Using Nanotechnology to Engineer Ultrasensitive Imaging Probes and Versatile Devices for Studying the Molecular Dynamics of Cells

Warren C.W. Chan, Jonathan Lai, Jane Zhang, Anupam Singhal
University of Toronto, 4 Taddle Creek Rd., 407
Toronto, ON, M5S 3G9
Warren.chan@utoronto.ca

The field of nanotechnology has recently gained widespread interest in numerous bio-related research areas. These nanometer-sized systems or particles have been pursued as novel precursor materials for the development of new tools to probe the behavior of biological systems that cannot be achieved by traditional materials or methods. This interest is driven by the recent discoveries of unique size-dependent optical and electronic properties associated with nanomaterials. This seminar will cover two core topics: (1) utilization of semiconductor nanocrystals, also known as quantum dots, for ultrasensitive multiplexible molecular imaging and analysis, (2) construction of optically-switchable surfaces for studying cell-cell interactions and cell migration using nanoparticle/polymer composites.

Semiconductor quantum dots are composed of atoms from groups I-VII, II-VI or III-V and are defined as particles with physical dimensions smaller than the exciton Bohr radius. Because of this feature, nanocrystals exhibit quantum confinement effect and thus, have unique optical and electronic properties not observed by larger crystallites. These nanocrystals have tremendous advantageous over traditional optical tags such as continuous absorption profiles, size and materials tunable emission, 20 times brighter and 100 times more stable against photobleaching than organic dyes, and 2.5 times narrower spectral linewidths. Theoretically, a set of 80 spectrally unique nanocrystals, assuming spectral resolution of 20 nm, can be synthesized that ranges in emission from 300 nm to 1900 nm. Furthermore, molecular barcoding technologies can be created using quantum dots for the analysis of >100 proteins and genes simultaneously.

Beyond quantum dots, we will also describe the integration of metallic nanoparticles with thermosensitive hydrogels for building surfaces that can specifically deliver growth factors, drug agents, oligonucleotides, and other biomolecules to single cells. Analytical tools that can probe or image gene expression such as capillary electrophoresis and quantum dot-probes can be integrated with these surfaces for studying the behavior of protein dynamics of cells in response to changes in their local microenvironment. Questions such as how does changes in molecular microenvironment alter the function and properties of a single or group of cells? What molecules or combination of molecules are involved in guiding the migration of cells? How does molecular changes in a single cell affect their interactions with a group of cells? can be addressed using these surfaces. The ability to answer questions is imperative for the advancement of cancer research and tissue engineering.