Cell and tissue engineering includes the study of cellular mechanics and cell signaling, mechanotransduction, biosystems engineering and computational biology, nanotechnology, microfluidics, bioMEMS and gene chips, functional tissue engineering and biomaterials, tissue structure-function and cell-matrix interactions.

The Musculoskeletal Biomechanics Laboratory (MBL)

The **Musculoskeletal Biomechanics Laboratory** (MBL), directed by **Prof. Gerard Ateshian**, focuses on the biomechanics and biotribology of articular cartilage in human joints. In particular, this laboratory investigates the remarkable mechanical and frictional properties of articular cartilage through a combination of theoretical and experimental analyses. The MBL has resolved long-standing questions into how cartilage can maintain very low friction as the bones of our joints articulate, leading to the development of engineered cartilage using live cartilage cells and newly developed bioreactors.

The Biomaterials and Interface Tissue Engineering Laboratory

The Biomaterials and Interface Tissue Engineering Laboratory, directed by **Prof. Helen Lu**, develops functional grafts that direct cellular responses, regulate the formation and integration of multiple and stratified tissue types, and maintain long-term functionality when introduced into the body. We hope to achieve these goals by elucidating the fundamental mechanisms that govern cell-biomaterial and cell-cell interactions and apply these in advanced scaffold designs that are tailored to function at the interface of multiple tissues.

The Bone Bioengineering Laboratory (BBL)

The Bone Bioengineering Laboratory (BBL), directed by **Prof. Ed Guo**, focuses on major areas in bone biomechanics and bioengineering, including cellular/molecular mechanisms of trabecular bone response to mechanical and hormonal stimulation, micromechanics of cortical bone, and intervetebral disc response to mechanical loads. Additionally BBL is developing 3D image analysis and recognition of trabecular bone microstructure and 3D bone cell culture systems.

Cellular Engineering Laboratory

The **Cellular Engineering Laboratory**, directed by **Prof. Clark Hung**, pursues basic science research on the regulation of cells and tissues physical effects, including cell deformation, fluid flow effects, osmotic pressure. These studies foster strategies in applying physical forces to tissue substitutes, restoring normal tissue structure-function in orthopedic (e.g., articular cartilage) and other load-bearing tissues of the body. The laboratory contributes to the development of strategies that alleviate the most prevalent and chronic problems afflicting the musculoskeletal system such as osteoarthritis, and problems related to sports and occupational injuries.

Microscale Biocomplexity Laboratory

The **Microscale Biocomplexity Laboratory**, directed by **Prof. Lance Kam**, combines micro- and nano-fabrication, molecular biology, and advanced microscopy to understand how the distribution and dynamics of molecules in the extracellular environment drives cellular function. These efforts cover a range of systems, including neural, immune, and epithelial tissues, with applications from brain circuitry to new biomaterials that provide enhanced control over cell response.

Molecular and Microscale Bioengineering Laboratory

The **Molecular and Microscale Bioengineering Laboratory**, directed by **Prof. Samuel Sia**, develops new tools to study multiple cells types and their extracellular environments in 2D and 3D (including the growth of blood vessels). In particular, microtechnology techniques are used to position the cells, and molecular design to tune the cellular interactions with their surroundings. In addition, we are developing MEMS devices for global health, which have the potential to revolutionize public health by allowing complicated medical testing procedures to be performed on a small microfluidic chip. We are developing new lab-on-a-chip diagnostic devices specifically for use in resource-poor settings such as developing countries (such as those in sub-Saharan African and southeast Asia) overcoming challenges that include cost, ease of use use, and portability.

Neurotrauma and Repair Laboratory

The **Neurotrauma and Repair Laboratory**, directed by **Prof. Barclay Morrison**, has a single overarching goal: to reduce the societal costs of traumatic brain injury (TBI), which affects 1.5 million new patients annually at a cost of $69 billion. This laboratory established the first macro-array description of in vitro post-traumatic genomic alterations and correlation of those changes with mechanical injury parameters and developed an organotypic brain slice system for investigating injury biomechanics. Activities include development of stretchable microelectrode arrays for more stable neural prosthesis interfaces, vertically aligned carbon nanofiber electrophysiology arrays, and novel delivery technologies for crossing the blood brain barrier.

Stem Cells and Functional Tissue Laboratory

The **Laboratory for Stem Cells and Functional Tissue Engineering**, directed by **Prof. Gordana Vunjak-Novakovic**, is well-known for tissue engineering of functional human grafts using stem cells in conjunction with biomaterial scaffolds custom-designed to mimic the native tissue matrix and advanced bioreactors. The cells are employed as actual “architects” of the tissue, the scaffold serves as a template for tissue formation, and the bioreactor provides a controlled environment for functional tissue assembly. A “biomimetic” approach to tissue engineering is pursued, where the design of scaffolds and bioreactors are inspired by the native developmental milieu, in order to direct the cells to differentiate into the right phenotype and form the right tissues.

Synthetic Biological Systems Laboratory

The Synthetic Biological Systems Laboratory, directed by **Prof. Tal Danino**, focuses on the areas of synthetic biology, programming bacteria for cancer, and quantitative and systems biology. The lab aims to understand the underlying design principles of gene networks and use them to build applications that shape the environment, energy, and human health.

Nanotherapeutics and Stem Cell Engineering Laboratory

The Nanotherapeutics and Stem Cell Engineering Laboratory, led by **Prof. Kam Leong**, focuses on understanding and exploiting the interactions of cells with nanostructures for therapeutic applications. Discrete nanostructures in the form of multi-functional nanoparticles are applied to deliver drugs, antigen, protein, siRNA, and DNA to cells for drug, gene, and immunotherapy. Continuous nanostructures in the form of electrospun nanofiber and imprinted nanopattern are applied to influence cellular behavior, particularly human embryonic and adult stem cells.

The image at the top of the page is from the "Colonies: Living Cells as Art" series, a collaboration between Columbia's Synthetic Biological Systems Laboratory, with artist Vik Muniz.

Vik is well-known for creating art out of unusual materials at exploring scale, with one of his projects documented in the academy-award nominated film Waste Land. For this collaboration, we developed techniques to pattern really small and intricate patterns out of living, biological materials like bacteria and cells. These images were photographed on a microscope and made into wall-sized prints.