Editorial

Physical Sciences-Oncology Centers: Bridging Engineers and Oncologists for a New Perspective on Fighting Cancer

NICOLE M. MOORE, ANNA MARIA CALCAGNO, SEAN HANLON, LARRY A. NAGAHARA,
and NASTARAN Z. KUHN

National Cancer Institute, Center for Strategic Scientific Initiatives, Office of Physical Sciences-Oncology, Bethesda,
MD 20892, USA

(Received 20 October 2010; accepted 20 October 2010; published online 2 November 2010)

Associate Editor David Odde oversaw the review of this article.

At the 2010 Biomedical Engineering Society (BMES) Annual Meeting, the National Cancer Institute (NCI) Office of Physical Sciences-Oncology (OPSO) co-chaired a new session initiated by Cynthia Reinhart-King (Cornell University) entitled “The Physics and Engineering of Cancer Cells and Their Microenvironment” with the goal of building long-term support and recognition for biomedical engineers investigating cancer. The session emphasized the application of methodologies grounded in physics and engineering to the study of cancer to uncover new insights, identify new targets, and pursue novel therapeutic strategies. This session included invited speakers, such as Denis Wirtz (Johns Hopkins University (JHU)) and Roger Kamm (Massachusetts Institute of Technology (MIT)), whose work is at the forefront of applying engineering approaches to understanding cancer phenomena and complexity.

It is no coincidence that the commencement of this interdisciplinary BMES session complements a new initiative launched by the NCI. In the Fall of 2009, OPSO started the Physical Sciences-Oncology Centers (PS-OC) program, awarding 12 specialized centers that comprise a virtual network of scientists that span the fields of engineering, physics, mathematics, chemistry, cancer biology and clinical oncology. To encourage trans-disciplinary communication, each PS-OC is

led by a physical scientist together with a senior investigator from the field of cancer biology or clinical oncology and supported by expert teams of researchers from both of these disparate fields.

This program stems from the Physical Sciences in Oncology Initiative, commenced in 2007 by then-NCI Director John Niederhuber and then-NCI Deputy Director Anna Barker. The NCI sponsored a series of three strategic “think tanks” to bring together over 300 thought leaders from across these fields to ascertain how NCI could more effectively engage the physical sciences in cancer research. Four thematic areas emerged from these meetings in which physical sciences approaches and principles could profoundly influence and improve our knowledge of cancer biology over both spatial and temporal scales. These themes are (1) de-convoluting cancer’s complexity, (2) information coding, decoding, transfer, and translation in cancer, (3) evolution and evolutionary theory of cancer, and (4) physics (physical laws and principles) of cancer. Each new PS-OC was required to develop an organizing framework that employs one, or more, of the four thematic areas to address major questions and barriers in cancer research.

Engineers within the PS-OC Network are contributing to these thematic areas by applying their unique toolbox to cancer questions and are simultaneously gaining clinical and biological knowledge to advance these technologies. Currently, multiple tools exist in the biomedical engineering field that are readily applicable to cancer-related phenomena. As trans-disciplinary scientists, biomedical engineers are well positioned to communicate and work together with clinicians and cancer biologists to approach questions

Address correspondence to Nastaran Z. Kuhn, National Cancer Institute, Center for Strategic Scientific Initiatives, Office of Physical Sciences-Oncology, Bethesda, MD 20892, USA. Electronic mail: nastaran.kuhn@nih.gov

in cancer biology and apply these existing tools for cancer research. Highlighted below are several examples of this interplay between the physical sciences and oncology that exist within the PS-OC Network.

Three dimensional (3D) system platforms are an example of a tool that is extensively used for tissue engineering and regeneration but can potentially provide valuable disease models for understanding tumor initiation, growth, angiogenesis, and metastasis. PS-OC engineers at JHU, Cornell University, and the University of California, Berkeley are employing 3D fabricated systems as tumor models to investigate the role of extracellular matrix composition and stiffness, receptor/ligand interactions and pore size on cell migration,³ morphology, angiogenesis,¹ and protein expression. Physical and biological cues translated from these models will broaden insight into new strategies and future cancer treatment, such as novel inhibitors of angiogenesis or the role of matrix stiffness and inflammation on metastasis.

Advances in nanotechnology have spawned numerous microfluidic-based assays that provide a platform for high throughput single cell analysis, biomarker detection and diagnosis, and cell isolation. Engineers from the University of Southern California (USC), Cornell University, Princeton University, and MIT PS-OCs are fabricating microfluidic devices to identify antibody levels in human serum, for isolation and single cell analysis of circulating tumor cells,⁶ and to monitor cell division and differentiation at a single cell level,⁷ respectively. Translation of these devices to clinical applications is a realistic goal for measuring cancer cell heterogeneity, metastasis, and biomarker screening.

Finally, delivery and transport of therapeutics and imaging agents across biological barriers has long been an emphasis of the biomedical engineering community. Increased communication between these investigators and oncologists for clinical translation and progression of treatment options is being achieved through the PS-OC program. Examples are seen at the University of Texas Health Science Center PS-OC in their development of particles for thermal ablation and chemotherapeutic delivery systems.^{5,8} Conversations with oncologists have sparked innovative design of materials that go beyond standard thinking to address multiscale delivery mechanisms focused on the patient as a whole (rather than just the cell).

In addition to these physical tools, new standards for cancer diagnosis and treatment are dependent on the development of predictive models of tumor growth,⁴ metastasis, drug delivery, drug resistance and cellular evolution² that are currently being realized at the USC and Dana-Farber Cancer Institute PS-OCs. Biomedical engineers are uniquely equipped with the ability to bridge across length and time scales and to

integrate physical and biological measurements to provide new insights into cancer's complexity. As an example, the power to correlate tumor size and drug resistance to form a predictive treatment tool will have a profound impact on personalized care.

Overall, even though the support of biomedical engineers in cancer research and the PS-OC Network are still in their infancy, the NCI anticipates this new path will foster the development of innovative ideas, technologies and new fields of study based on combined knowledge of the biological and physical laws and principles that govern cancer behavior. Facilitating an open discussion within BMES through a new symposium session is one of the first steps to accomplishing this goal. Further effort by PS-OC Network investigators and other investigators who are connecting the disparate fields of cancer biology and the physical sciences will be required to achieve paradigm shifts in cancer research, diagnosis, and treatment. Please visit physics.cancer.gov for more information about the Physical Sciences-Oncology program, the PS-OCs, funding opportunities, and recent scientific news and publications.

ACKNOWLEDGMENTS

The authors would like to thank the editors David Odde and Ed Guo for the opportunity to discuss the PS-OC Network and convey the importance of cellular and molecular engineering in cancer research. Special thanks to Cindy Reinhart-King, recipient of the BMES 2010 Rita Schaffer Memorial-Young Investigator Award, for requesting the session at BMES and 2010 BMES Annual Conference program chair Krishnendu Roy and Cellular and Molecular Engineering Track Chairs, Andrés García and Laura Segatori, for supporting the start of this new session.

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