OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Nanotechnology-Inspired Grand Challenges for the Next Decade

ACTION: Notice of Request for Information

SUMMARY: The purpose of this Request for Information (RFI) is to seek suggestions for *Nanotechnology-Inspired Grand Challenges for the Next Decade*: ambitious but achievable goals that harness nanoscience, nanotechnology, and innovation to solve important national or global problems and have the potential to capture the public's imagination. This RFI is intended to gather information from external stakeholders about potential grand challenges that will help guide the science and technology priorities of Federal agencies, catalyze new research activities, foster the commercialization of nanotechnologies, and inspire different sectors to invest in achieving the goals. Input is sought from nanotechnology stakeholders including researchers in academia and industry, non-governmental organizations, scientific and professional societies, and all other interested members of the public.

DATES: Responses must be received by July 16, 2015 to be considered.

ADDRESSES: You may submit responses by any of the following methods (email is preferred):

- *Email:* NNIChallenges@nnco.nano.gov. Include [*Nanotechnology-Inspired Grand Challenges*] in the subject line of the message. The response may be in the body of or as an attachment to the email.
- *Mail*: Attn: Tarek Fadel, National Nanotechnology Coordination Office, ATTN: NNI Grand Challenges RFI, 4201 Wilson Blvd., Stafford II, Suite 405, Arlington, VA 22230. If submitting a response by mail, please allow sufficient time for mail processing.

Instructions: Responses must be unclassified and should not contain any information that might be considered proprietary, confidential, or personally identifying (such as home address or social security number).

Disclaimer: Federal agencies may or may not use any responses to this RFI as a basis for a subsequent project, program, or funding opportunity. Responses to this RFI will not be returned. The Office of Science and Technology Policy is under no obligation to acknowledge receipt of the information received, or provide feedback to respondents with respect to any information submitted under this RFI. No requests for a bid package or solicitation will be accepted; no bid package or solicitation exists. In order to protect the integrity of any possible future acquisition, no additional information will be provided and no appointments for presentations will be made in reference to this RFI. This RFI is issued solely for information and planning purposes and does not constitute a solicitation. Responders to this RFI will have no competitive advantage in receiving any awards related to the submitted input on a potential Nanotechnology-Inspired Grand Challenge.

FOR FURTHER INFORMATION CONTACT: Tarek Fadel, (703) 292-7926, NNIChallenges@nnco.nano.gov, National Nanotechnology Coordination Office. Any requests for clarification must be received no later than seven (7) business days prior to the close of this RFI in order to receive a timely response.

SUPPLEMENTARY INFORMATION:

Background Information

The National Nanotechnology Initiative (NNI), established in 2001, is a U.S. Government research and development initiative of 20 Federal departments, independent agencies, and independent commissions (hereafter referred to as "agencies") working together toward the common challenging vision of 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 (see www.nano.gov). The combined, coordinated efforts of the participating agencies have accelerated the discovery, development, and deployment of nanotechnology to address agency mission goals and broader national needs. Over the next decade, nanotechnology has the potential to build on the great progress already made under the NNI and solve a wide range of important national and global problems.

In its recent review of the NNI, the President's Council of Advisors on Science and Technology (PCAST) recommended that agencies engage research, development, and industrial stakeholders in the identification and selection of grand challenges in order to focus and amplify the impact of Federal nanotechnology activities (see www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf). Grand challenges are an element of the President's *Strategy for American Innovation* that help catalyze breakthroughs needed to advance national priorities. A *Nanotechnology-Inspired Grand Challenge* should be an ambitious but achievable goal that harnesses nanoscience, nanotechnology, and innovation to solve important national or global problems and has the potential to capture the public's imagination. The challenge should inspire different sectors to invest resources to achieve the ambitious goal and stimulate a network of

activities that will drive scientific ideas towards commercial products while catalyzing new discoveries.

An effective grand challenge has the following characteristics (as defined by PCAST as noted above, as well as the Administration here: http://www.whitehouse.gov/grand-challenges):

- A measurable end-point that is highly ambitious but achievable.
- Requires advances in fundamental scientific knowledge, tools, and infrastructure for successful completion.
- Has clear intermediate milestones (measurable and valuable in their own right) that will be achieved en route to the final goals.
- Drives the need for collaboration between multiple disciplines, some of which do not normally interact, causing multiple organizations to come together to collaborate and to share resources and information to solve the challenge.
- Spans efforts from discovery and fundamental science to engineering demonstration and commercialization; i.e., catalyzes the transition of technologies from laboratory to market.
- Is too big to be undertaken by one or even a few organizations.
- Is exciting enough to motivate decision makers to provide funding and resources and multiple organizations to collaborate, share resources, and information to solve the challenge.
- Captures the imagination of the public, thereby facilitating strong support for the resources required to achieve the goals.

Although nanoscale science and technology is a broadly enabling discipline, not every worthwhile grand challenge is likely to be solved using nanotechnology. The objective of this

RFI is to identify compelling, ambitious grand challenges where the known benefits of nanoscale science and technology, including the unique properties of engineered nanomaterials, are likely to play an enabling role in the solution to each challenge within the next decade.

Information Requested

The Office of Science and Technology Policy (OSTP) requests suggestions for nanotechnology-inspired grand challenges achievable in the next decade that solve important national or global problems and are relevant to the mission of one or more of the agencies participating in the NNI (see www.nano.gov/partners). In order to illustrate how such grand challenges should be framed and to help stimulate the development of additional grand challenges, the NNI agencies, working with the National Nanotechnology Coordination Office (NNCO) and OSTP, have developed a number of potential grand challenges for the next decade, which are listed below. In addition to seeking suggestions from the community for other grand challenges, comments are sought as to the merits of these examples, including how they could be improved, along with additional information supporting these examples as detailed in the questions that follow.

Examples of potential *Nanotechnology-Inspired Grand Challenges for the Next Decade*

By 2025, the nanotechnology R&D community is challenged to achieve the following:

1. *Increase the five-year survival rates by 50 percent for the most difficult to treat cancers.* Although great progress has been made in diagnosing and treating many types of cancer, some types remain very deadly, such as pancreatic, lung, and some types of brain cancers where fewer than 20 percent of patients survive five years. From multiplexed biomarker detection enabled by nanosensor arrays for early diagnosis, to targeted nanoparticle-based therapeutics, nanotechnology has tremendous potential to dramatically improve the

outcome and quality of life for these cancer patients compared to their current prognoses. The resulting technological advances will undoubtedly improve the diagnosis and treatment of other types of cancer and diseases as well.

2. *Create devices no bigger than a grain of rice that can sense, compute, and communicate without wires or maintenance for 10 years, enabling an "internet of things" revolution.* Incorporating sensors, electronics, and networking into a vast array of everyday objects to create an Internet of Things will lead to a revolution in how we interact with the world — from traffic jam-free cities and self-driving cars, to clothing that monitors our health and safety. This revolution will require new paradigms for logic, memory, communication, and sensing, along with energy storage, harvesting, and transmission, that dramatically reduce power consumption and extend the life of the devices needed to interconnect this new world.

3. *Create computer chips that are 100 times faster yet consume less power.*
   The technology that has enabled ever-faster and more powerful computer chips that are the foundation of the information technology revolution is reaching its limit. In order to continue to benefit from the advances in computing speed and power we have come to rely on, revolutionary breakthroughs are needed to dramatically lower the power needed to operate the basic electronic switch underlying the digital computing era. Achieving this goal will lead to portable devices that anticipate our needs, faster "exascale" computers that will accurately model the planet's climate and rapidly design new materials, and energy efficient data centers that will quickly turn the deluge of data that the world is generating into useful information when and where it is needed.

4. *Manufacture atomically-precise materials with fifty times the strength of aluminum at half the weight and the same cost.*

   The development of new materials enabled by nanotechnology is hindered by the fact that their properties often fall far short of what would be predicted based upon the properties of nanoscale building blocks. Atomically precise manufacturing will enable ultra-lightweight, durable, high strength materials that could drastically increase the energy efficiency of cars and other transportation systems, and lead to dramatic improvements in a broad range of other applications, ranging from catalysts that convert sunlight to fuel, to electronics that consume much less energy.

5. *Reduce the cost of turning sea water into drinkable water by a factor of four.*

   Water supplies world-wide are vulnerable to threats such as contaminants, changes in land use, shifting and increasing population, climate change, and extreme weather. And one in nine people (750 million worldwide) lack access to clean drinking water. Although sea water is widely available, it currently costs approximately $2,000 to desalinate an acre foot of water (or about $6 per 1000 gallons) — about twice the rate a typical homeowner pays for tap water. Advances in nanotechnology, such as nanoporous materials for separation membranes and nanoparticles that remove contaminants, offer the possibility of much faster, cheaper, and more environmentally-friendly methods for desalination and other treatment applications that could dramatically improve the global supply of drinkable water.

6. *Determine the environmental, health, and safety characteristics of a nanomaterial in a month.*

The need to more quickly and accurately determine whether engineered nanomaterials may pose a risk to the public and the environment continues to be a major challenge to the commercialization of nanotechnology for societal and public benefit. Much more efficient methods, including high-throughput toxicity measurements, sensors to detect nanomaterials in the environment, and accurate, predictive models for risk assessment, are needed to ensure that the safety of each product containing engineered nanomaterials is understood throughout its lifecycle, enabling new products to be quickly and confidently made available to the public.

Questions

Respondents are asked to address the following general questions for each grand challenge proposed, including for any of the grand challenge concepts listed above (or proposed variations):

- What is the audacious yet achievable goal proposed?
- Why is it important for the Federal government and others to invest in solving this challenge?
- What would success look like? How would you know the challenge has been met? For the examples provided, are the proposed end points appropriate and ambitious yet achievable?
- What would be potential nanotechnology solutions to the challenge and what intermediate steps and activities are necessary to develop those solutions?
- What potential metrics and milestones could be used to measure intermediate progress towards solving the challenge?
- Can the challenge be achieved in the next decade? If not, how long will it take?

- Why is this challenge worth pursuing now? What recent advances, trends, or research point to this challenge being solvable in the proposed time frame?
- What opportunities are there for partnerships between the Federal government, State and regional governments, foundations, industry, and academia to support the solution of the challenge?
- Why do you expect this challenge to capture the public's imagination?

Ted Wackler, Deputy Chief of Staff and Assistant Director

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