Ideas

In order to achieve the NSF mission, one of the agency's key strategies is to support the most promising ideas in research and education. The expected outcomes of these investments are a fundamental knowledge base that enhances progress in all science and engineering areas and partnerships that connect discovery to innovation, learning and service to society.

(Millions of Dollars)

	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate
Ideas	$1,962	$2,251	$2,220

FY 2002 support for Ideas totals $2,220 million, a decrease of $31 million, or 1.4 percent, below FY 2001. This provides funding for research projects that include researchers and postdoctoral associates as well as undergraduate and graduate assistants. Funds are also provided for items necessary for performing research, such as instrumentation and supplies, and for related costs such as travel and conference support. Research in core disciplinary areas as well as studies within NSF's four priority areas are included within funding for Ideas. Through outreach activities, NSF seeks out and supports excellent proposals from groups and regions that traditionally have not fully participated in science, mathematics, and engineering.

Support provided primarily to further NSF's other strategic outcomes, People and Tools, is essential for facilitating Ideas – discovery across the frontier of science and engineering, connected to learning, innovation, and service to society. NSF's investment in People promotes the integration of research and education and ensures that the U.S. has world-class scientists and engineers, a workforce that is scientifically and mathematically strong, and a public that understands and can take full advantage of basic concepts of science, mathematics, engineering and technology. Support for Tools provides access to state-of-the art facilities and platforms which are essential for world-class research.

In FY 2002, NSF will continue its efforts to increase the average size of awards. This effort will contribute to increasing the efficiency of the Foundation's merit review process and achieve greater cost-effectiveness for both NSF and the university community.

The FY 2002 Request focuses on areas that build strength in the science and engineering disciplines, enable the development of new and emerging fields, and provide leadership to improve the health and continued vitality of the Nation's science, mathematics, engineering, and technology (SMET) education.

Areas of emphasis within NSF's core research will include:

- Interdisciplinary mathematics: $20.0 million will enhance the transfer of results and applications from mathematics and statistics research to the science and engineering disciplines, challenge the limits of current mathematical theories, and develop a new cadre of researchers who are trained in both mathematics and science.

- Research in cognitive neuroscience: emphases on the neuroscience of child development, language, and social behavior.

- Genome enabled science: emphases on activities from genome sequencing and the assembly of primary sequence databases through functional analyses, also known as "functional genomics," to integrative research.

- Quantum science and engineering: address new opportunities in the quantum realms of physics, materials research, chemistry, biological molecules, mathematics, quantum computing and quantum communications, cosmology and engineering.

- Planetary energetics and dynamics: studies of tectonic and mass-energy dynamics at the continent-ocean interface will aid in the mitigation and prediction of earthquakes, storms, and storm tracks.

- Human-computer systems: emphases include instantaneous translation, access to meaningful information, and information relevant to contexts.

- Engineering the service industry: emphasize decentralized decision making and information sharing in complex systems.

- The Experimental Program to Stimulate Competitive Research (EPSCoR), a State-NSF partnership, will continue to support improvements in academic research competitiveness. In FY 2002, funding for EPSCoR through the Education and Human Resources appropriation totals $74.81 million. Linkages between EPSCoR and other NSF-supported research activities are expected to result in up to $25 million in additional funding directed to research in EPSCoR states.

- The Small Business Innovation Research (SBIR) program is supported at the mandated level of at least 2.5 percent of extramural research. The program will total $70.65 million, level with FY 2001.

Also included within support for Ideas are funds for fundamental research within the Foundation's four priority areas:

Biocomplexity in the Environment (BE) – At the leading edge of environmental science and engineering, this multidisciplinary priority area focuses on understanding interdependency, complexity, and human influences in natural systems. Activities explore new models of dynamic behavior, feedback between highly-coupled systems across spatial and temporal scales, and relationships between organisms and their physical environments. This investment will increase our understanding of human impacts on the environment; improve scientific and technical capabilities for environmental studies, data management, and long-term investigations; and enhance our ability to forecast environmental conditions, thus improving environmental decision-making.

Information Technology Research (ITR) – To improve ways to gather, store, analyze, share and display information, this multi-agency priority area, led by NSF, expands research on software, networking, scalability, and communications. The program increases access to terascale computing power, enabling researchers to tackle problems previously considered too complex to address – such as long-range weather forecasting, simulation of galaxy formation, and protein folding. FY 2002 will expand our research in multidisciplinary areas, focusing on fundamental research at the interfaces between scientific areas, including information technology. Additional investments will support research on the uses and impact of IT on our society, on our economy, and on our educational system. Because the information technology sector has contributed substantially to recent U.S. economic growth, these investments must remain a top priority.

Nanoscale Science and Engineering – In its second year, the multi-agency National Nanotechnology Initiative will expand fundamental research on phenomena at molecular and atomic scales and develop new techniques to facilitate application. Recent advances have already begun to spawn useful new materials and promising innovations that will touch every part of our lives, from our medicine cabinets – with targeted drug delivery systems, vaccines, and electronic biosensors to detect cancer in its earliest stages – to our workplace – with faster, more efficient computers and networks. As countries currently compete for global preeminence in these technologies, this investment will strengthen U.S. leadership and boost efforts to build a nanotech-ready workforce.

Learning for the 21st Century – The multidisciplinary learning research component of this priority area contributes to NSF's investment in Ideas. It involves cross-cutting research incorporating fields such as design of learning environments, human-computer interactions, cognitive psychology, cognitive neuroscience, computational linguistics, child development, sociology, and complex educational systems. Activities in this element include the Interagency Education Research Initiative (IERI), the Research on Learning and Education (ROLE) program, and other research activities related to child learning and cognitive development.

Centers

NSF supports a variety of individual centers and centers programs which contribute to NSF's investment in Ideas. The centers play a key role in furthering the advancement of science and engineering in the U.S., particularly through their encouragement of interdisciplinary research and the integration of research and education. While the programs are diverse, the centers generally share common commitments:

- To address scientific and engineering questions with a long-term, coordinated research effort. Center programs involve a number of scientists and engineers working together on fundamental research addressing the many facets of complex problems;

- To include a strong educational component that establishes a team-based cross-disciplinary research and education culture to train the nation's next generation of scientists and engineers to be leaders in academe, industry and government; and

- To develop partnerships with industry that help to ensure that research and education are relevant to national needs and that knowledge migrates into innovations in the private sector.

The center programs which contribute to the Ideas goal are listed below.

(Millions of Dollars)

	Year of Program Initiation	FY 2000 No. of Centers	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate
Engineering Research Centers and Groups	1985	36	55	63	62
Science & Technology Centers	1987	17	52	41	45
Industry/University Cooperative Research Centers	1973	53	5	5	5
State/Industry/University Cooperative Research Centers	1991	3	1	1	1
Centers of Research Excellence in Science and Technology	1987	10	9	9	9
Plant Genome Virtual Centers	1998	23	31	31	31
Materials Centers	1994	29	54	58	54
Center for Ecological Analysis and Synthesis	1995	1	2	2	2
Long-Term Ecological Research Program	1980	24	17	17	17
Earthquake Engineering Research Centers	1988	3	6	6	6
Chemistry Centers	1998	12	10	9	9
Mathematical Sciences Research Institutes	1982	3	8	8	15
Information Technology Centers	2000	33	33	50	53
Other Centers[1]	NA	3	6	9	15
TOTAL		250	$288	$309	$325

Totals may not add due to rounding.
[1] Other Centers include the Research Centers on the Human Dimensions of Global Change, the National Consortium on Violence Research and Physics Frontiers Centers.

FY 2002 support for centers is about $325 million, an increase of approximately $15 million over FY 2001.

- Information Technology Centers, initiated in FY 2000, support fundamental research in information technology that incorporates scientific applications or addresses social, ethical and workforce issues. An increment of $3.0 million for this program will provide support for an additional 3-5 awards in FY 2002.

- FY 2002 funding of $62.32 million will support 20 ongoing Engineering Research Centers and 16 Engineering Research Groups. FY 2002 funding of $5.99 million will be provided for the three ongoing Earthquake Engineering Centers. These centers have formed partnerships with industry and other practitioners to produce significant knowledge, technology and educational advances that strengthen industry and prepare a science and technology workforce capable of innovating in a broad range of technology fields.

- NSF will continue support for the Science and Technology Centers program. Support at a level of $19.49 million for the five new centers awarded in FY 2000 will continue. Funding for the remaining 12 STCs in the second cohort ends in FY 2001 in accordance with plans. The rollover of these funds will support an FY 2002 competition at a level of $25.62 million to establish a new cohort of STCs.

- Funding for Materials Centers will decrease by $3.31 million to a total of $54.25 million. Up to three new Materials Research Science and Engineering Centers and one new International Materials Institute will be established through open competition for a total of $4.0 million. Funding will be generated by phasing out existing Centers. The new centers will focus on critical areas such as nanoscience and engineering, information technology, and the interface between materials and biology.

- The Physics Centers program will increase by $5.50 million, to a total of $10.50 million, to establish at least two additional Physics Frontier Centers. This will support a total of up to four centers to catalyze new areas such as atom lasers, quantum information science, computational physics, biological physics, and astrophysics.

- As part of the interdisciplinary mathematics area of emphasis, increased funding of $7.0 million for the Mathematical Sciences Research Institutes will provide support for up to four new Institutes in interdisciplinary mathematical sciences.

Additional information for selected centers supported by NSF is provided below:

FY 2000 Estimates for Selected Centers
(Millions of Dollars)

	Number of Participating Institutions	Number of Partners	Total NSF Support	Total Leveraged Support	Number of Participants
Engineering Research Centers and Groups [1]	147	439	$55	$100	10,482
Science & Technology Centers	91	160	$52	$76	2,756
Industry/University Cooperative Research Centers and State/Industry/University/Cooperative Research Centers	115	753	$6	$69	1,901
Centers of Research Excellence in Science and Technology	10	96	$9	$9	2,900
Plant Genome Virtual Centers	50	27	$31	$3	2,800
Materials Centers	80	280	$54	$55	5,500
Long Term Ecological Research Program	167	116	$17	$30	2,500
Earthquake Engineering Research Centers	39	111	$6	$11	171
Chemistry Centers	51	75	$10	$2	630

Number of Participating Institutions: all academic institutions which participate in activities at the centers.
Number of Partners: the total number of non-academic participants, including industry, states, and other federal agencies at the centers.
Total Leveraged Support: funding for centers from sources other than NSF.
Number of Participants: the total number of people who utilize center facilities, not just persons directly supported by NSF.
[1] Number of Participating Institutions, Number of Partners, Total Leveraged Support and Number of Participants are for Engineering Research Centers only. Data for Engineering Research Groups is not available.

FY 2002 Performance Goal for Ideas

The following table summarizes NSF's FY 2002 Performance Goal for Ideas. For additional information, see the FY 2002 Performance Plan.

Strategic Outcomes	No.	Annual Performance Goals[1] for Strategic Outcomes	FY 2002 Areas of Emphasis
IDEAS **<u>Outcome Goal:</u>** **To enable "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."**	**III-2**	**NSF's performance for the Ideas Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority (4 of 6) of the following indicators:** ● Discoveries that expand the frontiers of science, engineering, or technology; ● Discoveries that contribute to the fundamental knowledge base; ● Leadership in fostering newly developing or emerging areas; ● Connections between discoveries and their use in service to society; ● Connections between discovery and learning or innovation; and ● Partnerships that enable the flow of ideas among the academic, public or private sectors.	Balance of portfolio, including projects that are innovative, risky, or multidisciplinary Priority areas: - Biocomplexity in the Environment - Information Technology Research - Nanoscale Science and Engineering Core research and education activities - Interdisciplinary mathematics

[1] This performance goal is stated in the alternate form provided for in GPRA legislation.

Highlights (Ideas)

NSF investments in fundamental research provide support for cutting-edge research and education in many fields and help to maintain the nation's capacity to conduct research in science and engineering. Selected examples of accomplishments of NSF-supported investments are described below.

Efficient Map-making in 3-D Settings With Mobile Robots: Mapping unfamiliar terrain or buildings with robots has high potential for working in hazardous or distant places. With accurate maps, robots can find their way and with accurate robot navigation, maps can be made. But like the chicken and egg problem, when neither is present it has been difficult for computers to get started on either task. At Carnegie Mellon University, Sebastian Thrun has developed a new statistical mapping algorithm that enables teams of mobile robots equipped with 2D-laser range finders to build joint maps together in real-time. The new method is fast and remarkably robust and can generate accurate maps of large cyclic environments even in the absence of any odometric data, in real-time and on a low-end computer. Thrun's work received the Best Conference Paper Award at the *2000 IEEE International Conference on Robotics and Automation* held in San Francisco in April 2000.

Urban Ecology: A Baltimore Ecosystem Study is focusing on how people at different scales – households, neighborhoods, and municipalities – affect water quality in the regional watersheds. Initial research has shown a significant relationship between concentration of political and economic power in the city and the different levels of investment in green infrastructure among neighborhoods. Additional research is focusing on how households affect water quality through irrigation, use of fertilizers and pesticides, as well as on how such land management practices vary with household demographic and socioeconomic characteristics.

Keeping Structures Safe: The use of de-icing salts and chloride-containing additives on concrete has caused a large increase in the number of structures – e.g., bridges, buildings and port structures – having problems with corroded steel. To help solve this problem, researchers at Carnegie Mellon University are developing a new electronic chip that uses nuclear magnetic resonance (NMR) to detect the chloride ion in concrete. Detection using NMR typically requires large expensive devices; this team is going to make it possible with a single chip. The team includes professors from civil engineering, chemical engineering, electrical engineering and physics. The NMR chip will help the country maintain its structures better and more economically. NMR chips placed throughout structures can warn engineers when the free chloride level in the concrete reaches a dangerous level so that steps can be take to prevent corrosion and loss of the structure.

Neural Networks: Scientists attempting to understand the human brain have developed computer models called neural networks which try to simulate the computational power of the nervous system. For every human action involving vision, memory, or language, the brain enlists dynamic interacting populations of nerve cells to perform that task. New approaches use a nonlinear neural network combined with computer simulations that mimic the way humans solve problems, not like a digital computer, but by memorizing facts, simplifying, and estimating answers. Progress in these areas has contributed to the design of "smart" machines and other forms of artificial intelligence.

Evidence that the cosmos is "flat": A microwave telescope borne by a huge balloon for 10½ days 120,000 feet over Antarctica provided detailed observational evidence that the large-scale geometry of the universe is flat. The research, supported by NSF and NASA, was published in *Nature* and widely publicized, including in the *New York Times* and the *Washington Post,* on April 27, 2000. The telescope provided high angular resolution images of the heat produced in the Big Bang 12-15 billion years ago. The intense heat still is detectable as a faint glow called cosmic microwave background radiation. Point-to-point variations in the heat reveal structure in the universe when it was only 300,000 years old.

Cracks Along Continental Shelf: Researchers have discovered cracks along the edge of the continental shelf off the coast of Southern Virginia formed by continuous and massive blowouts of gas. The implications of these findings – published in Geology, May 2000 – are important for geohazards on the East Coast of the United States because they could trigger landslides and tsunamis. Similar gas blowouts have damaged or destroyed oilrigs in the Gulf of Mexico and the North Sea.

Router Improvements Widely Adopted: Internet traffic is growing at incredible rates. Optical communications technologies are able to accommodate these increases, but there is a severe bottleneck in the electronics implementing the packet routing functions. High impact pioneering research in how Internet routers look up addresses rapidly to achieve high throughput resulted in new techniques that initially decreased the address lookup time by a factor of eight without the addition of new hardware. These ideas have been patented and licensed to several routing-equipment manufacturers, including Lucent, GTE, NEC, and Microsoft. NSF's research support has created an entirely new approach to designing high-speed Internet routers, which will address the needs of a multi-billion dollar market.

Nobel Laureates in Chemistry: The 1999 Nobel Prize in Chemistry was awarded to Ahmed Zewail for his pioneering real-time studies of the ultrafast making and breaking of chemical bonds. Alan J. Heeger, Alan G. MacDiarmid and Hideki Shirakawa shared the Nobel Prize for Chemistry in 2000 for the discovery and development of conductive polymers, so-called polymer metals. Zewail has been continuously funded by the NSF for 20 years. NSF has supported the collaboration between Heeger, a physicist and MacDiarmid, a chemist, since the 1970s.

Control of Invasive Fire Ants: Researchers have discovered that the growing threat of imported Brazilian fire ants to native North American ecosystems is associated with a lack of natural enemies such as phorid flies. In Brazil, these flies are important parasites that affect fire ant behavior and competition with other ant species. The absence of natural enemies has allowed a tremendous expansion of exotic fire ants throughout much of the U.S. with significant ecological and economic harm. Project findings have reached popular audiences through reports on National Public Radio, CNN, and the BBC. Knowledge gained from this research may open the way for effective control of this disastrous invasive species.

Anticipating "Brownouts": NSF-supported researchers have discovered new methods to anticipate "brownouts" in electric power systems due to voltage collapse problems. Software implementing these methods is being adopted by electric utilities. The new software allows utilities to quickly assess the transfer capability based on operational voltage stability margins. The models take into account power system conditions and limitations. Utilities can determine whether it is likely that their power needs will be met or the potential conditions under which there may be problems that will require other power sources. Researchers are helping to assess the new markets for electricity as they emerge and to provide a fundamental understanding of the effects of these new markets on electric power system reliability.

Technology Investment and Student Achievement: Project Hiller is a longitudinal study in which 40 incoming freshmen and 20 teachers have been supplied with laptop computers every year for three years in a Union City, NJ school of almost exclusively Hispanic students with limited competence in English. Results have shown consistent increases in student achievement brought about by long-term investment in technology and the reform of curriculum and teaching. The researchers found that technology, used well, improves achievement, makes students feel both knowledgeable and competent, increases teachers' expectations of these students, and serves to create a culture among students in which it is acceptable to be academically successful. Within each track, Hiller participants posted higher scores than non-Hiller peers across the board in every subject, and mean scores for Hiller general track students in each subject were higher than the mean scores for non-Hiller honor students.