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Science and Technology: Recommendations for the Next Administration

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Overview

Science and technology (S&T) affect almost every area of policy including national security, the economy, health and safety, the environment, education, energy, and agriculture. There is a close relationship between S&T and the ability of the nation to meet economic, security, and social goals. This connection is clear to government leaders not only in the United States and other developed nations, but especially in China, India, and other countries of the developing world.

The discovery of new knowledge and technologies and their diffusion into the public domain drives innovation and contributes to sustainable economic growth and social well-being. Innovative applications of S&T create new industries and better jobs, increase productivity and fuel economic growth. Targeted research in universities and national laboratories contributes directly to the development of new sources of carbon-free energy and ways to use energy more efficiently; improved public health and affordable health care for all Americans; stewardship of the environment and the diversity of life on the planet; security of our homeland; the effectiveness of our educational systems; and the overall enhancement of the standard of living of people in the United States and throughout the world.

It is our view that President-elect Barack Obama should make S&T a higher priority than it has been in recent years. His decision in late December to name John Holdren as a science advisor with the rank “Assistant to the President” is an encouraging indication that White House policies will be based on evidence-based science. But there is still much work to be done. Specifically, the president-elect should:

- *Recommendation 1:* Insure that federal policy is grounded in the best scientific and technical information and advice.
- *Recommendation 2:* Enhance federally funded science and engineering research and development in high-priority areas.
- *Recommendation 3:* Mandate a comprehensive review of all federal programs in K-12 education and implement major reforms, particularly in the nation’s approach to science, technology, engineering, and mathematics education.

Background

Applications of the knowledge and tools that result from advances in S&T influence virtually every aspect of people's lives—how they live, work, communicate, stay healthy and happy—as well as public policy issues as diverse as energy, national security, and public health. To assure that the best policy decisions are made, it is essential that the best scientific and technical information and advice are available. This requires that scientists and engineers be willing to commit several years of their careers to public service. It also requires that the administration recruit outstanding qualified people to top positions in government and on federal advisory committees.

Our government's policy toward S&T also has important ramifications for industry and employment. U.S. science and engineering research has spearheaded innovation that has been a driving force for our economy since World War II. New products for market and powerful medical treatments and innovative technologies that lead to new jobs all come out of discoveries and inventions based on science and engineering R&D, often from universities. With the current economic downturn, many federal programs will struggle to keep their funding. Investing in R&D is not only an investment in the future sustainability of the country, but is also a means to help promote the innovation needed to improve our current economic situation and, in the case of purchases of equipment and construction of large facilities, contributes directly to business recovery and job creation.

But none of this will be possible unless the U.S. education system is reformed. The crisis in American K-12 education is well documented and has received considerable attention by many administrations. Nevertheless, it remains one of the most serious challenges facing this country. It will require new ideas and presidential leadership. Education in the United States is vital to creating a Science, Technology, Engineering, and Mathematics (STEM) workforce necessary to compete internationally. Not only will the nation need outstanding scientists and engineers to replace the Apollo generation of baby boomers, but it will also need workers in a broad spectrum of jobs who have technical knowledge and skills that greatly surpass those of earlier generations.

Recommendations

Recommendation 1: Insure that federal policy is grounded in the best scientific and technical information and advice.

> "Science, like any field of endeavor, relies on freedom of inquiry; and one of the hallmarks of that freedom is objectivity. Now more than ever, on issues ranging from climate change to AIDS research to genetic engineering to food additives, government relies on the impartial perspective of science for guidance."
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> —President George H.W. Bush, April 23, 1990.

Recommendation 1.1: Appoint a nationally respected scientific leader to be the president's science advisor, with the rank "Assistant to the President for Science and Technology" and nominate that individual to be director of the White House Office of Science and Technology policy (OSTP) within the first month of the new administration.[1]

We are encouraged by the president-elect's decision in late December to name as scientific advisor John Holdren, a noted Harvard University physicist and winner of a "genius" grant from the MacArthur Foundation. Holdren will report directly to the president, another encouraging step. Below, we spell out what his role ideally should encompass:

Findings:

- The principal responsibilities of the science advisor are to:
  - Advise the president and others within the Executive Office of the President;
  - Lead an interagency effort to develop and implement sound science and technology policies, priorities and budgets in support of the president's agenda;
  - Work with the director of the Office of Management and Budget (OMB) to convey priorities to the agencies;
  - Coordinate with the private sector to ensure that the federal policies and programs that relate to S&T contribute to the nation's economic prosperity, sustainability, and national security;

[1] Based on recommendations from the National Academies report "Science and Technology for America's Progress," available at www.nap.edu and the Woodrow Wilson Center report "OSTP 2.0: Critical Upgrade," available online at http://www.wilsoncenter.org/news/docs/OSTP%20Paper1.pdf.

    - Build strong partnerships among federal, state and local governments, other countries, and the scientific community;
    - Evaluate the scale, quality, and effectiveness over the long term of the national effort, public and private, in S&T.[2]
- Traditionally, the science advisor serves as director of OSTP, a Senate-confirmed position.
- As director of OSTP, the science advisor oversees the effectiveness of the federal R&D investment and reports, as requested, to Congress.

It is essential that the president's science advisor be a scientist (or engineer) of high standing within the technical professional community. The nation's leading scientists, engineers, and other professionals will need to be assured that the results of their research and the advice they provide to the government will be used appropriately for the benefit of the American people. The individual selected as science advisor should also be respected by policymakers and have a good understanding of how the federal government works, how large research or education enterprises are managed, and a sense of the most important national S&T policy issues (including but not limited to R&D). In addition, the science advisor should be able to effectively articulate important scientific and technical issues, including principles and ideals, discoveries, opportunities, and potential consequences, to the general public and policymakers.

The title "Assistant to the President," while not a statutory requirement for the position of science advisor, nevertheless is important, since having direct access to the president also insures that the science advisor will be included in all important discussions in the White House that deal with matters related to S&T. It also shows that S&T is a high priority for the new administration. Science advisors to former Presidents George H.W. Bush and Bill Clinton all held this title.

Furthermore, it is critically important that the president's science advisor be named early in the administration, preferably before inauguration day, so that he or she can be of assistance to the president in selecting the heads of several agencies that focus on S&T and developing the administration's agenda and priorities. The current science advisor, John Marburger III, was nominated in June and confirmed in October 2001, almost ten months after the administration

[2] The OSTP mission: http://www.ostp.gov/cs/about_ostp.

took office and following the 9/11 terrorist attacks. During the period between George W. Bush's inauguration and Marburger's confirmation, the administration made a number of important science policy decisions on topics from embryonic stem cell research to climate change and the environment. In addition, Marburger was not given the title "Assistant to the President."

Recommendation 1.2: Relocate the White House Office of Science and Technology to space within the Dwight David Eisenhower Executive Office Building.

Findings:

- It was tradition, until the George W. Bush Administration, that the offices of the science advisor (director of OSTP) and his or her staff be located in the Dwight David Eisenhower Executive Office Building, with easy access to most offices of the president, vice president, and their senior advisors;
- OSTP was moved to a location outside the White House complex after the terrorist attacks of September 11, 2001, just prior to Marburger's confirmation as director of OSTP.

The physical location of the science advisor and his or her OSTP staff is critically important to the effectiveness of the position. Advising the president also means working closely with the president's other senior policy advisors and councils—economic, national security, domestic, energy and environment, information technology—and their offices to ensure that they have the information they need on domestic and international policy matters in their purview. Since S&T are increasingly fundamental to every other area of policy, the science advisor and OSTP staff must have easy access to the other offices.

Recommendation 1.3: Nominate individuals to serve as heads of the federal agencies and offices involved in supporting R&D as well as the four associate directors of OSTP within the first two months of the new administration.

Findings:

- Agencies and offices that provide most of the federal government's R&D support include the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Energy's Office of Science, the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautical and

Space Agency (NASA), the U.S. Geological Survey (USGS), and the Department of Defense Advanced Research Projects Agency (DARPA).

- OSTP is authorized to appoint up to four associate directors (all subject to Senate confirmation). The George W. Bush administration filled only two (S&T) associate director positions in OSTP.

Within the first month of the administration, if not before, the science advisor should develop a short list of candidates for the top S&T positions and four associate OSTP directors so that they can be appointed within the first two months of the new administration. The science advisor will likely already know many of these individuals and will be in an ideal position to evaluate their qualifications by consulting with leaders in the broad S&T community. These candidates should be well-respected scientists or engineers who have the confidence of the president as well as the staff of their agency or office.

The early Senate nominations of these individuals for these positions will help smooth the transition between administrations and provide an early start to move the president's agenda forward as it concerns S&T. And, with the early selection and Senate confirmation of four associate directors of OSTP, these important S&T officials will be able to help the science advisor select OSTP staff and move rapidly to address the president's S&T priorities and define how the agencies will work with the science advisor, OSTP, and OMB.

Recommendation 1.4: Appoint leaders in the science, engineering and technology community to serve on the President's Council of Advisors on Science and Technology (PCAST) within the first three months of the new administration.

Recommendation 1.5: Re-establish the cabinet level interagency National Science and Technology Council (NSTC), chaired by the President, within the first month of the new administration.

Findings:

- PCAST is an external presidential advisory committee that provides independent advice to the president on S&T matters and helps to evaluate federal S&T policy and programs.[3]
- PCAST was originally formed in 1990 by President George H.W. Bush, with the advice of his science advisor, Allan Bromley, to enable the president to receive advice from the private and academic sectors on technology, scientific research priorities, and mathematics and science education.
- PCAST, in recent years, has consisted of members who are nongovernment professionals, with the director of OSTP serving as chair or co-chair along with a committee member.
- In contrast to PCAST, NSTC is a government body, a cabinet-level council established in 1993 to coordinate S&T policy within the executive branch. Along with the director and associate directors of OSTP, NSTC coordinates interagency activities, and recommends program priorities and budget allocations for interagency federal S&T programs.[4]
- The members of the NSTC are cabinet secretaries and heads of the agencies (sometimes represented by their deputies) most involved in supporting R&D and, in principle, is chaired by the president. The work of the Council is carried out by a number of coordinating committees with representatives from all the relevant R&D agencies.

PCAST and NSTC are two important S&T advisory bodies available to the president on S&T policy matters. PCAST can offer the new administration high-quality advice and an independent view from the academic and private sector. They can also help the president and science advisor understand S&T trends, sharpen assessments of options and consequences, and advise them on the formulation of policies.[5] We recommend that PCAST be in place within the first few months of the administration.

The administration should also re-establish NSTC. NSTC, a government body, is most effective in planning and coordinating the implementation of interagency S&T activities. In order to better coordinate the work of the agencies, NSTC needs to be empowered to influence agency priorities

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[3] PCAST information based on Web site: http://www.ostp.gov/cs/pcast.
[4] NSTC information based on Web site: http://www.ostp.gov/cs/nstc.
[5] Based on recommendations the Woodrow Wilson Center report "OSTP 2.0: Critical Upgrade," available online at http://www.wilsoncenter.org/news/docs/OSTP%20Paper1.pdf.

and budgets. Substitutions at NSTC meetings should be limited to deputy secretaries or deputy heads of other agencies to emphasize the importance of their decisions.

Recommendation 1.6: Insure that the president's science advisor sits on all White House councils that relate to S&T matters.

The agencies and the science advisor (along with the OSTP and OMB staff) need to work as a "team" in support of the president's agenda. Federal agencies are largely independent of one another, and the Congressional appropriations process often discourages cooperation. Better coordination of agencies' activities across government is necessary, if an S&T agenda is to be elevated in the next administration. That can only happen if the president makes it a priority. By serving on all White House policy councils that have S&T issues (e.g. national security, economic, domestic and possibly energy and climate policy councils), the science advisor can be of assistance to other senior presidential advisors in developing policy options for the president's consideration.

Recommendation 1.7: Issue an executive order directing federal agencies to restore the integrity of science in policymaking by insuring that all policies are based on the best evidence-based scientific information and expert advice.

Findings:

- In the 2004 report "Scientific Integrity in Policymaking," the Union of Concerned Scientists documented several incidents that occurred during the George W. Bush administration, in which scientific findings and scientists' opinions and advice were manipulated to serve a political agenda without regard for the potential impact of the results.[6]
- The report also highlighted individuals appointed to scientific advisory committees who had well-known biases or financial conflicts of interests, which created doubts about the objectivity of their advice.
- Furthermore, the report described instances where research findings and reports that did not support the administration's political agenda were withheld from public view or altered at the behest of the White House or political appointees in several federal agencies, including the

[6] Union of Concerned Scientists (UCS), 2004, "Scientific Integrity in Policy Making: An Investigation into the Bush Administration's Misuse of Science." Cambridge, MA: Union of Concerned Scientists. February 18. An updated edition of this report, published in March 2004, is available online at http://www.ucsusa.org/rsi.

State Department, Environmental Protection Agency (EPA), and the Centers for Disease Control and Prevention (CDC). These actions affected how topics such as climate change, environmental risks, sexually transmitted diseases, birth control, and sex education were addressed by the administration and how scientific findings were described in government reports or on Web sites.

Americans expect their government to formulate policies and regulations based on the best available scientific and technical information. An executive order will insure that the agencies take appropriate steps to restore the integrity of evidenced-based science in setting policies and implementing programs: provide accurate scientific and technical information in government reports and on Web sites, appoint only the most qualified scientists and technical experts to scientific advisory committees without regard to their political views, and allow federal government scientists to speak out on matters within their areas of expertise.

Recommendation 2: Enhance federally funded science and engineering research and development in high-priority areas.

> "Since the Industrial Revolution, the growth of economies throughout the world has been driven largely by the pursuit of scientific understanding, the application of engineering solutions, and continual technological innovation."
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> —National Academies Report "Rising Above the Gathering Storm"[7]

Because of the recession that now threatens the welfare of millions of Americans, much attention is being given to economic stimulus and recovery. President Obama will set priorities for the upcoming budgets, advancing some initiatives and programs at the expense of others. We believe that increased investments in S&T R&D activities and infrastructure will contribute to the nation's economic recovery as well as insure its long-term economic sustainability and security.

[7] The National Academies, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," 2007. Available at www.nap.edu.

Recommendation 2.1: Increase science and engineering research budgets for agencies and programs singled out in the "America COMPETES Act" to achieve the ten-year doubling (beginning with FY2008) specified by the act, and for other agencies and programs that use merit review for their funding decisions.

Findings:

- U.S. federal investment in non-defense R&D (which is mainly research) as a fraction of GDP is predicted to drop to 0.4 percent GDP in 2008 from 0.7 percent GDP in 1970.[8]
- While the United States spends approximately $140 billion—or 2 percent of its total annual budget—on R&D; most of this money is spent on development and testing of large weapons systems for the Department of Defense. Only $56 billion (fiscal year 2007) is invested in research (basic and applied) conducted in universities, medical schools, and national laboratories.
- Over the past eight years, the NSF budget has seen only modest increases. From its peak in 2004, the NSF budget has declined in constant dollars every year since that time.
- The NIH budget is roughly half of the total federal investment in nondefense R&D. But, after seeing its budget double from 1998 to 2002, the NIH budget has received increases below the rate of inflation each year (from a 3.2 percent increase in fiscal year 2004 to a 0.0 percent projected increase in fiscal year 2009). In constant dollars, the NIH budget has actually decreased since 2005, after adjusting for inflation.
- The "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act," passed by Congress with strong bipartisan support and signed into law by President George W. Bush in 2007, authorized a doubling of NSF by 2011 and DOE's Office of Science in ten years. Furthermore, it approved a NIST increase to $937 million from $703 million by 2011. But none of the increases in funding were appropriated in fiscal year 2008 and 2009 budgets.

Clearly, increases in agency budgets, especially during a time of economic crisis and fiscal constraints, will receive a high level of scrutiny. We believe that increased investments in S&T are in the best interest of the nation's economic recovery and sustainability. Peer review is the best mechanism to insure these funds are spent wisely. The doubling of the research budgets for

[8] American Association for the Advancement of Science (AAAS), http://www.aaas.org.

agencies highlighted in the "America COMPETES Act" (NSF, DOE's Office of Energy Research and NIST) involves appropriating a 14 percent increase for FY2009 followed by 7 percent annual increases over a decade. Other agencies and programs that use merit review for their funding decisions, including NIH, should be considered for similar growth. These increases are prudent investments that are likely to pay big dividends in both the short and long run. The additional funding would lead to significantly improved grant funding rates ideally to a level above 25 percent. Furthermore, it would make optimal use of the intellectual capital that has been developed in universities and national laboratories.

Because future budgets are unpredictable, the administration should require all agencies to have contingency plans in place to soften the impact in case future budget increases are not realized. Such planning should be a central part of each annual budget request.

Recommendation 2.2: Place a high priority on increasing funding for early-career research; high-risk, high-reward (potentially transformational) research; and give increased attention to international collaborations.

> "Ninety-nine percent of the discoveries are made by one percent of the scientists."
>
> —Julius Axelrod, Nobel Laureate[9]

Findings:

- Many agencies have difficulty cultivating and rewarding new investigators. From 1980 to 2006, the average age for the first grant at NIH increased from 37.2 to 42.4, while faculty positions in medical schools more than doubled (medical schools receive approximately 55 percent of NIH's research funding).[10] At NSF, it is estimated that the average age for a first award is 39 to 40.[11]
- NSF defined "transformational research" as "research driven by ideas that have the potential to radically change our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such

[9] Julius Axelrod, in the Proceedings of the American Philosophical Society, Vol. 149, No. 2, June 2005.
[10] Data available from NIH on their Web site: www.nih.gov.
[11] NSF 2006 Survey of Doctoral Recipients, www.nsf.gov/statistics/srvydoctoratework/.

research also is characterized by its challenge to current understanding or its pathway to new frontiers."[12]

- The American Academy of Arts and Sciences release a report in 2008 titled "Advancing Research in Science and Engineering (ARISE): Investing in Early-Career Scientists and High-Risk, High-Reward Research," which listed recommendations on how to help promote early-career faculty and promote high-risk (potentially "transformational") research projects in an effort to nurture young scientists.[13]

Young scientists increasingly face long graduate and post-doctoral training periods before having an opportunity to establish independent careers. They also experience significantly lower funding rates than more veteran investigators and, hence, must spend more time preparing additional grant proposals. Furthermore, agencies have trouble funding truly daring and high-risk ideas, where the opinions of expert reviewers are often mixed. When funding is limited, reviewer decisions tend to be conservative. Projects that are innovative, but unconventional, usually get put aside in favor of low-risk projects with more predictable results and new investigators lose out to more established researchers. While science often proceeds in incremental steps, unexpected breakthroughs, resulting from bold paradigm shifts, and projects challenging accepted ideas, make the biggest contributions to new innovations. But regardless of the budget levels, additional funding should be provided to improve funding of early-career investigators and high-risk, high-reward ("transformational") projects.

PCAST could be tasked to assess how agencies are encouraging early-career researchers and high-risk, potentially transformational projects and recommend steps the agencies should take to give higher priority to these areas. Recommendations from the ARISE report include creating large, multi-year awards for early-career faculty and considering targeted programs, grant mechanisms, and policy to foster transformative research.

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[12] Quote from National Science Board briefing by NSF, "Enhancing Support of Transformative Research at the National Science Foundation," August 10, 2007, http://www.nsf.gov/nsb/documents/2007/tr_report.pdf.
[13] Based on recommendations from the American Academy of Arts and Sciences report, "ARISE: Investing in Early-Career Scientists and High-Risk, High-Reward Research."

In addition, while international research projects are encouraged by several agencies, particularly in cases where partners are desirable to share costs of large facilities, overall international collaborations have not been a particularly high priority. With the rapid growth of research budgets and expertise, particularly in parts of Asia and South America, it will be increasingly important—indeed in our own self interest—to encourage collaborations between U.S. researchers and their foreign counterparts. PCAST could be tasked to review international collaborations across the federal government and make recommendations to the president. The National Science Board could also contribute a valuable perspective on this matter.

Recommendation 2.3: Create a set of "Presidential Grand Research Challenges" and interdisciplinary federal research budget initiatives focused on specific national needs in the first year of the administration.

Findings:

- Grand challenges have proved helpful in past administrations to focus interagency research activities on national goals.
- For instance, the "Grand Challenges in Global Health" created in 2003 and funded by the Bill and Melinda Gates Foundation revolutionized and prioritized biomedical research for the developing world.[14]

The science advisor, working with the agencies through NSTC should be charged to develop for the president a number of options for "grand research challenges." The challenges should be interdisciplinary and interagency research efforts that are focused on vital national needs. Possible areas include

- Efficient energy storage and transmission,
- Carbon-free energy production,
- National health disparity,
- Sustainable development,
- Carbon sequestration,
- Adaptation to climate change,

[14] The Bill and Melinda Gates Foundation Grand Challenges for Global Health: http://www.gcgh.org.

- Innovation and emerging technologies (e.g. nanotechnology, synthetic biology, next-generation computing, and communication) and
- Renewal of the nation's infrastructure (e.g. new transportation systems).

This focus on interdisciplinary and interagency grand challenges should not preclude disciplinary "grand challenges" in such fields as high-energy elementary particle physics, astronomy and particle astrophysics, geosciences, life sciences, materials science, computing and communications, and fields of engineering. Proposals for these initiatives, which often involve large shared facilities, should be sought from the respective research communities and reviewed by the R&D agencies.

PCAST could be asked for early advice on grand challenges and also tasked to review options developed by the science advisor, as was done when President Clinton was considering his National Nanotechnology Initiative.

Recommendation 2.4: Remove restrictions on federal funding of stem cell research.[15]

Recommendation 2.5: Carry out a comprehensive review of U.S. space policy and the status of NASA planning.[16]

Recommendations 2.4 and 2.5 address two areas of science policy that were heavy impacted by the Bush Administration: 1) strict limitations of human embryonic stem cell research and 2) the U.S. space program and NASA's de-emphasis of science. Visit the Baker Institute's Policy Recommendations page for more information at http://www.bakerinstitute.org/front-page/news/policy-recommendations-for-the-next-administration.

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[15] Kirstin Matthews and Neal Lane, "Human Embryonic Stem Cell Research: Recommendations for the Next Administration" at www.bakerinstitute.org

[16] George Abbey and Neal Lane, "Space Policy: Recommendations for the Next Administration," *in progress, to be posted at* www.bakerinstitute.org.

Recommendation 3: Mandate a comprehensive review of all federal programs in K-12 education and implement major reforms, particularly in the nation's approach to science, technology, engineering and mathematics education.

> "If you can solve the education problem, you don't have to do anything else. If you don't solve it, nothing else is going to matter all that much"
>
> —Alan Greenspan, Federal Reserve Board Chairman.

Disadvantaged by today's U.S. K-12 educational system, the average American simply does do not know enough mathematics and science to be able to effectively contribute to changing technological workforce that requires continued learning. Meanwhile, nations like China, India, and other countries in the developing world are focusing their resources on education and training with the hope of leapfrogging the United States in the global market, the "flat world" of author Thomas Friedman. All studies of the U.S. educational challenges make clear that major reforms are needed and that there is no single solution. It is a complex problem requiring attacks on several fronts.

Progress in qualitatively improving K-12 education in the United States will require bold ideas and major reforms, far beyond what have been attempted in the past. Serious consideration should be given to funding multidisciplinary research, including large-scale experiments, to better understand how technology can be used to improve student learning. For this, we recommend PCAST study the issue and make recommendations for innovative and daring projects to improve the system.

Recommendation 3.1: Increase the numbers of well-trained K-12 teachers in science and mathematics and provide support for their continuing education and retention in the profession.

Findings:

- In 1999, 68 percent of U.S. 8th grade students received instruction from a mathematics teacher who did not hold a degree or certification in mathematics.[17]

[17] National Science Board, "Science and Engineering Indicators 2004," http://www.nsf.gov/statistics/seind04/.

- In 2000, 93 percent of students in grades 5–9 were taught physical science by a teacher lacking a major or certification in the physical sciences (chemistry, geology, general science, or physics).[18]

The National Academies report "Rising Above the Gathering Storm" highlighted K-12 education as one of the nation's top priorities.[19] The report recommended that the federal government provide funding for scholarships to university mathematics and science majors who are willing to teach mathematics and science after graduation. It also recommended supporting continuing education programs to strengthen the skills of current mathematics and science teachers. This could be done through summer institutes, masters programs, and Advance Placement (AP) and International Baccalaureate (IB) training programs, all of which have been shown to be effective. By training and educating thousands of teachers and giving them the necessary tools to teach STEM programs, millions of students can be impacted. Although these steps are not revolutionary, past experience makes results virtually guaranteed.

Recommendation 3.2: Insure that every student who graduates from an American high school possesses a good understanding of mathematics, the life and physical sciences, as well as engineering and technology, according to a set of mandatory national standards.

> "America's high schools are obsolete. By obsolete I don't just mean that our schools are broken, flawed, and under-funded—though a case could be made for every one of those points. By obsolete, I mean that our high schools—even when they're working exactly as designed—cannot teach our kids what they need to know today …. This isn't an accident or flaw in the system; it is the system."
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> —Bill Gates, former CEO of Microsoft and Chairman of the Bill and Melinda Gates Foundation

[18] National Center for Education Statistics. Schools and Staffing Survey, 2004, "Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987–88 to 1999–2000 (revised)." 2004.
[19] The National Academies, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," 2007, www.nap.edu.

Findings:

- Less than one-third of U.S. 4th grade and 8th grade students performed at or above a level called "proficient" in mathematics.[20]
- U.S. fifteen-year-olds ranked 24th out of forty countries that participated in a 2003 administration of the Program for International Student Assessment (PISA) examination, which assessed students' ability to apply mathematics concepts to the real-world.[21]

Another aspect of empowering teachers to teach well is the curriculum. In order to be successful in this increasingly knowledge-based world, a fundamental understanding of science and mathematics is absolutely essential. High school graduates who do not have this knowledge and skills are seriously disadvantaged in seeking good jobs and advancing their fields. This implies, at the very least, the need for a uniform set of national mathematics and science standards. These standards should highlight the scientific method and inquiry-based education as well as the basic principles and theories in the natural sciences (i.e. biology, chemistry, physics, and earth sciences) and important aspects of engineering and technology. Ideally, every school—public and private—should be required to adopt these standards. We believe it is in the national interest that everyone who lives and works in this country have a basic understanding of the physical and biological natural world around them and possess the mathematical and technical skills they will need to be productive and involved citizens.

The continued rapid development of computing and the Internet has made possible new powerful approaches to teaching by employing modern information technology. One example is the online mathematics-teaching tool "Reasoning Mind,"[22] which was highlighted in the recent report on Texas education by The Academy of Medicine, Engineering, and Science of Texas (TAMEST).[23]

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[20] National Center for Education Statistics. 2006, "The Nation's Report Card: Mathematics 2005," http://nces.ed.gov/nationsreportcard/pdf/main2005/2006453.pdf.

[21] National Center for Education Statistics, "International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results from the US Perspective." 2005.

[22] Reasoning Mind information available online at http://www.reasoningmind.org/

[23] TAMEST, "The Next Frontier: World-Class Math and Science Education for Texas" December 2008, online at http://tamest.org/education/

NSF has a mandate to support activities that seek to improve teaching and learning in STEM areas. In addition to the work of NSF, other federal agencies should be encouraged to give higher priority to K-12 education. For example, DOE, DOD, NASA, and NOAA and others could develop stronger partnerships between the R&D laboratories, centers, and institutes they support and schools in their region. Many such ongoing activities are impressive. Much could be done with encouragement by the president and coordination by the science advisor and NSTC.

Recommendation 3.3: Increase funding for student fellowships and advanced degree programs in science, engineering and medicine.

Recommendation 3.4: Lower or remove barriers that prevent scientists and engineers, who are born abroad, as well as foreign-born young people who wish to become scientists or engineers, from coming to the United States.

> "If you want good manufacturing jobs, one thing you could do is graduate more engineers. We had more sports exercise majors graduate than electrical engineering grads last year."
>
> —Jeffrey R. Immelt, Chair & CEO, General Electric.

Findings:

- In 2004, there were half as many bachelor degrees in physics awarded than in 1956, the last graduating class before Sputnik.[24]
- More S&P500 CEOs obtained their undergraduate degrees in engineering than any other field.[25]
- 86 percent of U.S. voters believed that the United States should increase the number of STEM workers so that we can compete internationally.[26]
- In the STEM workforce, 38 percent of Ph.D. graduates in 2000 were foreign-born.[27]

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[24] National Center for Education Statistics, "Digest of Education Statistics 2004."
[25] S. Stuart, "2004 CEO Study: A Statistical Snapshot of Leading CEOs." 2005.
[26] The Business Roundtable, "Innovation and U.S. Competitiveness: Addressing the Talent Gap. Public Opinion Research." January 12, 2006.
[27] The National Academies, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," 2007. Available online at www.nap.edu.

- Barriers include visa restrictions and process, as well as export-control policies that make it difficult for foreign-born research students to use standard equipment available to U.S. citizens.

In order for the United States to continue to be a world leader in S&T, it must encourage the nation's young people to seek advanced education and training in preparation for careers in science and engineering. The next administration should encourage students to pursue careers in science and engineering by funding additional scholarships and fellowships for undergraduate and graduate students. These programs should be designed to produce students who are trained for a variety of careers outside of academia.

Moreover, barriers should be lowered to allow more foreign students who wish to study in this country and professional scientists and engineers who wish to develop their careers here. It has become increasingly clear that the nation's leadership in S&T depends to a large extent on talent from abroad. But, with growing opportunities elsewhere, many of the best students and professionals are going to Europe or other parts of the world or staying in their home countries to study and work. To attract and retain these talented scientists and engineers, the next administration will need to improve the visa approval process for international students, increase the number of foreign scientists and engineers who are allowed to immigrate to America, and revise the export control regulations. The administration should consider implementing an automatic one-year visa extension on all science and engineering doctorates to help retain them in the United States. These and other recommendations are contained in the National Academies' "Rising Above the Gathering Storm" report.

Conclusion

Science and technology impact most areas of public policy including domestic and national security, energy and climate change, the environment, health and safety, agriculture, transportation, education and, of most immediate concern, the economy and jobs for Americans. From federal investments in science and engineering R&D, we obtain new knowledge and technologies that improve the ability of our nation to meet its economic, security, and social goals. In the United States, scientific discoveries and technological breakthroughs have been shown to drive innovation, which plays a vital role in sustainable economic growth.

The first few months of the Obama administration will provide a unique opportunity to set the nation on a progressive track to advance American S&T and applications to societal goals. That will require that the administration's S&T team, consisting of presidential appointees in the agencies and advisors in the White House, be in place very early in the administration. The early appointment of the president's science advisor is particularly important, so that the president will have access to all the necessary information as he makes early decisions about priorities and budgets for the agencies and programs. Particular attention should be given to research funding, which has lost ground to inflation for many years, and to STEM education, a continuing national crisis.