Tissue Engineering Research

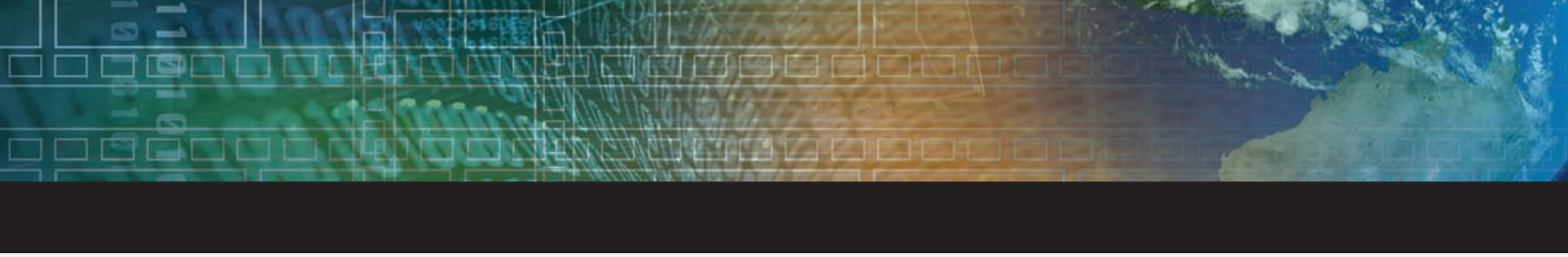
Tissue engineering relies on biomaterials science – the interface between cell biology and engineering applications. Scientists at the University of Maryland's Fischell Department of Bioengineering are developing new muscular-skeletal and bone-joint tissues, among other engineered bio-applications. Tissue engineering uses the remarkable properties of human cells to design and build products for biomedical application. Engineered cellular matrixes can be self-generating, much like living tissue, and many of these materials are compatible with the body's immune system. Some of these engineered tissues biodegrade after the therapeutic goal is achieved. Not only do engineered tissues offer exquisite functional properties, but these neo-synthetics are constructed under simulated physiological conditions. Maryland bioengineers offer a number of clinically-ready applications as well as proof-of-concept material prototypes.

Biophysical Understanding of Cell and Protein Behavior

The Cell Biophysics Laboratory studies how molecules move across cellular membranes. Understanding the conditions of cellular transport is key to understanding communication at the protein-messenger level. J. Helim Aranda-Espinoza, director of the Laboratory, examines the biophysics of pores and vesicles in human cells. Proteins and other molecules either squeeze or bootstrap themselves across cell membrane layers. Knowing how the pores (holes) and vesicles (sacks) facilitate transport in natural and engineered tissues is key to understanding cell–to-cell communication. Such cell structure-specific analysis provides a model for artificial tissue generation. Cell-focused structural research helps bioengineers develop materials that do not set off an immune cascade of rejection responses. Aranda-Espinoza looks also at the flexibility of cell components under changing conditions. For example, he identified a relationship between decreased concentration of cholesterol and reduced flexibility in heart aortic tissues. Aranda-Espinoza's work helps fine-tune therapies for heart disease.

http://terpconnect.umd.edu/~helim/

The Molecular Mechanics Laboratory focuses on protein structure and motion. Director Joonil Seog studies the biophysics of proteins. By measuring very small forces, Seog can "see" the molecular origin of macroscopic behavior. When muscle tissue is examined through atomic force microscopy, Seog can "see" that the giant muscle protein titin provides passive elasticity during muscle stretching. Such ultra small-scale analysis reveals the structure-function relationship of biological molecules. Seog's work on protein biophysics is a basis for deeper understanding of protein agglutination diseases ranging from the deformed red blood corpuscles in sickle-sell anemia to the placqueing of proteins that characterize Alzheimer's disease. Seog also works on cartilage proteins by exposing them to micro-stresses. This research yields biophysical detail important in designing the next generation of knee and hip replacements.



The Biomechanics of Bones and Spinal Discs for Orthopedic Intervention

The Tissues Engineering and Biomaterials Laboratory works on fabricating bone and joint-compatible tissues. These tissue innovations can help clinicians treat traumatic bone injuries, as well as osteoarthritic and inflammatory joint diseases. Traditional bone repair techniques are crude, relying on metal pins and screws. But John Fisher is using stem cells in the regeneration of delicate facial bones. This regeneration work depends on Fisher's ability to build artificial bone matrices that function seamlessly with natural bone tissue and has resulted in artificial bone grafts with function and aesthetics far superior to current orthopedic repairs. In related work, Fisher is refining a novel cyclic acetal biomaterial that will be applied in delicate cleft lip and cleft palate repairs

http://www.bioe.umd.edu/~jpfisher

The Orthopaedic Mechanobiology Laboratory explores the role of mechanical stress in modulating biological response of musculoskeletal tissues. Adam Hsieh, director, studies the biomechanics of vertebral discs in the spine. Understanding the complex fluid and tissue matrices of these cushions suggests novel, low-invasive therapies for back problems. For example, Hsieh investigates the effect that load – weight as a stressor – has on protein structures within vertebral discs. Injection therapies based on the ideal "protein-pudding" of resilient vertebral discs are often more effective than traditional and invasive disc-lamination surgery. Hsieh is also studying the RNA of collagen proteins to better understand the signaling of the degenerative process. One additional investigation area for Hsieh concerns how stem cell treatments might interact at a cellular level with spinal disc proteins.

http://www.bioe.umd.edu/orthomechlab/

The Neuromuscular Bioengineering Laboratory studies the electrical and chemical transport systems of neurons and the associated skeletal-muscle filaments. Sameer Shah studies neuron signaling mechanisms to better understand early signs of degenerative nerve and muscle diseases. Neurodegenerative diseases often show early sub-clinical signs of breakdown in neuronal transport. These diseases include Alzheimer's, Huntington's, Parkinson's, and prion (mad-cow) diseases, as well as motor neuron diseases such as Lou Gehrig's disease. Regenerating nerve tissue remains elusive, yet Shah's biophysical approach to neuromuscular cells and transport reveals both design and disease process in these complex sensory systems. Shah developed a traffic particle software package used widely by neuromuscular scientists. By thinking of electrical impulses as particles, researchers can locate discrete nerve dysfunction. The traffic model of nerve transport helps clinicians develop diagnostic tools to detect transport breakdowns early.

http://www.bioe.umd.edu/~sameer