

National Science Foundation

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The **National Science Foundation (NSF)** is a United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health. With an annual budget of about US\$7.0 billion (fiscal year 2012), the NSF funds approximately 24% of all federally supported basic research conducted by the United States' colleges and universities.^[3] In some fields, such as mathematics, computer science, economics, and the social sciences, the NSF is the major source of federal backing.

The NSF's director and deputy director are appointed by the President of the United States, and confirmed by the United States Senate, whereas the 24 presidentially appointed members of the National Science Board (NSB)^[4] do not require Senate confirmation. The director and deputy director are responsible for administration, planning, budgeting and day-to-day operations of the foundation, while the NSB meets six times a year to establish its overall policies. The current NSF director, confirmed in March 2014, is astronomer France A. Córdova, former president of Purdue University.^[5]

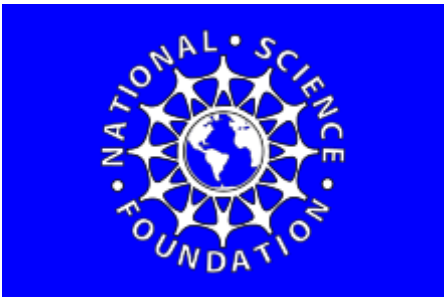
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National Science Foundation



Seal of the National Science Foundation



Flag of the National Science Foundation

Agency overview

Formed	May 10, 1950
Headquarters	Arlington, Virginia, U.S. ^[1]
Motto	Where Discoveries Begin
Employees	1700
Annual budget	\$7.46 billion for 2016 ^[2]
Agency executive	France A. Córdova, Director
Website	www.NSF.gov (http://www.nsf.gov/)

Grants and the merit review process

The NSF seeks to fulfill its mission chiefly by issuing competitive, limited-term grants in response to specific proposals from the research community. The NSF also makes some contracts. Some proposals are solicited, and some are not; the NSF funds both kinds. The NSF does not operate its own laboratories, unlike other federal research agencies, notable examples being the NASA and the National Institutes of Health (NIH).

The NSF receives over 50,000 such proposals each year, and funds about 10,000 of them.^[6] Those funded are typically projects that are ranked highest in a 'merit review' process, introduced in 1997.^[7] Reviews are carried out by ad hoc reviewers and panels of independent scientists, engineers, and educators who are experts in the relevant fields of study, and who are selected by the NSF with particular attention to avoiding conflicts of interest. For example, reviewers cannot work at the NSF itself, nor for the institution that employs the proposing researchers. All proposal evaluations are confidential: the proposing researchers may see them, but they do not see the names of the reviewers.

The first merit review criterion is 'intellectual merit', the second is that of the 'broader societal impact' of the proposed research; the latter has been met with opposition from the scientific and policy communities since its inception in 1997.^[8] In June 2010, the National Science Board (NSB), the governing body for NSF and science advisers to both the legislative and executive branches, convened a 'Task Force on Merit Review' to determine "how well the current Merit Review criteria used by the NSF to evaluate all proposals were serving the agency."^[9] The task force reinforced its support for both criteria as appropriate for the goals and aims of the agency, and published a revised version of the merit review criteria in its 2012 report, to clarify and improve the function of the criteria. However, both criteria already had been mandated for all NSF merit review procedures in the 2010 re-authorization of the America COMPETES Act.^[10] The Act also includes an emphasis on promoting potentially transformative research, a phrase which has been included in the most recent incarnation of the 'merit review' criteria.^[11]

Most NSF grants go to individuals or small groups of investigators, who carry out research at their home campuses. Other grants provide funding for mid-scale research centers, instruments, and facilities that serve researchers from many institutions. Still, others fund national-scale facilities that are shared by the research community as a whole. Examples of national facilities include the NSF's national observatories, with their giant optical and radio telescopes; its Antarctic research sites; its high-end computer facilities and ultra-high-speed network connections; the ships and submersibles used for ocean research; and its gravitational wave observatories.

In addition to researchers and research facilities, NSF grants also support science, engineering and mathematics education from pre-K through graduate school. Undergraduates can receive funding through Research Experiences for Undergraduates summer programs.^[12] Graduate students are supported through Integrative Graduate Education Research Traineeships (IGERT)^[13] and Alliance for Graduate Education and the Professoriate (AGEP) programs^[14] and through the Graduate Research Fellowships, NSF-GRF. K-12 and some community college instructors are eligible to participate in compensated Research Experiences for Teachers programs.^[15] In addition, an early career-development program (CAREER) supports teacher-scholars that most effectively integrate research and education within the mission of their organization, as a foundation for a lifetime of integrated contributions.^[16]

Scope and organization

The NSF's workforce numbers about 1,700, nearly all working at its Arlington headquarters. That includes about 1,200 career employees, 150 scientists from research institutions on temporary duty, 200 contract workers, and the staff of the National Science Board office and the Office of the Inspector General, which examines the foundation's work and reports to the NSB and Congress.

In June 2013 it was announced that the NSF would relocate its headquarters to Alexandria, Virginia in 2017.

Research directorates

The NSF organizes its research and education support through seven directorates, each encompassing several disciplines:

- **Biological Sciences** (molecular, cellular, and organismal biology, environmental science)^[17]
- **Computer and Information Science and Engineering** (fundamental computer science, computer and networking systems, and artificial intelligence)^[18]
- **Engineering** (bioengineering, environmental systems, civil and mechanical systems, chemical and transport systems, electrical and communications systems, and design and manufacturing)^[19]
- **Geosciences** (geological, atmospheric and ocean sciences)^[20]
- **Mathematical and Physical Sciences** (mathematics, astronomy, physics, chemistry and materials science)^[21]
- **Social, Behavioral and Economic Sciences** (neuroscience, management, psychology, sociology, anthropology, linguistics, science of science policy and economics)^[22]
- **Education and Human Resources** (science, technology, engineering and mathematics education at every level, pre-K to grey)^[23]



Other research offices

The NSF also supports research through several offices within the Office of the Director:

- Office of Cyberinfrastructure^[24]
- Office of Polar Programs^[25]
- Office of Integrative Activities^[26]
- Office of International Science and Engineering^[27]

Overseas offices

NSF also has three overseas offices, to promote collaboration between the science and engineering communities of the United States and other continents' scientific communities:^[28]

-  Brussels for Europe, formerly based in Paris^[29]
-  Tokyo for East Asia, except China^[30]
-  Beijing for China^[31]

Crosscutting programs

In addition to the research it funds in specific disciplines, the NSF has launched a number of projects that coordinate the efforts of experts in many disciplines, which often involve collaborations with other U.S. federal agencies.^[32] Examples include initiatives in:

- Nanotechnology^[33]
- The science of learning^[34]
- Digital libraries^[35]
- The ecology of infectious diseases^[36]

History and mission

The NSF was established by the National Science Foundation Act of 1950.^[37] Its stated mission is "To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense."^[38]

Some historians of science have argued that the result was an unsatisfactory compromise between too many clashing visions of the purpose and scope of the federal government.^[39] The NSF was certainly not *the* primary government agency for the funding of basic science, as its supporters had originally envisioned in the aftermath of World War II. By 1950, support for major areas of research had already become dominated by specialized agencies such as the National Institutes of Health (medical research) and the U.S. Atomic Energy Commission (nuclear and particle physics). That pattern would continue after 1957 when U.S. anxiety over the launch of Sputnik led to the creation of the National Aeronautics and Space Administration (space science) and the Defense Advanced Research Projects Agency (defense-related research).

The NSF's scope has expanded over the years to include many areas that were not in its initial portfolio, including the social and behavioral sciences, engineering, and science and mathematics education. The NSF is the only U.S. federal agency with a mandate to support *all* non-medical fields of research.

Budget and performance history

The NSF has come to enjoy strong bipartisan support from Congress. Especially after the technology boom of the 1980s, both sides of the aisle have generally embraced the notion that government-funded basic research is essential for the nation's economic health and global competitiveness, and for national defense. That support has manifested itself in an expanding budget—from \$1 billion in 1983 (\$2.19bn in 2010 dollars) to just over \$6.87 billion by FY 2010, (fiscal year 2011 request and 2010 enacted level (<http://www.nsf.gov/about/budget/fy2011/index.jsp>)) stagnating since with \$6.9 billion for FY 2013.^[40] NSF has published annual reports since 1950, which since the new millennium have been two reports, variously called Performance Report and Accountability Report or Performance Highlights and Financial Highlights; the latest available FY 2013 Agency Financial Report was posted December 16, 2013, and the 6 page FY 2013 Performance and Financial Highlights was posted March 25, 2013.^[41] Recently, the organization has been focusing on obtaining high return on investment from their spending on scientific research.^[42]

Legislative history

In the midst of World War II US policymakers became convinced that something had to be done with America's scientific infrastructure. Although the federal government had established nearly 40 scientific organizations between 1910 and 1940, the US relied upon a primarily laissez-faire approach to scientific research and development. Growing rubber shortages and other war-related bottlenecks led many to rethink America's decentralized and market-driven approach to science. Despite a growing consensus that something had to be done, there was no consensus on what to do. Two primary proposals emerged, one from New Deal Senator Harley M. Kilgore and another from Vannevar Bush.^[43]

Harley Kilgore's vision

Narratives about the National Science Foundation typically concentrated on Vannevar Bush and his 1945 publication *Science-The Endless Frontier*.^[44] This began to change in the late 1970s when scholars looked closer at the historical record,^[45] discovering that the NSF first appeared as a comprehensive New Deal Policy proposed by Sen. Harley Kilgore of West Virginia. Swept into office on the wave of new deal politicians, Kilgore was a small businessman with a deep distrust of monopolies. Looking about the landscape of wartime research Kilgore was

concerned about the largely laissez-faire approach to producing technologies and products. He was also concerned about the lack of coordination between the federal government and private firms, believing that organizational chaos would lead to a failure in technology production. He was distressed by the concentration of research activities in the hands of a few elite universities and a few private firms. He feared that monopolistic industries had no incentives to develop the products needed for war and postwar economic and social welfare. His solution was to propose a comprehensive and centralized research body that would be responsible to many stakeholders and that would be in charge of producing both basic and applied research. According to this vision, research would no longer be driven by the invisible hand of the market. Research projects would be selected by the public. This public would be represented by a committee of stakeholders including commuting members, industry, and academia. Research results and products would not be owned by private interests, instead the public would own the rights to all patents funded by public monies. Rather than let the market pursue applied research, the proposed agency would pursue both basic and applied research that would support science direct economic and social importance. Responding to his worry about concentration, research monies would be equitably spread across universities.^[43]

Vannevar Bush's approach

Kilgore's proposals met mixed support. Non-elite universities as well as small businesses supported his proposals. The Budget Bureau also supported him. Opponents feared that the policy would take research out of the hands of scientists. Others suggested that the policy would socialize a large and independent section of the economy. Another opponent was Vannevar Bush, who was the liaison between Congress and the Office of Scientific Research and Development. He recognized some of the same problems as Kilgore highlighted, and liked some things in Kilgore's proposals, but he thought that the proposed federal science agency should have a much different form. Bush did not like the idea of letting social interests and community members drive science policy. He feared that the selection of research projects would become politicized, and he also had complete faith in the ability of scientists to pick the best possible projects. Furthermore, in contrast to Kilgore, he felt that the agency should have the narrower mandate of pursuing only basic science, rather than basic and applied science. Unlike Kilgore, he believed the public should not own research results and products, instead responsible researchers should own the research results. Broadly speaking, Bush's vision was significantly more narrow than Kilgore's proposal. It maintained the status quo in patenting arrangements, it limited project selection to scientists, and it narrowed projects to basic research.^[43]

Reception and passage of the 'Technology Mobilization Act' in 1950

Kilgore first introduced his policy in 1942 under the title the Technology Mobilization Act. After failing multiple attempts, the NSF Act passed in 1950. The final bill mostly took on the character of Vannevar Bush's proposal. Broadly speaking it brought about a fragmented or pluralistic system of federal funding for research. During the eight years between initial proposal and final passage, new and existing agencies claimed pieces from the original proposal, leaving the science foundation with limited responsibilities. In the end the final policy represented a failure for those who believed in popular control over research resources, and those who believe that planning and coordination could be extended to the sphere of science policy. Conversely the final policy represented a victory for business interests who feared competition from the government in the area of applied research and who saw Kilgore's patent law proposal as a threat to their property rights and for scientists who gained control of what would later become an important source of resources and professional autonomy.^[43]

Timeline

Pre–World War II

Academic research in science and engineering was not considered a federal responsibility; almost all support came from private contributions and charitable foundations. Governmental research into science and

technology was largely uncoordinated; military research was compartmentalized to the point where different branches were often working on the same subject without realizing it.

1940–49

Amidst growing awareness that US military capability depended on strength in science and engineering, Congress considered several proposals to support research in these fields. Separately, President Franklin D. Roosevelt sponsored creation of organizations to coordinate federal funding of science for war, including the National Defense Research Committee and the Office of Scientific Research and Development both from 1941-1947. Senator Harley M. Kilgore introduced the "Science Mobilization Act" (S. 1297) in 1942, which did not pass.^{[43][45]} Vannevar Bush, head of the Office of Scientific Research and Development which ran the Manhattan Project that outlived it, wrote a report on what should be done in the postwar years to further foster government commitment to science and technology, entitled *Science—The Endless Frontier*.^[46] issued to President Harry S. Truman in July 1945. The report laid out a strong case for federally funded scientific research, arguing that the nation would reap rich dividends in the form of better health care, a more vigorous economy, and a stronger national defense and proposes creating a new federal agency, the National Research Foundation. Despite broad agreement over the principle of federal support for science, working out a consensus how to organize and manage it required five years.^[47]

1950–1959

In 1950 Harry S. Truman signed Public Law 507, or 42 U.S.C. 16^[48] creating the National Science Foundation.^{[49][50]} which provided for a National Science Board of twenty-four part-time. In 1951 Truman nominated Alan T. Waterman, chief scientist at the Office of Naval Research, to become the first Director. With the Korean War underway, the agency's initial budget was just \$151,000 for 9 months. After moving its administrative offices twice, NSF began its first full year of operations with an appropriation from Congress of \$3.5 million, far less the almost \$33.5 million requested with which 28 research grants were awarded. After the 1957 Soviet Union orbited Sputnik 1, the first ever man-made satellite, national self-appraisal questioned American education, scientific, technical and industrial strength and Congress increased the NSF appropriation for 1958 to \$40 million. In 1958 the NSF selected Kitt Peak, near Tucson, Arizona, as the site of the first national observatory, that would give any astronomer unprecedented access to state-of-the-art telescopes; previously major research telescopes were privately funded, available only to astronomers who taught at the universities that ran them. The idea expanded to encompass the National Optical Astronomy Observatory, the National Radio Astronomy Observatory, the National Solar Observatory, the Gemini Observatory and the Arecibo Observatory, all of which are funded in whole or in part by NSF. The NSF's astronomy program forged a close working relationship with NASA, also founded in 1958, in that the NSF provides virtually all the U.S. federal support for ground-based astronomy, while NASA's responsibility is the U.S. effort in space-based astronomy. In 1959 the U.S. and other nations concluded the Antarctic Treaty reserving Antarctica for peaceful and scientific research, and a presidential directive gave the NSF responsibility for virtually all U.S. Antarctic operations and research in form of the United States Antarctic Program.

1960–1969

Emphasis on international scientific and technological competition accelerated NSF growth. The foundation started the "Institutional Support Program", a capital funding program designed to build a research infrastructure among U.S. universities; it was the single largest beneficiary of NSF budget growth in the 1960s. In 1960, the NSF's appropriation was \$152.7 million and 2,000 grants were made. In 1968 the Deep Sea Drilling Project began (until 1983), which revealed evidence about the concepts of continental drift, sea floor spreading and the general youthfulness of the ocean basins compared to Earth. The program became a model of international cooperation as several foreign countries joined. By 1968, the NSF budget stood at nearly \$500 million.

1970–1979

In 1972 the NSF took over management of twelve interdisciplinary materials research laboratories from the Defense Department's Advanced Research Projects Agency (DARPA). These university-based laboratories had taken a more integrated approach than did most academic departments at the time, encouraging physicists, chemists, engineers, and metallurgists to cross departmental boundaries and use systems approaches to attack complex problems of materials synthesis or processing. The NSF expanded these laboratories into a nationwide network of Materials Research Science and Engineering Centers. In 1972 the

NSF launched the biennial "Science & Engineering Indicators" report^[51] to the US President and Congress, as required by the NSF Act of 1950. In 1977 the first interconnection of unrelated networks was developed, run by DARPA.

1980–1989

During this decade, increasing NSF involvement lead to a three-tiered system of internetworks managed by a mix of universities, nonprofit organizations and government agencies. By the mid-1980s, primary financial support for the growing project was assumed by the NSF.^[52] In 1983, NSF budget topped \$1 billion for the first time. Major increases in the nation's research budget were proposed as "the country recognizes the importance of research in science and technology, and education". The U.S. Antarctic Program was taken out of the NSF appropriation now requiring a separate appropriation. The NSF received more than 27,000 proposals and funded more than 12,000 of them in 1983. In 1985, the NSF delivered ozone sensors, along with balloons and helium, to researchers at the South Pole so they can measure stratospheric ozone loss. This was in response to findings earlier that year, indicating a steep drop in ozone over a period of several years. The Internet project continued, now known as NSFNET.

1990–1999

In 1990 the NSF's appropriation passed \$2 billion for the first time. NSF funded the development of several curricula based on the NCTM standards, devised by the National Council of Teachers of Mathematics. These standards were widely adopted by school districts during the subsequent decade. However, in what newspapers such as the Wall Street Journal called the "math wars", organizations such as Mathematically Correct complained that some elementary texts based on the standards, including Mathland, have almost entirely abandoned any instruction of traditional arithmetic in favor of cutting, coloring, pasting, and writing. During that debate, NSF was both lauded and criticized for favoring the standards. In 1991 the NSFNET acceptable use policy was altered to allow commercial traffic. By 1995, with private, commercial market thriving, NSF decommissioned the NSFNET, allowing for public use of the Internet. In 1993 students and staff at the NSF-supported National Center for Supercomputing Applications (NCSA) at the University of Illinois, Urbana-Champaign, developed Mosaic, the first freely available browser to allow World Wide Web pages that include both graphics and text. Within 18 months, NCSA Mosaic becomes the Web browser of choice for more than a million users, and sets off an exponential growth in the number of Web users. In 1994 NSF, together with DARPA and NASA, launched the Digital Library Initiative.^[53] One of the first six grants went to Stanford University, where two graduate students, Larry Page and Sergey Brin, began to develop a search engine that used the links between Web pages as a ranking method, which they later commercialized under the name Google. In 1996 NSF-funded research established beyond doubt that the chemistry of the atmosphere above Antarctica was grossly abnormal and that levels of key chlorine compounds are greatly elevated. During two months of intense work, NSF researchers learned most of what is known about the ozone hole. In 1998 two independent teams of NSF-supported astronomers discovered that the expansion of the universe was actually speeding up, as if some previously unknown force, now known as dark energy, is driving the galaxies apart at an ever-increasing rate. Since passage of the Small Business Technology Transfer Act of 1992 (Public Law 102-564, Title II), NSF has been required to reserve 0.3% of its extramural research budget for Small Business Technology Transfer awards, and 2.8% of its R&D budget for small business innovation research.

2000–2009

NSF joined with other federal agencies in the National Nanotechnology Initiative, dedicated to the understanding and control of matter at the atomic and molecular scale. NSF's roughly \$300 million annual investment in nanotechnology research was still one of the largest in the 23-agency initiative. In 2001, NSF's appropriation passed \$4 billion. The NSF's "Survey of Public Attitudes Toward and Understanding of Science and Technology" revealed that the public had a positive attitude toward science, but a poor understanding of it.^[54] During 2004–5 NSF sent "rapid response" research teams to investigate the aftermath of the Indian Ocean tsunami disaster^[55] and Hurricane Katrina.^[56] An NSF-funded engineering team helped uncover why the levees failed in New Orleans. In 2005, NSF's budget stood at \$5.6 billion, in 2006 it stood at \$5.91 billion for the 2007 fiscal year (October 1, 2006 through September 30, 2007), and in 2007 NSF requested \$6.43 billion for FY 2008.^[57]

2010–present

President Obama requested \$7.373 billion for fiscal year 2013.^[58] Due to the October 1st 2013 shutdown of the Federal Government, and NSF's lapse in funding, their website was down "until further notice," but was brought back online after the US government passed their budget. In 2014, NSF awarded rapid response grants to study a chemical spill that contaminated the drinking water of about 300,000 West Virginia residents.^[59]

Public attitudes and understanding

NSF surveys of public attitudes and knowledge have consistently shown that the public has a positive view of science but has little scientific understanding. The greatest deficit remains the public's understanding of the scientific method. Comparison surveys elsewhere in the world, including Japan and Europe, have indicated public interest in science and technology is lower than in the US, with China a notable exception. A majority of Americans (54%) had heard "nothing at all" about nanotechnology in 2008.^[60]

Criticism

In May 2011, Republican Senator Tom Coburn released a 73-page report, "National Science Foundation: Under the Microscope",^{[61][62]} receiving immediate attention from such media outlets as *The New York Times*, Fox News, and MSNBC.^{[63][64][65]} The report generated significant controversy, due to its accusations about various research projects, and its critical view of the social sciences, while critics of the report claimed political bias.

See also

- American Association for the Advancement of Science
- Capital Jury Project
- C-MORE, the Center for Microbial Oceanography: Research and Education, an NSF Science and Technology Center
- International Council on Nanotechnology
- Mid-InfraRed Technologies for Health and the Environment (MIRTHE) (largely based at Princeton University in the US)
- National Digital Information Infrastructure and Preservation Program
- National Digital Library Program (NDLP)
- Research council
- Scientific literacy
- Science and Technology Policy Institute
- SedDB, online database for sediment geochemistry
- U.S. Civilian Research & Development Foundation
- United States National Academy of Sciences
- Glossary of areas of mathematics
- Glossary of astronomy
- Glossary of biology
- Glossary of chemistry
- Glossary of engineering
- Glossary of physics

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31. "NSF Beijing Office".
32. crosscutting (http://www.nsf.gov/funding/pgm_list.jsp?type=xcut)
33. Nanotechnology (<http://www.nsf.gov/crssprgm/nano/>)
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64. Office of Sen. Tom Coburn (2010-04-07). "Senate Report Finds Billions In Waste On Science Foundation Studies". Fox News. Retrieved 2011-09-09.
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Further reading

- Oral history interview with Bruce H. Barnes, 26-Sep-1990 (<http://purl.umn.edu/107103>) - Charles Babbage Institute, University of Minnesota. Barnes describes his duties as a program director at NSF. He provides brief overviews and examples of NSF's support of research in theoretical computer science, computer architecture, numerical methods, software engineering, and the development of networking. He describes NSF's support for the development of computing facilities through the 'Coordinated Experimental Research Program'.
- Science and Engineering Indicators (<http://nsf.gov/statistics/seind14/index.cfm/overview>) published biannually since 1972 by the National Science Board, provides quantitative information on the U.S. and international science and engineering enterprise.

External links

- Official Website (<http://www.nsf.gov/>)
- National Science Foundation (<https://www.federalregister.gov/agencies/national-science-foundation>) in the Federal Register
- IGERT (<http://www.igert.org/>)
- TerraFly Autopilot Walk from Metro to NSF offices (<http://cake.fiu.edu/NSF-Walk/>)
- Historic technical reports from the National Science Foundation (and other federal agencies) are available in the Technical Report Archive and Image Library (TRAIL) (<http://www.technicalreports.org/>)



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