

National Nanotechnology Investment in the FY 2010 Budget¹

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INTRODUCTION

The emerging fields of nanoscale science, engineering, and technology—which investigate how to measure and restructure matter at the atomic and molecular levels to create materials, devices, and systems with fundamentally new properties and functions—are leading to unprecedented understanding and control over the basic building blocks and properties of all natural and manmade things. The fiscal year (FY) 2010 funding request for nanoscale science, engineering, and technology (in brief, *nanotechnology*) research and development (R&D) in 13 federal departments and agencies is **\$1.64 billion** (Table I-8). This investment is known as the National Nanotechnology Initiative (NNI) and began in FY 2001, with a budget of \$494 million.³ The NNI engages 25 federal departments and agencies (Appendix A) in long-term, strategic collaboration to accelerate the discovery, development, and deployment of nanotechnology. Because of the NNI, federal agencies have initiated major new nanotechnology R&D activities under a common vision that supports national goals and agency missions, an extensive infrastructure of nanotechnology research and education centers has been established, and participating agencies are working together to maximize the effectiveness of their individual and collective investments on society.

¹ The print version of this chapter is condensed. The full version is available online at <http://www.aaas.org/spp/rd/rdreport10/>

² The author is Senior Advisor to the National Science Foundation (NSF) and key architect of the National Nanotechnology Initiative. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the NSF.

³ See the NNI website at <http://nano.gov>

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The NNI vision is a future in which understanding and control of matter at the nanoscale will lead to a revolution in technology and industry that benefits society. The four goals of the NNI are to: advance a world-class nanotechnology research and development program; foster the transfer of new technologies into products for commercial and public benefit; develop and sustain educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology; and support responsible development of nanotechnology.

Several agencies involved in NNI have committed an additional \$140 million for nanotechnology in FYs 2009-2010 with funding from the **American Recovery and Reinvestment Act (ARRA)** of 2009 as follows (as of June 1, 2009):

- **NSF**: \$108 million investment across all nanotechnology fields.
- **DOE**: \$25 million for capital equipment replenishment and augmentation at the five Basic Energy Sciences Nanoscale Science Research Centers (NSRCs) and a part of \$277 million for Energy Frontier Research Centers (EFRCs).
- **NIH**: a part of the NIH/NIEHS Challenge Grants in Health and Science Research and Grand Opportunity Grant Program in Engineered Nanomaterial Environmental Health and Safety.
- **NIST**: \$7 million as a part of NIST laboratories research.

NNI-supported R&D is reported in eight program component areas (PCAs); the PCAs and proposed FY 2010 funding levels across all NNI agencies are as follows: (1) fundamental nanoscale phenomena and processes, \$507 million; (2) nanomaterials, \$297 million; (3) nanoscale devices and systems, \$355 million; (4) instrumentation research, metrology, and standards for nanotechnology, \$84 million; (5) nanomanufacturing, \$50 million; (6) major research facilities and instrumentation acquisition, \$219 million; (7) environment, health, and safety (EHS), \$88 million; and (8) education and societal dimensions, \$36 million.

The 21st Century Nanotechnology R&D Act (Public Law 108-153) authorized long-term funding levels for five agencies (NSF, DOE, NASA, NIST, and EPA), and new legislation for multiyear reauthorization is currently in preparation in Congress.

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SUMMARY OF FY 2010 BUDGET REQUEST FOR NNI

The FY 2010 President's Request is approximately \$1.64 billion for federal investment in nanotechnology. Approximately 65 percent of the total NNI funding supports academic research. About 25 percent of NNI funding supports R&D at government laboratories, and about 10 percent supports industry R&D.

The FY 2010 NNI budget request provides increased support for research on fundamental nanoscale phenomena and processes, from \$479 million in FY 2008 to \$507 million in FY 2010. With additional funds provided under ARRA, the corresponding enacted funding in FY 2009 totals \$548 million. The proposed budget reflects growth in funding for instrumentation research, metrology, and standards (from \$69 million in FY 2008 to \$84 million in FY 2010) and in major research facilities and instrumentation acquisition (from \$194 million in FY 2008 to \$219 million in FY 2010).

Environmental, health, and safety (EHS) R&D funding requested for FY 2010 (\$88 million) is \$20 million higher than actual funding in FY 2008 (\$68 million). In this document, EHS R&D is defined as research whose primary purpose is to understand and address potential risks to health and to the environment posed by nanotechnology (reported under PCA 7). Therefore the proposed \$88 million for FY 2010 does not include substantial research reported under other PCAs.

NATIONAL SCIENCE FOUNDATION (NSF)

The FY 2010 request for NSF nanotechnology activities is approximately \$423 million, a \$26 million increase over the FY 2009 current estimate (see Table 1). NSF will provide \$108 million in additional support for nanotechnology from ARRA funds in FY 2009 and FY 2010 (\$35 million by the Directorate for Engineering and \$73 million by the Directorate for Mathematical and Physical Sciences).

Table 1. NSF Directorate Budgets for NNI funding
NSF National Nanotechnology Initiative Funding
(Dollars in Millions)

	FY 2008 Actual	FY 2009 Plan	ARRA Estimate	FY 2010 Request
Biological Sciences	58.73	56.60	-	56.60
Computer and Information Science and Engineering	14.51	11.00	-	11.00
Engineering	144.45	140.02	35.00	148.00
Geosciences	10.29	6.33	-	6.33
Mathematical and Physical Sciences	173.73	178.06	72.81	195.86
Office of International Science and Engineering	0.50	-	-	-
Social, Behavioral and Economic Sciences	2.25	1.67	-	1.67
Subtotal, Research and Related Activities	404.46	393.68	107.81	419.46
Education and Human Resources	4.10	3.50	-	3.50
Total, National Nanotechnology Initiative	408.56	397.18	107.81	422.96

Totals may not add due to rounding

NNI activities at NSF are coordinated by the Nanoscale Science and Engineering (NSE) Group. The NSF investment would be expanded to develop and strengthen critical fields and to establish the science and engineering infrastructure and workforce needed to exploit the opportunities presented by new capabilities. Environmental, health, and safety implications of nanotechnology, including development of predictive toxicity of nanomaterials, would be investigated in three dedicated multidisciplinary centers and by more than 50 smaller groups with a total annual budget of \$29.9 million. Ten networks for research, education, and user facilities would be operating in 2010 (see Table 2). The Major Research Instrumentation Program and other programs would continue to support the creation of smaller academic nanoscale science and engineering facilities.

DEPARTMENT OF DEFENSE (DOD)

The FY 2010 request for DOD is \$379 million, a decrease from the FY 2009 estimate in the current plan, which includes congressionally directed funds (see Table I-8). Because DOD is a mission-oriented agency, its nanotechnology programs are simultaneously focused on scientific and technical merit and potential relevance to DOD. The principal DOD participants in the NNI are the Directorate for Defense Research and Engineering (DDR&E), the Defense Advanced Research Projects Agency (DARPA), the Air Force, the Army, and the Navy. The Defense Threat Reduction Agency (DTRA), the U.S. Army Medical Research and Material Command, and the Manufacturing Technology

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(MANTECH) program are evaluating nanotechnology as an investment area. DOD supports nanoscale science and technology in order to meet the national security mission.

Table 2. NNI R&D centers, user facilities, and networks.

Name	Institution(s)
<i>NSF – ten networks</i>	
National Nanofabrication Infrastructure Network (NNIN) – 15 nodes (user facilities)	Cornell University – main node
Network for Computational Nanotechnology (NCN) – 7 nodes (user facilities)	Purdue University – main node
National Nanomanufacturing Network (NNN)	University of Massachusetts, Amherst – main node
Nanotechnology in Society Network (NCN)	Arizona State University and University of California, San Diego
Nanoscale Center for Learning and Teaching (NCLT)	Northwestern University – main node
Nanoscale Informal Science Education (NISE) Network	Museum of Science, Boston – main node
Nanoscale Science and Engineering Centers (NSEC)	University of Columbia – main node
Materials Science and Engineering Centers (MRSECs)	Distributed centers
Centers for the Environmental Implications of Nanotechnology (CEIN)	University of California, Los Angeles, and Duke University
Center for National Nanotechnology Applications and Career Knowledge (NACK)	Pennsylvania State University
<i>DOE – one network of five user facilities</i>	
Center for Functional Nanomaterials	Brookhaven National Laboratory
Center for Integrated Nanotechnologies	Sandia National Laboratory and Los Alamos National Laboratory
Center for Nanophase Materials Sciences	Oak Ridge National Laboratory
Center for Nanoscale Materials	Argonne National Laboratory
Center for Molecular Foundry	Lawrence Berkeley National Laboratory
<i>NIH – four networks</i>	
NHLBI Program of Excellence in Nanotechnology	Four distributed centers
Nanomedicine Development Centers	Eight distributed centers
Centers of Cancer Nanotechnology Excellence	Eight distributed centers
Nanotechnology Characterization Laboratory (user facilities)	Frederick, Md. campus
<i>NIST – two user facilities</i>	
Center for Nanoscale Science and Technology (CNST)	Gaithersburg, Md. campus
NIST advanced nanofabrication facility (NanoFab)	Gaithersburg, Md. campus

DEPARTMENT OF ENERGY (DOE)

In FY 2010, the total request for DOE is \$351 million, including a \$106 million increase over the FY 2008 actual (see Table I-8). The FY 2010 request includes a substantial increase in funding for research at the nanoscale for activities related to energy conversion and storage, fundamental studies of materials at the nanoscale, instrumentation for characterizing materials at the nanoscale, and research relevant to environmental and ecological aspects of nanomaterials. The FY 2010 request includes a large investment for all five Nanoscale Science Research Centers (NSRC). Support for fundamental scientific research on nanoscale phenomena would be by grant programs and DOE National Laboratory research efforts

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS): NATIONAL INSTITUTES OF HEALTH (NIH) AND NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

The total HHS request for nanotechnology in FY 2010 is \$338 million, which would support activities in NIH (\$326 million) and NIOSH (\$12 million). The FY 2010 NIH request would be invested in several roadmap initiatives⁴. NIH's priority for nanotechnology research continues to be creating novel diagnostic and therapeutic approaches and devices, and operating research capabilities to understand fundamental biomedical mechanisms. A consortium of 17 NIH institutes re-released the solicitation, Nanoscience and Nanotechnology for Biology and Medicine, both for regular research grants and feasibility projects. Large centers and related programs at the National Cancer Institute (NCI), National Heart, Lung, and Blood Institute (NHLBI), and Nanomedicine Roadmap Initiative would continue in 2010. There is a continued ramp-up of nanotechnology R&D funding for programs including implementing the Nanomedicine Roadmap Initiative, the NCI's Nanotechnology Platform Partnerships and Nanotechnology Characterization Laboratory, the NHLBI's Programs of Excellence in Nanotechnology, and the Nanotechnology Program Area at the National Institute of Biomedical Imaging and Bioengineering.

The FY 2010 NIOSH request would allow intramural and extramural projects targeted to addressing critical research gaps around occupational safety and health of nanotechnology and nanomaterials. NIOSH will

⁴ <http://nihroadmap.nih.gov>

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operate the Center of Excellence for Nanotechnology Research, with the role of coordinating nanotechnology-related activities across the institute and addressing critical occupational health issues. The agency plans to continue to develop partnerships with stakeholders and other organizations to enable the translation of agency activities into appropriate workplace practices.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

The FY 2010 request for EPA is \$18 million, a \$2 million increase from the FY 2009 estimate. In line with EPA's Nanotechnology White Paper (2007) and its strategic planning process, this program includes intramural research within EPA's Office of Research and Development, as well as the extramural program that has been in place for several years. EPA has launched a collaborative process on Nanoscale Materials Stewardship for voluntary reporting of nanomaterials production under the provisions of the Toxic Substances Control Act (TSCA). EPA would continue to focus the majority of its research in 2010 on health and environmental implications of nanomaterials. EPA would increase its efforts in the area of risk assessment and risk management needs for nanomaterials. Finally, EPA would research nanoscale technologies as potential solutions to environmental problems.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

The FY 2010 NASA request for nanotechnology programs is \$17 million. The NASA Office of Advanced Technology Program integrates nanotechnology development in three areas: materials and structures; nanoelectronics and computing; and sensors and spacecraft components. A major focus is to advance and exploit the zone of convergence between nanotechnology, biotechnology, and information technology. In addition to basic nanoscience and nanotechnology research, NASA plans to invest in various application areas.

DEPARTMENT OF HOMELAND SECURITY (DHS)

The FY 2010 request for DHS nanotechnology programs is approximately \$12 million, an increase of \$3 million over the FY 2009 plan. The funding increase would enable planned program scope changes associated with transitioning of technologies from proof of concept to prototype development. The DHS Directorate for Science and Technology (S&T) supports nanotechnology research that will enable

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critical enhancements to homeland security applications in advanced threat detection systems and materials and systems for mitigation and blast protection.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

The NIST FY 2010 budget request for nanotechnology is \$91 million, an increase of \$3.5 million compared to the FY 2009 estimate. The Center for Nanoscale Science and Technology (CNST, Gaithersburg campus) will focus on collaborative nanotechnology research on cost-effective manufacturing of products made with components the size of atoms and molecules. Additional foci at NIST include the development of standard reference materials for nanotechnology and research related to nanomanufacturing, as well as nanoelectronics. NIST has a large range of collaborations with industry.

NIST funding for EHS aspects of nanotechnology would increase from \$3.2 million in FY 2009 to \$6.2 million in FY 2010 to advance the development of an accurate characterization framework urgently needed by all federal agencies. NIST has also established a series of collaborative research programs focused on the new area of quantum nanotechnology.

FOOD AND DRUG ADMINISTRATION (FDA)

FDA will be addressing scientific and policy concerns and issues related to nanotechnology use for the entire spectrum of FDA-regulated products under the auspices of the FDA Nanotechnology Task Force and Nanotechnology Interest Group (NTIG), which is composed of scientists qualified to provide input on product development.

DEPARTMENT OF AGRICULTURE (USDA): COOPERATIVE STATE RESEARCH, EDUCATION AND EXTENSION SERVICES (CSREES) AND FOREST SERVICE (FS)

The FY 2010 request for USDA is approximately \$9 million (\$3.3 million for CSREES and \$5.4 million for FS). The budget request is expected to be lower than the effective budget for FY 2010, because, in accord with standard USDA practice, these figures do not include the special research grants earmarked by Congress. USDA conducts its nanotechnology research both in-house, at Agriculture Research Service (ARS) National Laboratories, and extramurally, through the partnership

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between the CSREES, the land grant universities (LGUs), and SBIR. The CSREES also provides leadership and financial support for education and outreach in all the states and territories of the United States through the LGUs.

CSREES's Agriculture and Food Research Initiative (AFRI) priorities include detection and intervention technologies for enhancing food safety and agricultural biosecurity; effective and safe delivery of bioactives in functional foods for improving human health and wellness; and product traceability, identity preservation, and tracking to embrace the continuous advancement of information technology for better decision-making. The FS plans to focus on applications of nanotechnology to enhance utilization of forest resources and research on low-cost forest product feedstocks for nanomanufacturing. The FS would support research to determine the basic nanoscale cell wall architecture of wood and bark, wood-binder interaction, and utilization of nano-carbon materials recovered from gasification of woody biomass, as well as characterization of nanoscale structures of chemically and physically altered wood fiber cell wall surfaces.

DEPARTMENT OF TRANSPORTATION (DOT)

The DOT Federal Highway Administration (FHWA) budget request for approximately \$3 million in FY 2010 would support research aimed at improving fundamental understanding of the structure and properties of highway construction materials at the nanoscale.

DEPARTMENT OF JUSTICE (DOJ)

The DOJ National Institute of Justice (NIJ) has two programs that involve nanotechnology. The first program, DNA Research and Development, would continue basic research as well as the demonstration of chip-based or micro-device technologies to analyze DNA in forensic applications. The second program, Chemical and Biological Defense, is developing wearable, low-cost devices using nanotechnology to provide warning of exposure to unanticipated chemical and biological hazards in sufficient time for its wearer to take effective protective measures.

Appendix A. NNI members (25 federal departments and agencies)

Federal Agencies Participating in the NNI (June 2009)
Federal agencies with budgets dedicated to nanotechnology research and development
Cooperative State Research, Education, and Extension Service (CSREES, Department of Agriculture) Department of Defense (DOD) Department of Energy (DOE) Department of Homeland Security (DHS) Department of Justice (DOJ) Department of Transportation (DOT) Environmental Protection Agency (EPA) Forest Service (FS, Department of Agriculture) National Aeronautics and Space Administration (NASA) National Institute of Standards and Technology (NIST, Department of Commerce) National Institute for Occupational Safety and Health (NIOSH, Department of Health and Human Services/Centers for Disease Control and Prevention) National Institutes of Health (NIH, Department of Health and Human Services) National Science Foundation (NSF)
Other participating agencies
Bureau of Industry and Security (BIS, Department of Commerce) Consumer Product Safety Commission (CPSC) Department of Education (DOEd) Department of Labor (DOL) Department of State (DOS) Department of the Treasury (DOTreas) Food and Drug Administration (FDA, Department of Health and Human Services) International Trade Commission (ITC) Intelligence Technology Innovation Center (ITIC) Nuclear Regulatory Commission (NRC) Technology Administration (TA, Department of Commerce) U.S. Geological Survey (USGS) U.S. Patent and Trademark Office (USPTO, Department of Commerce)