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SPECIAL ISSUE

Nanobiointerfaces: Interfaces Between Biological Entities and Nanomaterials

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Just as in the case of chemical reactions in the flask, many critical interactions in biological systems occur at interfaces; these biointerfacial interactions (a.k.a., juxtacrine interactions) influence a variety of phenomena including cell apoptosis, differentiation, adhesion, and migration. The interfacial recognition and reaction of cells, organelles, and viruses, and also of the active sites of proteins have been monitored, analyzed, or imaged with chemical probes and, recently, nanometer-scaled ones, with the aim of increasing our understanding of biochemical and biological phenomena at the molecular level and applying it to medicinal and biomedical areas. In addition, further developments in nanoscience and nanotechnology make it possible to manipulate biological entities, especially living cells, and their activities at the single-cell level for intended purposes by deliberately controlling biosurfaces with nanoscale materials or structures.

Since the early work by George M. Whitesides on soft-lithography-based pattern generation and characterization of cells, various chemical strategies have been developed to provide nanobiointerfaces for studying biological systems and applying them to various technological areas including nanotheranostics and cell therapy. Three-dimensional cellular architectures mimicking tissues have been constructed by designing sophisticated nanomaterials for biospecific cellular interfacing and programmed assembly. Single cells have also been a target for nanobiointerface manipulation, extending the capabilities of traditional bioencapsulation to nanometer-scaled cell-surface engineering. Cellular reprogramming is also made possible by nanobiointerfacial control, exemplified by magnetogenesis, and unforeseen cellular behaviors have been observed on nanostructured cell-culture platforms. Targeted delivery of therapeutic agents has been achieved by specific recognition and interaction at cell surfaces, and a polyvalent approach to cellular (or viral) recognition may lead to the development of effective therapeutics in nanomedicine.

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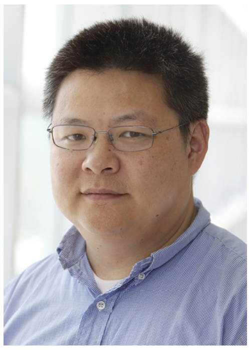
This manuscript is part of a Special Issue on Nanobiointerfaces. Click here to see the Table of Contents of the special issue.

Insung S. Choi obtained his B.S. and M.S. degrees in organic chemistry at Seoul National University (Seoul, Korea) under the supervision of E. Lee, and did his Ph.D. degree at Harvard University (Cambridge, USA) in 2000 under the supervision of G. M. Whitesides. After postdoctoral work with R. Langer at MIT (Cambridge, USA), he was appointed as assistant professor at Korea Advanced Institute of Science and Technology (KAIST; Daejeon, Korea) in 2002 and professor in 2007. He is currently Professor of Chemistry and of Bio and Brain Engineering and Director of the Center for Cell-Encapsulation Research.

Ravi Kane is currently the Garry Betty/V Foundation Chair and GRA Eminent Scholar in Cancer Nanotechnology. Prof. Kane received a B.S. in Chemical Engineering from Stanford University in 1993. Prof. Kane went to graduate school at MIT, where he received an M.S. in Chemical Engineering Practice and a Ph.D. in Chemical Engineering working with Bob Cohen and Bob Silbey. After postdoctoral research with George Whitesides in the Department of Chemistry and Chemical Biology at Harvard University, he joined Rensselaer Polytechnic Institute (RPI) as an assistant professor in 2001. He was promoted to associate professor in 2006, to full professor in 2007, and to the P.K. Lashmet Professor in 2008. He also served as the head of RPI's Howard P. Isermann Department of Chemical and Biological Engineering before moving to Georgia Tech in 2015.



After receiving his B.S. and M.S. from Nanjing University in 1987 and 1990, Bing Xu obtained his Ph.D. in 1996 from the University of Pennsylvania. Before starting his independent research at the Hong Kong University of Science and Technology in August 2000, he was an NIH postdoctoral fellow at Harvard University. He was tenured as an associated professor in January 2006 and became a full professor in July 2008 at HKUST. Based on his works in HKUST and Brandeis, Bing Xu is identified on the Thomson Reuters "Highly-Cited Researchers 2014 & 2015 in Chemistry" lists. He currently is a professor in the Department of Chemistry, Brandeis University. His research focuses on the applications of supramolecular biomaterials/processes in biology and medicine.

Fundamental studies on nanobiointerfaces in nature have also led to the development of chemically designed nanobiointerfaces that mimic the structural and functional features in nature. Several functional-coating strategies have been developed, such as material-independent coating and omniphobic coating, and various organic and inorganic nano- and micrometric structures have been synthesized by adopting self-assembly processes and biomineralization, respectively.

These recent advances in nanobiointerfaces have benefited from collaborative contributions from various disciplines, such as chemistry, physics, materials science, polymer science, biochemistry, cell biology, biomedical engineering, and medicine. Bio- and cytocompatible nanomaterials, polymers, and self-assembled structures have been synthesized ex situ or in situ, biointerfaces have been fabricated, and reliable techniques for analysis, detection, and characterization have been developed.

This Special Issue is dedicated to recent interdisciplinary efforts in nanobiointerfaces, from synthesis and characterization to application. For example, Prof. Ariga introduces the importance of nanointerfaces in biological studies in his Focus Review, "Interfaces Working for Biology: Solving Biological Mysteries and Opening Up Future Nanoarchitectonics". Prof. Rijn demonstrates this concept with surfaces in his article "Double Linear Gradient Biointerfaces for Determining Two-Parameter Dependent Stem Cell Behavior" and Prof. Akashi and Prof. Ito also report on the "Construction of Mouse-Embryonic-Cell-Derived 3D Pacemaker Tissues by Layer-by-Layer Nanofilm Coating". Nanobiointerfaces can also play an important role at the surfaces of nanoparticles. In their article, Prof. Xia and Prof. Jo describe the "Targeted Delivery of Anti-miR-712 by VCAM1-Binding Au Nanospheres for Atherosclerosis Therapy". Other articles discuss more fundamental topics: for example, Prof. Matsui's Communication, "Biomimetic Crystallization of $MnFe_2O_4$ Mediated by Peptide-Catalyzed Esterification at Low Temperature" and Prof. Gazit's Focus Review, "The Self-Assembly of Helical Peptide Building Blocks". We hope that the great articles in this Special Issue will not only describe the current status of research in nanobiointerfaces but, more importantly, will also inspire many scientists and engineers investigating both fundamental science and application-based research.