and complex that the whole of the federal workforce cannot stay adequately informed to manage science and technology-laden issues.

Attracting scientists and engineers to government service is difficult. Research universities gear training and orientation of young scientists to research and teaching careers, and scientists who may have an interest in a stint in public service are well aware of the difficulties they will encounter should they wish to return to the fast-moving research world after years of intellectual focus elsewhere. A significant factor in diminishing the attractiveness of a federal career for scientists and engineers in the past decade was the perception that federal entities undervalued or even rejected scientific findings in favor of ideological or political aims. The expanding use of earmarks in the awarding of research funds exacerbated this perception. All of these factors have

contributed to problems in recruiting scientists and engineers to federal service. (Although financial remuneration is significantly higher in the private sector, that is true as well for professionals in law, economics, political science, and other disciplines who nevertheless find significant nonmonetary rewards in government service.)

A highly successful and valued thirty-year-old program is the Science and Technology Policy Fellowship. The American Association for the Advancement of Science program places young PhD-level scientists and engineers in Congressional offices and Executive Branch agencies for one year. Science and engineering societies fund fellows based in Congressional offices, and the Executive Branch agencies fund fellows based there. The fellowships provide valuable opportunities for young scientists and engineers to participate in and contribute to public policy, and many choose to remain in federal service. The fellows, in turn, greatly benefit the receiving federal entities.

For public servants outside the scientific and engineering disciplines, maintaining basic STEM literacy is a major challenge. Frontier science and technology is fast moving and complex. It is daunting for the layperson to understand the fundamentals of the scientific method and to keep generally informed of scientific progress in a range of fields. Yet STEM knowledge is now a *sine qua non* for successful careers, companies, and communities and, an effective federal workforce. For federal employees to stay STEM-capable relevant to their professional responsibilities requires opportunities for periodic education and training that are rarely available for employees outside the military and intelligence communities.

Achieving a “science-informed, technology-strengthened” federal government will take years, perhaps a decade. It will require political will, Presidential leadership, White House management, and significant Congressional support. Means will include new information and communication (ICT) technologies adapted to the federal policy environment—not only the Internet and videoconferencing, but also wikis and blogs, social networking, and analytical tools now under development that aim to harness global collective intelligence in the service of the most intractable and complex problems. Costs in some areas may well offset savings in others. A simple example of savings from ICT investment is the potential to “offshore” or direct to a home office much of the transactional and administrative work of embassies such as video interviews and biometric identity checks for visa applications.^{xiii}

New Data and Analytical Tools Required

A science-informed, technology-strengthened government must adopt new tools to understand, track, and manage the challenges of the twenty-first century that are so complex as to seem intractable. These challenges are complicated and global, and they are likely to be with us for decades. Jack Gibbons, who served as assistant to President Clinton on science and technology, has spoken of the “time constants.” Dr. Gibbons explains that “the time constants of politics, like business, are measured in months to maybe a year or so, but the time constants of the issues we face as a nation or as a globe are measured in fractions or multiples of a century. It is this discontinuity between the perspectives of the long and short time constants that presents challenges to governance.”

To manage policy problems, the federal government currently utilizes a wide array of instruments to provide a foundation of data, information, and analysis to formulate alternative policy options, institute decisions and implementation, and engage major actors beyond Washington, D.C. Deliberative bodies such as interagency task forces, senior study groups, bipartisan commissions, and nongovernmental entities are tasked to assess problems and make recommendations. For issues involving science and technology, the National Academies’ studies represent the “gold

standard,” providing synthesis of knowledge and recommendations for questions posed by government agencies. None of these mechanisms, however, seem to provide a range of capabilities equal to the complex, global, protracted nature of twenty-first-century challenges.

Governmental entities are just beginning to employ new tools made possible by the Internet and the information revolution. In 2006 the intelligence community began using self-organizing knowledge web sites, known as wikis, and information-sharing sites, known as blogs, to aid the intelligence community to manage the pace and complexity of the intelligence challenges. *Intellipedia*, a wiki now used by more than 35,000 U.S. intelligence, diplomatic, and military organizations, allows authenticated users to aggregate information and knowledge by creating, editing, and discussing articles in a topically focused space.^{xiii} A primary asset of *Intellipedia* is the capability to handle rapidly changing, complicated threats and to allow the intelligence community to become complex and adaptive in response. Equally valuable was *Intellipedia*’s communication and collaboration function.

Accordingly, a wiki tool could be usefully employed by the Department of Homeland Security’s Science and Technology Directorate, which recently was the target of a congressionally mandated review of the structure, processes, and execution of its cross-government leadership role. The review acknowledged the significant challenge the directorate faced in herding multiple federal agencies to pull together a comprehensive strategic research plan but was devastatingly critical of its failure to do so. The review cited lack of a cohesive strategy, cultural insularity, and an absence of vision.^{xiv} A Homeland Security Science and Technology wiki may not be adequate to address shortcomings of culture and vision, but, as demonstrated in the case of the intelligence communities’ communication and collaboration problems, it could help bring together fragmented structures through increased communication, information sharing, and transparency.

As useful as wikis and blogs are for knowledge capture, they do not address the need for coherent policy responses to complex problems that require multidisciplinary expertise, involve competing perspectives and are international in scope. New tools known as “argumentation” or “rationale capture” are now on the drawing board and aim to exploit the Internet’s potential for enabling collective intelligence to solve complex problems.^{xv} The aim would be the development of tools to aggregate scientifically grounded data, information, and insights and to enable the capture of “collective intelligence” to analyze, debate, and help identify ways to address seemingly intractable global problems over time.

Toward a Science and Technology-Enhanced Congress

Congress is a central player in federal actions on science and technology, yet, as with the Executive Branch, serious impediments hamper informed and effective Congressional implementation of legislative, oversight, budgetary, and policy responsibilities. Congressional efforts on matters related to science and technology are handicapped by a number of long-standing problems.

A contentious debate over the years related to science and technology in the Congress has centered on the need for a source of science and technology analytical support and the associated arguments, pro and con, for reestablishing the Office of Technology Assessment (OTA). Congress created the research entity in 1972 and terminated it in 1995.^{xvi} A number of independent studies have considered the viability of resurrecting OTA and also considered alternative institutional models such as expanded use of the Congressional Research Service (CRS), the Government Accountability Office (GAO), the Congressional Budget Office (CBO), and the National Academies or the creation of a new entity either within Congress or operated by a nongovernmental organization.^{xvii}

In recent years, there have been various Congressional initiatives to develop a science and technology advisory entity. These have included efforts to restore OTA, to create a new entity to conduct technology assessments for Congress, and to create a technology assessment capability in the GAO or under its direction.^{xviii} None of these initiatives have been successful in providing the Congress with science and technology analytical capabilities related to the range of challenges for which Congress has major legislative and budgetary responsibilities. Accordingly, the 111th Congress inherited what is considered by many observers to be a structure bereft of science and technology analytical support in a time of science and technology-infused national and global challenges.

It is a circumstance that should not be tolerated. A new Congressional entity providing science and technology-related education and training for new Congressional members and staff and shepherding a Congressional science and technology wiki could provide policy-relevant data and information, as well as horizontal networks with federal, corporate, and academic science and technology enterprises. The nature of a well-developed wiki, with its transparency and editing functions, should provide the timely, credible data and information the Congress needs. Comprehensive analyses of important issues, however, would still be lacking.

A Congressional science and technology wiki could also address the weaknesses of a key determinant of the way Congress works and one that resists change—the committee structure. The Congressional committee and subcommittee structure in large measure affects the way policy issues are defined and framed, which committees are involved, and which Congressional members participate in debate and actions. This complex structure fragments responsibility for broad national concerns such as homeland and national security and hampers overview of crosscutting issues, such as funding for energy R&D or the policies and programs of multiple agencies that affect technology competitiveness.

A Congressional wiki could constitute a flexible, collaborative means of addressing the problems inherent in the now stove-piped committee and subcommittee structure. A shared wiki with the Executive Branch, if deemed acceptable to both branches of government, would provide a common basis of data and information on which to base communication and cooperation on key policy issues.

Conclusion

President Obama's April 2009 address to the National Academy of Sciences in which he deemed science "more essential for our prosperity, our security, our health, and our environment, and our quality of life than it has ever been"^{xix} and announced new initiatives and investments in scientific research, innovation, and education set federal science and technology policy on a new path. His remarks were designed to signal to the scientific community that strengthening research and innovation is one of his top priorities and, more broadly, to convey to the public the message that the nation's science and technology enterprise can help meet seemingly insurmountable twenty-first-century problems and ensure a stronger, healthier, and more prosperous future for our children.

Making the President's vision a reality will require an overarching national strategy to ensure the strength of the nation's innovative capacity and global competitiveness; policy debate informed by credible and balanced science and technology-related data, information, and analysis; new information and communication technology tools for networking and mobilizing collective intelligence to address complex, intractable problems; a federal workforce strengthened by the

hiring of a new generation of scientists and engineers and by continuing STEM education opportunities for all federal employees; and increased collaboration with advanced technology companies and relevant international partners. In short, it requires a science-savvy, technology-enhanced federal government.

Endnotes

ⁱ STEM (science, technology, engineering, and mathematics)

ⁱⁱ National Science Board, *Science and Engineering Indicators 2004*, Vol. 1, NSB 04-1, Arlington, VA: National Science Foundation, 2004.

ⁱⁱⁱ American Association for the Advancement of Science Report XXXIV: Research and Development FY 2010.

^{iv} Ibid

^v The National Academies are an advisory group composed of the National Academy of Sciences, National Academy of Engineering, National Research Council, and the Institute of Medicine.

^{vi} National Research Council, *Beyond "Fortress America": National Security Controls on Science and Technology in a Globalized World*, National Academies Press, 2009.

^{vii} National Research Council, *Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges*, National Academies Press, 2008.

^{viii} "Securing Our Nation's Cyber Infrastructure," speech by President Obama, May 29, 2009.

^{ix} "Cyber IN-SECURITY: Strengthening the Federal Cybersecurity Workforce," Partnership for Public Service and Booz Allen Hamilton, July 2009.

^x Norman Ornstein, "Social Networking Sites May Be Model for the Government," *Roll Call*, July 15, 2009.

^{xi} William A. Wulf, "Changes in Innovation Ecology," *Science* editorial, Vol. 316, No. 5829, June 1, 2007, Page 1253.

^{xii} Jerrold D. Green, "The Future of Diplomacy: Real Time or Real Estate?" *RAND Review*, summer 2008.

^{xiii} The catalyst for the intelligence community's adoption of these tools was the paper "The Wiki and the Blog: Toward a Complex Adaptive Intelligence Community," by D. Calvin Andrus. PhD, Office of Application Services, CIA, September 10, 2005.

^{xiv} "Department of Homeland Security Science and Technology Directorate: Developing Technology to Protect America," a report by a panel of the National Academy of Public Administration, June 2009.

^{xv} Mark Klein, "Achieving Collective Intelligence via Large-Scale On-line Argumentation," Center for Collective Intelligence, MIT Sloan School of Management working paper 4647-07; available at <http://ssrn.com/abstract=1040881>.

^{xvi} On November 8, 1994, the Republicans won control of both houses of Congress for the first time in forty years and embarked on implementing their "Contract with America," a ten-point legislative plan to cut federal taxes, balance the budget, and dismantle a host of welfare and other programs. The Congressional Office of Technology Assessment was an early casualty of Republican rule.

^{xvii} A recent extensive exploration of alternatives may be found in *Science and Technology Advice for Congress*, edited by M. Granger Morgan and Jon M. Peha and published by Resources for the Future in 2003.

^{xviii} A Congressional Research Service report, "Technology Assessment in Congress: History and Legislative Options," by Genevieve J. Knezo, reviews the history of Congressional efforts to restore OTA or to establish alternative institutional arrangements, Order Code RS21586, May 20, 2005.

^{xix} Barack Obama, "Remarks by the President at the National Academy of Sciences Annual Meeting," April 27, 2009, http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-at-the-National-Academy-of-Sciences-Annual-Meeting