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# NANOTECHNOLOGY IN BIOLOGICAL DETECTION AND CHARACTERIZATION

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Nanotechnology has achieved incredible milestones in the roughly 25 years that it has been recognized as an independent field of scholarship, but perhaps none has been as significant as the tectonic shift it has brought about toward interdisciplinary science. It is now hard to believe that physicists, engineers, chemists and biologist once occupied their own spheres and rarely crossed boundaries to work cooperatively. This is because we are living in an age where all of these disciplines are studied in tandem under the banner of "nano." As a result, each field has grown: physics has entered a world where quantum mechanics has become an observable; the overcoming of engineering challenges at the nanoscale has enabled precise control of matter and an understanding of how molecular machines might work; chemistry, which has always occurred at these scales, is being understood in new and exciting ways; and biology has undergone a sea change in both understanding and scope.

It is the last of these that has inspired the theme of this special issue of *Nano LIFE*, which focuses on the development and use of nanotechnology for fundamental investigations of biological systems. The tools and techniques offered by nanotechnology allow for structures to be created on the same size scale as individual cells and biomolecules, instigating a new "bottom up" approach to sensing and characterization that was impossible to envision before. Advances in this emerging field of "nanobiotechnology" are presented in the pages that follow, describing new materials and methods that offer insight into the basic functions of biology and/or aid in the transition from fundamental studies to diagnostic and clinical applications.

Two articles in this issue look at new nanomaterials with properties designed to enhance biological imaging capabilities. Vance *et al.* present a new method for producing carbon-coated nanoparticles.[1] The resulting material has potential to overcome the toxicity of conventional quantum dots, which has been an important barrier to their widespread utility. Dorcena *et al.*, on the other hand, demonstrate a new synthesis method for carbon dots

(C-dots) in poly(lactic-co-glycolic acid) (PLGA), the inherent properties of which offer a stable alternative to traditional fluorescent labels.[2]

Five articles are related to biosensing, either using nanotechnology to improve biosensors or using sensors with nanoscale features to study biological systems. Choudhary *et al.* demonstrate the use of functionalized polymer nanoparticles as a potentially low-cost approach for modifying transducer surfaces in sensing applications.[3] They demonstrate the utility of this approach by detecting $\beta$-galactosidase selectively using a quartz crystal microbalance with a nanoparticle-functionalized sensing surface. Dutta *et al.* couple Dynamic Force Spectroscopy with Surface Plasmon Resonance to analyze binding between integrins (transmembrane cellular receptors) and fibrinogen (a protein involved in clotting of blood).[4] Wang *et al.* measure the stiffness of various bacterial species using an Atomic Force Microscope and employ this data to predict the transport of cells through packed sand columns.[5] Davis *et al.* present a new electrochemical sensor that incorporates nanoelectrodes inside a nanochannel for detecting double stranded DNA.[6] Webster *et al.* also use an electrochemical sensor which has nanoelectrodes inside a nanochannel, but they detect and monitor the concentration of pyocyanin, a metabolite produced by *Pseudomonas aeruginosa*.[7]

A number of reviews in this special issue that summarize the current state-of-the-art in a range of relevant areas, including nanotopography for cellular studies, microfluidics for vascular research, detection methods based on aptamer recognition elements and cytotoxicity assays. Yang provides a wide-ranging review of the application of nanotopographical surfaces to observe modulation of cellular phenotype and function.[8] Abaci *et al.* review existing microfluidic technology that is used to create and regulate artificial vascular microenvironments, and highlight the recent advances that have resulted from the incorporation of these microfluidic devices in vascular research.[9] Ocsoy *et al.* provide a broad review of aptamers conjugated to nanomaterials, such as nanoparticles and graphene oxide, for sensing of biological molecules and cells.[10] Finally, Webster *et al.* present an introduction to investigations involving the cytotoxicity and genotoxicity of nanomaterials, and is an excellent primer for those new to the field of nanotoxicity.[11] Each of these articles represents a significant research area within nanobiotechnology.

As Guest Editors of the *Nano LIFE* Special Issue on Nanotechnology in Biological Detection and Characterization, we thank all of the authors for their submissions. We also thank all of the reviewers of the submitted papers, who donated their valuable time and provided vital assistance in evaluating manuscripts and offering guidance to the authors. The advice and support provided by other editors and the World Scientific Publishing Company is also much appreciated. We sincerely hope that readers will find the articles valuable and enlightening in their research activities.

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