

**Calendar No. 772**

107TH CONGRESS }  
2d Session }

SENATE

{ REPORT  
{ 107-350

**21st CENTURY NANOTECHNOLOGY  
RESEARCH AND DEVELOPMENT ACT**

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R E P O R T

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND  
TRANSPORTATION

ON

S. 2945



NOVEMBER 20, 2002.—Ordered to be printed

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED SEVENTH CONGRESS

SECOND SESSION

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### 21st CENTURY NANOTECHNOLOGY RESEARCH AND DEVELOPMENT ACT

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Mr. HOLLINGS, from the Committee on Commerce, Science, and  
Transportation, submitted the following

### REPORT

[To accompany S. 2945]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 2945) to authorize appropriations for nanoscience, nanoengineering, and nanotechnology research, and for other purposes, having considered the same, reports favorably thereon without amendment and recommends that the bill do pass.

#### PURPOSE OF THE BILL

The purpose of the bill, as reported, is to authorize a coordinated inter-agency program that will support long-term nanoscale research and development which will lead to potential breakthroughs in technologies related to a number of areas, including materials and manufacturing, nano-electronics, medicine and healthcare, the environment, energy, chemicals, biotechnology, agriculture, information technology, and national and homeland security.

#### BACKGROUND AND NEEDS

Nanoscience, often referred to as nanotechnology, is an emerging scientific field which aims to create devices, materials, and systems at the nanometer scale. A nanometer is one billionth of a meter ( $10^{-9}$  m), or roughly 100,000 times smaller than a strand of human hair. Nano-technologists are studying and designing materials and systems at this sub-microscopic level.

Nanotechnology is a multi-disciplinary field, combing all aspects of the traditional sciences. Nanotechnology requires expertise in engineering, chemistry, physics, materials science, biology, and computer science. A field like quantum computing, the next stage in the information technology revolution, builds on knowledge and achievements in quantum mechanics and computer science to de-

velop systems with processing powers that are several orders of magnitude greater than currently possible.

The future of nanotechnology is touted as the next industrial revolution. It will enable scientists to create advanced materials and systems. For example, in combining an understanding of a material's properties and the ability to manipulate atoms, scientists are expected to be able to produce a substance that is stronger than steel, yet as light as a feather. Nanotechnology is still in its infancy. It has recently passed theoretic feasibility and is entering the laboratory. Breakthroughs in nanotechnology promise to fundamentally alter the way we manufacture products.

According to the NanoBusiness Alliance, the nanotechnology market currently generates \$45 billion a year in worldwide sales. This is projected to grow to \$700 billion by 2008. A more conservative prediction by the National Science Foundation (NSF) is that the market for nanotechnology will reach \$1 trillion by 2015. The potential gains are immense. It is key for the United States to maintain an intellectual lead and use that knowledge to maintain its commercial edge.

The National Nanotechnology Initiative (NNI) was created in 2001 with the goal of coordinating the Federal government's research and development efforts in nanotechnology. Federal support is crucial because nanotechnology is so nascent that few companies will invest in it because the pay-offs are so far into the future. Venture capitalists also shy away from nanotechnology for the same reasons. Universities tend not to have sufficient funds to engage in such exploratory work. Only the Federal government can bridge the gap for the next few decades before this research can be applied widely to commercial products. The Federal government has a history of sponsoring research that opens new frontiers (atomic physics, space exploration, and development of the Internet). Many believe that nanotechnology is the next such frontier.

#### LEGISLATIVE HISTORY

On September 17, 2002, the Subcommittee on Science, Technology, and Space conducted a hearing on the 21st Century Nanotechnology Research and Development Act which was introduced by Senators Wyden, Allen, Lieberman, Mikulski, Landrieu, and Clinton the same day. This hearing included the following witnesses: The Honorable Richard Russell, Associate Director for Technology, Office of Science and Technology Policy; Mr. F. Mark Modzelewski, Executive Director of the NanoBusiness Alliance; Dr. Samuel I. Stupp, Board of Trustees Professor, Materials Science, Chemistry, and Engineering and Director of the Institute for Bioengineering and Nanoscience in Advanced Medicine, Northwestern University; Dr. R. Stanley Williams, Fellow and Director of Quantum Science Research, Hewlett Packard; and Mr. Nathan Swami, Executive Director of Initiative for Nanotechnology in Virginia, University of Virginia.

On September 19, 2002, the Commerce Committee met in Executive Session and ordered the bill reported without amendment.

## SUMMARY OF MAJOR PROVISIONS

*Authorization of appropriations*

S. 2945, as reported, would authorize appropriations for several government agencies for nanoscale science and technology research and development in the amount of \$476 million for fiscal year (FY) 2003 and \$547.3 million in FY 2004, for a total of \$1.02 billion over the next two years, as follows:

[In millions of dollars]

Agency	FY 2003	FY 2004	Total
National Science Foundation .....	221.0	254.1	475.15
Department of Energy .....	139.3	160.2	299.495
National Aeronautics and Space Administration (NASA) .....	22.0	25.3	47.3
National Institutes of Health (NIH) .....	43.2	49.7	92.88
National Institute of Standards and Technology (NIST) .....	44.0	50.6	94.6
Environmental Protection Agency (EPA) .....	5.0	5.7	10.75
Department of Justice .....	1.4	1.6	3.01
Total .....	475.9	547.3	1,023.185

The funding level for FY 2003 reflects the President's requested level for these programs, and the FY 2004 level is fifteen percent higher than the FY 2003 request.

*National Nanotechnology Research Program*

S. 2945, as reported, would authorize the President to establish a National Nanotechnology Research Program (NNRP) with the goal of coordinating long-term Federal nanotechnology research and development. The program would build on the NNI, providing Federally funded research through participating government agencies. The NNRP would include: (1) grand challenges that will promote the advancement of the field; (2) regional interdisciplinary research centers that provide access to facilities for academia and industry; (3) the development of an adequate research infrastructure; (4) the creation of a Center for Ethical, Societal, Educational, Legal and Workforce Issues Related to Nanotechnology, which will support social science research on nanotechnology; and (5) the development of mechanisms to promote prompt technology transfers. Additionally, the program would emphasize the interdisciplinary nature of the nanotechnology field, and as a result, give preference to universities that show a commitment to interdisciplinary curricula and research.

*Program coordination and management*

S. 2945, as reported, would authorize the National Science and Technology Council (NSTC) to oversee the planning, management and coordination of the NNRP. The NSTC would be required to coordinate the budget requests of, and provide guidance to, participating departments and agencies. The NSTC would submit an annual report to Congress detailing the goals, grand challenges, and program funding areas of the NNRP.

S. 2945 also would authorize the President to establish a Nanotechnology Advisory Panel, which would advise the President and the NSTC on goals and objectives of the NNRP. The Panel, modeled on the President's Information Technology Advisory Council, would be responsible for providing an annual evaluation of the

NNRP, including a review of the program's management, a review of the balance of the research portfolio across agencies and disciplines, and recommendations for new grand challenges, and other charges. The President would have the authority to appoint up to 20 individuals to serve on the panel.

S. 2945, as reported, also would authorize the President to create a National Nanotechnology Coordination Office (NNCO) to serve as the primary point of contact for Federal nanotechnology activities. The NNCO would provide day-to-day technical and administrative support to assure full coordination of nanotechnology research efforts.

#### ESTIMATED COSTS

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. CONGRESS,  
CONGRESSIONAL BUDGET OFFICE,  
*Washington, DC, October 1, 2002.*

Hon. ERNEST F. HOLLINGS,  
*Chairman, Committee on Commerce, Science, and Transportation,  
U.S. Senate, Washington, DC.*

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the enclosed cost estimate for S. 2945, the 21st Century Nanotechnology Research and Development Act.

If you wish further details on this estimate, we will be pleased to provide them. The CBO staff contact is Kathleen Gramp.

Sincerely,

BARRY B. ANDERSON  
(For Dan L. Crippen, Director).

Enclosure.

#### *S. 2945—21st Century Nanotechnology Research and Development Act*

Summary: S. 2945 would authorize the appropriation of about \$1 billion over the 2003–2004 period for civilian research and development (R&D) on nanotechnology (these technologies involve manipulating matter at the atomic level). It would allocate this funding among seven agencies: the National Science Foundation, Department of Energy, National Aeronautics and Space Administration, National Institutes of Health, National Institute of Standards and Technology, Environmental Protection Agency, and the Department of Justice. Other provisions would establish programmatic and reporting guidelines for agency initiatives and create a scientific advisory board and office. Finally, S. 2945 would direct the Office of Science and Technology Policy to coordinate agency initiatives and sponsor biennial studies by the National Academy of Sciences (NAS) on how R&D efforts in the United States compare with those of other countries.

Assuming appropriation of the authorized amounts, CBO estimates that implementing this bill would cost \$989 million over the 2003–2007 period. CBO estimates that enacting S. 2945 would have no effect on direct spending or revenues.

S. 2945 contains no intergovernmental or private-sector mandates as defined in the Unfunded Mandates Reform Act (UMRA) and would impose no costs on state, local, or tribal governments. Public universities and agencies would benefit from grants to create interdisciplinary centers for research in nanotechnology. These entities may incur costs as a result of participating in the grant program, but such costs would be voluntary.

**Estimated cost to the Federal Government:** The estimated budgetary impact of S. 2945 is shown in the following table. The costs of this legislation fall within budget functions 250 (general science, space, and technology), 300 (natural resources and the environment), 376 (commerce and housing credit), 550 (health), and 750 (administration of justice).

	By fiscal year, in millions of dollars—					
	2002	2003	2004	2005	2006	2007
SPENDING SUBJECT TO APPROPRIATION						
Nanotechnology spending under current law:						
Budget authority <sup>1</sup> .....	424	0	0	0	0	0
Estimated outlays .....	344	231	54	15	7	2
Proposed changes:						
Estimated authorization level .....	0	476	547	0	1	0
Estimated outlays .....	0	186	425	292	67	19
Nanotechnology spending under S. 2945:						
Estimated authorization level <sup>1</sup> .....	424	476	548	0	1	0
Estimated outlays .....	344	417	479	307	74	21

<sup>1</sup>The 2002 level reflects agencies' estimates of the amount appropriated for that year for R&D on nanotechnology, a full-year appropriation for 2003 for these agencies has not yet been enacted.

**Basis of estimate:** For this estimate, CBO assumes that the amounts authorized will be appropriated near the start of each fiscal year and that outlays will occur at rates similar to those for other R&D programs at each agency. The amounts shown in the table reflect the amounts specified in S. 2945 for agency R&D and the cost of the NAS studies comparing the U.S. program to those of other countries. Based on information from the NAS, CBO estimates that each biennial study on international trends would cost about \$1 million.

**Intergovernmental or private-sector impact:** S. 2945 contains no intergovernmental or private-sector mandates as defined in UMRA and would impose no costs on State, local, or tribal governments. Public universities and agencies would benefit from grants to create interdisciplinary centers for research in nanotechnology. These entities may incur costs as a result of participating in the grant program, but such costs would be voluntary.

Estimate prepared by: Federal costs: Kathleen Gramp; impact on State, local, and tribal governments: Susan Sieg Tompkins; impact on the private sector: Jean Talarico.

Estimate approved by: Peter H. Fontaine, Deputy Assistant Director for Budget Analysis.

#### REGULATORY IMPACT STATEMENT

In accordance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation, as reported:

*Number of persons covered*

The Committee believes that the bill will not subject any individuals or businesses affected by the legislation to any additional regulation.

*Economic impact*

This legislation authorizes significant funding for research and development in nanoscale science and technology. However, it is not expected to have an adverse economic impact on the Nation.

*Privacy*

This legislation will not have a negative impact on the personal privacy of individuals.

*Paperwork*

This legislation will not increase paperwork requirements for private individuals or businesses. It would require the following reports: (1) an annual report by the Advisory Panel reviewing the program's success according to metrics established by the Panel; (2) a budget request by each Federal agency or department participating in the program submitted to the Office of Management and Budget (OMB); (3) an annual report to Congress produced by the NSTC detailing the funding levels for each agency and department participating in the program; and (4) a triennial review conducted by the National Research Council evaluating the program's technical success, management and coordination, and funding levels.

## SECTION-BY-SECTION ANALYSIS

*Section 1. Short title*

Section 1 would set forth the short title of the bill as "The 21st Century Nanotechnology and Research Development Act."

*Section 2. Findings*

Section 2 would provide findings concerning the potential benefits of nanotechnology, including potential breakthroughs in materials and manufacturing, electronics, medicine and healthcare, the environment, energy, chemicals, biotechnology, agriculture, information technology, and national security.

*Section 3. Purpose*

This section would provide for the coordination of an inter-agency program to support long-term nanoscale research and development in certain key areas.

*Section 4. National nanotechnology research program*

Subsection (a) would require the President to establish a program to fund and coordinate basic nanoscience and engineering research among Federal agencies, academic laboratories, and the private sector.

Subsection (b) would identify the program's goals as to assure the United States remain a world leader in nanotechnology, which will help meet national goals for advances in health, manufacturing, technology, education, science, energy, the environment, and national security. The program also would consider philo-

sophical, ethical, and other societal concerns in conjunction with the development of nanotechnology.

Subsection (c) would identify major research and development areas. Funding would be authorized to provide awards of less than \$1 million each to single investigators and small groups conducting long-term fundamental, innovative research, and to fund the development of university-industry-laboratory and interagency partnerships. The program also would support “Grand Challenges”, including multidisciplinary nanotechnology research centers to achieve long-term objectives, such as stronger and lighter nano-materials, nanoelectronics, healthcare applications, energy and environmental advances, and national security.

The appropriate agencies would fund 10 new “Interdisciplinary Nanotechnology Research Centers” in the range of \$3 million to \$5 million each year for 5 years. Grants could be renewed for another 5-year term following a positive performance review. The Centers would assist in reaching other priorities, including fundamental research, grand challenges, education, development and utilization of specific research tools, and promoting partnerships with industry. To the greatest extent possible, agencies participating in the program would establish geographically diverse centers, including at least one center participating in the NSF Experimental Program to Stimulate Competitive Research. The program would be authorized to use underutilized manufacturing facilities in areas of high unemployment for production engineering and research testbeds for micron-scale technologies.

The Director of the NSF would be required to establish a new Center for Ethical, Societal, Educational, Legal, and Workforce Issues Related to Nanotechnology at a funding level of \$5 million per year. The center would be required to track and research the societal, ethical, educational, legal, and workforce issues related to nanotechnology. The program, through its participating agencies, would ensure cooperation and collaboration with United States industries in all relevant research efforts and develop mechanisms to ensure prompt technology transfer.

#### *Section 5. Program coordination and management*

Subsection (a) would direct the NSTC to oversee the planning, management, and coordination of the Federal nanotechnology research and development program. The NSTC would be required to: establish a set of broad applications for nanotechnology; submit an annual report to the Senate Committee on Commerce, Science, and Transportation and the House of Representatives Committee on Science; coordinate with Federal agencies, including the Department of Defense; consult with academic, industry, State and local governments and other appropriate groups in conducting nanotechnology research; establish an Information Services and Applications Council to promote access to and early application of new nanotechnologies; and measure the program’s performance against its goals.

Subsection (b) would require the President to establish a National Nanotechnology Advisory Panel (NNAP) composed of up to 20 nanotechnology experts who are not Federal employees. The panel must represent a cross-section of views and expertise, including those related to the societal, ethical, educational, legal, and

workforce issues in nanotechnology. The panel would meet not less than twice annually, issue an annual report measuring performance goals, and advise the President and inform Congress on matters relating to the NNRP.

Subsection (c) would require the President also to create a NNCO in which a full-time staff will provide day-to-day technical and administrative support to the Council and Advisory Panel, and be the point of contact for Federal nanotechnology activities for government organizations, academia, industry, professional societies, and others to exchange technical and programmatic information.

Subsection (d) would establish criteria for the report by the National Nanotechnology Advisory Panel. The annual report would review the program's technical success according to the program's stated goals; review the program's management, coordination, and funding levels; assess the degree of participation by minority-serving institutions; review policy issues arising from advances in nanotechnology; recommend new goals, grand challenges, and investments; and evaluate the application of new nanotechnologies to commercial and military products.

In addition, subsection (d) would require each Federal agency participating in the nanotechnology program, as part of its annual request for appropriations, to submit a report to OMB that identifies each element of its nanotechnology research that contributes directly to the nanotechnology program. In the President's annual budget request to Congress, OMB would be required to state the amount of funding for each agency related to nanotechnology research.

The NSTC would be required to submit an annual report to Congress regarding the nanotechnology research development program, including its goals, progress, and funding. No later than 6 months after enactment, the Director of the NSF would be required to enter into an agreement with the National Research Council of the National Academy of Sciences to conduct a triennial evaluation of the Federal nanotechnology research and development program, and submit that study to the Senate Committee on Commerce, Science, and Transportation and House of Representatives Committee on Science. The first such evaluation shall be transmitted no later than 12 months after the date of enactment, with subsequent evaluations transmitted every 3 years thereafter.

#### *Section 6. Authorization*

NSF would be authorized to spend \$221 million in FY 2003 and \$254.15 million in FY 2004 to carry out the Act. Of the authorized funds, \$40 million in FY 2003 and \$50 million in FY 2004 would be allocated specifically for grants of up to \$5 million each for multidisciplinary nanotechnology research centers. Of the authorized funds, \$5 million would be authorized for a university-based Center for Societal, Ethical, Educational, Legal and Workforce Issues Related to Nanotechnology. Of the authorized funds, \$5 million for each fiscal year would be provided to the NNCO and \$5 million would be provided to the Science and Technology Policy Institute for use in competitive grants to address research areas which are not being adequately addressed by the agencies' current research programs.

To carry out the Act, other agencies would be authorized appropriations in the following amounts: Department of Energy: \$139.3 million for FY 2003 and \$160.195 million for FY 2004; NASA: \$22 million for FY 2003 and \$25.3 million for FY 2004; National Institutes of Health: \$43.2 million for FY 2003 and \$49.68 million for FY 2004; National Institute of Standards and Technology: \$44 million for FY 2003 and \$50.6 million for FY 2004; Environmental Protection Agency: \$5 million for FY 2003 and \$5.75 million for FY 2004; Department of Justice: \$1.4 million for FY 2003 and \$1.61 million for FY 2004.

*Section 7. Additional reports, studies, and plans*

Subsection (a) would require the President, through NSTC, to enter into an agreement with the National Research Council of the National Academy of Sciences to conduct a biennial study of the relative position of the United States compared to other nations with respect to nanotechnology research and development. The study would address the following issues: the current and likely future position of United States private, academic, and government sector research in nanotechnology relative to other nations; niche technology research areas where the United States is trailing other nations; and institutions, funding, and human resource factors that are critical to maintaining leadership status in this field. Not less than 6 months after receipt of each study, the NSTC would develop a plan for addressing issues raised in the study, including strategies for investment, strategies for promoting international research cooperation, and institutional and human-resource changes to be made to achieve or maintain leadership status in this field. NSTC will submit the National Research Council study and the NSTC plan to the Senate Committee on Commerce, Science, and Transportation and the House of Representatives Committee on Science, not later than 18 months after the date of the enactment and every 2 years thereafter.

As authorized by subsection (b), the NSF Director would be directed to encourage, conduct, coordinate, commission, collect, and disseminate studies on the societal, educational, and workforce implications of nanotechnology through the Center for Societal, Ethical, Educational, and Workforce Issues established under section 4 (c). The NSF Director would collect data to assess the anticipated nanotechnology workforce needs based on detailed occupation, industry, and firm characteristics, and determine the adequacy of the trained talent pool in the United States. The Director also would be required to submit reports on these issues to the President, the NSTC, the Senate Committee on Commerce, Science, and Transportation, and the House of Representatives Committee on Science not later than 18 months after the date of enactment of this Act.

*Section 8. Definitions*

This section defines key terms in the Act, including “Advisory Panel”, “fundamental research”, “grand challenges”, “interdisciplinary nanotechnology research center”, “nanotechnology”, “program”, and “research infrastructure”.

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, the Committee states that the bill as reported would make no change to existing law.

