Patient-Inspired Engineering and Nanotechnology

At the end of July 2015, we held a workshop on micro- and nanotechnologies in medicine at the Brigham and Women's Hospital of Harvard Medical School to discuss emerging technologies in engineering with a focus on biomedical applications.[1] For a week, leading scientists, engineers, and physicians presented on and discussed topics ranging from basic sciences to medical devices and commercialization. One of the important aims of the workshop was to provide opportunities for clinicians and engineers to meet and to identify important biomedical problems that patients face.

The workshop highlighted significant recent advances in nanoscience and nanotechnology, including in smart surfaces, nanoelectronics, DNA engineering, and hybrid materials. While such advances have enhanced our understanding of biological phenomena and enabled new directions for research, it became apparent that some of these advances were not aligned with the clinical needs of patients. The clinicians involved presented the needs of patients and pointed to how targeting both common and specialized problems in diagnostics and treatment could have tremendous impact on medicine, in saving lives and preserving/enhancing quality of life. Often, engineering solutions are akin to a hammer looking for a nail. We argue for a different, targeted approach to developing engineering solutions to key problems in medicine (and other areas).[2−5] Physicians at the workshop provided clinical perspectives on some of the common problems in medicine today, including infection; musculoskeletal, cardiovascular, and neural diseases; and cancer. The workshop discussions highlighted the critical need for physician participation in helping guide the development and clinical applications of emerging technologies for maximum impact.

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Physicians can provide key insights into clinical problems and disease diagnoses, as well as their challenges in clinical management, clinical progression, and long-term outcomes. Physicians can also provide insight into the social and economic aspects of disease and treatment, which are often ignored in engineering research and development. Better understanding of how a disease impacts the patient can help guide the selection, exploration, development, and translation of potential engineering solutions. While there are many inspirations to the engineering solutions we see today in biology and medicine, we believe that a patient-inspired approach to engineering would best align the tools developed to medical needs. A patient-inspired approach that focuses on the clinical problem(s) and needs of the patient will undoubtedly lead to diagnostics, tools, and therapeutics that are more relevant and straightforward to translate. Closer interactions between physicians, engineers, and scientists will increase the impact of nanotechnology in society as technological advances are made more clinically relevant to patients (Figure 1). In upcoming issues of *ACS Nano*, we will carry these discussions further and share the thinking of a number of the workshop participants and others with an eye toward advancing the targeted development of advanced technologies for medicine.[4]

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Announcement. We are pleased to announce that the first molecular nanocar race will be held in November of this year at Futurapolis in Toulouse, France, to be followed in the fall of

Published online August 25, 2015
10.1021/acsnano.5b05000

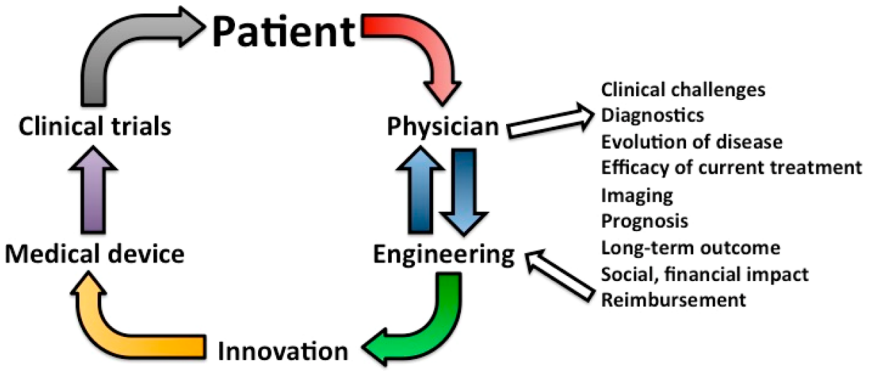

Figure 1. Medical devices, diagnostics, and therapeutics can be developed, improved, and put to use more directly and efficiently by patient-inspired approaches to engineering and technology in which physicians, scientists, and engineers together target needed advances.

2016 by another race at the French national event *Fête de la Science*.[6,7] The competitors in the first race come from Austria, France, Germany, Japan, and the United States.

Disclosure: Views expressed in this editorial are those of the authors and not necessarily the views of the ACS.

Acknowledgment. The authors thank Linda Baum, Lee Goodglick, and Donald Ingber for thoughtful discussions, and the Biomaterials Innovation Research Center at MIT, Wyss Institute for Biologically Inspired Engineering at Harvard University, and Brigham and Women's Hospital for support of the workshop. P.S.W. thanks the Kavli Foundation and Wyss Institute for support of his stay at Harvard.

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REFERENCES AND NOTES

1. 3rd Annual Workshop on Micro- and Nanotechnologies for Medicine: Emerging Frontiers and Applications, Cambridge, Massachusetts, USA; http://biomemsworkshop.tissueeng.net/wp/ (Accessed August 5, 2015).
2. Weiss, P. S. A Conversation with Dr. Leroy Hood: Visionary Biologist and Biotechnologist. *ACS Nano* **2007**, *1*, 242–247.
3. Cha, C.; Liechty, W. B.; Khademhosseini, A.; Peppas, N. A. Designing Biomaterials To Direct Stem Cell Fate. *ACS Nano* **2012**, *6*, 9353–9358.
4. Khademhosseini, A.; Aizenberg, J.; Amiji, M. M.; Analoui, M.; Andrews, A. M.; Boyden, E. S.; Han, J.; Kamm, R. D.; Karp, J. M.; Oklu, R.; et al. Emerging Trends in Micro- and Nanoscale Technologies in Medicine: From Basic Discoveries to Translation. Manuscript in preparation.
5. Hinchet, R.; Kim, S.-W. Wearable and Implantable Mechanical Energy Harvesters for Self-Powered Biomedical Systems. *ACS Nano* **2015**, *9*, DOI: 10.1021/acsnano.5b04855.
6. Joachim, C.; Rapenne, G. Molecule Concept Nanocars: Chassis, Wheels, and Motors? *ACS Nano* **2013**, *7*, 11–14.
7. Weiss, P. S. Nano Races, Prizes, and Awards. *ACS Nano* **2014**, *8*, 1.