## Primary Laboratories and Facilities

There are currently nine Biomedical Engineering research laboratories at City College. These CCNY facilities are amplified by the extensive laboratories at our hospital partners where many of our students do experimental research.

### Cardiovascular Dynamics and Biomolecular Transport Laboratory (Prof. Tarbell)

The Wallace Coulter Laboratory for Cardiovascular Dynamics and Biomolecular Transport studies the role of fluid mechanics and transport processes in the physiological and pathophysiological functions of the cardiovascular system. One of our major efforts is to understand the influence of fluid dynamics in the initiation and progression of atherosclerosis, a degenerative disease of the large human arteries which leads to heart attacks and strokes. We are investigating the fluid mechanics of arteries and the response of arterial cells (endothelial and smooth muscle cells) to fluid mechanical forces using cell culture models in vitro and computer simulations. We were the first group to compute the fluid flow shear stresses on smooth muscle cells (SMC's) induced by transmural flow and have subsequently exposed cultured SMC's to similar stress environments in defined flow fields to determine their biomolecular responses. In complementary research, we have pioneered in vitro studies of convection and diffusion of macromolecules across monolayers of endothelial cells which form the blood contacting surface of all blood vessels. We were the first group to clearly demonstrate that the transport properties of the endothelial layer are very sensitive to their fluid mechanical environment and will respond to changes in fluid shear stress. Studies of the biomolecular mechanisms underlying these responses are in progress.

### Microcirculation Laboratory (Prof. Fu)

In the microcirculation laboratory we perform in vivo permeability measurements on intact single microvessels to investigate the mechanisms of microvessel permeability related diseases such as tumor metastasis, thrombosis, strokes, brain injuries and Alzheimer's disease. We use cutting-edge fluorescence image techniques such as in vivo intracellular calcium concentration imaging to explore signal transduction events. We use quantitative fluorescence video, confocal and photometer microscopy to measure microvessel permeability and cell migration rate change caused by mechanical, physical and chemical stimuli. Information obtained from the experiments serves to develop and test mathematical models of microvascular transport based on fundamental principles of biomechanics, in order to advance basic understanding of the role of the microcirculation in maintaining life. The analysis forms the basis to understand various diseases from a cellular and molecular point of view. It also provides information to design new drugs and drug delivery methods.

Microfluidic Devices Laboratory (Prof. Vazquez)

Our laboratory develops microfluidic devices and nanotechnology that enable measurement, analysis, and imaging of both macromolecules and live cells. Our microdevices are fabricated on site using microcontact printing, which utilizes equipment such as a reactive ion etcher, spin coater, sputtering machine, and high power density UV light. We have utilized these microfluidic devices to facilitate in vitro studies of chemotactic cellular activity in collaboration with physicians and researchers from the Hospital for Special Surgery. In addition, our laboratory has adapted these devices to investigate the mechanics of chemotactic migration of oncogenic cells in collaboration with clinicians and researchers at Memorial Sloan Kettering Cancer center. Both investigations utilize nanotechnology to label receptor tyrosine kinase signaling during cellular chemotaxis, adhesion, proliferation, and phenotypic changes. Our nanotechnology incorporates Quantum Dot bioconjugates that are surface functionalized and characterized on site using confocal microscopy, atomic force microscopy, and static light scattering. Our research laboratory has also begun investigation of Quantum Dot delivery into live cells using virosomes, which utilize the electron microscopy facility at the for Structural Biology on campus.

Biosensors and Biomaterials Laboratory (Prof. Gilcrhist)

This laboratory is focused on the design of novel biomaterials and biosensors from molecules of cellular origin. These molecules include nanostructured self-assembling proteins, membrane protein receptors, and thermostable phospholipids. In most cases the molecules are obtained from cell culture in a lab-scale bioreactor. Molecular engineering and bioconjugate chemistry approaches are applied to alter the properties of the parent molecules purified from cells. In some cases we are building in spectroscopic reporter groups so that the design process is both guided and monitored using biomolecular spectroscopy and surface analysis techniques. The main instrumentations in use in the laboratory are a bioreactor for cell culture and a time-resolved fluorescence microspectrometer for biomaterial imaging and spectroscopy. The lab is also fully equipped for protein purification, with an HPLC/FPLC setup and prep-scale 2D electrophoresis.

Neural Engineering: Applied bioelectricity, neurophysiology, and medical devices (Prof. Bikson)

Neural engineering includes the application of engineering principles to solve fundamental problems in neuroscience and to produce practical solutions to human neurological problems. The aims of this laboratory include: 1) establishing the mechanisms by which weak (e.g. power line, mobile phone) and strong (electrical prosthesis, deep brain stimulation) electric fields modulate brain function; 2) elucidating the neuronal network dynamics, including non-synaptic mechanisms, facilitating emergent physiological (“gamma”/cognition) and pathological (epilepsy) network oscillations; 3) rapid-prototyping and validation of innovative therapeutic and diagnostic technologies. The Neurophysiology laboratory is equipped with state-of-the-art electrophysiology/microscopy equipment which allows the monitoring of bioelectrical activity generated by populations of neurons and by single visualized neurons. The lab also employs shared resources of the Neural Engineering Group (Bikson, Parra, Kelly) for whole-brain electrophysiology (EEG), eye tracking, electrical circuit design and high-end computing resources.

Neural Engineering: Signals and Computation (Prof. Parra)

Current experimental techniques focus on interpreting and modulating brain activity in humans non-invasively using electro-encephalography and trans-cranial electrical stimulation, or in short, "reading" and "writing" the brain with electric fields. The work is often coupled with auditory and visual psychophysics and always incorporates computational or mathematical models, or in short, "modeling" the brain. To establish basic cellular mechanism it also relies on in-vitro electrophysiology. For the work with human subjects the laboratory has a sound-damped electromagnetically shielded room, a portable 128-channel system and eye tracker with drivers for real-time analysis and closed-loop stimulation and adaptive displays. Research grade audio equipment is available to perform auditory perception experiments. Our custom equipment for trans-cranial electric stimulation (AC and DC) with simultaneous EEG recording is unique inthe world. In addition to data collection the laboratory performs data analysis of brain signals and images as well as computational modeling of spiking networks using a variety of computational tools. The lab leverages shared resources of the Neural Engineering Group (Bikson, Parra, Kelly) for electrophysiology on the single-neuron, population and whole-brain levels, microscopy, eye tracking, electrical circuit design and high-end computing resources with modeling software.

Neural Engineering: Systems and Behavior (Prof. Kelly)

Our research is focused on measuring and characterizing perceptual and cognitive brain signals that relate to behavior. Through paradigm innovation and signal processing, we strive to link non-invasively recorded electrical brain signals (EEG) in humans to specific neural computations involved in perception, attention and decision-making. We deploy our paradigms and dependent measures to studies of neurological and psychiatric disorders through several active clinical collaborations. The Neural Systems Lab is equipped with an acoustically and electromagnetically shielded room, high-resolution eye tracking and a high-density active-electrode system for electroencephalography (EEG). The lab also has access to shared resources of the Neural Engineering Group (Bikson, Parra, Kelly) for electrophysiology on the single-neuron, population and whole brain levels, microscopy, electrical circuit design and high-end computing resources with modeling software.

Tissue Mechanics Laboratory (Prof. Fritton)

The focus of the Tissue Mechanics Laboratory is to understand the adaptive response of bone to altered mechanical loading, including bone's mechanosensory system. A major focus of the lab is to investigate fluid flow in bone as a possible mechanism of mechanical signal transduction. The facility is also used to study the microstructure of bone tissue and relate it to the gross structure, material properties, and behavior of whole bones. Equipment in the laboratory includes a MTS Mini-Bionix servohydraulic materials testing system along with high-end PCs used for image analysis and finite element modeling.

Laboratory of Multiscale Biomechanics and Functional Imaging (Prof. Cardoso)

The Laboratory of Multiscale Biomechanics and Functional Imaging aims to integrate biomechanics, bioinstrumentation, signal and image processing to study health disorders in the osteoarticular and cardiovascular fields. Our laboratory is involved in developing experimental, theoretical and numerical multiscale approaches to determine the biomechanical and functional competence of living tissues before and after their degeneration occurs (i.e., bone fragility, osteoarthritis and rupture of thin caps on atherosclerotic blood vessels). To integrate these interdisciplinary goals, our laboratory is equipped with a new Phased Array Ultrasound System, electronics and machine shop, computational infrastructure for three-dimensional imaging processing and Finite Element Modeling, and a wet lab for basic histology processing. Furthermore we are developing an Acoustic Microscope and a small animal facility that will include an operating room, anesthesia machine and a PC-controlled Continue Passive Motion device.

Laboratory of Microfluidic HTS Technology and Tissue Engineering (Prof. Wang)

One focus of this laboratory is directed at the development of microfluidic cell arrays to study sigaling pathways, such as apoptosis and inflammation, for the high throughput screening (HTS) of drugs using current discoveries in biomedical sciences and advanced technologies in BioMEMS. The long term collaboration with Memorial Sloan Kettering Cancer Institute facilitates the development of microfluidic 3D cell arrays for HTS. Another focus of the lab is to investigate thermal effects on 3D tissue regeneration in synthetic extracellular matrices using stem cells and explore the role of heat shock proteins in the tissue development, injury protection and repair. Bone marrow mesenchymal stem cell isolation and characterization are routinely performed in the lab. Currently we are focused on bone and cartilage regeneration.