Grand Challenges for Nanoscience and Nanotechnology

All of our editors and we expect that the majority of our readers at *ACS Nano* are fascinated by the opportunities both within nanoscience and nanotechnology[1,2] and beyond, in which the discoveries found and tools developed in our fields are applied to other areas of science, engineering, and medicine, as well as to global issues.[3,4] It is becoming increasingly common for interested parties to ask questions as to how science and technology, in general, and nanoscience and nanotechnology, in particular, can serve humanity's current and future needs. It is our contention that the advances in our field will enable our community to spearhead many of these discovery and translational efforts because we have already assembled an interdisciplinary workforce and put in the effort to learn to speak each other's languages, sharing problems and approaches along the way, and providing innovative solutions to societal challenges that could not previously be addressed.[5,6]

One of the founders of our field, the late Rick Smalley of Rice University, listed the areas of greatest challenge for the world and thus greatest opportunity, believing that there was a nanotechnology answer for each.[7] These topics included energy, water, food, the environment, poverty, terrorism and war, disease, education, democracy, and population. While these areas remain important, the advances made by the first two decades of nanotechnology now enable us to be more specific in addressing goal-directed *societal* grand challenges that can be solved by novel nanoinspired solutions. This effort is in step with requests from the White House that have proposed a number of Grand Challenges as a means to inspire innovation, cooperation, and action. The U.S. National Academy of Engineering defined and listed several with this spirit in mind[8] and continues to call for solutions in activities around the world.

In the United States, the White House of Office of Science and Technology Policy (OSTP) has asked for specific suggestions of grand challenge topics to be addressed through nanotechnology (due July 17, 2015), including nanoscale materials, nanoscale operations, and nano-enabled products.[9] This call was motivated in part from last year's assessment of the U.S. National Nanotechnology Initiative,[10] in which the U.S. Presidential Council of Advisors for Science and Technology (PCAST) surveyed the global advances since the onset of the Initiative to recommend that the time is right for the implementation of Grand Challenges by multidisciplinary teams with academia/industry cooperation to utilize the nanotechnology toolbox to solve important national and global problems in ways that capture the public's imagination. The call was made for interdisciplinary teams to formulate themes and topics that can be accomplished in the next decade through a stretch of the imagination. *ACS Nano* Editor-in-Chief Paul Weiss moderated an online discussion on this topic with Dr. Lloyd Whitman of OSTP, in which many of our readers participated; if you missed it, you can see and listen to a recording on line.[11] A number of *ACS Nano* editors and members of our advisory board also served in the PCAST panel, helping to provide guidelines for the implementation of the second phase of nanotechnology. As described in *ACS Nano*, President Obama's BRAIN Initiative originated from nanoscientists, nanotechnologists, and others, suggesting that the tools of nanotechnology could be applied in parallel to study neural circuits in the brain, which function at the nanoscale in terms of intercellular communication.[3,12,13] We look forward to bringing together analogous teams and interdisciplinary discussions in areas such as the applications of the materials genome, clean energy, environmental remediation, clean water, agriculture and food supply, the microbiome, and nanomedicine to revolutionize the approaches taken and to breaking through refractory barriers impeding scientific progress and improvement of our world.

A number of broad challenges have been posed by the European Union, including Societal Challenges; Health, Demographic Change, and Wellbeing; Secure, Clean, and

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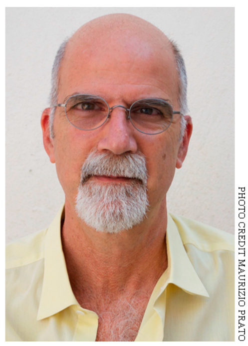
Efficient Energy; Food Security, Sustainable Agriculture, and Forestry; Marine, Maritime, and Inland Water Research; and the Bioeconomy, as well as other less nano-related topics.[14,15] The European Union has funded two specific flagship efforts, one in graphene (and other two-dimensional materials)[16] and the Human Brain Project, which seeks to simulate the human brain[17] and complements the U.S. and other global efforts.

In healthcare and diagnostics, we are seeing tremendous progress in the laboratory, ranging from nanodelivery[18] to artificial organs[19] to diagnostics.[20,21] The next steps involve determining how to get these advances to the clinic.[22] A number of global challenges in disease, poverty, water, and other areas could be addressed by leveraging the significant advantages nanosystems hold over the traditional methods of biological sensing, imaging, tissue reconstruction, delivery, and precision-intervention in biological systems. Likewise, in energy conversion and storage, tremendous activity and promise exist; the key challenges now involve the translation, scale up, and commercialization into industrial-scale solutions, hence the emphasis on public/private cooperation.

The safe commercialization of nanomaterials remains a key issue in which new approaches to testing and regulation are required to bring products that are nano-enabled or contain engineered nanomaterials to market.[23,24] We see increasing opportunities in food,[25,26] agriculture, eco-safety,[27] understanding microbiome(s), and alternatives to antibiotics for infectious disease. We look forward to encouraging the advances and impact of these and other areas and opportunities.

Around the world, parallel, overlapping, complementary, and other efforts are taking shape to tackle the great challenges we face, both intellectual and existential. We use *ACS Nano* to help identify these challenges and how nanoscience and nanotechnology can be used to address them; we hope that you do, as well.

Announcements. We are delighted to announce the winners of the 2015 ACS Nano Lectureship Awards. The winners are Prof. Hua Zhang for the Asia/Pacific region, Prof. Peidong Yang for the Americas, and Prof. Maurizio Prato of the University of Trieste for Europe/Africa/Middle East. The lectureships and companion lectures will be presented this September at ChinaNano 2015 in Beijing, China. Please be sure to join us there!



The winners of the 2015 *ACS Nano* Lectureship Awards are (left) Prof. Hua Zhang of Nanyang Technological University for the Asia/Pacific region, (center) Prof. Peidong Yang of the University of California, Berkeley for the Americas, and (right) Prof. Maurizio Prato for Europe/Africa/Middle East. The lectures this year will be presented this September at ChinaNano 2015 in Beijing, China. Photo Credit Hua Zhang, Mei Wang, and Maurizio Prato.

Prof. Hua Zhang is on the faculty of the School of Materials Science and Engineering at Nanyang Technological University. His research focuses on two-dimensional materials, including syntheses of graphene-based nanomaterials and high-quality, ultrathin metal sulfide nanocrystals.[28−32] He develops syntheses and elucidates and applies the properties of these materials, in catalysis, sensing, energy, and electronics.

Prof. Peidong Yang is the S.K. and Angela Chan Distinguished Professor of Energy and Professor of Chemistry at the University of California, Berkeley. He explores semiconductor nanowire science and technology, particularly in the use of semiconductor nanowires for photonics, thermoelectrics, and solar energy conversion, and has made significant advances in artificial photosynthesis.[33−36]

Prof. Maurizio Prato is on the faculty in the Department of Chemistry and Pharmaceuticals at the University of Trieste. His research focuses on the design and synthesis of tailored nanostructures for bionanotechnology, including new cell penetration methods for drug delivery and neuronal scaffolds and for solar energy conversion and storage.[37−39] He has explored new synthetic protocols and analytical methods, enabling innovative, controlled, and reproducible ways for the designer functionalization of carbon nanostructures, with the ultimate goal of tackling technologically relevant problems.

Finally, *ACS Nano* and our sister journal *Nano Letters* have increased our cooperation and interactions, as described in an editorial to appear soon in *Nano Letters*.[40]

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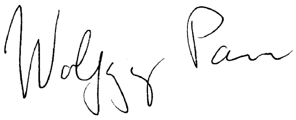

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