NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

NNI Funding

(Dollars in Millions)

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Request
Biological Sciences	$53.67	$50.28	$48.80
Computer and Information Science and Engineering	10.26	10.67	10.15
Education and Human Resources	2.50	2.50	2.50
Engineering	182.88	174.75	166.00
Geosciences	1.55	0.30	0.30
Mathematical and Physical Sciences	197.37	171.01	180.62
Social, Behavioral and Economic Sciences	1.67	1.00	1.40
International and Integrative Activities	0.10	0.10	0.10
Total, NNI	**$450.00**	**$410.61**	**$409.87**

Totals may not add due to rounding.

NSF's contribution to the multiagency National Nanotechnology Initiative (NNI) encompasses the systematic understanding, organization, manipulation, and control of matter at the atomic, molecular, and supramolecular levels in the size range of about 1 to 100 nanometers. Novel materials, devices, and systems – with their building blocks designed on the scale of nanometers – open up new directions in science, engineering, and technology with potentially profound implications for society. With the capacity to control and manipulate matter at this scale, science, engineering, and technology researchers are realizing revolutionary advances in areas such as order-of-magnitude faster computers with less energy consumption: catalysts for industry; molecular medicine; nanosensors to monitor health and environment; efficient and large scale nanomanufacturing of nanotechnology-based products; more resilient materials and system architectures; and sustainable development for water, energy, and food resources utilization. NSF contributes to the NNI goals and five program component areas (PCAs) outlined in the 2014 NNI Strategic Plan and the NNI Supplement to the President's Budget for Fiscal Year 2015 (www.nano.gov).

FY 2015 NNI Funding

NSF supports nanoscale science and engineering throughout all the research and education directorates as a means to advance discovery, invention, and innovation and to integrate various fields of research. NNI enables increased interdisciplinarity at atomic and molecular levels for about 6,000 active awards with full or partial contents on nanoscale science and engineering (NSE). About 10,000 students and teachers will be educated and trained in nanoscale science and engineering in FY 2015. The first PCA including five Nanotechnology Signature Initiatives (NSIs) will increase by $2.68 million, as compared to FY 2014 Estimate, to $115.59 million. The main change is in Nanoelectronics for 2020 and Beyond NSI with an increase of $3.50 million. The Sustainable Nanomanufacturing NSI and the Nanotechnology for Knowledge Infrastructure NSI will be dedicated to research on breakthrough materials, advanced manufacturing, and nanoinformatics in core programs, dedicated networks, and as part of the Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) NSF-wide investment. Three Nanosystems Engineering Research Centers (NERC), with a total estimated budget of approximately $55.0 million for five years were established in September 2012 and started full operation in FY 2013. Partnerships of new NERCs with small businesses in the areas of nanomanufacturing and commercialization will be strengthened while maintaining about the same level of NSF investment. In FY 2015, NSF continues its contributions to translational innovation programs, including Grant Opportunities for Academic Liaison with Industry (GOALI); Industry/University Cooperative Research

Centers (I/UCRC); the NSF Innovation Corps (I-Corps) program; and the two subcomponents of Partnerships for Innovation (PFI) – Accelerating Innovation Research (AIR) and Building Innovation Capacity (BIC). The NSF Small Business Innovation Research (SBIR) program has an ongoing nanotechnology topic with subtopics for nanomaterials, nanomanufacturing, nanoelectronics and active nanostructures, nanotechnology for biological and medical applications, and instrumentation for nanotechnology. Overall, total NNI funding in the FY 2015 Request of $409.87 million is relatively unchanged from the FY 2014 Estimate of $410.61 million.

In FY 2015, NSF will continue its funding for the Environmental, Health and Safety (EHS) PCA at $22.33 million, representing nearly 5.5 percent of its overall NNI budget. Requests for research are primarily directed at environmental, health, and safety implications and methods for reducing the respective risks of nanotechnology development.

NSF sponsored an international study on long-term research entitled *Nanotechnology Research Directions for Societal Needs in 2020*[1]. It provides an assessment of nanotechnology development in the last ten years (2000-2010) and a long-term vision of the field in the next decade (2010-2020). This study evaluates the outcomes as recommended by the first report issued in 1999, *Nanotechnology Research Directions: A vision for the next decade*, adopted as an official document of the National Science and Technology Council (NSTC). NSF co-sponsored with five other NNI agencies the study entitled *Converging Knowledge, Technology and Society*[2] evaluating the convergence of nanotechnology with other emerging areas.

Nanotechnology Signature Initiatives (NSIs)

The FY 2015 Request includes $115.59 million for the NSIs. Special emphasis will be on:

- Nanotechnology for Solar Energy Collection and Conversion ($27.67 million) – Enhancing understanding of energy conversion and storage phenomena at the nanoscale, improving nanoscale characterization of electronic properties relevant to solar energy, and utilization of the unique physical phenomena that occur on the nanoscale to help overcome current performance barriers and substantially improve the collection and conversion of solar energy. This initiative is aimed at using nanotechnology to help overcome current performance barriers and substantially improve the collection and conversion of solar energy.
- Sustainable Nanomanufacturing ($23.40 million) – Establishing manufacturing technologies for economical and sustainable integration of nanoscale building blocks into complex, large-scale systems by supporting product, tool, and process design informed by and adhering to the overall constraints of safety, sustainability, and scalability. This signature initiative specifically focuses on high-performance structural carbon-based nanomaterials, optical metamaterials, and cellulosic nanomaterials. This initiative will establish manufacturing technologies for economical and sustainable integration of nanoscale building blocks into complex, large-scale systems. A program solicitation on Scalable Nanomanufacturing is under way in FY 2014 and another is planned in FY 2015.
- Nanoelectronics for 2020 and Beyond ($38.02 million) – Discovery and use of novel nanoscale fabrication processes and innovative concepts to produce revolutionary materials, devices, systems, and architectures to advance the field of nanoelectronics. This initiative is aimed at discovering and using novel nanoscale fabrication processes and innovative concepts to produce revolutionary materials, devices, systems, and architectures to advance the field of electronics. Collaboration in Nanoelectronics Research Initiative with Semiconductor Research Corporation and the National Institute of Standards and Technology (NIST) is planned to continue in FY 2015.

[1] NSF/WTEC 2010, Springer, available on www.nsf.gov/nano and www.wtec.org/nano2/
[2] NSF/WTEC 2013, Springer, available on www.nsf/gov/nano and www.wtec.org/NBIC2-Report/

- Nanotechnology Knowledge Infrastructure ($19.0 million) – Activities surrounding the fundamental, interconnected elements of collaborative modeling, a cyber-toolbox, and data infrastructure for nanotechnology, leveraging and extending existing and emerging resources, programs, and technologies to create an infrastructure to accelerate the vetting of new knowledge and to enable effective data utilization. This initiative aims to provide a community-based, solution-oriented knowledge infrastructure for discovery, innovation and nanoinformatics (with NNI agencies). The Network for Computational Nanotechnology (NCN) conducts key activities in support to this NSI.
- Nanotechnology for Sensors and Sensors for Nanotechnology ($7.50 million) – Use of nanotechnology and nanoscale materials to build more sensitive, specific, and adaptable sensors in order to overcome the technical barriers associated with conventional sensors, and development of new sensors to detect engineered nanomaterials across their life cycles in order to assess their potential impacts. This initiative supports materials and technologies that enable new sensing of biological, chemical and nanoscale materials, including sensors for nano-EHS. A dedicated program on Nanosensors established in the Chemical, Bioengineering, Environmental and Transport Systems (CBET) division will support this effort.

Foundational Research
The FY 2015 Request includes $181.36 million for the discovery and development of fundamental knowledge pertaining to new phenomena in the physical, biological, and engineering sciences that occur at the nanoscale. The request also incudes funding for research aiming to understand scientific and engineering principles related to nanoscale structures, processes, and mechanisms. Research is also supported that is aimed at discovery and synthesis of novel nanoscale and nanostructured materials and at a comprehensive understanding of the properties of nanomaterials ranging across length scales, and including interface interactions. Research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, ethical, and legal implications is also supported.

Nanotechnology-Enabled Applications, Devices, and Systems
The FY 2015 Request includes $46.57 million for research and development that applies the principles of nanoscale science and engineering to create novel devices and systems, or to improve existing ones. This includes the incorporation of nanoscale or nanostructured materials and the processes required to achieve improved performance or new functionality, including metrology, scale up, manufacturing technology, and nanoscale reference materials and standards. To meet this definition, the enabling science and technology must be at the nanoscale, but the applications, systems, and devices themselves are not restricted to that size.

Research Infrastructure and Instrumentation
The FY 2015 Request includes $44.02 million for the establishment and operation of user facilities and networks, acquisition of major instrumentation, workforce development, and other activities that develop, support, or enhance the Nation's physical or human infrastructure for nanoscale science, engineering, and technology. This PCA includes research pertaining to the tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems. While student support to perform research is captured in other categories, dedicated educational and workforce efforts ranging from curriculum development to advanced training are included here as resources supporting the human infrastructure of the NNI.

Environment, Health, and Safety
The FY 2015 Request includes $22.33 million, to support research and development primarily directed at understanding the environmental, health, and safety impacts of nanotechnology development and corresponding risk assessment, risk management, and methods for risk mitigation.

Coordination with Other Agencies

The NSF program is coordinated with 25 departments and agencies through the NSTCs subcommittee on Nanoscale Science, Engineering and Technology (NSET). Some specific coordination efforts are:

- Sustainable Nanomanufacturing (NIST, Department of Energy (DOE), EPA, Intelligence Community (IC), National Institutes of Health (NIH), National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Department of Agriculture USDA/FS);
- Nanoelectronics (NIST, DOD, DOE, IC/DNI, NASA);
- Environmental issues (EPA, USDA/NIFA, Consumer Product Safety Commission (CPSC));
- Solar energy conversion (DOE, IC/DNI, National Aeronautics and Space Administration (NASA), NIST, NSF, USDA/NIFA);
- NSECs, NNIN and NCN centers and networks (DOD, NASA, DOE, NIH); and
- Nano-sensors (with NIH, and USDA).

These agencies also partner with NSF to sponsor joint workshops on nanotechnology research directions, and representatives from agencies involved in NNI activities participate in grantees conferences.

NNI Funding by Program Component Area

(Dollars in Millions)

	FY 2013 Actual	FY 2014 Estimate	FY 2015 Request
1. Nanotechnology Signature Initiatives	$115.16	$112.91	$115.59
Nanotechnology for Solar Energy	*25.53*	*25.17*	*27.67*
Sustainable Nanomanufacturing	*27.05*	*24.72*	*23.40*
Nanoelectronics for 2020 and Beyond	*36.66*	*34.52*	*38.02*
Nanotechnology Knowledge Infrastructure	*9.76*	*20.90*	*19.00*
Nanotechnology for Sensors	*16.16*	*7.60*	*7.50*
2. Foundational Research	209.21	180.63	181.36
3. Nanotechnology-Enabled Applications, Devices, and Systems	49.32	46.87	46.57
4. Research Infrastructure and Instrumentation	56.28	44.87	44.02
5. Environment, Health, and Safety	20.03	25.33	22.33
Total, NNI	**$450.00**	**$410.61**	**$409.87**

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