From: AAAS Report on U.S. R&D in FY 2010, Washington, D.C., June 2009 (Preprint)

25
National Nanotechnology Investment in the FY 2010 Budget Request

M.C. Roco[1]
Fellow, ASME

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-10). This investment is known as the National Nanotechnology Initiative (NNI) and began in FY 2001, with a budget of $494 million.[2] The NNI engages 25 Federal departments and agencies (Appendix A) in long-term, strategic collaboration to accelerate the discovery, development, and deployment of nanotechnology. The budget increase is justified by the current results and potential to expand fundamental knowledge and contribute to national priorities such as economic competitiveness and public health. NNI has enabled the following major accomplishments:

- Federal agencies have initiated major new nanotechnology R&D activities under a common vision that support national goals and agency missions.
- An extensive infrastructure of nanotechnology research and education centers has been established.
- Participating agencies are working together to maximize the effectiveness of their individual and collective investments on society.

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. Beginning in 2000 with research focused on basic understanding of specific phenomena, and progressively advancing towards nanosystems and revolutionary products, NNI aims to reach mass application of nanotechnology by 2020. The four goals of the NNI are to:

---

[1] The author is Senior Advisor to the National Science Foundation (NSF) and key architect of the National Nanotechnology Initiative. The views expressed in this paper are not necessarily those of NSF.

[2] See the NNI website <http://nano.gov>.

- 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.
- Support responsible development of nanotechnology.

Several agencies involved in NNI have committed 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 (RC1: develop methods to evaluate the health and safety of nanomaterials) and Grand Opportunity Grant Program in Engineered Nanomaterial Environmental Health and Safety.
- NIST: $7 million as a part of NIST Laboratories research.

Application areas for NNI include electronics for information technology; high-performance, lower-maintenance materials and design for manufacturing, defense, transportation, space, and the environment; applications in medicine, health care, and agriculture; and expanding the possibilities for sustainable development. In FY 2010, priority in R&D funding will continue be given to research on: (1) advancing the knowledge frontiers of nanoscale phenomena and processes to extend systematic control over matter at the nanoscale, and in particular to quantum phenomena and self-assembling processes; (2) materials with emerging behavior, including activities related to the hydrogen economy; (3) active nanostructures and complex nanosystems; (4) enabling the design of hierarchically structured materials and efficient nanomanufacturing from the molecular scale; (5) nano-biosystems and medicine; (6) silicon nanoelectronics and beyond; (7) development of instrumentation, metrology, and standards; and (8) environmental, health, and safety (EHS) issues.

NNI investment will also address the following four societal dimensions: the education and training of the new generation of workers for future industries; ethical and other social issues raised by the development of nanotechnology; the establishment and operation of major scientific user facilities with advanced instrumentation to foster the research community; and the creation partnerships to enhance industrial participation in the nanotechnology revolution. The convergence of nanotechnology with information technology, modern biology,

and social sciences will reinvigorate discoveries and innovation in almost all areas of the economy.

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.

The National Science and Technology Council (NSTC) Subcommittee on Nanoscale Science, Engineering, and Technology (NSET) coordinates joint NNI activities that create synergies between the individual agencies in a variety of topics and modalities of collaboration.[3] NSET identifies the most promising research directions; funds complementary/synergistic fields of research that are critical for the advancement of the nanoscience and engineering field; develops a balanced infrastructure (portfolio of programs, development of new specific tools, instrumentation, simulation infrastructure, standards for nanoscale); correlates funding activities for centers and networks of excellence; cost-shares high-cost R&D activities; develops a diverse workforce with the breadth and depth of expertise necessary for nanotechnology; studies the diverse, complex implications on society such as the effects of nanostructured material manufacturing on the environment and the effects of nanodevices on health; and avoids unnecessary duplication of efforts. NSET also addresses NNI management issues, the interaction with nanotechnology regional alliances, and international activities. NSET updated its long-term strategic investment plan in December 2007.[4]

Four NSET working groups (Nanomaterials Environmental and Health Implications, NEHI; Nanomanufacturing, Industry Liaison, and Innovation, NILI; Nanotechnology Public Engagement and Communication, NPEC; and Global Issues in Nanotechnology, GIN) provide support for partnerships.

[3] Details are in NNI Supplement to the President's FY 2010 Budget, Washington, D.C., May 2009
[4] The NNI Strategic Plan, NSET, Washington, D.C., December 2007

Regular evaluation is an important component of NNI activities. The President's Council of Advisors on Science and Technology (PCAST), which was assigned as the National Nanotechnology Advisory Panel (NNAP) called for in the 21st Century Nanotechnology R&D Act, reviewed NNI in the report **NNI at Five Years** (2005) and again in 2008.[5] The National Research Council has conducted three reviews of NNI, published in 2002, 2006, and 2008; the 2008 report focused on environmental, health, and safety aspects of NNI activities.

NNI COLLABORATIVE ACTIVITIES

In line with the priorities of the 2007 NNI Strategic Plan, NNI agencies collaborate on activities for R&D, technology transfer, international cooperation, development of standards and regulations, and infrastructure. Below are some examples of specific NNI collaborations coordinated by NSET in each of these areas.

Research and Development

- NSF and DOD are collaborating with the Semiconductor Research Corporation to develop the next generation of nanometer-scale lithography technology.
- EPA, NSF, USDA and NIH are planning a joint announcement with the European Commission (EC) on nano-EHS for 2010.
- NIH and NSF are actively exploring ways to expand the scope of the institutional NCI-NSF Integrative Graduate Education and Research Traineeships (IGERT) awards initiated in FY 2005 in support of nanobiotechnology training.
- NSF and DOD are planning a new initiative on "Quantum Information Science and Systems Engineering."
- DOD (ARO) and DOE (Sandia National Laboratory) are cooperating on efforts to develop monolithic absorber/bolometric sensors for terahertz detectors.
- NSF, NASA, and EPA are sponsoring interdisciplinary research at the intersection of nanotechnology, biotechnology, and information technology.
- DOD, DOE, NASA, and NSF are cooperating on materials and device development and modeling for direct thermal-to-electrical energy conversion in areas of thermoelectric, thermophotovoltaics, and thermionics.
- NIH (NCI) and NIST will collaborate on nanobiotechnology, including novel opto-immunoassays for probing the molecular pathology of prostate cancer.

[5] PCAST, NNI Second Assessment and Recommendations of NNAP, April 2008

- NIST, FDA, NIH, NSF and other agencies are cooperating on particle characterization and standards development.
- DOD, DOE (Sandia National Laboratory), NASA, and NSF are collaborating on modeling and simulation of nanoelectronics.

Technology Transfer

- NSF and other NNI agencies held the "Regional, State, and Local Initiatives in Nanotechnology" workshop in Oklahoma City, Ok., on April 1–3, 2009.
- NSF, NIST, and the industry-led Nanoelectronics Research Initiative collaborate on reviewing proposals and on supporting pre-competitive research.
- NIH is formulating a "NanoHealth Enterprise," which will be a partnership with other Federal agencies, private industry, and international partners to address research needs for safe development of nanoscale materials and devices.
- Six agencies fund nanotechnology research under the Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) programs.
- NNI agencies are continuing participation in liaison groups with the electronics, forest products, and chemical industries, and with the industry research management community, and they are considering the formation of comparable groups with other sectors, such as constructions and predictive nanomaterials.

Infrastructure

- NNI has created an extensive network of more than 80 large research centers, user facilities, and other infrastructure (see Table I-10b) for nanotechnology research and collaboration.
- NSF, DOD, and NIST provide key support of the National Nanomanufacturing Network.
- NSF and EPA funded the Center for Environmental Implications of Nanotechnology (CEIN) at Duke University, in addition to the CEIN established at the University of California, Los Angeles.
- NSF, Department of Education, and Department of Labor co-organized a joint workshop and developed collaborative activities around several networks: NCN, NNIN, NISE, NCLT, and CEIN.
- NIH, FDA, and NIOSH continue to collaborate in support of the Nanotechnology Characterization Laboratory (NCL) established by the National Cancer Institute.
- DOE, DOD, NASA, NIH, and NIST are collaborating on infrastructure development, both among centers and between centers and networks.
- DOE, NSF, NIH, and NIST will collaborate on development and use of neutron and synchrotron facilities.

Development of Standards and Regulations

- An FDA task force released a report in 2007 addressing scientific questions related to the application of its regulatory authorities to nanotechnology-enabled products.
- EPA issued a white paper on nanotechnology in 2007 and initiated the Nanoscale Materials Stewardship Program under the Toxic Substances Control Act (TSCA) in January 2008 to gather and develop information from manufacturers, importers, processors, and users of engineered chemical nanoscale materials.
- NSF, with EPA collaboration, initiated two Centers for Environmental Implications of Nanotechnology (CEIN) in 2008.
- NIOSH continues to update its guidance document on best practices for safe handling of nanomaterials in the workplace and has posted a draft document providing interim guidance on medical screening of workers potentially exposed to engineered nanoparticles.
- Joint interagency solicitations are in preparation for research addressing potential environmental and health implications of nanotechnology continue.
- NNI agencies are coordinating research internationally as well, with outreach to the European Union and Japan in particular, both on a bilateral basis and through international organizations.

International Cooperation

- The Organization for Economic Cooperation and Development (OECD) Working Party on Manufactured Nanomaterials, chaired by the U.S., has begun its work addressing health and safety issues; a second OECD working party formed under the Committee for Scientific and Technological Policy is addressing broader issues such as economic impact, education and training, and public communication.
- The National Nanotechnology Coordination Office and several NSET member agencies represent the U.S. on the International Organization for Standardization (ISO) Technical Committee on Nanotechnologies (ISO TC 229), and the U.S. leads the ISO TC 229 working group on EHS aspects of nanotechnology.
- Technical experts from multiple agencies, including DOD, DOE, EPA, NIOSH, NCI, NIST, and USDA/FS, are working to develop international documentary standards in nanotechnology through the International Organization for Standardization, as coordinated by the American National Standards Institute's U.S. Technical Advisory Group to ISO TC229.
- The Federal agencies' Interagency Committee on Standards Policy (ICSP) provides an additional forum for information exchange and coordination on standards policy issues relating to nanotechnology.

- NNI agencies are participating in standards development activities within ASTM International's Committee E56 (Nanotechnology), International Electrotechnical Commission Technical Committee (Nanotechnology Standardization for Electrical and Electronics Products and Systems), and the Institute of Electrical and Electronics Engineers' Nanotechnology Council.

SUMMARY OF FY 2010 BUDGET REQUEST FOR NNI

The FY 2010 President's Request is approximately $1.64 billion for Federal investment in nanotechnology. The FY 2010 Request increases nanotechnology funding at NSF, DOE, NIH, NIST, EPA, and DHS. The proposed budget decreases at DOD may be explained by the reassignment of applied nanotechnology projects to other areas of relevance, as well as by the overall budget constrains in FY 2010. 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 (approximately 7 percent for small business 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, such as research on instrumentation and metrology and on fundamental interactions between biosystems and engineered nanoscale materials, both of which are important in the performance and interpretation of toxicological research. NNI's EHS investment will be aligned with the report, **Strategy for Nanotechnology-Related Environmental, Health, and Safety Research**, published in February 2008 by NSET.

FY 2010 budget requests for particular departments and agencies are described below.

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	FY 2009 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

NSF supports fundamental knowledge creation, education, and infrastructure across all disciplinary areas at the nanoscale. NNI activities at NSF are coordinated by the Nanoscale Science and Engineering (NSE) Group. The NSF investment will 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, will be investigated in three dedicated multidisciplinary centers and by more than 50 smaller groups with a total annual budget of $29.9 million. NSF plans to increase investment in nanotechnology research to address energy conversion and storage, “green” electronics, and water filtration. NSF will support an initiative on “Beyond Moore’s Law Scaling”, at the confluence between nanotechnology and information technology. NSF will continue and develop the partnership with Nanoelectronics Research Initiative together with Semiconductor Research

Association and NIST, and expand research and education to other long-term fundamental issues in nanoelectronics, photonics, and magnetics.

NSF will support the National Center for Nanotechnology Applications and Career Knowledge (NACK, Pennsylvania State University) with national outreach to two-year community and technical colleges and four-year small universities and colleges. Several regional hubs for advanced nanotechnological education will be established in FY 2009 and FY 2010. The Nanotechnology Undergraduate Education program will focus on nanoengineering and nanosystems, with increased funding compared to FY 2009.

Ten networks for research, education, and user facilities will be operating in 2010 (see Table I-10b). The Major Research Instrumentation Program and other programs will continue to support the creation of smaller academic nanoscale science and engineering facilities. The National Nanofabrication Infrastructure Network (NNIN) will be provided $10 million in ARRA funds to acquire advanced nanofabrication and characterization instrumentation and tools that will enable users to accomplish state-of-the-art research projects. The Nanotechnology in Society Network will extend its national and international network. NSF will support activities of a new Society for the Study of Nanoscience and Emerging Technologies with an international network of researchers, students, stakeholders, and policymakers.

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-10). 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 Materiel Command, and the Manufacturing Technology (MANTECH) program are evaluating nanotechnology as an investment area.

DOD supports nanoscale science and technology in order to meet the national security mission. The DOD structures its S&T investment into basic research (6.1), applied research (6.2), and advanced technology development (6.3); the latter two focus on transitioning scientific discovery into innovative technology. An illustration of DOD activities is NRO working with industry for nanotechnology development in order to foster a faster transition from nanotech R&D to industry dual-use.

DEPARTMENT OF ENERGY (DOE)

In FY 2010, the total request for DOE is $347 million, including a $107 million increase over the FY 2008 actual (see Table I-10). The FY 2010 request includes a substantial increase in funding for research at the nanoscale for activities related to the 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 predominant DOE components of the NNI are research programs and facilities supported by **DOE's Office of Science** and **Office of Energy Efficiency and Renewable Energy.**

The FY 2010 request includes a large investment for all five Nanoscale Science Research Centers (NSRC). Support for fundamental scientific research on nanoscale phenomena will be by grant programs and DOE National Laboratory research efforts. The Energy Frontier Research Centers, larger collaborative efforts in which a portion of the activity relates to nanoscale science, are also continued. Nanoscience funding increases in FY 2010 are also due to expected contributions from the start-up Advance Research Projects Agency for Energy (ARPA-E), which supports activities related to solar energy conversion, chemical imaging, nuclear energy, ultrafast science, instrumentation for characterization, and other areas. However, much of the increase in 2010 over 2009 results from the initiation of Energy Innovation Hubs focusing on electrical energy storage and solar fuels, in which it is anticipated that a fraction of the activity will be appropriately characterized as nanoscience.

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 will be invested in several roadmap initiatives (http://nihroadmap.nih.gov/). 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 NCI, NHLBI, and Nanomedicine Roadmap Initiative will continue in 2010 There is a continued ramp-up of nanotechnology R&D funding for programs including implementing the Nanomedicine Roadmap Initiative, the National Cancer Institute's Nanotechnology Platform Partnerships and Nanotechnology Characterization Laboratory, the National Heart, Lung,

and Blood Institute'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 will allow intramural and extramural projects targeted to addressing critical research gaps around occupational safety and health of nanotechnology and nanomaterials. NIOSH will 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 will continue to develop partnerships with stakeholders and other organizations to enable the translation of agency activities into appropriate workplace practices. NIOSH will establish a suite of instruments and protocols for characterizing nanomaterials in the workplace environment. NIOSH will focus its efforts on: (1) developing recommendations for controlling occupational exposure to nanomaterials and addressing information gaps; (2) identifying categories of nanomaterials that can be distinguished on the basis of similar physicochemical properties; (3) toxicology and long-term health effects of nanomaterials likely to be commercially viable; and (4) explosion potential of various nanomaterials.

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 will continue to focus the majority of its research in 2010 on health and environmental implications of nanomaterials. EPA will increase its efforts in the area of risk assessment and risk management needs for nanomaterials. Finally, EPA will research nanoscale technology as potential solutions to environmental problems.

An EPA representative chairs the Organization for Economic Cooperation and Development (OECD) Working Party on Manufactured Nanomaterials (WPMN). Since 2008, the WPMN has engaged in a cooperative international program to test 14 nanomaterials types across environmental end points.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

The FY 2010 NASA request for nanotechnology programs is approximately $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. Areas to be emphasized include: ultra-high strength and multi-functional materials; high-density, low-power electronics; ultra-small and sensitive sensors; and highly miniaturized spacecraft systems [from microelectromechanical systems (MEMS) to nanoelectromechanical systems (NEMS)].

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 will 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 critical enhancements to homeland security applications in advanced threat detection systems and materials and systems for mitigation and blast protection. S&T supports the transfer of nanotechnology through academic and government laboratory partnerships with industry for the incorporation of nanotechnology-based solutions into commercial systems, and the development of advanced critical components for next-generation security systems.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

The NIST FY 2010 budget request for nanotechnology is $92 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. The NIST advanced nanofabrication facility, the NanoFab, doubled the number of users in 2008 and installed approximately $7 million of new nanofabrication tools in 2009. NIST investments in nanotechnology research are addressing national needs in energy, the environment, health care, IT security, manufacturing, and physical infrastructure.

NIST funding for EHS aspects of nanotechnology will 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. Under this request, NIST will significantly expand its nanotechnology EHS

activities through a coordinated initiative that leverages nanotechnology expertise and resources across its laboratories and facilities to develop analytical methods for quantifying the type and amount of nanomaterials in biological systems, the environment, and the workplace.

NIST has established a series of collaborative research programs focused on the new area of quantum nanotechnology at Yale University, Stanford University, Cornell University, and the University of Maryland at College Park in the United States; as well as with centers abroad at Delft University (The Netherlands), Humboldt University (Germany), The University of Waterloo (Canada), The National Research Council (Canada), The Donostia International Physics Center (Spain), and The Nicolas Copernicus University (Poland).

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 comprised of scientists qualified to provide input on product development. Under a tripartite memo of understanding, FDA, NIH (NCI), and NIST have agreed to collaborate and share expertise and data on particle characterization and standards development.

The FDA research program on nano-engineered materials reflects the need to build a knowledge base and experimental expertise necessary for regulation of products containing these materials. The results of this research will assist FDA in its mission to ensure the safety and efficacy of FDA-regulated products. These products include food, food additives, nutritional supplements, cosmetics, drugs, medical devices, and biologicals. Specifically, the work reflects the necessity for very different detection and characterization tools to support specific research on toxicity, biocompatibility, exposure assessment, formulation and suspension media affecting material properties, and product quality.

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

The FY 2010 request for USDA is approximately $8 million ($3 million for CSREES and $5 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 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 U.S. through the LGUs.

CSREES's Agriculture and Food Research Initiative (AFRI) nanotechnology research and development activity funding is approximately $5 million with funds from FYs 2009 and 2010 for a single solicitation in FY 2010. The program 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 USDA FS will focus on applications of nanotechnology to enhance utilization of forest resources and research on low-cost forest product feedstocks for nanomanufacturing. The FS will 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 will support research aimed at improving fundamental understanding of the structure and properties of highway construction materials at the nanoscale, for example, the use of atomic force microscopy to characterize the morphology of asphaltenes, which are the nanoparticle component of asphalt. The FHWA, in collaboration with the University of Connecticut and W.R. Grace, Inc., and with support from an NSF grant, will investigate the nanoscale mechanisms controlling hydration and setting of Portland cement concrete.

DEPARTMENT OF JUSTICE (DOJ)

The DOJ National Institute of Justice (NIJ) has two programs that involve nanotechnology. The first program, DNA Research and Development, will continue basic research as well as the demonstration of chip-based or micro-device technologies to analyze DNA in forensic applications. Nanotechnology will be integrated into the current crime laboratory processes and protocols to analyze forensic DNA samples. 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)

Table I-10a. NNI budget by agency.

NNI Budget by Agency (millions of dollars)				
	FY 2008 Actual	**FY 2009 Estimate**	**FY 2009 Recovery**	**FY 2010 Request**
National Science Foundation	409	397	108	423
Department of Defense	460	464		379
Department of Energy	240	332	25	347
Department of Health and Human Services/NIH	305	311	*	326
Department of Health and Human Services/NIOSH	7	7		12
Department of Commerce/NIST	86	88	7	92
Environmental Protection Agency	12	16		18
NASA	17	17		17
Department of Homeland Security	3	9		12
Department of Agriculture /Forest Service	5	5		5
Department of Agriculture /CSREES	6	3		3
Department of Transportation/FHWA	1	3		3
Department of Justice	0	0		0
TOTAL	**1,549**	**1,654**	**140**	**1,636**

* The amount of ARRA funding that NIH will invest in NNI activities was not available at the time of publication.

Table I-10b. NNI R&D centers, user facilities, and networks.

Name	Institution(s)
NSF – ten networks	
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
DOE – one network of five user facilities	
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
NIH – four networks	
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
NIST – two user facilities	
Center for Nanoscale Science and Technology (CNST)	Gaithersburg, Md. campus
NIST advanced nanofabrication facility (NanoFab)	Gaithersburg, Md. campus