Learning From the Bad: Virus-Inspired Design of Nanoparticles for Cell-Type Specific Drug Delivery

2PM - 3PM, Friday, Nov. 13, 2009
DeWalt Seminar Room (2164 Glenn L. Martin Hall)

Abstract: Animal viruses invade their hosts in a rather controlled manner, a process known as endocytosis. Biological studies revealed that virus invasion is both type selective: i.e., certain viruses are engulfed but not the others, as well as size selective, i.e., 50nm viruses are engulfed preferably but not 100nm ones. This fascinating adhesion-driven process makes one wonder: what are the fundamental mechanisms that govern specificities of endocytosis?

In this talk, we use synthesized viruses, nanoparticles (NPs), to elucidate the governing factors for endocytosis. The NP surface is coated with proteins (ligands) that are complementary to the receptors on the cell membrane. The molecular recognition and interaction of the ligand-receptor pairs enable specific targeting. Through thermodynamic arguments, we reveal that, unlike the adhesion between two inanimate objects, the adhesion strength between an NP and a living cell is a non-local, variable quantity that depends on not only the particle size and the ligand density, but also the receptor density that is actively regulated by the cell. The cellular uptake depends interrelatedly on the particle size and ligand density, featuring a two-dimensional phase diagram in the particle size and ligand density space. The variable adhesion strength specifies a lower and an upper phase boundary beyond which the cellular uptake vanishes. The design principles of the NPs obtained from our studies are validated by comparisons to the characteristics of viruses. Our findings are not only important for understanding the biological behaviors and evolutionary design of cells, but also for engineering NP-based therapeutic and diagnostic agents.

Biography: Dr. Sulin Zhang received his Ph.D. from the University of Illinois, Urbana-Champaign in 2002. He then worked as a postdoctoral associate in Northwestern University from 2002-2005 and an Assistant Professor at the University of Arkansas from 2005-2007. He was appointed to the current position as an Assistant Professor of Engineering Science and Mechanics at Penn State University since August, 2007. Dr. Zhang’s research interests generally lie in multiscale modeling of nanostructured and bio-inspired materials, and of processes that occur at nano-bio interfaces. He is particularly interested in the role of Mechanics in Biology. Dr. Zhang is the recipient of The Oak Ridge Ralph E. Powe Junior Faculty Enhancement Award in 2006, and the Early Career Development Award from National Science Foundation in 2007.

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