

EXECUTIVE OFFICE OF THE PRESIDENT
PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY
WASHINGTON, D.C. 20502

January 2017

Dear Mr. President,

The vision of the National Nanotechnology Initiative (NNI) is a future in which the ability to understand and control matter at the nanoscale leads to a revolution in technology and industry that benefits society.¹ The NNI has created a foundation for researchers to unearth the scientific secrets of the smallest scale and begin to amplify them into reimagined devices, systems, and new ways of engineering that will address some of the Nation's greatest challenges. Nanotechnology is already a part of many of the White House and agencies' current efforts including the Precision Medicine Initiative, the Manufacturing Innovation Institutes, and the Materials Genome Initiative, and revenue from nano-enabled products grew worldwide from \$339 billion in 2010 to more than \$1 trillion in 2013.²

The NNI is instantiated in law by the 21st Century Nanotechnology Research and Development Act.³ When the NNI began in FY2001, the total aggregated Federal agency budget for nanotechnology research and development (R&D) was \$464 million; that figure was \$1.4 billion in the FY2017 request. In the last 16 years, over \$24 billion has been dedicated to this effort. By Executive Order 13349, every 2 years we, your President's Council of Advisors on Science and Technology (PCAST), examine the Federal government's role in this national initiative. This letter report serves as our final review of the NNI for this Administration.

Grand Challenges

In our previous review released in October 2014, we observed that the NNI has spurred significant scientific discovery and understanding of nanoscale phenomena and has deeply integrated nanoscale science and technology into R&D portfolios across the Federal government.⁴ Our primary finding was that in order for the NNI to realize its vision of revolutionizing technology to benefit society, measurable progress is needed in translating scientific discovery to commercial products. In our primary recommendation, we said that the nanotechnology community can accomplish this by focusing on a series of specific technology goals, and the Federal government should support that effort by coordinating such focus using the Grand Challenge framework that has been successfully used on other large science and technology areas in your Administration (see Appendix).

¹ See: www.nano.gov/about-nni/what/vision-goals.

² Flynn, H., "Nanotechnology Update: Corporations Up Their Spending as Revenues for Nano-enabled Products Increase." 2014, Lux Research.

³ 21st Century Nanotechnology Research and Development Act, (Public Law 108-143), 108th Congress (2003-2004), www.congress.gov/bill/108th-congress/senate-bill/189?q=%7B%22search%22%3A%5B%22108-153%22%5D%7D&r=1.

⁴ See: www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf.

One year later, the Subcommittee on Nanoscale Science, Engineering, and Technology (NSET) of your National Science and Technology Council (NSTC) responded to our recommendation by announcing the first nanotechnology-inspired Grand Challenge: create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.⁵ This bold challenge to realize the future of computing addresses three Administration priorities—the NNI, the National Strategic Computing Initiative, and the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative. Led by co-chairs from the Department of Energy and the National Science Foundation, this effort is off to a commendable start and represents the first of what we recommend should be several outward-facing Grand Challenges that the nanotechnology community can take up as its own.

NSET presented the status of the first nanotechnology-inspired Grand Challenge to PCAST in November 2016. As a result of that meeting, and in keeping with the impact of Grand Challenges to help society harness the power of nanotechnology, we further recommend that NSET and necessary Federal agencies should announce at least two more Grand Challenges before our next review.

The appendix to this letter lists all the recommendations from our 2014 report. Two years on, we believe the spirit of these recommendations is still valid.

Nanomanufacturing

In 2014 we recommended actions to promote nanotechnology commercialization and specifically called for increasing the representation of nanomanufacturing in advanced manufacturing initiatives across the country. We called on NSET to suggest Manufacturing Innovation Institutes that are focused on nanotechnology. Building on the discoveries of the NNI, Federal investment in nanomanufacturing will catalyze entrepreneurs and industry to take laboratory discoveries to the marketplace, adding to the advanced manufacturing portfolio and further generating skilled manufacturing jobs in the United States.

National Research Council (NRC) Reviews

In addition to the biannual PCAST reviews, the National Research Council of the National Academies of Science, Engineering, and Medicine has been mandated to review the NNI every 3 years. In October 2016, the NRC released their latest report, which focused on actions to advance focused technical areas; to maintain and improve physical infrastructure and equipment; and to ensure necessary education and information sharing.⁶ To advance technical areas, the NRC committee recommended that the Federal partners in the NNI strengthen engagement with other initiatives to determine where other technology development depends on nanoscale phenomena and that agencies with nanotechnology R&D should, consistent with our 2014

⁵ Whitman, L., Bryant, R., Kalil, T., “A Nanotechnology-Inspired Grand Challenge for Future Computing,” Office of Science and Technology Policy Blog, www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing.

⁶ National Academies, *Triennial Review of the National Nanotechnology Initiative*. (2016) www.nap.edu/catalog/23603/triennial-review-of-the-national-nanotechnology-initiative.

recommendation invest in early stage nanomanufacturing research to advance current advanced manufacturing programs. PCAST supports these recommendations as well and commends the NSET for its recent outreach to other related initiatives.

Schedule of Reviews

The National Research Council has reviewed the NNI five times (2002, 2006, 2009, 2013, 2016), and this 2017 letter is the sixth PCAST review of NNI (2005, 2008, 2010, 2012, 2014, 2017), the fourth during in this Administration. In 2014, we recommended that the Administration work with Congress to reduce the number of reviews. We were particularly pleased to see that Congress passed the American Innovation and Competitiveness Act before adjourning its most recent session in December 2016.⁷ The Act reinstated and embraced the NNI, and in its trust for the Initiative, Congress reduced the number of mandated reviews by PCAST and NRC and instructed each group to release a report every 4 years. In keeping with our recommendations of 2014, we enthusiastically agree.

We recommend that PCAST complete its next comprehensive review of the NNI in 2018, 4 years after our last comprehensive review in 2014. Doing so will result in the NRC and PCAST reviews to alternate release every 2 years.

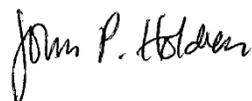
The vision of the NNI can only be realized if members of the nanotechnology community, supported by a solid foundation of ongoing basic research, focus their efforts toward specific revolutionary goals. The Federal government has an important role to play in bring that vision to reality.

This is the final letter we will write to you as your PCAST. We sincerely thank you for the opportunity to serve you, your Administration, and the United States for the past 8 years.

Sincerely,
President's Council of Advisors on Science and Technology

Co-Chairs

John P. Holdren



Eric Lander



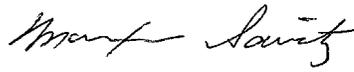
⁷ S.3084 - American Innovation and Competitiveness Act, 114th Congress (2015-2016)
www.congress.gov/bill/114th-congress/senate-bill/3084?q=%7B%22search%22%3A%5B%22American+Innovation+and+Competitiveness+Act%22%5D%7D&rl=1.

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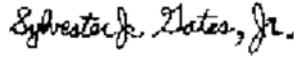
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Ed Penhoet



Barbara Schaal



Eric Schmidt



Daniel Schrag



Appendix. PCAST's 2014 NNI Review Recommendations

GRAND CHALLENGES FOR NNI 2.0 RECOMMENDATIONS

Recommendation 1. Establishing Grand Challenges is an effective means for focusing and amplifying the impact of Federal nanotechnology activities. The Nanoscale Science, Engineering, and Technology Subcommittee and the Office of Science and Technology Policy should identify a list of candidate nanotechnology Grand Challenges that address significant societal needs. At least one Grand Challenge should contain program elements aimed at manufacturing challenges specific to that focus area.

Recommendation 2. The Nanoscale Science, Engineering, and Technology Subcommittee and the Office of Science and Technology Policy should create and execute a process to engage research, development, and industrial stakeholders in the identification and selection of Grand Challenges on an ongoing basis.

Recommendation 3. Federal agencies, with support from the Office of Science and Technology Policy, should offer implementation tools like innovation prizes and public-private partnerships to encourage researchers to reach critical milestones on the path to completing Grand Challenges.

PROGRAM MANAGEMENT RECOMMENDATIONS

Recommendation 4. The Nanoscale Science, Engineering, and Technology Subcommittee should continue to be co-chaired by the Assistant Director, Nanotechnology in the Office of Science and Technology Policy and a representative of one of the participating agencies on a rotating basis. The Assistant Director should ensure that a leader for each active Grand Challenge also participates in a leadership role in the subcommittee. The Nanoscale Science, Engineering, and Technology Subcommittee should use Grand Challenges as the primary vehicle for actively managing the Federal nanotechnology activities toward directed outcomes.

Recommendation 5. PCAST should continue to carry out the Congressionally required periodic review of the NNI. Congress should align this review and the triennial National Research Council reviews to the same concurrent three-year time interval to reduce the burden on the Initiative. The Office of Science and Technology Policy, with the support of the National Nanotechnology Coordinating Office, should create and administer a separate standing committee of cross-sector nanotechnology experts that provides guidance, but does not evaluate, the NNI.

Recommendation 6. The Nanoscale Science, Engineering, and Technology Subcommittee, with the Department of Commerce, should execute a process to establish a common set of evaluation metrics to quantify and report the impact on workforce, productivity, and scientific knowledge in nanotechnology for all new research and commercialization programs beginning in FY2016.

COMMERCIALIZATION RECOMMENDATIONS

Recommendation 7. The Nanoscale Science, Engineering, and Technology Subcommittee should work with the Federal agencies to define potential Manufacturing Innovation Institutes dedicated to nanoscience and nanotechnology as part of the National Network for Manufacturing Innovation program.

Recommendation 8. The National Science Foundation (NSF), in consultation with the Nanoscale Science, Engineering, and Technology Subcommittee (NSET), should expand the NSF Innovation Corps to include a specific focus on entrepreneurship in the nanotechnology area, and NSET, the National Institutes of Health, and the Department of Energy should leverage this program concept to make it available to a broad range of scientists working in nanoscience and technology.

Recommendation 9. The National Nanotechnology Coordinating Office and the Department of Commerce should establish an annual nano-focused economic-development forum designed to bring together academic researchers, the venture capital community, biotechnology, and other industry in a format that enhances the possibility to create business partnerships.

RESEARCH ENTERPRISE RECOMMENDATIONS

Recommendation 10. Recognizing growing international funding competition that is attracting US-based talent to go abroad, NNI agencies should substantially support the best single investigators to pursue creative, high-risk research. In particular, the National Science Foundation, Department of Energy, Department of Defense, and National Institutes of Health should coordinate to ensure that at least five new National Security Science and Engineering Faculty Fellowship (NSSEFF)-style senior-investigator grants in nanoscience and nanotechnology are funded per year.

Recommendation 11. The National Science Foundation, National Institutes of Health, Department of Energy, Department of Defense, and the National Institute of Standards and Technology should strongly support nanoscale research centers and infrastructure networks to ensure the effective training of a new generation of transdisciplinary scientists and engineers, in particular by strongly supporting the Next-Generation National Nanotechnology Infrastructure Network.

ENVIRONMENTAL, HEALTH, AND SAFETY RECOMMENDATIONS

Recommendation 12. The Nanoscale Science, Engineering, and Technology Subcommittee should continue to support the development of a multidisciplinary nanotechnology environmental, health, and safety ecosystem that promotes non-animal based (alternative) test strategies for safety assessment and multi-stakeholder participation in regulatory decision-making and safe implementation to facilitate market access of nanomaterials and nanotechnology-enabled products.