National Science Board
2020 VISION
for the National Science Foundation

December 28, 2005

NSB-05-142

National Science Board

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NATIONAL SCIENCE BOARD

Terms Expire May 10, 2006

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The National Science Board consists of 24 Members and the Director of the National Science Foundation. The Members are appointed by the President and confirmed by the Senate. The Board serves as the policy making and oversight body of the Foundation, and as an independent body of advisors to the President and Congress on matters of national science and engineering policy.

*Resigned November 2005

National Science Board

December 28, 2005

MEMORANDUM FROM THE CHAIRMAN OF THE NATIONAL SCIENCE BOARD

SUBJECT: *National Science Board 2020 Vision for the National Science Foundation*

During Senate budget hearings in February 2005, Congress requested that the National Science Board (the Board), in its role as the policy making and oversight body of the National Science Foundation (NSF), develop a bold new vision for NSF. The Board was also requested to factor Federal fiscal realities into its vision for the future of NSF.

> *Given the constrained funding environment, it is even more critical that the National Science Board develop a long-term vision for NSF. In other words, we need a strategy that outlines how we can get the biggest bang for our buck through programs and activities supported by NSF ... This means articulating a vision for the future of science and technology, including the next bold cutting-edge areas of research.* (Chairman Christopher "Kit" Bond, Senate Veterans Affairs, Housing and Urban Development Appropriations Hearing, February 17, 2005)

The *National Science Board 2020 Vision for the National Science Foundation* (NSB-05-142) provides a vision statement for NSF that is informed by a sense of our Nation, our knowledge of the trajectory of global science and engineering research, and our confidence in a promising future. We are also providing strategic priorities, near-term goals, and enabling strategies for achieving this vision.

Beyond a focus on NSF, the Board believes that this document can also serve as a valuable compass for setting the course for science and engineering research and science education in our Nation.

Warren M. Washington
Chairman, National Science Board

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National Science Board
2020 Vision
for the National Science Foundation

Preamble

"Given the constrained funding environment, it is even more critical that the National Science Board develop a long-term vision for NSF. In other words, we need a strategy that outlines how we can get the biggest bang for our buck through programs and activities supported by NSF. This does not mean how NSF will alter its grant size and duration. This means articulating a vision for the future of science and technology, including the next bold cutting-edge areas of research. We also need a plan on how NSF will lead the research community in meeting these new bold challenges. The Board is ideally suited for this responsibility and I believe strongly that it is a core activity of the Board's mission. One of the specific areas that the Board should examine is the future of our Nation's math and science education." Chairman Christopher "Kit" Bond, Senate Veterans Affairs, Housing and Urban Development Appropriations Hearing, February 17, 2005.

Mission

"To promote the progress of science; to advance national health, prosperity, and welfare; to secure the national defense; and for other purposes." National Science Foundation Act of 1950.

History suggests that a nation that relinquishes the torch of science puts its future prosperity at risk and jeopardizes its place in the history of civilization.

2020 Vision

The National Science Board's (the Board's) vision for the future is informed by a sense of our Nation, our knowledge of the trajectory of global science and engineering (S&E) research, and our confidence in a promising future. History suggests that a nation that relinquishes the torch of science puts its future prosperity at risk and jeopardizes its place in the history of civilization. The Board believes that we must not let this fate befall our country.

The Board envisions a prosperous America that is powered by innovations flowing from the latest transformative scientific ideas with a workforce among the most scientifically and technically competent on the planet. We see an America in which every student graduates from high school with a sufficient grasp of the fundamental concepts in science and technology to live a full and productive life in an increasingly technological world and whose research and higher education enterprises – among the most creative and fruitful in the world – bring together the best minds for inquiry, discovery, and teaching. The Board also envisions an America whose knowledge, skills, and values are respected and influential in setting the aspirations and policies of the global research and technology enterprise.

The United States has the science and technology base from which to realize this vision. America's strength in fundamental research, coupled with consistent investments in science and technology over the past half-century, has attracted the best and brightest from around the world. The rapid intellectual advances achieved by this enterprise have produced major economic benefits and improvements to our quality of life. These investments have brought us to the dawn of a new era of explosive progress in science and engineering, one that holds not only the promise of dramatic insights into the fundamental nature of matter and the universe, but also into the most complex of phenomena, ranging from global weather to economic and social systems and the biological ecosystems that underpin our existence.

This new era is made possible by an unprecedented and continually increasing ability to observe the physical world, to simulate both natural and man-made systems in ways never before imagined, to efficiently store and analyze vast amounts of data, and to communicate information globally. The ability to understand and influence complex systems is changing – and will continue to change – human society more rapidly and far more profoundly than has been experienced in previous agricultural, industrial, and technological revolutions. Perhaps most importantly, the development of communications technology and systems worldwide allows new generations of professionals to live and work globally.

These breathtaking advances challenge the National Science Foundation (NSF, the Foundation) to reexamine its role in the global scientific enterprise and to focus its attention and resources sharply at the frontiers of knowledge generation.

The National Science Board's 2020 Vision for NSF is that the Foundation will:

- Drive the cutting edge of fundamental and transformative research;
- Tap the talents of all our citizens, particularly those belonging to groups that are underrepresented in the science and research enterprise, and continue to attract foreign students and scientists to the U.S.;
- Develop and test new approaches to teaching science to elementary and secondary school students and catalyze partnerships among schools, museums, aquariums, and universities to put these techniques into effective practice;
- Provide the bright minds in our research institutions with the tools and instruments needed to probe the frontiers of knowledge and develop ideas that can transform our understanding of the world; and
- Maintain the financial and talent resources to be an effective agent for excellence in the critical national enterprises of learning, discovery, and innovation.

Strategic Priorities

The Board recognizes that competing priorities may impose fiscal constraints that limit the Foundation's, and so the Nation's, aspirations. In weighing these competing priorities, the Nation must realize that the challenges we defer today will be faced by our children, and the opportunities we forego today will be charged to their future.

To achieve this 2020 Vision, the Foundation will focus on three Strategic Priorities:

- **Strategic Priority 1:** Ensure the Nation maintains a position of eminence at the global frontier of fundamental and transformative research, emphasizing areas of greatest scientific opportunity and potential benefit.

- **Strategic Priority 2:** Sustain a world-class S&E workforce and foster the scientific literacy of all our citizens.

- **Strategic Priority 3:** Build the Nation's basic research capacity through critical investments in infrastructure, including advanced instrumentation, facilities, cyberinfrastructure, and cutting-edge experimental capabilities.

In weighing these competing priorities, the Nation must realize that the challenges we defer today will be faced by our children, and the opportunities we forego today will be charged to their future.

History

NSF has played a key role in positioning the U.S. at the forefront of global research and innovation. In 1946, legislators contemplating the creation of a national science foundation were disturbed by the relative weakness of American science in fundamental studies.[1] This weakness was evidenced by several factors, including the scarcity of U.S. researchers awarded Nobel Prizes in chemistry, physics, and medicine and a serious deficit of trained American scientists. By the 1960s, evidence of the success of the foundation they established was abundant: U.S. researchers were regularly honored for their accomplishments in the sciences by many authorities, including the Nobel Foundation, and the American education enterprise that trained scientists and engineers was the envy of the world. More recently, an NSF-supported study found that 70 percent of the scientific papers cited in U.S. industry patents came from science supported by public funds and performed at universities, government labs, and other public agencies.[2]

"Americans believe that advances in S&T [science and technology] were the nation's and the government's greatest achievements during the 20th century."

Pew Research Center for the People and the Press, 1999.

Twentieth century progress flowing from the Foundation's investments in research, technology, and education included the formulation of fundamental new concepts, the development of vital new technologies, and the emergence of a vibrant network of pioneering people and institutions. The NSF investment in ideas and talent is

[1] Congressional Report S. Rep. No. 79-1136 at 5-7 (1946).
[2] Francis Narin, Kimberly S. Hamilton, and Dominic Olivastro, "The Increasing Linkage Between U.S. Technology and Public Science," *Research Policy* 26, No. 3 (December 1997): 317-30.

rightly deemed to have made a significant contribution to the development of many key commercial technologies, including fiber optics, wireless communications, magnetic resonance imaging, ultrasound, and the Internet. The myriad of innovative businesses built on NSF-supported scientific breakthroughs have contributed significantly to our knowledge base, to our economy, and to the high standard of living Americans enjoy. Foundation programs have also advanced the public's understanding of science and its importance to our Nation's economy and security.

"... new knowledge is perhaps the single most important driver of economic growth and the most precious and fully renewable resource available to individuals and societies to advance their material well-being. Economic advantage rests increasingly on the ability to exploit new scientific and technological advances. Robust support for basic research assures a deep reservoir of knowledge and provides flexibility and choices for addressing future needs."

National Science Board Strategic Plan (NSB-98-215), 1998, page 2.

However, the context in which the Foundation operates has changed significantly over the past decade. Globalization now links individual researchers, corporate research and national enterprises in diverse and increasingly complex ways. Mechanisms for transmitting ideas and technologies are more numerous and more nimble. Opportunities to discover, develop, and capitalize on ideas are available to many more nations. Thus, it is clearer today than ever before that our Nation's ability to sustain an eminent position cannot rest on past achievements and must not be presumed.

At the same time, a nexus of inherently global challenges confronts our world energy supply, environmental quality, public health, and national security. Scientists and engineers from every nation must rise to meet these and other emerging global challenges, developing new concepts to transform current capabilities and sustain society in the future.

The U.S. must respond creatively to such scientific challenges and to the emerging global nature of the research enterprise. Our ability to do so depends critically upon the vigor and quality of our S&E research and education enterprises. Yet the past few years have seen growing concerns that the U.S. is in fact slipping in research, technology innovation, and education – three essential pillars of a vibrant economy.

NSF is authorized and positioned intellectually to help the Nation rise to these challenges. This will require not only a vibrant research enterprise directed toward the frontiers of disciplines and crossing the boundaries between them, but also a 'critical mass' of talented participants in this enterprise. In addition, it will require reinvigorating our educational enterprise to ensure that our researchers and workforce remain competitive on the global stage, and that our entire citizenry has the level of science literacy that is increasingly essential in the 21st century.

Federal Fiscal Realities for the Early 21st Century

In 2002, Congress recognized the vitally important role of S&E in society by overwhelmingly approving the National Science Foundation Act of 2002 (P.L. 107-368). This Act authorized a doubling of the NSF budget over 5 years, to a total of almost $10 billion by FY 2007.

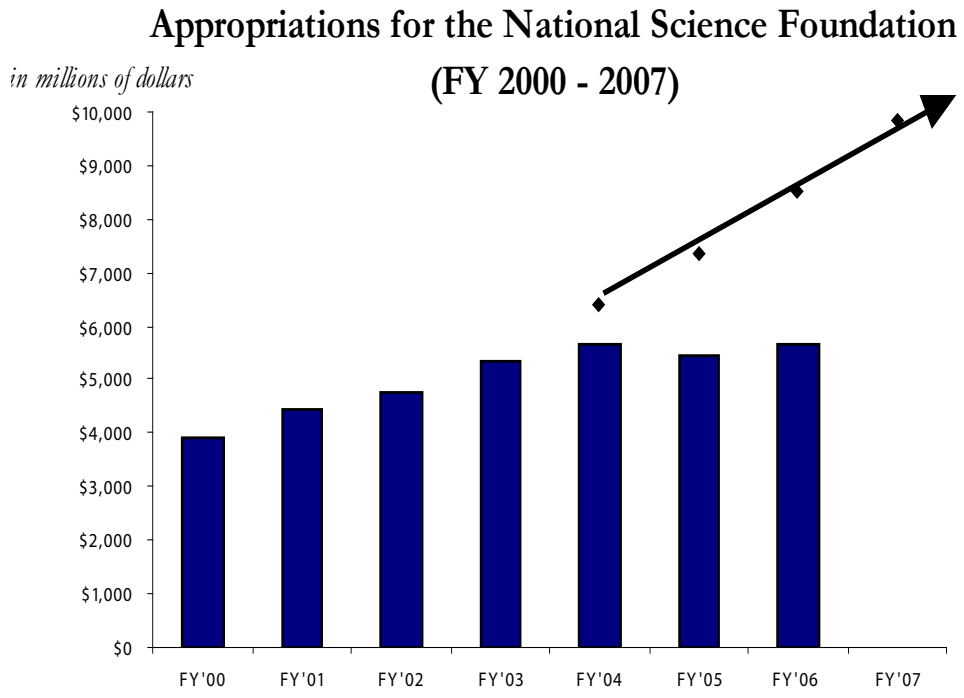

Figure legend: Actual annual appropriations (blue bars) for NSF in recent years with annual funding levels authorized (black points and arrow) by the NSF Act of 2002.

In response to a 2003 legislative directive, and in order to plan for this budget expansion, the Board prepared *Fulfilling the Promise: A Report to Congress on the Budgetary and Programmatic Expansion of the National Science Foundation* (NSB-03-151), which recommended focusing the anticipated new funds on the following six vital objectives.

- Improving the productivity of researchers and expanding opportunities for students.
- Opening new frontiers in research and education.
- Building a diverse, competitive, and globally engaged U.S. S&E workforce.

- Increasing the number and diversity of institutions that participate in NSF-funded activities.

- Providing scientists and engineers with advanced tools, facilities, and cyber-infrastructure.

- Maintaining NSF's excellence in management.

The Board continues to support the objectives described in its 2003 report to Congress, and believes that full realization of the 2002 authorization funding levels would produce a significant beneficial impact on the long-term economic strength of the Nation. In recent years, the Foundation has had to annually turn down over a billion dollars of proposed research – work judged by independent experts to have significant scientific merit and potential societal benefits. As globalization continues, it is increasingly easy for such ideas to move to places where the vision, talent, and resources exist to pursue them; taking along the economic and national security benefits they are likely to yield.

While other agencies have prescribed mandates in specific fields of S&E research, NSF is charged with supporting a comprehensive research portfolio encompassing all non-medical fields and disciplines.

Near-Term Goals for Attaining the 2020 Vision for NSF

Profound shifts in the Federal budget landscape since Congress authorized doubling of funding for NSF make necessary thoughtful definition of near-term milestones the Foundation can achieve as it pursues this 2020 Vision of vitality and excellence in the Nation's S&E research and education enterprise. The Board believes that the following Near-Term Goals are appropriate initial steps for NSF.

- **Near-Term Goal 1: NSF leadership will develop a comprehensive strategic plan, consistent with the Strategic Priorities and Enabling Strategies set by the Board, which emphasizes the areas of greatest scientific opportunity and potential benefit to the Nation.**

  The Foundation is unique among Federal agencies that support science. While other agencies have prescribed mandates in specific fields of S&E research, NSF is charged with supporting a comprehensive research portfolio encompassing all non-medical fields and disciplines. In navigating today's constrained budget environment, NSF must remain science-driven and agile in order to respond quickly as new opportunities emerge within the scientific community. This will demand difficult decisions and draws into focus the need for priority-setting in and among scientific disciplines. NSF will draw on the expertise of the research and education communities and the Board's 2020 Vision to identify bold cutting-edge areas of research, and develop a strategy by which the Foundation will more efficiently and effectively nurture and support areas of scientific opportunity and potential benefit to the Nation.

- **Near-Term Goal 2: NSF will strengthen opportunities for supporting transformative research.**

  The Foundation must support the most innovative and potentially transformative research – research that has the capacity to revolutionize existing fields, create new subfields, cause paradigm shifts, support discovery, and lead to radically new technologies. The Board recently critically reviewed the NSF merit review system and found it to be fundamentally sound.[3] However, a peer review system can sometimes be conservative, screening out high-risk, potentially high-impact research proposals. Ongoing review and evaluation make clear to the Board that the Foundation's current solicitation, review, and selection processes must evolve, in some respects substantially, in order to achieve the transformative potential the Board envisions. NSF will implement the recommendations resulting from this ongoing review,[4] in order to create an environment that is more open to and encouraging of such proposals from the research community.

- **Near-Term Goal 3: NSF will critically evaluate current education investments and develop new strategies to increase their impact on the quality of science, technology, engineering, and mathematics (STEM) education.**

  NSF plays a vital role in American STEM education, both in schools and for the general public. The Foundation has the unique ability to work not only in formal educational settings, such as schools and universities, but also through the science centers and museums to which so many American parents, students, and teachers turn for further learning. These 'informal science' institutions have the ability both to improve the teaching of S&E in schools and to serve as natural bridges among academia, the general public, and our school communities. New strategies that explicitly encompass both formal and informal education have the potential to improve the Foundation's impact on the Nation's critical needs for a scientifically literate citizenry, a vibrant research community, and a workforce with world-class science and technology competencies. NSF leadership will ensure that the Foundation's investments in education enhance the integration of the research enterprise with education, and drive productive collaboration and exchange of techniques among K-12 educators, museum professionals, and universities.

The Foundation must support the most innovative and potentially transformative research – research that has the capacity to revolutionize existing fields, create new subfields, cause paradigm shifts, support discovery, and lead to radically new technologies.

[3] National Science Board. *Report of the National Science Board on the National Science Foundation's Merit Review System*, September 2005, (NSB-05-119).
[4] National Science Board. *Committee on Programs and Plans Charge to the Task Force on Transformative Research*, December 16, 2004, (NSB/CPP/TR-04-1).

- **Near-Term Goal 4: NSF will ensure that new and more diverse generations of faculty have significant opportunities to obtain research funding.**

  The Nation's universities are vital institutions both for maintaining the strength of the U.S. basic research enterprise and for producing individuals with advanced S&E competencies to serve in the workforce. The Nation has done less well in tapping the potential of underrepresented minorities, women, and persons with disabilities. Developing this potential, especially to advance underrepresented minorities into the professoriate, will lead to expanded opportunities for individuals and improve our national competitiveness and prosperity. NSF will encourage post-secondary institutions to achieve greater faculty diversity with thoughtfully conceived and executed programs for recruiting and retaining S&E faculty from underrepresented minority groups. NSF will ensure ample levels of funding for the early career Ph.D.s who are the next generation of S&E faculty essential for the continued vitality of U.S. universities.

Enabling Strategies

The following Enabling Strategies, designed to build upon and reinforce NSF's strengths, are actions the Board believes will better align the Foundation with the Strategic Priorities and position it to achieve the Near-Term Goals.

- **Enabling Strategy 1: NSF will provide the infrastructure, including advanced instrumentation, facilities, cyberinfrastructure, and cutting-edge experimental capabilities, which enable transformative research.**

  The development and availability of new instrumentation has created novel research opportunities and fueled technological innovations in fields ranging from biotechnology, imaging, and nanotechnology to communications. Over the past decade, funding for academic research infrastructure has not kept pace with rapidly changing technology, expanding research opportunities, and the increasing number of users. Moreover, many research questions can be addressed only by using new generations of powerful technological tools. These new tools will make scientists and engineers more productive, and enable them to undertake more complex tasks and research problems. Investments in infrastructure will focus on information technology research, midsize infrastructure and instrumentation, large facility projects, cyberinfrastructure, and educational and training opportunities.

- **Enabling Strategy 2: NSF will strengthen existing international and interagency partnerships, and develop new partnerships.**

  S&E research is a global enterprise. The global economy that emerged in the second half of the 20th century rests on the global communication infrastructure and relies on knowledge and continual innovation for growth. The worldwide exchange of ideas already fuels economic growth in advanced economies and will increasingly enable less developed nations to participate in the global economy.

  Given the importance of science and technology as engines of economic growth, NSF will develop and deploy a strategy to support a productive relationship between scientific and foreign policy objectives. In a contentious world, bilateral and multilateral cooperation in science and technology can help foster stable international relations. NSF will seek new opportunities for its programs to encompass collaborations with the developing economies. Where necessary, infrastructure investments will be made in support of these collaborations. NSF will take a leadership role in support of collaborative international S&E research and education.

In a contentious world, bilateral and multilateral cooperation in science and technology can help foster stable international relations. NSF will seek new opportunities for its programs to encompass collaborations with the developing economies.

- **Enabling Strategy 3: The Foundation will maintain the excellence of NSF staff and management.**

  The quickening pace of discovery, plus demands for excellence in science education, have substantially increased the workload of NSF staff and management. At the same time, the constrained budget environment is forcing Foundation leadership to make difficult decisions, set clear priorities, and focus investments in priority areas. Meeting these challenges requires a highly trained, results-oriented NSF workforce operating in a continuous learning environment. NSF will ensure that its workforce has access to new technologies and management approaches to maintain efficiency and effectiveness in serving the Nation's research and education communities.

Conclusions

Our Nation depends on the creation and use of new knowledge to generate jobs, ensure a high quality of life for its citizens, and maintain global pre-eminence in discovery and innovation. The National Science Foundation is internationally respected for its effectiveness in identifying and supporting the people and ideas that advance critical scientific understanding, help create useful technologies, and expand human capacity. Other nations are emulating NSF's model and investing heavily in their scientific enterprises. Through the process of globalization, technical expertise and S&E workforce capabilities are being cultivated and employed outside American borders – a clearly positive development for humankind. However, this development must not come at the expense of America's own capabilities and competitive advantage.

The Nation must continue to invest in science and technology to maintain future prosperity and security.

Compounding these trends, increasing demands, and tightening constraints on Federal discretionary budget dollars have substantially curtailed the ability of NSF to invest in fundamental research and the training of the next generation of scientists, engineers, and STEM educators. The tragic consequences of this confluence are the loss of opportunities for discovery, a slower pace of science and technology advancement, and a diminished position for America in the global marketplace for innovation.

For over 50 years, the Federal Government has sustained a visionary investment in the U.S. research and education enterprise. That Federal effort has expanded the horizon of scientific discovery and engineering achievements and brought substantial economic benefits to the Nation. The expanding frontiers of knowledge offer extraordinary opportunities for research and innovation. However, if the U.S. is to remain a leader in science and technology in the 21st century, all our citizens must be well versed in the fundamentals of mathematics, science, and engineering. As other nations ramp up their investment in S&E education, research, and innovation, the U.S. cannot be complacent. The Nation must continue to invest in science and technology to maintain future prosperity and security.

Guided by a clear vision and carrying out a sound strategic plan, the Foundation will continue to serve the vital interests of the Nation by strengthening the vitality, creativity, and productivity of the U.S. science and engineering enterprise.

The Board has prepared this report, *National Science Board 2020 Vision for the National Science Foundation* (NSB-05-142), to articulate these opportunities and constraints. The Board's overarching vision, in conjunction with Strategic Priorities, Near-Term Goals and Enabling Strategies, will guide the Foundation as it develops a strategic plan to address new challenges in a complex fiscal and operational environment. Guided by a clear vision and carrying out a sound strategic plan, the Foundation will continue to serve the vital interests of the Nation by strengthening the vitality, creativity, and productivity of the U.S. science and engineering enterprise.

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The document is available electronically: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsb05142.

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