BIOINSPIRED ENGINEERING

Session co-chairs: Jing Cheng, Tsinghua University School of Medicine, and William Murphy, University of Wisconsin

The intricate design principles and precision engineering inherent in nature provide an ideal inspiration for engineering applications. Nature can design molecules that bind to one another and form three-dimensional assemblies. Nature also produces cells that can shift their function dynamically, from mature cells with specific functions to stem cells with virtually unlimited potential. Finally, nature can generate tissues and organs that coordinate the behaviors of many cell types simultaneously, resulting in intricately designed tissues and tissue interfaces. Thus, nature's ability to engineer biological systems ranges from simple small molecules to complex multi-cellular tissue structures, and in each level of design there is a marriage of structural design and functional outcome. Nature's unique engineering capabilities have recently led investigators worldwide to develop new bioinspired technologies, including new drugs, biomaterials, biosensors, drug-delivery systems, and engineered tissues. In each case, nature's fundamentals can be mimicked and exploited to achieve new functions.

This session will introduce bioinspired approaches to engineering, and will explore the hierarchy of bioinspired engineering, extending from molecular-level to tissue-level. The first speaker, Timothy Deming from UCLA, will address principles of molecular assembly, and use of these principles to assemble synthetic materials. Intermolecular interactions inspired by nature can be used to synthesize materials that are useful in biomedical applications such as drug delivery and tissue engineering. The second speaker, Fanyi Zeng, will describe molecular "reprogramming" approaches that regulate stem cell behavior. Recent pioneering discoveries from Dr. Zeng and others demonstrate that stem cells can be produced from adult cells, revealing new possibilities in biology and medicine. The third speaker, Jianhua Qin, will describe "lab-on-a-chip" micro-devices that integrate living cells as intelligent components. Cells have a unique ability to sense and respond to signals, and are perhaps ideal components of micro-devices for biosensing applications. The fourth speaker, Helen Lu, will describe tissue engineering approaches that mimic tissue and organ development processes. Tissues and organs are intricately designed, and interfaces between distinct tissue types are critical to proper function. However, tissue interfaces include multiple types of cells and protein matrices that are extremely challenging to re-create. Dr. Lu's work has demonstrated that mechanical and chemical inputs can influence formation of tissue interfaces, which is an important advance in tissue engineering. Collectively, these presentations will represent a primer on engineering approaches that mimic and exploit biological systems. Furthermore, the diversity of functions demonstrated in biological systems suggests that existing bioinspired engineering approaches represent only the tip of the iceberg.