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A Matter of Size: Triennial Review of the National Nanotechnology Initiative—*Report Brief*

NATIONAL MATERIALS ADVISORY BOARD

Background

The National Nanotechnology Initiative (NNI) was created in 2000 to focus and coordinate the nanoscience and nanotechnology research and development (R&D) activities being funded by several federal agencies. The purpose of the NNI is to marshal these research activities in order to accelerate responsible development and deployment of nanotechnology for economic benefit and national security. To take stock of the progress of the NNI, Congress, in P. L. 108-153, the 21st Century Nanotechnology Research and Development Act, directed the National Research Council to carry out a review of the program every three years. This report presents the results of the first of those reviews, which addresses the economic impact of nanotechnology developments and provides a benchmark of U.S. R&D efforts relative to those undertaken by foreign competitors. In addition, the report offers an assessment of the current status of responsible development of nanotechnology and comments on the feasibility of molecular self-assembly.

Observations

Organization The National Science and Technology Council, in order to focus NNI activities, established the subcommittee on Nanoscale, Science, Engineering, and Technology (NSET). NSET involves over 20 federal agencies, 11 of which provide the majority of R&D funding. The National Nanotechnology Coordination Office (NNCO) provides administrative and technical support for NSET. The goals of the NNI are to maintain a world-class R&D program, facilitate technology transfer, develop educational resources, and support responsible development of nanotechnology.

NNI Accomplishments and its Results *The* NNI is a long-term undertaking, and it is difficult at best to make any firm projections of economic impacts of nanotechnology research so early in the life of the initiative. Although data about NNI activities are not well collected, enough evidence is available, however, to suggest that the initiative is successfully coordinating nanoscale R&D across the federal government.

The establishment of NSET, five new DOE Nanoscale Research Centers, several NNI-industry consultative boards, and the NSF National Nanotechnology Infrastructure Network are some of the examples of NNI's accomplishments to date. Increased interagency coordination under the NNI umbrella is an important consequence.

International indicators, however, suggest that the nation is facing increasing competition in nanotechnology. Funding in Japan and the European Union for nanoscale R&D is each comparable to that of the United States, and the U.S. percentage of relevant published papers worldwide is declining.

In the area of economic development, trends toward more technology transfer are evident, but sufficient data are not yet available for a rigorous analysis of the economic impact of nanotechnology. It appears that nanotechnology is more likely to lead to improvements in existing products than to completely new products.

Findings and Recommendations

Federal Support Although early indications about the success of the NNI are positive, additional actions will be required to attain the promise of nanoscience and nanotechnology. In particular, the federal government should sustain support of the NNI in a way that ensures a balance between short-term goals and long-term R&D and a strong supporting infrastructure.

Nevertheless, it is clear that the contribution to date of the NNI to national goals such as the development of commercial technologies and processes, new R&D tools, and the education of scientists and engineers, makes a strong case for continuing support of the initiative. For example, investment in the NNI to date has led to the establishment of broadly based, interdisciplinary research programs that are likely to produce valuable advances in nanotechnology in the coming decade.

Advisory Panel While the designation of PCAST as the NNI advisory panel testifies to the importance of the initiative, it lacks an independent advisory group with specific expertise in nanoscience and nanotechnology. The federal government should establish an independent advisory panel with appropriate experience to facilitate cutting-edge research on and responsible development of nanotechnology. Such a dedicated panel could provide advice on setting priorities, balancing large-scale and individual investigator research, and the value of high-risk, high pay-off interdisciplinary research.

Economic Impacts The lack of consistent reporting of data on agency investment in nanotechnology limits any analysis of the economic impacts of the NNI. In addition, more consistent reporting will enhance priority setting for nanotechnology funding. Agencies participating in the NNI should develop and enhance means for consistent reporting and tracking funds used to support nanotechnology R&D.

New indicators and better methodology are also needed if future assessment of economic impacts is to be more quantitative. NSET should determine what data are needed to aid future economic impact analysis. In particular, it should direct a study on the feasibility of developing metrics to quantify return to the U.S. economy from the federal investment in nanotechnology R&D. Specific attention should be paid to technology transfer and commercial development of nanotechnology.

Education To supply the workers with interdisciplinary skills that are being sought by companies involved in nanotechnology R&D, new approaches to science and technology education and training will be needed. Coordination among the NNI agencies to address these and other education and workforce concerns has not been strong. NSET should create a working group on education and the workforce that engages the Departments of Education and Labor as active participants.

Responsible Development Although some evidence exists that engineered nanomaterials have adverse effects on laboratory animals, NNI environmental, health, and safety (EHS) research to date has been inconclusive. Research on environmental, health, and safety effects of nanotechnology needs to be expanded. Such research must be well defined and reproducible. Furthermore risk assessment protocols need additional development to assess potential risks of nanotechnology development. .

Broad public outreach is very important for developing policies and regulations about nanotechnology development. Establishment of such activities by NNI and NSF are welcome developments for ensuring greater public participation. An integrated approach involving a wide-range of disciplines and the public is needed to address effectively ethical and social consequences of nanotechnology.

Molecular Assembly Self-assembly for the manufacturing of simple devices and materials is feasible, but because the probability of error increases as complexity grows, self-assembly for the manufacturing of more complex devices and materials has not been experimentally demonstrated.

Engineering of biological systems that can operate outside a living cell provides a model for future manufacturing systems. Predicting the reliability of such manufacturing systems, however, is very difficult and verifiable experimentation to support such prediction does not appear to exist. Experimentation leading to demonstration supplying ground truth for abstract models is appropriate to better characterize the potential for use of bottom-up or molecular manufacturing systems that utilize processes more complex than self-assembly.

For Further Information

Copies of *A Matter of Size: Triennial Review of the National Nanotechnology Initiative* can be obtained from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC 20418, 201-334-3313, <>

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