University of Pittsburgh | Swanson School of Engineering

SUMMARY OF BIOENGINEERING FACULTY RESEARCH 2021

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Bioengineering

Research Laboratories

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Steven Abramowitch, PhD

Associate Professor, *Musculoskeletal Research Center*
Associate Professor, *Department of Obstetrics, Gynecology and Reproductive Sciences*

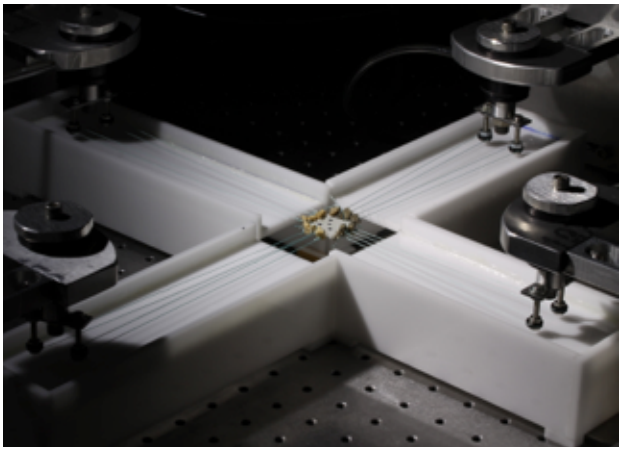
Tissue Mechanics Laboratory

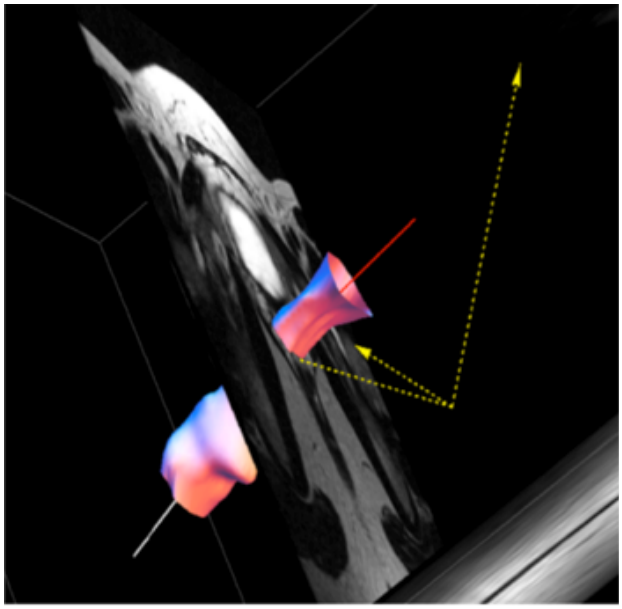
Dr. Steven Abramowitch is the Director of the Tissue Mechanics Laboratory (TML), which is located in the Musculoskeletal Research Center (MSRC) where he serves as Associate Director. Dr. Abramowitch's expertise is in the areas of female pelvic floor biomechanics and orthopedic biomechanics, and more specifically, the structural and functional mechanics of soft tissues in these systems.

Currently, the research focus of the TML is on the impact of pregnancy, delivery, and other life changing events (aging, menopause, etc.) on the structural integrity of the pelvic floor, in women. In addition, the lab aims to understand how changes in the structural integrity of the pelvic floor contributes to the pathogenesis of pelvic organ prolapse (POP), and if current clinical treatments and diagnostic measures for this disorder are effectively addressing the underlying pelvic floor abnormalities. Thus, the ultimate goals of these research efforts are to develop preventative treatment options for POP, and more effective, patient specific treatments.

The TML is equipped with experimental testing systems that measure the structural and mechanical properties of soft tissues and biomaterials in response to both quasi-static and dynamic loading conditions, including uniaxial and multi-axial tension, compression and shear. Computational mechanical analyses in the TML are based on custom codes for 3D image segmentation, reconstruction, and analysis of patient specific geometries obtained via various medical imaging modalities (MRI, CT, ultrasound, etc.). These data along with those from mechanical testing serve as inputs for finite element analyses (FEA).

These techniques are used to 1) rigorously characterize normal, healing, and diseased soft connective tissues, 2) to develop robust models that describe tissue function, and 3) to teach students and clinical fellows to conduct proper mechanical testing experiments and analysis.





Selected Referenced Journal Articles

1. Feola, A.J., Moalli, P.M., Alperin, M., Duerr, R., Gandley, R.E., Abramowitch, S.D. Impact of Pregnancy and Vaginal Delivery on the Passive and Active Mechanics of the Rat Vagina. Annals of Biomedical Engineering, 39(1), 549-58, 2010.
2. Abramowitch, S., Zhang, X., Curran, M., Kilger, R.: A Comparison of the Quasi-state Mechanical and Nonlinear Viscoelastic Properties of the Human Semitendinosus and Gracilis Tendons. Clinical Biomechanics, 25(4), pp. 325-31, 2010.
3. Abramowitch, S.D., Feola, A., Jallah, Z., Moalli, P.A.: Tissue mechanics, animal models, and pelvic organ prolapse: A review (Review Article). European Journal of Obstetrics Gynecology and Reproductive Biology, Volume 144, Supplement 1, pp. S146-S158, 2009.

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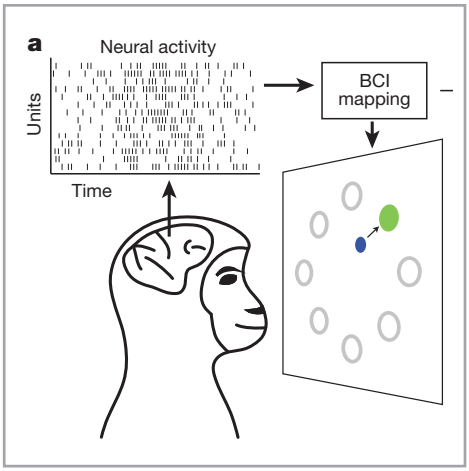
Sensory-Motor Integration Laboratory and Engineering

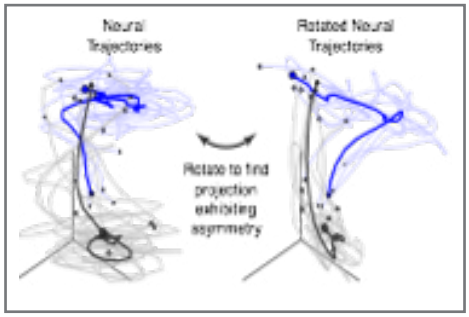
Dr. Aaron Batista's research group examines the neural control of visually-guided action. We seek to understand basic principles that underlie the function of the cerebral cortex, and to use those discoveries to improve the function of clinical brain-computer interface (BCI) systems as a treatment for paralysis. Here we describe two of the research endeavors taking place within the laboratory.



Neural constraints on learning

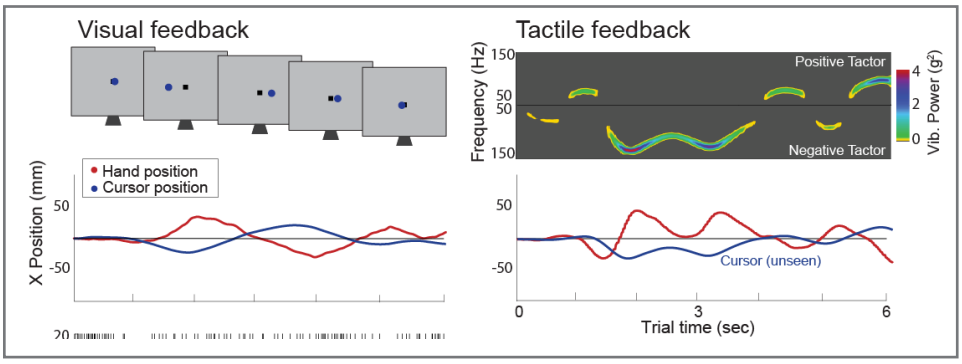
Why are some new skills learned relatively quickly, while others take far longer? What changes in the brain when we learn, so that pre-existing abilities are retained even as we learn new skills? We are examining the neural underpinnings of learning using a novel paradigm, brain-computer interface control, which allows us to study the neural basis of learning more directly than is possible with arm movements. We can directly request of our animals that they generate specific patterns of neural activity across a population of 100 or so neurons. We can then observe whether the animals are capable of generating the patterns we requested. Mathematical tools drawn from machine learning enable us to predict which new neural activity patterns (and, corresponding skills) are relatively easy to learn (a day or so), and which will be more difficult (a week or two), just by examining the pre-existing patterns of neural activity prior to learning.

This work is pursued along with colleagues Byron Yu and Steve Chase of Carnegie Mellon University. It is currently supported by an NIH R01 grant from the National Institute of Child Health and Human Development.



Multisensory Integration in Action

Our actions are shaped by our perceptual experience. Consider the fine adjustments a violinist makes to play the correct pitch. Sensory experience is often multimodal: we see, hear, and feel the thing with which we are interacting, and our movements are adjusted on-the-fly to achieve our objectives. We seek to understand how the brain uses sensory information to guide action, we train animals to perform challenging balancing tasks in a virtual environment. We record from motor and sensory areas, in the hope of discovering how the areas communicate to send detailed sensory information to sculpt the activity of motor neurons.



This work is pursued along with my Pitt Bioengineering colleague Pat Loughlin. It is supported by an NIH R01 grant from the National Institute of Child Health and Human Development.

Kurt E. Beschorner, PhD

Associate Professor, *Human Movement and Balance Lab*

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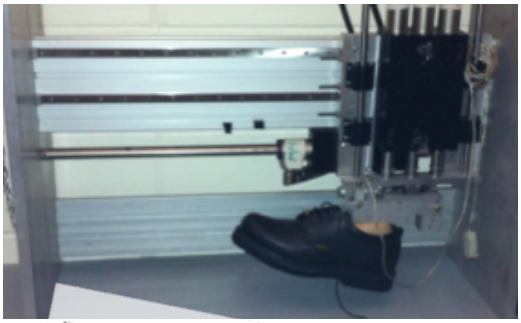
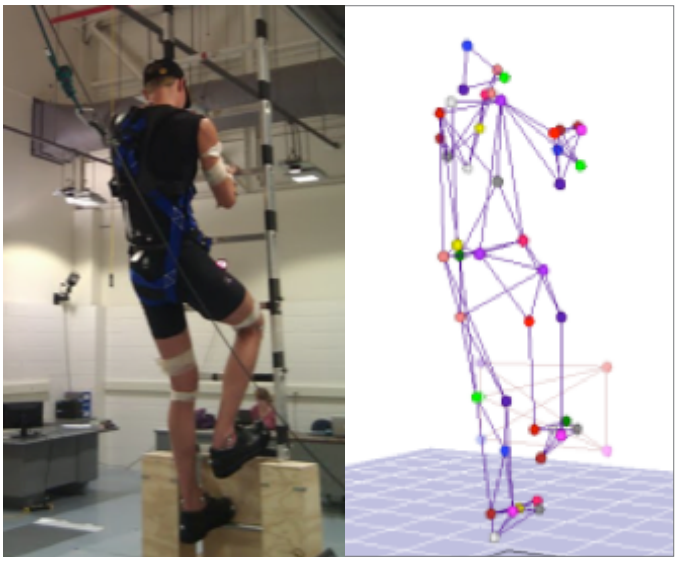
Research Mission: Dr. Beschorner's research focuses on the development of ergonomic solutions for preventing falling accidents through the utilization of core competencies in biomechanics and tribology. Dr. Beschorner's current research topics include 1) developing and applying innovative methods to model and assess the tribological interaction between shoe and floor surfaces in order to prevent slips and falls; 2) identify the personal and environmental factors that contribute to falls from ladders and develop strategies to reduce these falls; and 3) assessing the negative effects of multifocal lens glasses (bifocals/progressive lens glasses) on walking balance and identifying solutions that improve balance in this population. Dr. Beschorner's research has been funded by the National Institute of Occupational Safety and Health, Department of Labor and the National Institutes of Health.

Background: Dr. Beschorner received his BS in Mechanical Engineering from University of Illinois Urbana-Champaign and his PhD in Bioengineering from University of Pittsburgh. He also spent four years as an Assistant Professor of Industrial Engineering at the University of Wisconsin-Milwaukee where he founded and directed the Gait Analysis & Biodynamics Lab and the Human Tribology Lab.

Tribology of Slip and Fall Accidents

Slip and fall accidents are among the leading causes of injuries in the workplace and for older adults. The slipperiness of the shoe-floor interface is a major modifiable contributor to slip events. Dr. Beschorner's research focuses on the development of new experimental (right, top figure) and modeling techniques that guide interventions and improve our understanding about the tribological causes of slipping accidents. This research has led to the development of an under-shoe fluid pressure paradigm for mapping the fluid-drainage capability across shoe tread (right, bottom figure) and finite element modeling approaches that predict friction based on material properties and surface properties. Dr. Beschorner currently works with industry partners to enhance workplace safety through training, footwear programs, and workplace design.





Biomechanics of Fall Accidents

The biomechanical response to balance perturbations is dependent on a complex interaction between personal and environmental factors. Dr. Beschorner's research aims to characterize this complex interaction by measuring the biomechanical response to high fall risk scenarios in a safe, controlled laboratory environment. This approach is being applied to examine the impacts of ladder design and climbing style on fall risk (left figure) and to understand the personal and environmental factors that influence the fall risk and functional balance of wearers of bifocals and progressive lens glasses.

Harvey Borovetz, PhD

Distinguished Professor of Bioengineering
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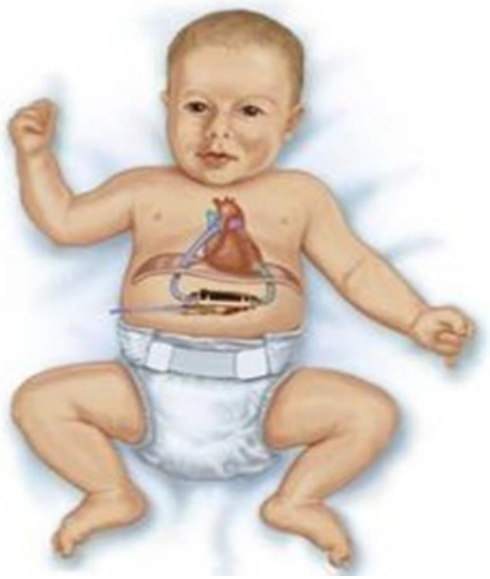
The PediaFlow® Pediatric Ventricular Assist Device (VAD)

PediaFlow R&D



With the support of two NHLBI contract awards, our consortium has developed mixed-flow turbodynamic (continuous flow) pediatric ventricular assist devices (VAD) utilizing a magnetically levitated impeller capable of producing 0.3-1.5 liters per minute (LPM) of blood flow for supporting infants and small children weighing 3-15 kg for up to six months duration. A particular focus of our work has been on achieving exceptional biocompatibility of our prototypes through state-of-the art CFD design of the blood flow path. The goal of our program is to operate our pediatric VAD clinically with minimal anticoagulation requirement and optimal biocompatibility.

Over 20 design variations were initially considered, with three pump topologies selected for further design refinement and evaluation. The three designs, two centrifugal and one mixed-flow pumps, were judged based on a multi-component objective function which factored several criteria including anatomic fit, estimated biocompatibility, heat generation and transfer, magnetically levitated suspension robustness, and manufacturability. This evaluation led to selection of the mixed-flow configuration.

The design was improved using computational fluid dynamics to minimize flow-induced blood damage via modification of the geometry of the predicted blood flow path. The housing was modified to improve surgical fixation. A transparent replica of the blood flow path was built to perform validation of the computer predictions by flow visualization analyses.

Other ongoing efforts were focused on controller development, materials selection, biocompatible coating application, nanotechnology based infection control, cannula design, and overall assessment of hemodynamic performance and cellular biocompatibility.

Pre-clinical testing of the current PediaFlow prototype ventricular assist device (the smallest mag lev blood pump to date, the size of an AA cell battery) was performed in vitro and in vivo. Our most recent 60-day implant demonstrated very low levels of both hemolysis and platelet activation. No thrombi were noted on explant, further validating the excellent biocompatibility of the PediaFlow pediatric VAD in anticipation of eventual clinical trial testing.

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Bryan N. Brown, PhD

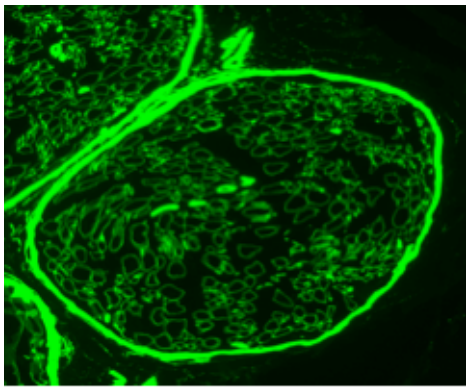
Associate Professor

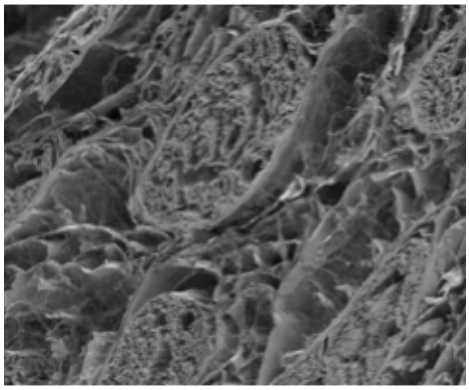
Brown Laboratory

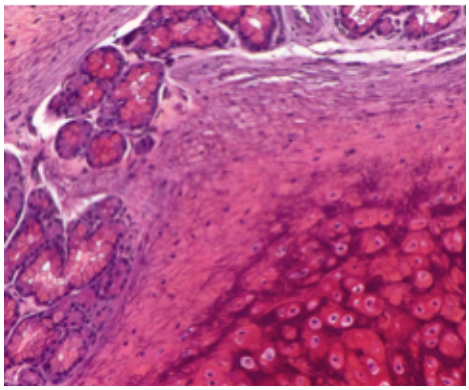
The Brown Laboratory is an interdisciplinary team housed within the McGowan Institute for Regenerative Medicine. The overarching mission of the Brown Laboratory is to couple a mechanistic understanding of the host inflammatory response in injury and disease with the development of context-dependent biomaterial-based strategies for tissue engineering and regenerative medicine. The focus of our current research is upon clinical applications where few effective solutions currently exist, with increasing emphasis upon unmet clinical needs in women's health.

Our laboratory is highly collaborative within the University of Pittsburgh, the University of Pittsburgh Medical Center, the McGowan Institute for Regenerative Medicine as well as a number of outside collaborations spanning basic science, engineering, medical and veterinary disciplines. Most of the ongoing projects within the Brown Laboratory combine basic science and immunology with engineering concepts towards the design, evaluation, and implementation of biomaterials in tissue engineering and regenerative medicine applications.

Under the direction of Dr. Bryan Brown consists of approximately eight undergraduate students, six graduate students, two postdoctoral associates, a laboratory technician, and administrative staff. In addition, it is common to have one or more clinician-surgeons or veterinarian involved with each ongoing project. The capabilities of the Brown Laboratory span a full spectrum of bench-top science and pre-clinical models and we can support first-in-human and clinical studies through collaborations with the University of Pittsburgh Medical Center.







Major Research Interests

- Macrophage Phenotype and Polarization
- Host Response to Biomaterials
- Extracellular Matrix Biomaterials
- Injectable Hydrogels
- Biomaterials Development
- Tissue Engineering
- Regenerative Medicine
- Stem Cells
- Preclinical Disease Models
- Women's Health
- Veterinary Medicine
- Clinical/Commercial Translation

Active Research Projects

- Assessment of the host response following mesh placement in pelvic organ prolapse
- Investigation of macrophage phenotype in pathogenesis of endometriosis
- Macrophage polarization and aging in the context of regenerative medicine
- A regenerative medicine approach to TMJ meniscus restoration
- Development of tissue specific hydrogels for peripheral nerve reconstruction
- Exploratory study of the application of regenerative medicine to the equine airway

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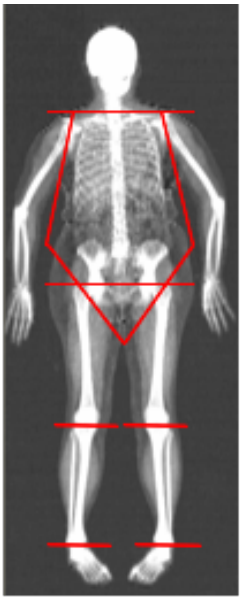
Background and Research Overview

Dr. Cham holds a B.Sc. degree and an M.Sc. degree in Physics from McGill University. Her doctoral training is in Bioengineering from the University of Pittsburgh. Dr. Cham's interests are focused on understanding (1) underlying biomechanical mechanisms of falls, e.g. postural strategies generated in response to slips and trips, and (2) human (e.g. sensory deficits, central nervous impairments) and environmental (e.g. lighting) factors contributing to balance and gait impairments. Her populations of interest include young and older healthy adults, as well as clinical populations such as individuals with autism, neurological conditions and vision-related conditions, e.g. glaucoma, age-related macular degeneration. Dr. Cham's research is supported by the National Institutes of Health (NIH), the National Institute of Occupational Safety and Health (NIOSH), industry and various foundations. Her collaborations with scientists from a very wide range of disciplines at the University of Pittsburgh and across other academic institutions are a key component of her research.

Examples of Ongoing Research Projects

Anthropometry

Body segment parameters (e.g. segment mass, center of mass location) are needed in many applications, including ergonomics and occupational biomechanics. They are also needed in biomechanical models to study joint loading during various tasks, gait and more. In this project, imaging methods are used (1) to assess the impact of body shape, specifically being obese or overweight, on body segment parameters in men and women, and (2) to develop regression models that accurately predict these variables.



Autism

The goal of this project is to determine the reasons for balance and gait impairments in Autism Spectrum Disorders (ASD). We focus on the relationship between these impairments and attention. Experiments involve adults with autism and control subjects standing and walking in challenging environments (dimmed lighting and/or walking on a soft carpet) while performing a secondary task (pushing a button when hearing an auditory stimulus). Findings will enhance our understanding of gross motor impairments and balance difficulties in ASD, both of which may contribute to the development of novel and more effective therapeutic approaches.

Vision Impairments

Visual field losses are a common type of vision impairment found in age-related ocular pathologies such as glaucoma and age-related macular degeneration. Falls are a serious public health concern in adults who have such conditions. One of Dr. Cham's project is to determine the impact of visual field losses on balance and gait. Findings will improve our understanding of the etiology of falls in older adults who have vision problems. Another related project of Dr. Cham and her collaborators is to develop standard methods that evaluate the efficacy and quality of emerging technologies and therapies on patients' lives with vision-related conditions.

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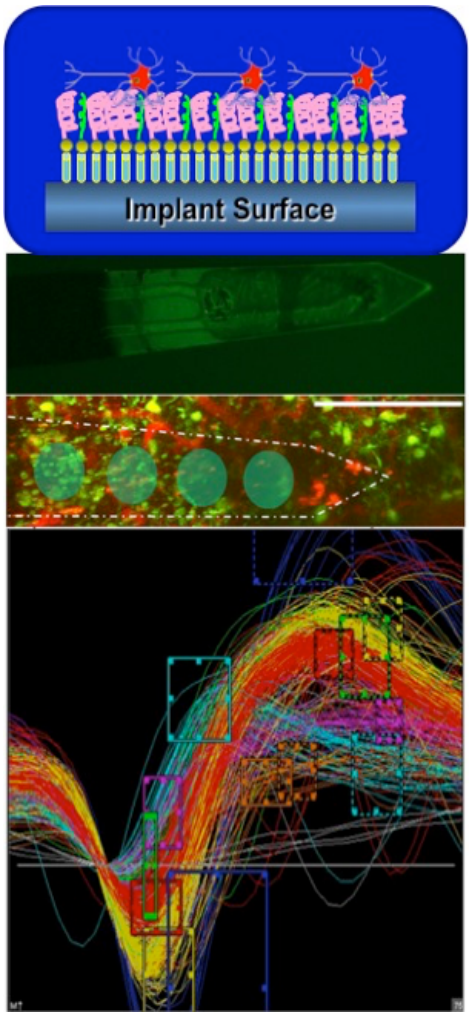
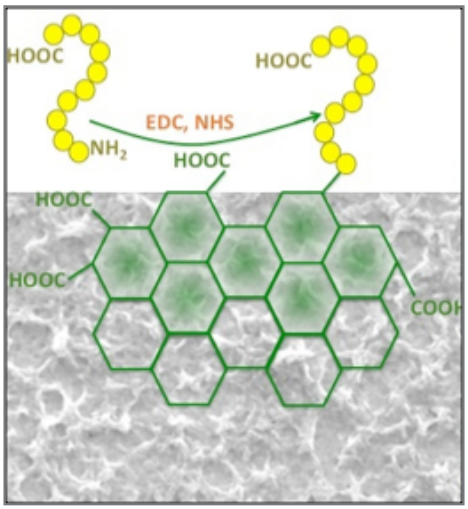
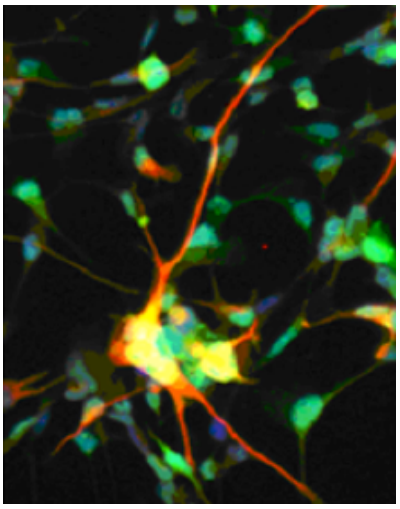


Research Description

Research projects are being conducted in the following areas: (1) Neural Electrode Device / Tissue Interface – Implantable neural electrode arrays elicit inflammatory tissue responses that lead to performance failure. We study the interaction between implanted material and neural tissue and develop multifunctional smart biomaterial to improve the electrode/host tissue interface. Approaches include biomimetic coating, controlled release of soluble drug and growth factors and stem cell seeding. (2) Control of Embryonic and Neural Stem Cell Growth and Differentiation via Surface Characteristics and Electrical Stimulation - Majority of the stem cell studies focus on the effect of soluble factors on stem cell behavior. We are interested in whether surface cues and electrical stimulation can guide the growth and differentiation of stem cells. The findings will provide design ideas for tissue engineering and regenerative medicine on how to direct the stem cell fate for functional integration into the host nervous system. (3) Cultured Neuronal Networks – An in vitro multi-electrode array system is established in the lab to answer neuroscience questions on how neuronal networks communicate or mature. Furthermore, we can build in vitro disease or injury models and use the model to screen therapeutic agents. (4) Neural Chemical Delivery and Sensing. Instead of establishing an electrical interface with host neurons, we are developing micro and nanotechnologies to chemically interface with them via delivery of neurotransmitters and modulators as well as detecting endogenous neurochemicals. These will be great tools for neuroscience research and can potentially be used as neuroprostheses alone or in conjunction with electrical neural interfacing devices.

By surface immobilization of biomolecules on the implant we seek to control the cellular interaction and promote intimate integration of the implant and neural tissue with the ultimate goal of reliable and stable long term neural recording or stimulation.





Expertise and Facilities

The NTE Lab has team with a multidisciplinary expertise ranging from polymer chemistry, electrochemistry, biomaterial and biocompatibility, microfabrication, molecular and cellular neurobiology to neural recording, stimulation and biological imaging. Our facility is equipped with wet lab material synthesis, electrochemical set up, in vitro cell culture, basic histological tissue processing and staining, small animal stereotaxic surgery, optical and fluorescent microscopy as well as electrophysiology.

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Research Interests

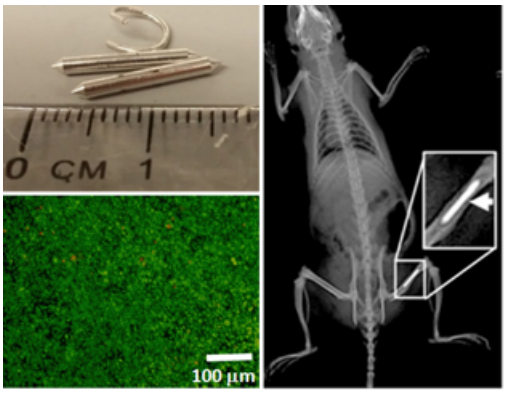
Dr. Datta's current research is focused on two broad areas of biodegradable biomaterials, and energy harvesting and storage. He has a strong solid background in Metallurgical Engineering (PhD), Materials Engineering (MS), as well as Nanotechnology along with a thorough understanding of Physical chemistry and various electrochemistry aspects of solid-state materials. His group mainly conducts fundamental, transformative and innovative biomaterials and energy related research in collaboration with Dr. Kumta, Dr. Roy, Dr. Jampani and Dr. Velikokhatnyi directed at fostering clean energy, regenerative therapies, national security and human welfare. The main focus of Dr. Datta's research in all of these areas is to develop (a) rapid experimental synthesis and processing tools; quantitative analytical and characterization tools; accelerated testing and rapid prototyping; techniques to validate and advance materials theory and (b) computational tools for predictive modeling, exploration, simulation and design.

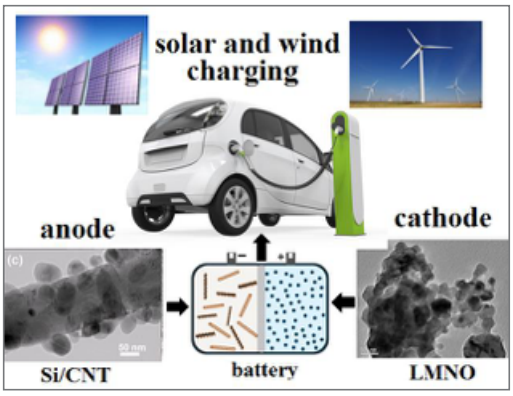
Biodegradable Biomaterials Related Research

In the area of biomaterials, Dr. Datta's group's goal is to create implantable devices and regenerative therapies by merging advances in biology, engineering, and materials sciences. Particularly, he aims to develop materials that will not only be compatible with patients, but can also direct the cellular responses of the patient in a desired manner. In this direction, his research is directed in identifying a novel class of suitable load bearing, non-toxic biocompatible and biodegradable metal alloys aided by density functional theory (DFT) calculations as a hard tissue substitute for orthopedic and craniofacial applications. Processing of near-net shape biocompatible and biodegradable porous 3D scaffolds exhibiting controlled corrosion and mechanical properties mimicking normal bone without eliciting any toxicity while regenerating new bone is under research and development by powder metallurgy (PM) and additive manufacturing (AM) processing techniques. In addition, Dr. Datta's research has directed towards development and optimization of stable organic and inorganic bioactive coatings on implants to decrease the alloys' corrosion rate and hydrogen evolution as well as increase the alloys' surface bioactivity, thus increasing the clinical relevance of biodegradable alloys. Surface functionalized micro- and meso-porous bio-composites is also under study for tunable delivery of biologics and drugs from the regenerative bone scaffolds.

Energy Harvesting and Storage Related Research

The ultimate vision of energy related research is the development of a coherent computational model and concomitant advanced experimental tools enabling rapid screening, development and manufacturing of advanced energy related materials with significant cost benefits. His group focuses on identification of ultra-low noble metal/non-noble metal electrocatalysts for water electrolysis, fuel cell and air battery, and carbon capture through CO_2 conversion to fuel. In the field of electrical energy storage technologies based on rechargeable batteries (Li-ion, Na- ion, Mg- ion batteries), supercapacitor and flow batteries, his research is directed at fulfilling the vision for meeting the *EV* (*electric vehicle*) *everywhere grand challenge and Renewable Energy Storage goal of* DOE. In this direction, his research is focused on rapid synthesis and advanced characterization of next-generation energy related materials in 1D nanotube, nanowire, 2D nono-film, nano-sheet or 3D hierarchical structures consisting of nano-particles or nanocomposite.





Research and development of electricity as electric vehicle fuel

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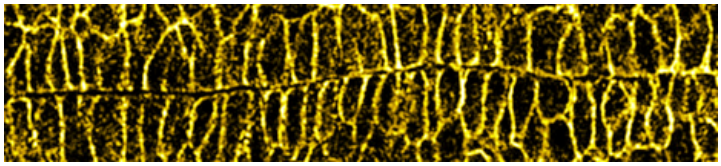
Mechanics of Morphogenesis

Our group has two long-term objectives: (1) to understand the mechanical processes that control morphogenesis, and (2) to apply principles of morphogenesis as a technology to advance cell and tissue engineering. Morphogenesis is the central process of tissue self-assembly that couples physical processes that move cells and tissues with the biological processes that give cells their identity, establish tissue architecture and physiological function. By necessity our research lies at the interface between cell biology, mathematics, physics, and engineering. Projects typicaly involve overlapping expertise that combine cell biological, biophysical, and bioengineering methods.

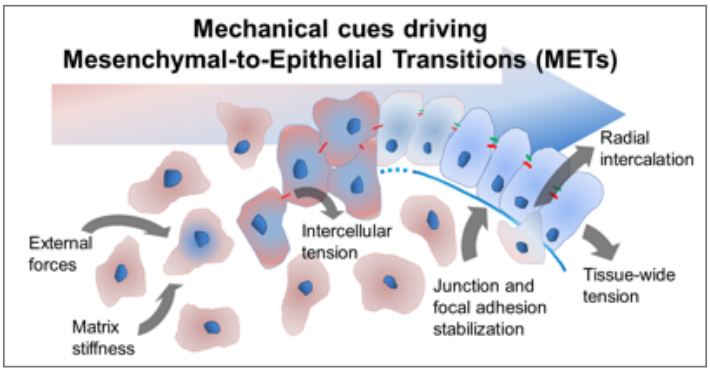
The Biomechanics of Tissue Elongation

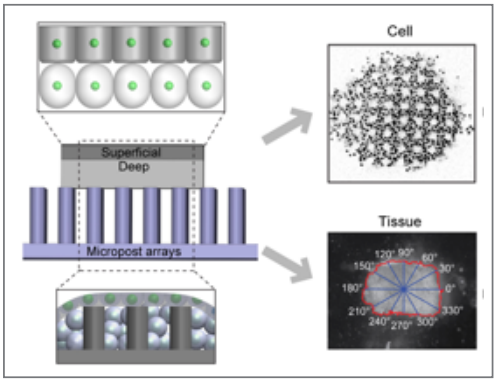
The elongation of the vertebrate body, from head to tail, during early development and the elongation of structures such as long bones during growth are driven by collective cell rearrangement of mesenchymal cells. Our research has uncovered hidden mechanical phenotypes where losses in force production can be compensated by reduced mechanical resistance. Genetic and cell signaling control actomyosin complexes responsible for the mechanics of early embryonic tissues but their spatial organization is regulated by cell geometry and architectural features of the embryo. Our studies in this area require development of micro-scale mechanical testing, high resolution confocal imaging, and theoretical and computational modeling. Discoveries from this project have provided novel insights into integration of genetic and mechanical programs of development and how these systems are robust against the variation in their environment.



Cardiac Progenitors Sense Mechanical Cues as they Assemble the Heart

The heart is assembled from cells that migrate halfway across the early embryo. As these cells migrate they take instruction from their surroundings, either through chemical signaling or through mechanical cues. These cues drive cells to transition from one type to another. Recently, we have found a fundamental transition, that converts cells from a loose mass to a structured sheet, requires cells sense their mechanical environment. An altered environment, leading to delayed or precocious transitions during these early stages, produce commonly seen structural defects analogous to those seen in human congenital heart defects.





Advancing Cell and Tissue Engineering

In these projects we seek to actuate morphogenetic programs within engineered microenvironments to achieve specific end-points. For instance, using 3D microfabricated structures to direct either single cell or collective migration within tissues. We utilize additive and subtractive manufacturing and scaffold-free engineering to enhance 'organs-in-a-dish' and 'organs-on-a-dish' applications. We develop microfluidic tools in order to control the local biochemical microenvironment enabling high spatial and temporal resolution actuation to be combined with rapid non-invasive interrogation by live-cell reporters.

Richard E. Debski, PhD

Professor, *Bioengineering*
Professor, *Orthopaedic Surgery*
Co-Director, *Orthopaedic Robotics Laboratory*
William Kepler Whiteford Faculty Fellow

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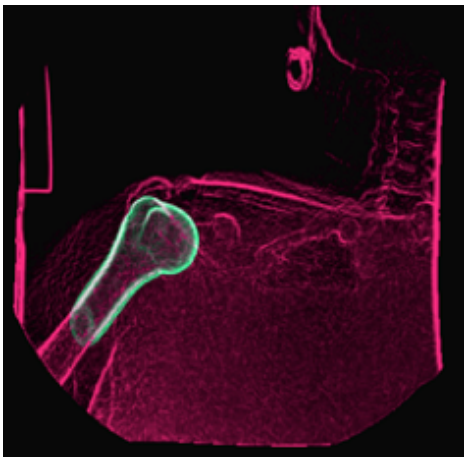
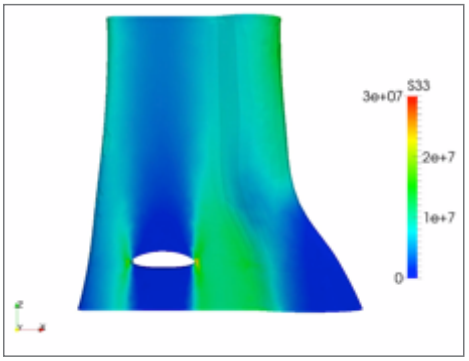
Dr. Debski's Background and Research Interests

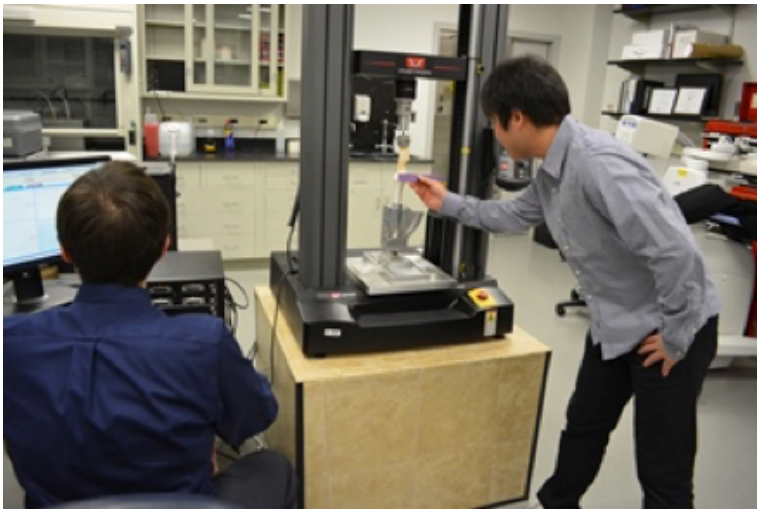


Richard E. Debski, PhD received both his B.S. (1991) and PhD (1997) in Mechanical Engineering from the University of Pittsburgh. Dr. Debski's research interests focus on orthopaedic biomechanics and are aimed at elucidating the contribution of ligaments, tendons, muscles, and bone to joint stability throughout the musculoskeletal system. Specifically, experimental and computational analyses are performed to examine the properties of the ligaments and joint capsules; determine ligament forces and joint kinematics; and evaluate the effect of injuries and repair procedures on joint motion. Novel experimental techniques such as a robotic testing system and Dynamic Shoulder Testing Apparatus rev.4 are utilized to answer research questions. Recent major projects have focused on improvement of diagnoses and repair procedures for injuries to the ligaments, capsules, and bony structures at the shoulder; improvement of rehabilitation for rotator cuff injuries; quantification of knee stability during the pivot shift test; and robotic technology for biomechanical testing.



Orthopaedic Robotics Laboratory

The mission of the Orthopaedic Robotics Laboratory is the prevention of degenerative joint disease by improving diagnostic, repair, and rehabilitation procedures for musculoskeletal injuries using state-of-the-art robotic technology. Thus, diarthrodial joint function will be elucidated and the roles of the bony and soft tissues assessed. The technology in the laboratory includes novel robotic systems and the lab serves as a multi-disciplinary CORE facility with collaboration promoted between investigators. The Orthopaedic Robotics Laboratory is a collaboration between the Department of Orthopaedic Surgery and Department of Bioengineering.



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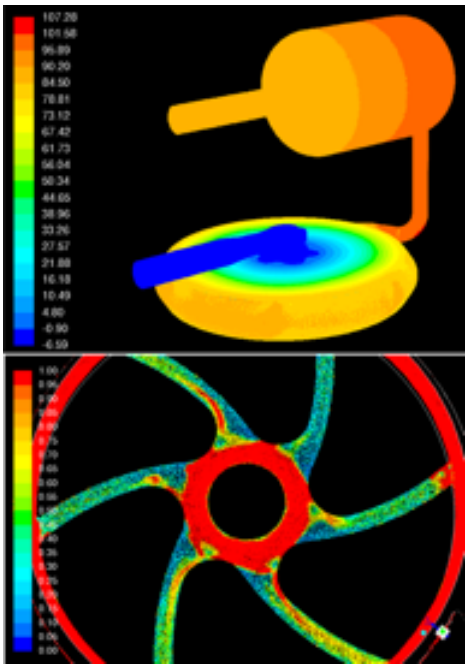
William Federspiel, PhD

William Kepler Whiteford Professor, Professor of Bioengineering, Professor of Critical Care Medicine and Chemical Engineering, Director, *Medical Devices Laboratory*

Under the direction of Dr. William Federspiel, the Medical Devices Laboratory is developing highly translatable medical devices by utilizing bio and chemical engineering principles such as biotransport, mass transfer, and fluid mechanics. Advanced respiratory assist devices for patients with acute and chronic lung injuries are being designed and investigated, in addition to particle-based adsorption technologies for the removal of targeted solutes from whole blood for the treatment of pathogenic reactions. Biotransport modeling, computational fluid dynamics, and in vitro and in vivo testing are employed in the development of these medical devices. The highly collaborative research efforts of the Medical Devices Laboratory combine the expertise and strengths of academic researchers, clinicians, and industrial partners. Translation of research into formal product development and clinical trials is a primary focus of the laboratory so that the technological advancements can benefit those in need.

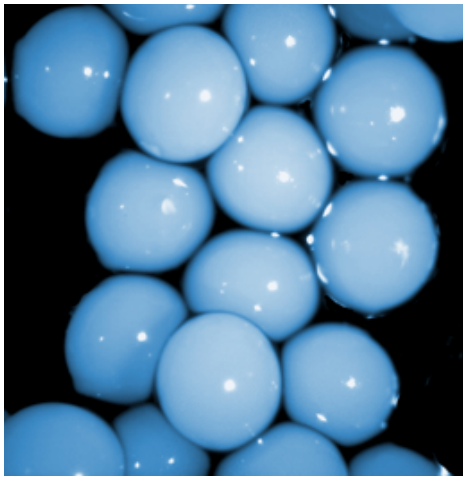
Respiratory Assist Devices

Each year nearly 350,000 Americans die of some form of lung disease. To address the limitations of existing methods of respiratory support, such as mechanical ventilation (MV) and extracorporeal membrane oxygenation (ECMO), the Medical Devices Lab is developing respiratory assist devices that could provide improved treatment. The Modular Extracorporeal Lung (ModEL) integrates a blood pump and highly efficient gas exchanging unit into a wearable device intended to replace ECMO and MV as a bridge to transplant or recovery during lung failure. The modular design enables configuration of the device with different gas-exchanging units depending on the type of support needed, resulting in a respiratory assist platform technology able to treat a variety of adult, and even pediatric, patients. Prior work in this area within the Medical Devices Lab led to the commercialization and market approval of the Hemolung Respiratory Assist System, a product of ALung Technologies. Development of novel bioactive coatings to improve device efficiency and hemocompatibility is also a focus of the Medical Devices Lab. Current efforts focus on the use of zwitterionic copolymers to reduce intra-device thrombus formation and carbonic anhydrase to enhance CO_2 removal efficiency.



Blood Conditioning Devices

Sepsis, a systemic inflammatory response due to an infection, is a major health problem that kills nearly 250,000 Americans each year and costs upwards of $20 billion annually. The Medical Devices Lab is designing novel extracorporeal blood purification devices to reduce organ damage in sepsis. These devices alter leukocyte response by selectively removing excess cytokines from circulation or 'reprogramming' immune cell behavior through cell-cell interactions. These treatments are hypothesized to both improve clearance of infection and reduce injury to remote organs. A device which removes blood antibodies to generate universal donor plasma is also under development. After treatment, the universal plasma can be safely transfused to all patients, regardless of blood type.



Neeraj J. Gandhi, PhD

Professor

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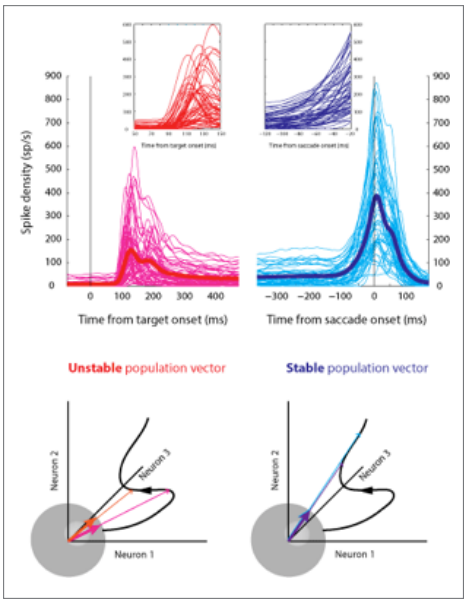
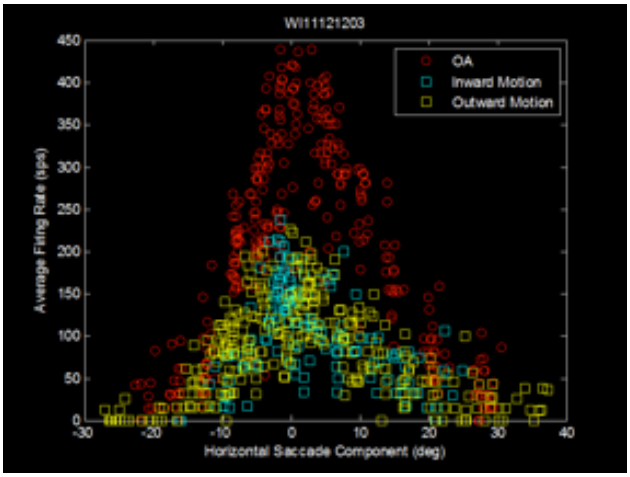
The nervous system continuously monitors the environment and produces overt or covert orienting behavior in response to relevant sensory stimulation. Research in the Cognition and Sensorimotor Integration (CSI) lab investigates neural mechanisms involved in the multiple facets of sensory-to-motor transformations, including cognitive processes. We employ a combination of experimental (extracellular recording, microstimulation, chemical microinjections, transient blink perturbation) and computational tools. An understanding of the cognitive and motoric processes that produce integrated orienting behavior has implications for neural prostheses as well as diagnostic value for deficits resulting from neuropsychiatric disorders (e.g., ADHD, schizophrenia) and ocular dysmotility (e.g., strabismus).

Neural Coding through Population Dynamics

The instantaneous firing rate of individual neurons has traditionally been assumed to be the primary neural correlate of sensory, cognitive, and motor processes. Although this so-called rate code can explain a number of perceptual and behavioral phenomena, it falls short in other instances. One of the research directions in the CSI lab involves considering alternatives to standard rate-based coding. This requires zooming out to the systems level and studying the dynamics of activity in a network or population of neurons. Using pooled single-unit recordings, we have found that the temporal structure of population activity fluctuates in the visual burst but remains stable in the motor burst of visuo-movement neurons, specifying a code to distinguish between incoming sensory output and premotor output. We plan to further explore the role of the population temporal code in sensorimotor integration using multi-electrode techniques as well as testing the robustness of the code using computational modelling.





Interception of Moving Stimulus

While navigating through their local environment, primates combine rapid (saccadic) and slow (pursuit) voluntary eye movements in an effort to gather visual information from stationary and moving objects. Throughout much of the twentieth century, these eye movements were mostly studied in isolation; however, recent experiments in several laboratories have shown that their neural substrates may overlap significantly. Future experiments in our laboratory will combine behavioral, neurophysiological, and computational techniques to compare the role(s) of the cortex, superior colliculus and oculomotor brainstem in the planning and execution of saccades to both static and moving stimuli. Basic knowledge gathered from these experiments will allow us to test specific hypotheses concerning the role of these structures in the maintenance of saccade accuracy and precision to both static and moving targets as well as the selection of targets in more complex environments.

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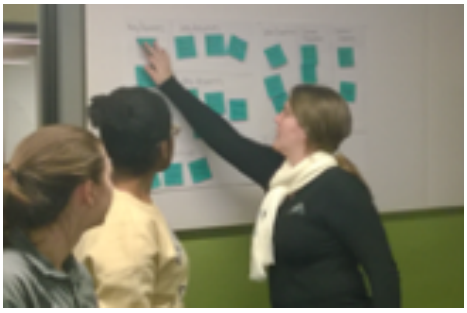
Mark Gartner, PhD

Professor of Practice

Interdisciplinary Design Education

Dr. Gartner's research interests include interdisciplinary medical product design education. He is the instructor of the two-semester "Senior Design" course in the Department of Bioengineering focusing on the risk-based medical product design process in context of the requirement of the Food and Drug Administration (FDA) and Centers for Medicare and Medicaid Services (CMS). An interdisciplinary partnership between the School of Nursing and the Department of Bioengineering embeds Senior-level nursing students into bioengineering design teams as the basis for expanded interactions in the clinical environment. This partnership also provides nursing students with an understanding of the medical product design, regulatory, reimbursement, and commercialization processes that can be leveraged in future patient-centric activities. Most importantly, this partnership provides an opportunity to prepare both students for future professional interactions and improve healthcare delivery. This work is supported by a five-year grant awarded by the National Institute for Biomedical Imaging and Bioengineering (R25 EB025793-01).



Conservation Engineering

Dr. Gartner's laboratory activities include the development of novel tools to address unmet needs in wildlife conservation and leverages bioengineering and mechatronic principles as the basis for a spectrum of devices and tools. Tools currently in development include an institutional tracking system for green sea turtle rehabilitation, the development of a low-cost manatee tracking device, and a system to allow physical examination of conscious polar bears. Dr. Gartner has worked on a range of conservation and education efforts with the Pittsburgh Zoo and PPG Aquarium including recently harvesting coral from the Navy's Mole Pier in Key West, Florida.

Medical Product Design

Dr. Gartner has led the development of a range of medical products in his career. This work has ranged from minimally invasive cardiological tool through cardiac and cardiopulmonary support systems. Most recently, his laboratory is collaborating with colleagues from the University of Massachusetts in the clinical trial of a vibro-tactile stimulation device for infants with neonatal abstinence syndrome. This technology represents the first non-pharmacological treatment intervention for abstinence and drug withdraw in newborn infants.

Biography

Mark Gartner earned a PhD in biomedical engineering from Carnegie Mellon, an ME in mechanical and biomedical engineering from Carnegie Mellon, and an MBA from the University of Pittsburgh.

Alan D. Hirschman, PhD

Professor of Bioengineering
Executive Director, *Center for Medical Innovation*

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Resesarch Interests

Dr. Hirschman's primary interest is in the application of technology to translational medicine and medical product innovation. He has been instrumental in the development of a Professional Master of Science in Bioengineering oriented toward Medical Product Engineering. This work also recently resulted in the Provost's approval of a Professional Certificate in Medical Product Innovation offered through the Swanson School of Engineering. He has developed several courses (Medical Product Ideation, Medical Product Development) to help train future product developers, managers, entrepreneurs, and investors in the medical product domain.

As Executive Director of the Center for Medical Innovation at the Swanson School of Engineering since 2011, Dr. Hirschman is responsible for tactical and strategic direction. His work is focused on matching physicians with engineers and students in SSOE to create funded project teams focused on the advancement of technologies into clinical practice.

Also, as a former executive at Bayer (MEDRAD® division), Dr. Hirschman is interested in bringing best industry practices to the new innovation and entrepreneurship efforts underway at the University of Pittsburgh.

Biographical Highlights

Dr. Hirschman came to the University of Pittsburgh in 2010 as a visiting professor in the Department of Bioengineering. In 2013 he received a full appointment as Professor of Bioengineering. Most of his career (30+ years) was in the medical device industry as an inventor, biomedical product development engineer, business development professional and corporate executive. Earlier in his career he worked as a research physicist and electrical/computer engineer. Dr. Hirschman earned his PhD in Electrical Engineering from Carnegie Mellon University and a Bachelor's in Physics from New York University. He is a Fellow of AIMBE and a Life Member of the IEEE.

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Tamer S. Ibrahim, PhD
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7 Tesla Neuroimaging Studies with the Tic-Tac-Toe Radiofrequency Coil System

Introduction

Recently FDA-approved 7 Tesla (T) MRI can provide improved signal-to-noise ratio, resolution, and image contrast when compared with standard clinical MRI scanners (usually 1.5T or 3T). However, proton imaging at higher frequencies (~300MHz) and shorter wavelength (~13cm in brain tissues) can lead to inhomogeneities in the images and potentially cause high localized radiofrequency (RF) power deposition in the tissue. The Tic-Tac-Toe (TTT) RF coil system provides improved homogeneity and reduced power deposition. It is achieved thanks to an innovative coil design and a methodology of operation. Several clinical MRI sequences have been performed and compared with commercial RF coils, demonstrating the superior performance of the Tic-Tac-Toe RF coil system. Numerous clinical studies including NIH funded studies (~2,000 subjects) are currently being conducted using this coil at the University of Pittsburgh.

Material and Methods

The Tic-Tac-Toe (TTT) radiofrequency head coil for 7T MRI

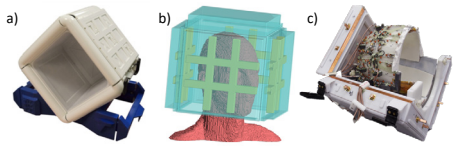


Fig. 1: in a), the implemented 16-channel TTT transmit RF coil; in b), the computational modeling of the RF coil; in c), the implemented RF coil with an 32-channel receive insert

B_1^+ maps in the brain: TTT vs NOVA RF coils

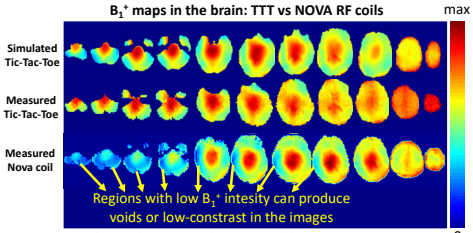


Fig. 2: The B_1^+ (magnetic field responsible for spin excitation) field homogeneity is highly degraded at 7T MRI due to a higher operational frequency (~297MHz). The TTT presents a more homogeneous field distribution when compared with the NOVA coil (a commercial coil) [1].

Results

Image comparison with the 32-channel NOVA commercial RF coil

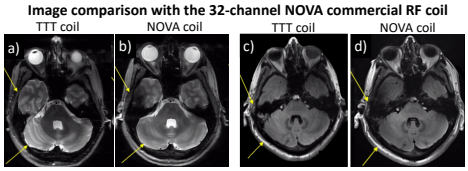


Fig. 3: In a), Turbo spin echo (TSE) sequence using the TTT coil with resolution of 0.4x0.4x2mm. In b), the same TSE sequence acquired with the commercial NOVA coil. In c), FLAIR sequence acquired with TTT coil with resolution of 0.7x0.7x2mm. In d), the same FLAIR sequence acquired with NOVA coil. The arrows point to regions of dark spots in the NOVA coil images and compare with similar regions on the TTT coil images [1].

High-resolution susceptibility weighted images showing cortical microvessels

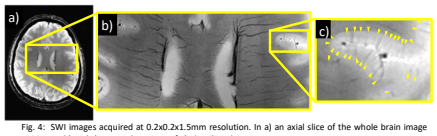


Fig. 4: SWI images acquired at 0.2x0.2x1.5mm resolution. In a) an axial slice of the whole brain image acquisition. In b) and c), zoomed versions of a), detailing the micro-structures.

High resolution angiography without contrast agents

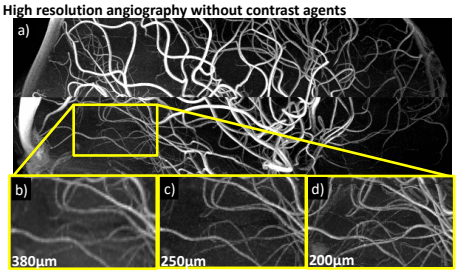


Fig. 5: Maximum intensity projection of a TOF acquisition showing brain vasculature in sagittal orientation and small vessels detectability with the increase in image resolution. In a), 2-slab 0.25mm isotropic image showing whole brain vasculature; In b), 0.38mm isotropic acquisition; In c), 0.25mm isotropic acquisition. In d), 0.20mm isotropic resolution acquisition showing an extra amount of vessels that are only detectable at higher resolution (arrows).

Functional MRI

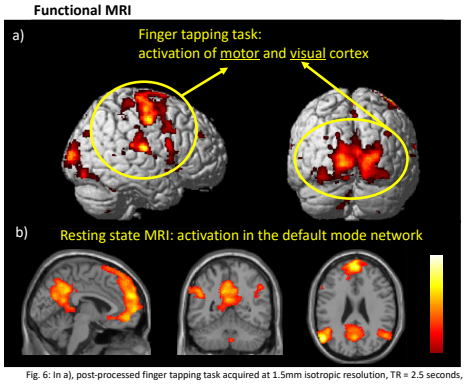


Fig. 6: In a), post-processed finger tapping task acquired at 1.5mm isotropic resolution, TR = 2.5 seconds, 3 min total acquisition time, 1 subject. In b), post-processed resting state functional MRI, acquired at 2mm isotropic resolution, TR = 1s, 8 min total acquisition time, 1 subject.

Diffusion MRI and fiber tracking

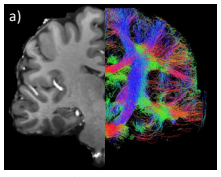


Fig. 7: In a), an structural MPRAGE image acquired at 0.75mm isotropic (skull removed using FSL package). In b), fiber tracking based on DTI acquisition, 64 directions, 1.5mm isotropic resolution. The colors are defined for different orientations of the fibers.

Post-mortem

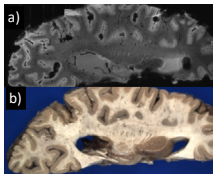
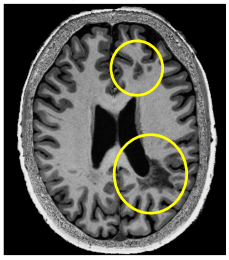


Fig. 8: In a), susceptibility weighted images acquired at 0.35mm isotropic, 32 min acquisition time, in a post-mortem brain fixated with formalin. In b), a photograph of similar slice in the same brain.

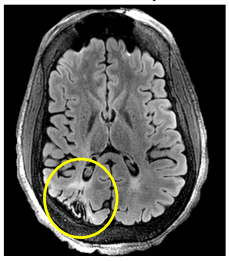
Table 1: 7T MRI studies conducted at the RF Research Facility at University of Pittsburgh

Study	# of Subjects	Time Pts. Per Subject	Funding Source	Status
Healthy Brain Aging	30	2	Aging Ins.	Finished
Major Depressive Disorder	20	1	NIH P30	Finished
Childhood Adversity & Visceral Circuits	4	1	NIH K01	Finished
Schizophrenia	36	1	NIH R21	Finished
RF Coil Development & Late Life Depression	60	2	NIH R01	Ongoing
RF Coil Development & Small Vessel Disease Model	40	1	NIH R01	Ongoing
Small Vessel Disease in Pre-clinical Alzheimer's Dis.	60	1	NIH R01 Suppl.	Ongoing
Sickle Cell Disease	200	2	NIH R01	Ongoing
Lithium Intervention in Alzheimer's Dis.	80	3	NIH R01	Ongoing
Adult Psychopathology & Disorders	90	2	NIH R01	Ongoing
Midlife Neurocognitive Disparities	300	1	NIH R01	Ongoing
Depression in Dementia Caregivers	90	2	NIH K01	Ongoing
Neural Mechanism of Monoaminergic Engagement in Late Life Depression	100	Up to 6	NIH R01	Ongoing
Normal Aging	40	1	NIH R01	Ongoing
Multiple Sclerosis	50	1	UPMC	Ongoing
Pre-clinical Alzheimer's Dis. & Postoperative Cognitive Dysfunction	20	2	UPMC	Ongoing
Behavioral Mechanisms Linking Personality to Health in Midlife	320	1	NIH R01 Suppl.	Ongoing

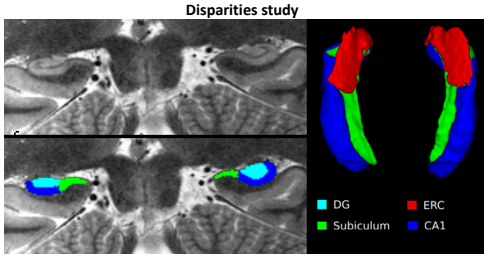
White matter legions (circle): Multiple Sclerosis study



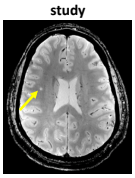
Stroke (circle): sickle cell disease study



Automatic hippocampus segmentation: Midlife Neurocognitive Disparities study



Lacunar infarct (arrow): depression study



White matter hyperintensities (arrows): Healthy Brain aging study (left) and Small Vessels disease in preclinical Alzheimer's disease study (right)

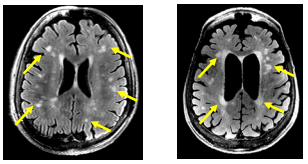


Fig. 9: Sample of some studies listed in Table 1 using the developed 16-channel TTT RF array (Fig. 1a). There are 4 completed studies and 13 ongoing patient studies with approximated 2,000 patients scheduled.

Future Directions

64-channel Tic-Tac-Toe RF transmit coil for 7T MRI

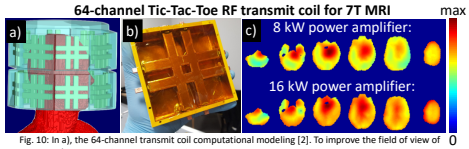


Fig. 10: In a), the 64-channel transmit coil computational modeling [2]. To improve the field of view of the projector/monitor in fMRI studies, the frontal panels can be removed, resulting in a 56-channel coil. In b), one assembled side of the coil. In c), simulated B_1^+ field distribution: for an 8kW power amplifier capabilities (default in older 7T MRI scanners) a homogeneity (measured by the coefficient of variation - CV) of 15.2% is achieved in the brain. For an 16 kW power amplifier (available for the recently FDA approved Siemens 7T MAGNETOM Terra), an CV of 10.6% can be achieved in the brain.

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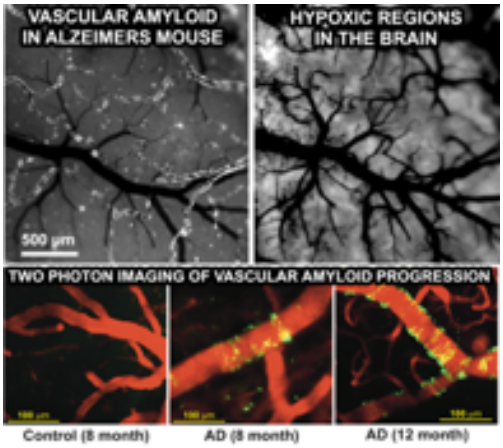
We develop multimodal neuroimaging platforms to explore system-level neurovascular and metabolic events during neurogenesis, normal development and neurodegeneration. We are interested in the life of brain cells inside living animals, particularly in the context of neuronal activity, oxygen, glucose and iron metabolism. In pursuit of this knowledge we employ a set of interdisciplinary approaches that combine molecular tools such as optogenetics and reporter protein design with systems-level methods such as Magnetic Resonance Imaging, two-photon and intrinsic optical imaging. We seek to identify accessible molecular targets connected to brain dysfunction. Our work delivers cellular-level insights into human functional and metabolic imaging.

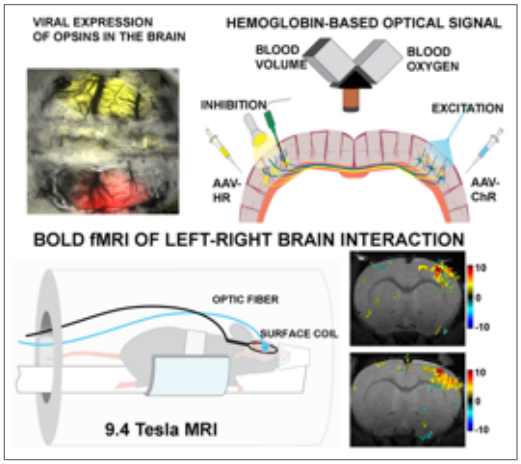
Vascular Deficits in Alzheimer's Disease

The brain has no significant energy storage, and cellular activity evokes adaptive changes in the blood flow to deliver oxygen. We survey the dynamic vascular and metabolic events that develop synergistically in the vessel and the tissue with the amyloid accumulation during Alzheimer's disease (AD) progression. The aim is to deliver functional and mechanistic roadmap on how these interconnected processes contribute to AD pathogenesis and how they interact with sex, genetic and environmental factors. Our goal is to reveal which events lay at the origin of initial brain dysfunction in order to provide early diagnostic markers for AD as well as suitable targets for intervention.



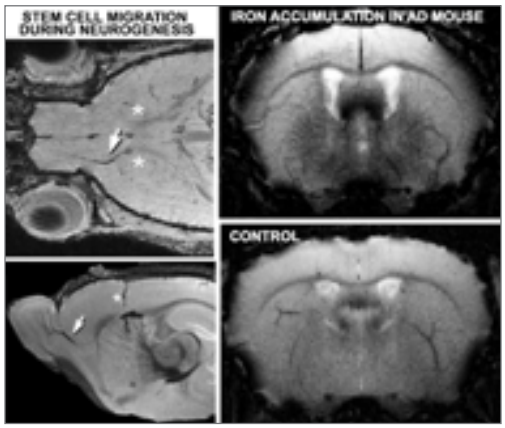
Long-range Brain Connectivity

Cortico-cortical interactions are inherently difficult to study. Using optogenetic tools, optical and functional MR brain imaging we explore the neurovascular activity that drives the transcallosal interaction of left and right brain and elucidate the observed variability in human functional imaging. These findings have significant implications in stroke recovery, investigating the spread of seizures from one side of the brain to the other and bilateral control of brain-machine interfaces.



Metalloprotein-based MRI

We combine molecular engineering and MRI to modulate contrast in brain cells via the expression of novel iron-binding, paramagnetic metalloproteins in the ferritin family. Following transgene expression, the ferritin shells sequester physiologically available iron, and biomineralization of the ferritin core renders the complex paramagnetic, producing MRI contrast. By combining an MRI reporter with a cell-specific expression, a multitude of applications exist. For example, we can track cell migration after neurogenesis. More recently, we have employed the same MRI approaches optimized for iron imaging to evaluate iron accumulation in models of Alzheimer's disease.



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Takashi "TK" Kozai, PhD

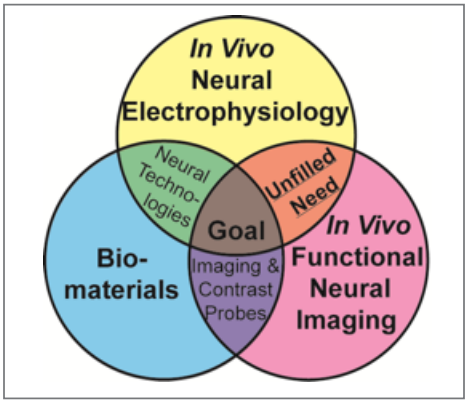
Assistant Professor
NeuroTech Center, Brain Institute

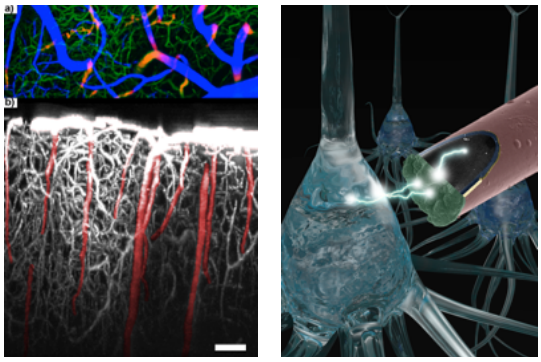
Bio-Integrating Optoelectric Neural Interface & Cybernetics Lab

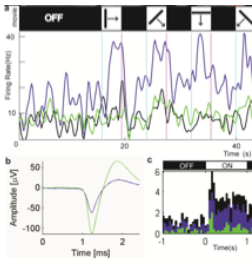
Our lab employs a highly transdisciplinary approach to understand interactions at micro-scale neural interfaces and to develop next-generation Neural Technologies that attenuate or reverse negative tissue interactions. Specifically, we focus on **elucidating** *biological structures* and *biochemical pathways* that *control* physiological function and bidirectional communication between the *nervous system* and *neural interface* technology. We then apply these newly discovered constraints and possibilities into designing novel technologies.

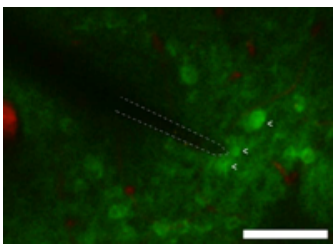
In order to elucidate real-time long-term cellular and molecular tissue interactions to chronically implanted medical devices, we employ *in vivo* functional electrophysiology, two-photon microscopy, electrochemistry, and electrical and optical stimulation techniques. In addition, we leverage principles in molecular and cellular neurobiology, electrical engineering, mechanical engineering, computer science, physics, biochemistry, material science, optics, and biomaterials. The availability of new optical methods to image brain function and new genetically engineered mice and rat models present a leading-edge opportunity to understand normal and pathological brain function in new ways with exquisite dynamic details.

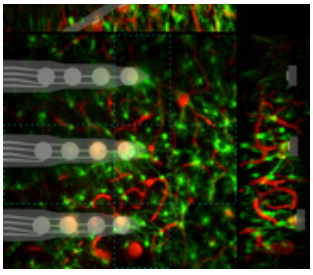
These technologies allow us to advance our understanding of the brain and brain interfaces, as well as create new avenues for diagnosis and treatment of brain pathologies.











Current Research Projects

1. **Blood-brain barrier (BBB) dysfunction** plays an important role in cellular damage in neurological diseases and brain injuries. This project quantifies structural, cellular, and molecular level tissue response to chronic implants in the brain in real-time through combining multiphoton imaging technology and neural engineering technology.
2. **Microthread probes** are new classes of ultrasmall neural interfaces that uses leading-edge biocompatible polymers to develop innovative 'microthread neural probes' that are ultra-small and flexible, with bioactive surfaces and nanostructured electrode sites for enhanced signal transduction. We create these microthread probes using advanced carbon nanotube (CNT) and bioactive polymer coating technologies for chronic recording, chronic electrical stimulation, chronic wireless stimulation, chronic chemical sensing, and chronic wireless drug delivery.
3. **In vivo evoked two-photon imaging and electrophysiology.** Past studies characterizing the CNS response to implants have used postmortem histology at discrete time points. This approach suffers from a large degree of variability and fails to capture the dynamic molecular, cellular and vascular changes of the host. To address this issue, we have developed an experimental set-up to directly image the electrode-tissue interface in live animals using 2-photon microscopy in conjunction with evoked electrical recording (Visual and Somatosensory Cortex). We employ this experimental setup to rigorously characterize dynamic tissue changes that occur around neural camouflage coated devices and a variety of pharmaceutical and genetic intervention strategies.

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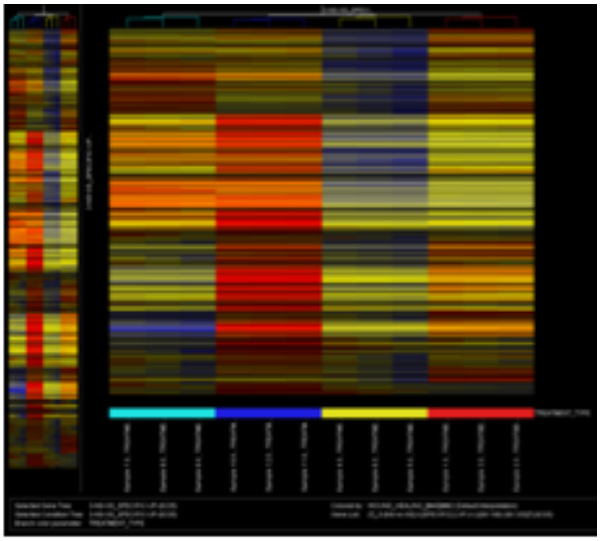
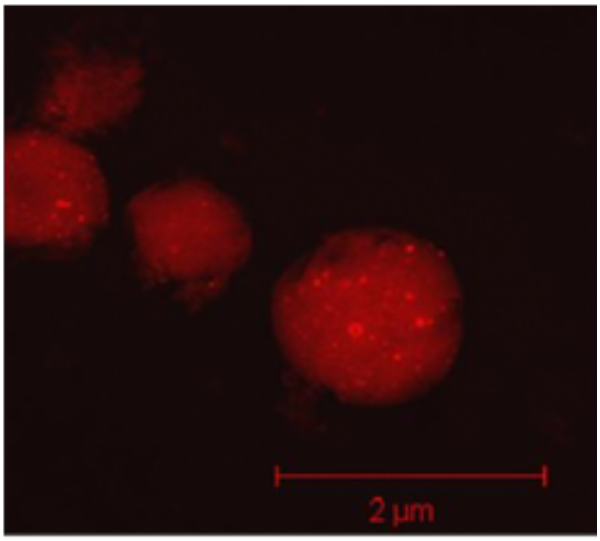
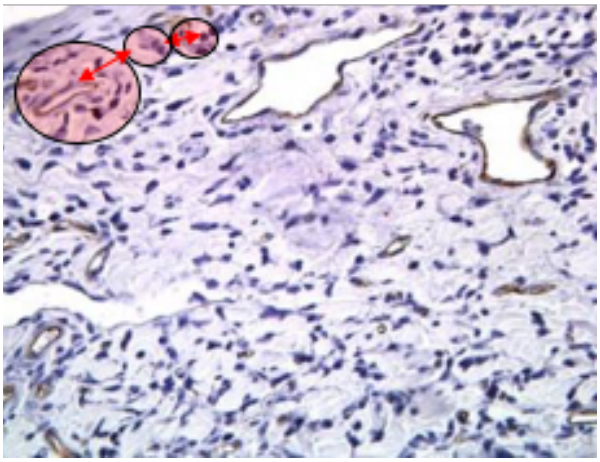
Modulation of Molecular Disarray using Biomaterials-based Therapy

Dr. Mangesh Kulkarni is a research assistant professor of Bioengineering at University of Pittsburgh and a faculty member of McGowan institute of regenerative medicine. Following the completion of MD and M.Tech degrees in India, he received his PhD in biomedical engineering from National University of Ireland Galway in 2012. Dr. Kulkarni's research is primarily translational in the fields of tissue engineering, regenerative medicine and molecular therapeutics.

Most of the regenerative processes are complex with multiscale structural/ functional organization and spatio-temporally controlled attributes. Therefore, a holistic understanding of stem cell biology & molecular events and development & application of novel bioengineering solutions is central to regenerative medicine. Employing techniques such as next generation sequencing, digital PCR, *in situ* hybridization, Dr. Kulkarni investigates the molecular signature of disease state to pinpoint players in the etiopathology of the disease aspects, for example regeneration and repair in diabetes. Dr. Kulkarni focuses on development of biomaterials based regenerative therapies that can be tuned either a) for modulating the function of stem cells and/or immune cells by delivery of the deficient biomolecules or repression of the overexpressed biomolecules or b) utilizing stem cells as factories producing an array of immunomodulatory and regenerative factors. He is working in close collaboration with Dr. Bryan Brown in the areas of innate immunity and host response to biomaterials.







Research Interests

- Tissue Engineering
- Regenerative Medicine
- Development of Biomaterials-based Delivery Systems
- Molecular Diagnostics and Therapeutics, particularly involving Non-coding RNA
- Cell-free Therapeutic Strategies such as Stem Cells Secretome Therapy
- Innate Immunity and Host Response to Biomaterials

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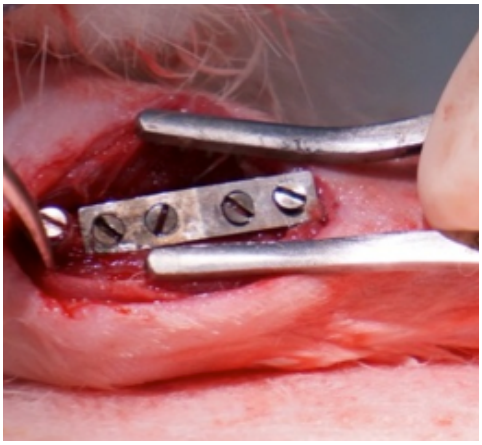
Prashant N. Kumta, PhD

Edward R. Weidlein Chair *and* **Professor**
School of Dental Medicine
McGowan Institute of Regenerative Medicine

Brief Biography of Dr. Prashant Kumta

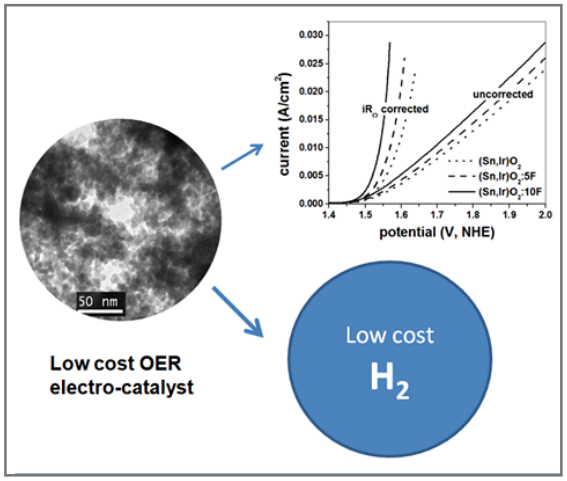
Professor Kumta's research interests cover two broad areas: energy storage, generation, conversion and biomaterials. He earned his Bachelor of Technology with Honors in metallurgical engineering from the Indian Institute of Technology, Bombay, India in 1984. He then earned his MS and PhD in Materials Science and Engineering from the University of Arizona in 1987 and 1990, respectively. After graduation, Professor Kumta joined the Department of Materials Science and Engineering at Carnegie Mellon University, where he was promoted to Full Professor with tenure in 1999. He joined the University of Pittsburgh in 2007, where he now manages a large group of researchers, research faculty (Dr. Datta, Dr. Roy, Dr. Velikokhatnyi and Dr. Jampani) and students. Professor Kumta is the author or co-author of more than 270 refereed journal publications and has given more than 460 conference presentations. He is currently the Editor-in-Chief of "Materials Science and Engineering: B, Advanced Functional Solid-State Materials," an International Journal by Elsevier Publications.

Research in Biomaterials



In the biomaterials area, Professor Kumta's group focuses on the creation of clinically relevant novel biomaterials for next-generation therapies in regenerative medicine. His group is also currently developing novel materials for craniofacial and orthopedic applications comprising new biodegradable metals and injectable calcium phosphate (CaP)-based resorbable bone cements and polymers for mineralized tissue regeneration and stem cell viability. Additive manufacturing techniques are also employed to generate user specific scaffolds using biocompatible and biodegradable metals and ceramics. Research is also on-going to understand the effects of morphology, and surface structures of CaP based nano-particles for targeted and surface mediated non-viral gene delivery. Biodegradable stents and drug eluting coatings are also under development to prevent coronary and pediatric pulmonary arterial sclerosis, repair intracranial aneurysms, and fill atrial septal defects. Another area of biocompatible materials under development is the understanding of cell-surface interaction between organic and inorganic materials as well as generation of chemical and biosensors for detection of biomarkers for cardiovascular and traumatic brain injury related conditions.

His laboratories house a wide range of state-of-the-art equipment for materials synthesis and characterization, cell and tissue culture, and 3D printing of advanced materials and structures.



Research in Energy Storage

Professor Kumta's research group is involved in the study of novel reversible lithium-ion, sodium-ion, and magnesium-ion batteries. These energy storage systems utilize myriad nanostructured configurations and architectures that can be synthesized at low-temperatures using innovative vapor, solid and liquid phase methods. Research is also being conducted to develop improved supercapacitors, photoelectrocatalysts for water splitting and hydrogen generation as well as electro-catalysts for low temperature proton exchange membrane (PEM) based fuel cells. These technologies rely on nanostructured heterostructures and systems synthesized using indigenous low-temperature sol-gel and economic template approaches. His research also explores reduced noble metal containing electronically conductive and electrochemically stable catalysts for efficient hydrogen generation via acid based water electrolysis using density functional theory (DFT) based techniques.

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Professor and Associate Chair

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BioSignal and Systems Analysis Laboratory

Many biological and biomedical signals and systems change over time (e.g., speech, hearing, vision, balance), and tracking these changes is important for disease monitoring and understanding the underlying physiological processes. The *BioSignal and Systems Analysis Laboratory* conducts research into multisensory integration and motor control, nonstationary signal processing, and the quantitative analysis and modeling of biomedical signals and systems. Specific activities include human postural control (Fig. 1); frequency tracking and instantaneous frequency estimation of biomedical signals such as gait and heart rate (Fig. 2); and developing sensory substitution modalities (e.g., vibrotactile feedback) to improve impaired sensorimotor function or for brain-machine interfaces (Fig. 3).

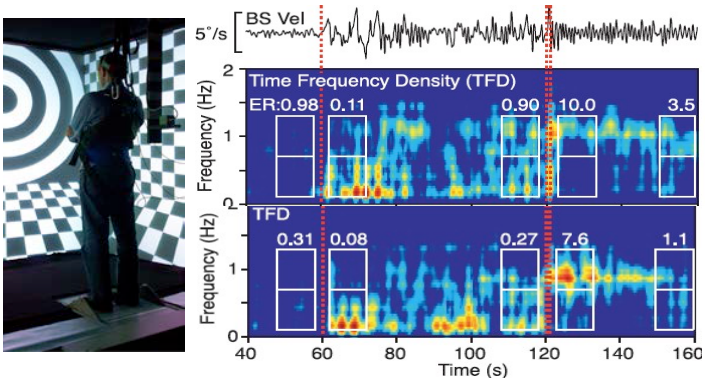

Fig. 1: Time-frequency analysis of human balance uncovers sensory adaptation [Peterka 2004, Mahboobin 2005].

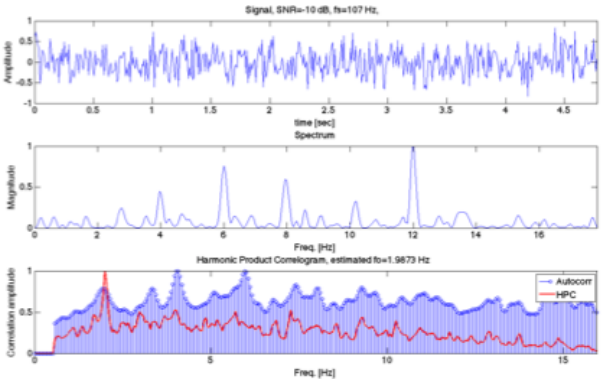

Fig. 2: Frequency tracking of a noisy quasi-periodic signal.

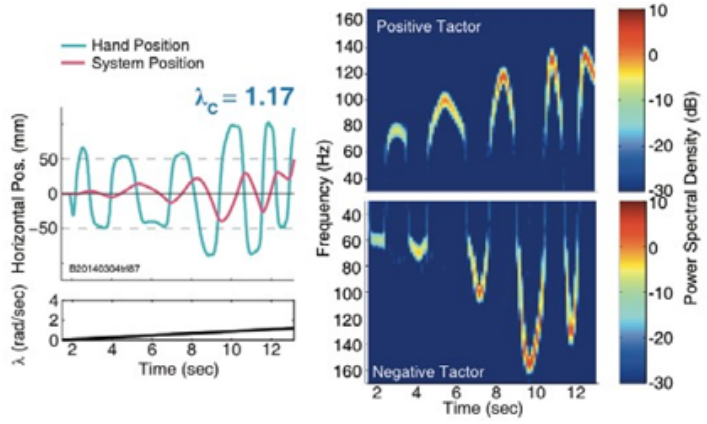

Fig. 3: Subject performance in a control task with vibrotactile feedback [Quick 2014].

Principal Investigator Brief Biography

Patrick Loughlin earned a PhD in electrical engineering from the University of Washington, an MS in bioengineering from the University of Utah, and a BS in biomedical engineering from Boston University. He has been a faculty member at Pitt since 1993. Dr. Loughlin is a Member of the Editorial Board for the *IEEE Transactions on Biomedical Engineering*, and a Fellow of AIMBE, ASA and IEEE.

Selected Publications

- Quick *et al.*, Assessing vibrotactile feedback strategies by controlling a cursor with unstable dynamics, *IEEE EMBC*, 2014.
- Cenciarini *et al.*, Stiffness and damping in postural control increase with age, *IEEE Trans. Biomed. Engrng.*, 2011
- O'Connor *et al.*, Postural adaptations to repeated optic flow stimulation in older adults, *Gait & posture*, 2008
- Mahboobin *et al.*, A model-based approach to attention and sensory integration in postural control of older adults, *Neuroscience letters*, 2007
- Loughlin *et al.*, A Wigner approximation method for wave propagation, *J. Acoust. Soc. Amer.*, 2005
- Mahboobin *et al.*, Sensory re-weighting in human postural control during moving-scene perturbations, *Exp. Brain Research*, 2005
- Peterka *et al.*, Dynamic regulation of sensorimotor integration in human postural control, *J. Neurophys.*, 2004
- Loughlin *et al.*, Spectral characteristics of visually induced postural sway in healthy elderly and healthy young subjects, *IEEE Trans. Neural Sys. and Rehab. Engrng.*, 2001
- Loughlin, Spectrographic measurement of instantaneous frequency and the time-dependent weighted average instantaneous frequency, *J. Acoust. Soc. Amer.*, 1999
- Loughlin *et al.*, Time-varying characteristics of visually induced postural sway, *IEEE Trans. Rehab. Engrng.*, 1996
- Loughlin *et al.*, On the amplitude- and frequency-modulation decomposition of signals, *J. Acoust. Soc. Amer.*, 1996
- Loughlin *et al.*, Construction of positive time-frequency distributions, *IEEE Trans. Signal Process*, 1994

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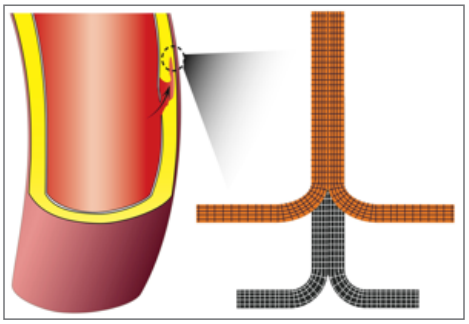
Spandan Maiti, PhD

Associate Professor

Primary research interest of our group lies in the predictive modeling and simulation of constitutive and failure response of complex materials. We study the evolution of these systems in a multi-physics environment at multiple spatial and temporal scales. A general objective of our research is to provide quantitative descriptions of the relationship between the measurable features of the microstructures of materials and their emergent macroscopic behavior. We employ a full suite of experimentally validated theoretical and numerical tools to achieve this feat. Our effort involves development of advanced theoretical techniques and numerical algorithms for materials modeling, and computational frameworks to conduct large- scale simulations in a massively parallel environment. While we develop new numerical techniques whenever necessary, the emphasis of our research is on investigating and predicting the physical aspects of complex materials behavior.

Currently our research activities span two application areas: A) Biomechanical behavior of soft tissues and B) electro-chemo-mechanical response of advanced energy storage materials. Of special interest are the microstructural features and events that lead to loss of mechanical integrity of these materials systems. We envisage that our research effort will unlock fundamental mechanisms responsible for damage, tear, and ultimate failure of these complex materials subjected to not only normal, but also altered operating environment.

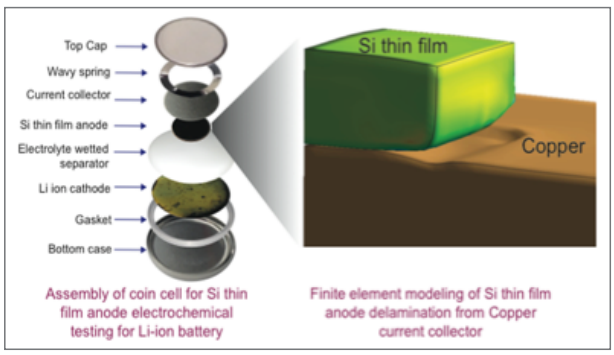
Mechanical Failure of Native Tissues



Clinical interventions resulting from biomechanical failure of soft fibrous tissues are common in occurrence. Yet, the microstructural mechanisms, associated biomechanical principles, and structure-property relationships mediating onset and propagation of tears in tissues remain elusive. Our research group focuses on two particular instances: dissection of aortic wall (left), and tear of rotator cuff tendon. Our computational modeling approach is based on characterization of microstructural features by appropriate computer representation of experimental images obtained from different microscopic modalities and integration of this microstructural information in computational models using fracture mechanics based numerical techniques, and large scale patient-specific simulations to predict progression of disease mediated by onset and progression of tear in relevant soft tissues. Our research is expected to yield mechanism-based information of early disease progression resulting in timely clinical intervention.

Mechanical Reliability of Energy Storage Materials

Alkali ion based rechargeable batteries (AIB) are currently at the forefront of electrical energy storage technologies. However, advanced electrode materials for AIBs (right) often suffer from mechanical reliability issues over repeated electrochemical charge and discharge cycles, hindering their commercial potential. Thus there is a critical need to tightly couple mechanical failure response of these materials with its electrochemical performance. Our research goal is to develop coupled multiphysics models for electrode materials linking atomistic scales to continuum, simulate their mechanical integrity under operating electrochemical conditions, and discover optimized material and morphology to meet specific performance goals. We develop a host of experimentally informed predictive modeling and simulation tools spanning multiple length and time scales to achieve this goal.



Assembly of coin cell for Si thin film anode electrochemical testing for Li-ion battery

Finite element modeling of Si thin film anode delamination from Copper current collector

Mark Redfern, PhD

William Kepler Whiteford Professor

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Background and Research Overview

Dr. Redfern is the William Kepler Whiteford Professor with a primary appointment in the Department of Bioengineering. He also holds secondary appointments in the Otolaryngology, Physical Medicine and Rehabilitation and Physical Therapy. His research spans a number of topics in the biomechanics, control of human movement and ergonomics. One of his long-standing research interests has been postural control and the rehabilitation of patients with balance disorders. He takes an engineering systems approach to modeling and understanding how various pathologies affect patients and what types of interventions can improve diagnosis and treatment. The influence of aging on balance control and the prevention of falls has been of particular interest. Dr. Redfern's research is truly interdisciplinary, working on funded projects with researchers from Otolaryngology, Rehabilitation Science, Engineering (Industrial, Electrical, Mechanical), the Robotics Institute at CMU, Physical Therapy, Psychiatry, and others. He has published over 150 peer-reviewed journal articles and his work has been cited in over 5,000 publications. His past funding has come from a variety of sources including federal (NIH, NIOSH, NSF, VA, CDC), foundations, and industry, totaling $16.5 million.

Examples of Ongoing Research Projects

Postural Control in the Elderly: Falls are the leading cause of injury in adults aged 65 and older. There are multiple factors involved, including reduced balance control, cognitive problems, poor vision, and medications. We are conducting studies to investigate how aging affects postural control resulting in instability and ultimately to falls. The most recent study investigates how reduced cognitive function impacts balance and stability. The study explores why certain aspects of cognition, such as decision processing speed, inhibitory function and visuospatial ability, have an impact on postural control and changes in these aspect of cognition can have a detrimental effect on balance and stability.

Vestibular Disorders: Patients with either central or peripheral vestibular disorders suffer from dizziness and imbalance. Current research conducted in partnership with the UPMC Center for Balance Disorders examines how patients with these disorders can improve function through vestibular rehabilitation therapies. The studies examine how sensory compensation occurs and explores improved therapeutic techniques, such as virtual reality to help patients suffering with different types of disorders.

Human Factors Engineering of Medical Devices: One critical aspect of developing and designing medical devices is understanding user-device interface. Human factors engineering focuses on designing devices to meet the capabilities of the user. One current project, in collaboration with the Food and Drug Administration, focusses on understanding the critical gaps in the design of medical devices from a human factors perspective and developing a decision support system to aid in the design process. Another recent project, the *Human Factors of Aging*, funded by the NIH, provides support for investigators who are translating their research into new devices and interventions for older adults.

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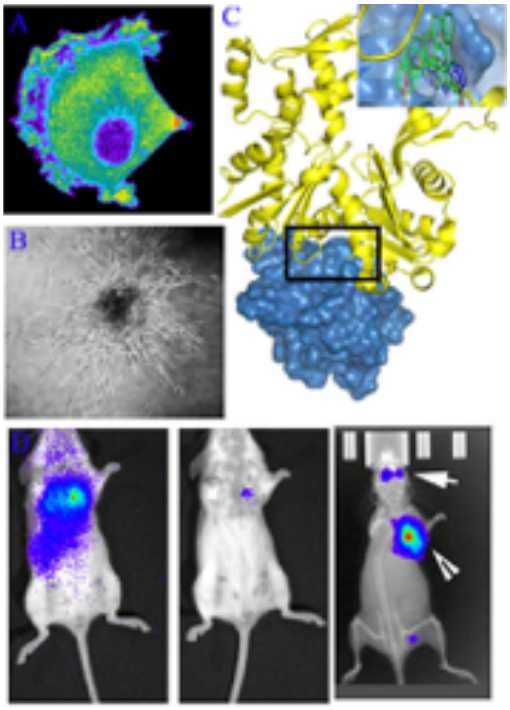
Actin Cytoskeleton in Health and Disease

Dynamic reorganization of actin cytoskeleton, a key feature of virtually all actin-dependent cellular processes, is orchestrated by concerted actions of various classes of actin-binding proteins and their transcriptional/post-transcriptional regulators. Dysregulation of many of these proteins contributes to a wide range of pathologies including malignant progression of cancer and metastasis, immune dysfunction and aberrant neovascularization in various disease contexts. Our overall research focus is studying the role of selective actin-associated proteins and their regulators (transcriptional and post-transcriptional) in physiology and pathology at the molecular levels. Specifically, we are aiming to 1) understand the role of some of these proteins in the regulation of tumor growth, specific steps of dissemination, metastatic colonization, and drug-sensitivity of cancer cells, 2) identify novel small molecules that have potential to suppress tumor metastasis, 3) identify novel anti-angiogenic compounds and 4) elucidate novel molecular regulation of key controllers of cell migration.

Major techniques: Protein biochemistry (immunoprecipitation, 2D gel electrophoresis), gene cloning, immunocyto/histochemistry, live cell imaging, cell migration/invasion, FRET, small molecule screening, mouse models of tumor progression (tumor graft, genetically engineered), angiogenesis assays (*in vitro, ex vivo* and *in vivo*), functional genomics and proteomics.



A. FRET imaging of protein-protein interaction
B. Sprouting angiogenesis from endothelial cell spheroids
C. Small molecule docking at protein-protein interface
D. Bioluminescence imaging of breast cancer metastasis

Selected Representative Publications:

1) Chakraborty S., Jiang C., Gau D., Oddo M., Ding Z., Vollmer L., Joy M., Schiemann W., Stolz D., Vogt A., Ghosh S., **Roy P.** (2018) Profilin-1 deficiency leads to SMAD3 upregulation and impaired 3D outgrowth of breast cancer cells **British J. Cancer** Oct 15. doi: 10.1038/s41416-018-0284-6.

2) Gau D., Lewis T., McDermott L., Wipf P., Koes D., **Roy P.** (2018) Structure-based virtual screening identifies a small molecule inhibitor of the profilin1-actin interaction. **J. Biol Chem** Feb 16; 293(7):2606-2616.

3) Joy M, Gau D, Castellucci N., Prywes R., **Roy P.** (2017) The Myocardin-related transcription factor MKL co-regulates the levels of two profilin isoforms **J. Biol Chem** May 25. pii: jbc.M117.781104. doi: 10.1074/jbc.M117.781104.

4) Ding Z., Joy M., Bhargava R., Gunsaulus M., Lakshman N., Miron-Mendoza M. Petroll M., Condeelis J., Wells A., **Roy P.** (2014) Profilin-1 downregulation has contrasting effects on early vs late steps of breast cancer metastasis **Oncogene** 33(16):2065-74.

5) Bae Y., Ding Z., Das T. Wells A., Gertler F., **Roy P.** (2010): Profilin1 regulates PI(3,4)P2 and lamellipodin accumulation at the leading edge thus influencing motility of MDA-MB-231 cells **PNAS** 107(50): 21547-21552.

6) Zou L., Jaramillo M., Whaley D., Wells A., Panchapakesa V., Das T., **Roy P.** (2007): Profilin-1 is a negative regulator of mammary carcinoma aggressiveness. **British Journal of Cancer 97**: 1361-1371.

7) Ding Z., Lambrechts A., Parepally M., **Roy P.** (2006): Silencing profilin-1 inhibits endothelial cell proliferation, migration and cord morphogenesis. **Journal of Cell Science** 119: 4127-4137.

8) Rajfur Z., **Roy P.**, Otey C., Romer L., Jacobson K. (2002): Dissecting the link between stress fibers and focal adhesions by CALI of EGFP-fusion proteins. **Nature Cell Biology** 4(4): 286-293

9) **Roy P.**, Rajfur Z., Jones D., Marriott G., Loew L., Jacobson K. (2001): Local photorelease of caged-Tß4 in locomoting keratocytes causes cell turning. **Journal of Cell Biology** 153 (5): 1035-1048.

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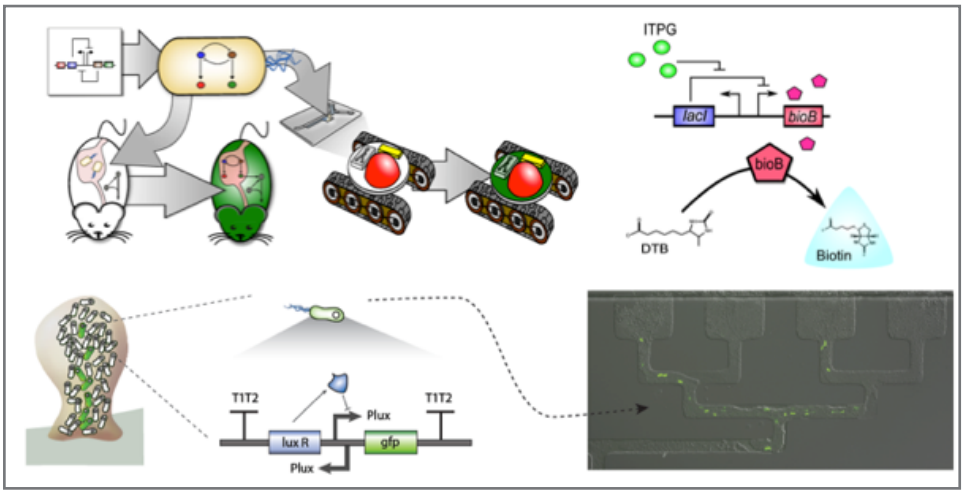
Engineered Living Systems and Synthetic Biology Lab

The Engineered Living Systems and Synthetic Biology Lab focuses on applying synthetic biology constructs, methods, and paradigms to solve a range of medical, industrial, and environmental problems. Our mission includes both understanding the fundamental biology of natural bioprocessing systems as well as re-engineering these systems with synthetic control circuits. We have expertise in multiple fields including gene circuit engineering, cell physiology and biomechanics, microfluidics, MEMS, and biomaterials. The research team currently develops new approaches in synthetic biology and links these technologies with biomimetic systems that mimic cell, tissue, and organism physiology. Active research areas include: (1) creating synthetic control modules for 2nd-messenger signaling in neurons (2) a living, bacterial microbiome for a biomimetic, robotic host, (3) artificial and engineered living microbiome constituents that deliver nutrients within organ-on-a-chip systems, (4) synthetically engineered cells that control material assembly, and (5) a biomimetic biofilm that combines microfluidics with synthetic biology to enable the discovery and monitoring of spatially segregated phenotypes within cell populations. These systems hold significant promise for both elucidating fundamental principles of physiology while also serving as new technologies for biomechanical engineering.



Biographical Highlights

Dr. Warren Ruder moved his research group to the University of Pittsburgh's Bioengineering department in January of 2017. Previously, he spent four and half years as an assistant professor in Virginia Tech's Biological Systems Engineering department, where he led the Engineered Living Systems Laboratory. His expertise is in synthetic biology, cellular and molecular biomechanics, and lab-on-a-chip systems. Dr. Ruder received his PhD in Biomedical Engineering and his M.S. in Mechanical Engineering from Carnegie Mellon University, and his B.S. in Civil and Environmental Engineering from MIT. From 2003-2005, he was a Health Science Specialist at the Veterans Affairs Boston Healthcare System and Harvard Medical School. From 2005-2009, Dr. Ruder was an inaugural NIH trainee in the Pitt-CMU Biomechanics in Regenerative Medicine program and a Dowd graduate fellow in the groups of Phil LeDuc and Jim Antaki. From 2010-2012, he was a postdoctoral research associate in the group of Jim Collins at Boston University (now at MIT), and Harvard University's Wyss Institute for Biologically Inspired Engineering.

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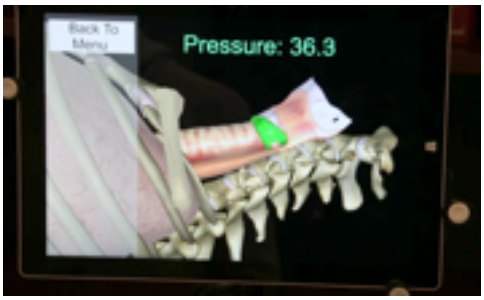
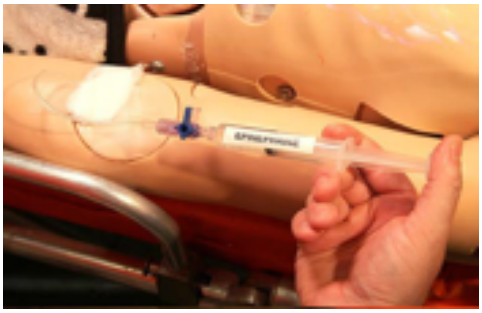
Joseph Thomas Samosky, PhD
Assistant Professor

Simulation and Medical Technology Laboratory

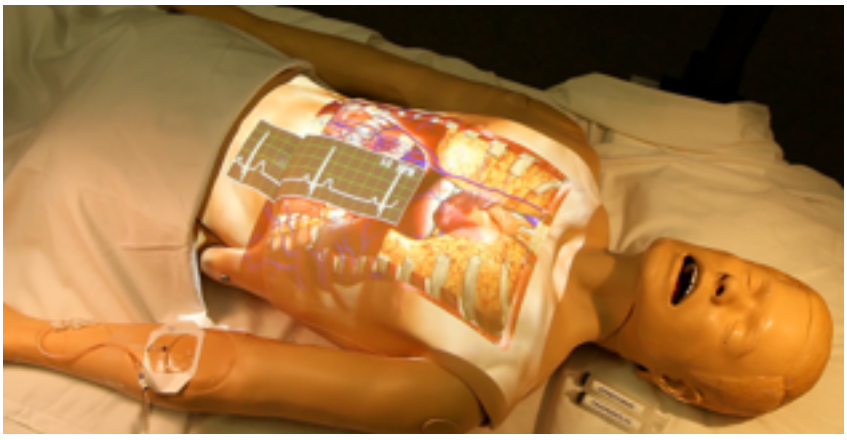
The Sim|Med|Tech Lab is a multidisciplinary research, development and innovation center directed by Dr. Joseph Samosky. Our mission is to integrate design, engineering and clinical medicine to invent next-generation enabling technologies for simulation-based healthcare training and new "smart" medical devices. Our ultimate goals are improving patient care and enhancing patient safety. Simulation-based training in healthcare offers hands-on, experiential learning with objective feedback while not exposing real patients to risk during training. Just as flight simulation revolutionized crew training and dramatically improved safety in aviation, simulation-based experiences can promote learning and enable medical students, physicians, nurses and first responders to practice skills and receive quantitative feedback on their performance before treating actual patients. Our research centers on the development of both fundamental new enabling technologies and practical systems for healthcare simulation, the user-centric design of real-time interactions, sensors, advanced information displays, learner-adaptive feedback, and autonomous operation.





BodyExplorer Augmented Reality Simulator

BodyExplorer is a next-generation medical simulator designed to enhance the ability of healthcare trainees to learn anatomy, physiology and clinical procedures though naturalistic interaction with an augmented reality enhanced full-body simulated patient. BodyExplorer is designed to enable 24/7 on-demand training and self-learning for students by providing an intuitive interface, immediate feedback and automated instruction using a highly sensorized physical body, projected augmented reality (AR), and an integrated virtual instructor. AR enables "x-ray vision" views inside the body, enabling trainees to see the internal effects and consequences of their actions. We have developed novel sensor systems for common clinical procedures such as identifying injected drugs and sensing the depth of insertion of an endotracheal tube. Injection of cardioactive drug simulants, for example, results in automatic changes to heart rate, audible heart sounds and displayed ECG waveforms.



Laboratory Director Dr. Joseph Samosky

Dr. Samosky received his PhD in Medical Engineering from the Massachusetts Institute of Technology and the Harvard-MIT Division of Health Sciences and Technology. He received his MS in Electrical Engineering and Computer Science from MIT, and his BS in Behavioral Neuroscience and BSE in Electrical Engineering from the University of Pittsburgh. His work has been recognized with the first-place award for technology innovation at the International Meeting on Simulation in Healthcare, a Coulter Translational Research Award, and exhibition at the ACCelerate Creativity and Innovation Festival at the Smithsonian Institution. Dr. Samosky is an enthusiastic advocate of experiential learning, design thinking and project-based, hands-on engineering education. He has mentored over 150 bioengineering students in senior design projects and also teaches in the Department of Bioengineering's Medical Product Innovation graduate program.

Sanjeev G. Shroff, PhD

Chair
Distinguished Professor of *and* **McGinnis Chair in Bioengineering**
Professor of Medicine

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Cardiovascular Systems Laboratory

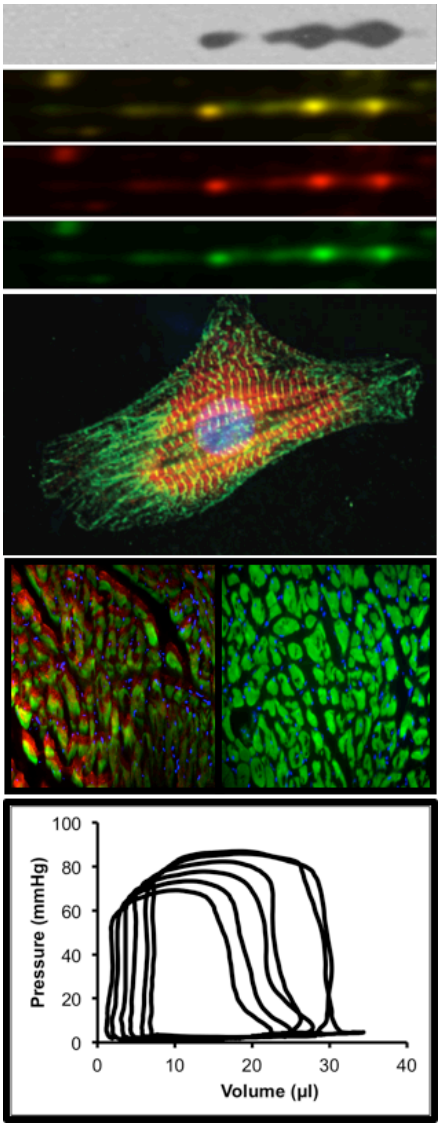
Our research interests are focused on three areas: (1) Relationships between left ventricular mechano-energetic function and underlying cellular processes, with a special emphasis on contractile and regulatory proteins and post-translational regulation of cardiac contraction (e.g., via phosphorylation or acetylation). Whole heart, isolated muscle (intact and detergent-skinned), and single cell experiments are performed using various animal models, including transgenic mice. (2) The role of pulsatile arterial load (vascular stiffness in particular) in cardiovascular function and potential therapeutic applications of vascular stiffness-modifying drugs and/or hormones (e.g., relaxin). Novel noninvasive measurement techniques are used to conduct longitudinal human studies, which are complemented by *in vivo* and *in vitro* vascular and cardiac studies with animal models. (3) The role of regional contraction dyssynchrony in global ventricular mechanics and energetics. In addition to basic research, we work on developing novel mathematical models of biological systems for scientific inquiry, education, and engineering design. Two ongoing research projects are described below.

Post-translational Regulation of Cardiac Muscle Contraction

Phosphorylation-mediated regulation of cardiac muscle contraction has been studied extensively. Our group has been focusing on cardiac Troponin I (cTnI), especially the effects of PKA- *vs.* PKC-mediated cTnI phosphorylation on cardiac contraction under normal and pathological conditions.[1,2] In collaboration with the Gupta laboratory (University of Chicago), we discovered a completely new post-translational modification, myofilament protein acetylation, that can regulate cardiac muscle contraction as potently as phosphorylation (↑acetylation ⟹ ↑ myofilament calcium sensitivity for force generation).[3,4] Experiments are currently underway to determine the biophysical mechanisms responsible for this novel contractile regulation and to examine its physiological significance under *in vivo* conditions. This basic science information regarding the post-translational regulation of contraction is being used to develop novel inotropic therapies.

Role of Relaxin in the Cardiovascular System

Our group has been working on examining the role of relaxin, traditionally considered to be a pregnancy-associated hormone, in the cardiovascular system. We have shown that exogenous relaxin administration produces significant vasodilation (↓ systemic vascular resistance) and vasorelaxation (↑ global arterial compliance) in both male and female animals.[5] Furthermore, relaxin-1 and its receptor mRNA are expressed in vascular tissues obtained from various mammals of both sexes, leading us to propose that the relaxin ligand-receptor system acts locally to regulate arterial function and the loss of one or both of these components may form the molecular basis of vascular aging.[6] We and others have shown that relaxin is a potent anti-fibrotic agent. In collaboration with the Salama laboratory (University of Pittsburgh), we recently showed that relaxin administration completely suppressed induced atrial fibrillation in aged spontaneously hypertensive rats and both the reversal of myocardial fibrosis and an increase in myocyte sodium current contributed to this suppression.[7] Current studies are aimed at further examining the therapeutic potential of relaxin in fibrosis-associated cardiovascular diseases (e.g., diastolic heart failure, atrial fibrillation).



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2. Kirk JA, *et al. Circ Res.* 105:1232-1239, 2009.
3. Gupta MP, *et al. J Biol Chem.* 283 (15):10135-10146, 2008.
4. Samant SA, *et al. J Biol Chem.* 290:15559-15569, 2015.
5. Conrad KP, Shroff SG. *Curr Hypertens Rep.* 13:409-420, 2011.
6. Novak J, *et al. FASEB J.* 20:2352-2362, 2006.
7. Parikh A, *et al. Circ Res.* 113:313-321, 2013.

George Stetten, MD, PhD

Professor

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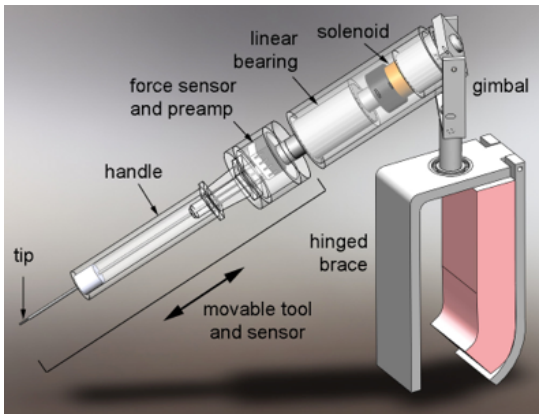
Primary Research Areas

The Visualization and Image Analysis (VIA) Laboratory, directed by George Stetten, MD, PhD, is developing new methods of displaying and analyzing images, primarily for medical applications. We have introduced a new device called the Sonic Flashlight® for guiding invasive medical procedures by placing ultrasound images directly within the patient (see top figure below), so that the clinician can see the internal anatomy in-situ, visually fused with the external anatomy and the surgical tool. After extensive development and successful testing in patients for the placement of catheters in the deep veins of the arm, we are currently looking for partners to commercialize the technology based on issued US and foreign patents to the University of Pittsburgh. With more than a decade of continuous funding from the NIH, we have extended the approach to holography-based displays and are currently developing a similar in-situ image guidance system to display optical coherence tomography under the surgical microscope to guide eye surgery. We are also developing a system called ProbeSight, using video cameras mounted on the ultrasound transducer to the incorporate visual information from the surface of the patient with the ultrasound data for better anatomical localization. Most recently, we are developing a new type of surgical tool, the Hand-Held Force Magnifier, which provides a magnified sense of force at the tip of the tool for microsurgery (lower figure), by actively pushing or pulling on the handle of the tool relative to a brace attached to the back of the hand. Other projects include FingerSight ™ to allow visually impaired individuals to sense the visual world with their fingertip, as well as automated image analysis systems for 2D and 3D medical images.

Background and Further Research

Professor of Bioengineering, University of Pittsburgh and Adjunct Research Professor, Robotics Institute, CMU. MD, State University of New York, Health Science Center at Syracuse, 1991; PhD (Biomedical Engineering), University of North Carolina at Chapel Hill, 1999. Dr. Stetten's recent research interests include image-guided surgery using an ultrasound device he invented called the Sonic Flashlight, and various adaptations of the underlying principle of in-situ image guidance, including one based on Optical Coherence Tomography for microsurgery. In addition, he is developing image analysis techniques for automated identification and measurement of anatomical structures, in particular vasculature in the brain and bones in joints using dynamic stereoscopic x-ray. He was a founding member of the National Library of Medicine's Insight Toolkit for image segmentation and registration and is a fellow in the American Institute of Medical and Biological Engineering. Working with Roberta Klatzky in CMU Psychology, he has developed a technology called FingerSight for the vision impaired, which involves fingertip video cameras linked to vibratory stimulators. He is also developing a new surgical tool that magnifies the sense of touch, enabling the surgeon to feel forces during delicate procedures. His teaching efforts include the development of a new open-standard testing format, enabling instructors to create and score their own multiple choice exams, called LaTeX Open-Format Testing (LOFT) and a student-built electronics instrumentation package called the PittKit. He is the founding director of the Music Engineering Laboratory in the Swanson School of Engineering and teaches a new honors course in the Engineering Foundations of Music.



A list of publications can be found at:
http://www.vialab.org/main/Publications/OriginalPapers.html

Gelsy Torres-Oviedo, PhD

Associate Professor
Co-director, *Human Movement Research Laboratory*

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Motor Adaptation Research Laboratory

We investigate the ability of the human motor system to adapt walking patterns and learn new movements upon sustained changes in the environment. I am interested in improving the gait of patients with unilateral cortical lesions, such as stroke. To this end, I also study how to stimulate learning mechanisms in post-stroke survivors via locomotor adaptation paradigms. I particularly focus on investigating 1) the adaptability of muscle coordination in patients and healthy subjects when they experience novel walking conditions, 2) the functional consequences (i.e., biomechanical changes) of the adapted muscle activity, and 3) the generalization of adaptation effects from treadmill walking to over ground locomotor movements. To attain these goals, I am an expert in quantifying human motor behavior through kinematic, kinetic and muscle activity recordings. I also understand how to design adequate psychophysical experiments to observe the adaptation of locomotion in human subjects with and without neurological disorders. Three ongoing research projects are described below.

Development of Personalized Gait Rehabilitation Post-stroke

A major challenge in physical rehabilitation is developing treatments that are both effective and efficient. Most physical treatments follow a general protocol for all patients, but often do not achieve similar positive results. It is well accepted that personalized treatments would improve clinical outcomes. However, current standard measures are frequently insensitive to detect individual variations across patients. Thus, sensitive measures to patient-specific impairments are needed to customize treatments accordingly. In this project we have two main goals: 1) to examine patient-specific deficits leading to step asymmetry during gait in individuals with stroke, and 2) to develop strategies to specifically target these deficits. To this end, we developed an analytical model and an innovative experimental approach to evaluate what patient-specific deficits underlie step asymmetry post-stroke. Based on this information we target asymmetries specific to each patient. These are key steps towards developing personalized gait rehabilitation after stroke.

Understanding the Effect of Aging in Locomotor Learning

While walking without falling in an ever-changing environment is easily achieved by most of us, older adults frequently fall -leading to fatal and non-fatal injuries. A critical process enabling us to navigate with ease across different terrains is motor adaptation, which allows us to adjust our movements to match environmental demands. For example, we adapt our stepping when walking on icy-surfaces to avoid falling. Despite the relevance of motor adaptation for balance control in walking, little is known about how this process changes with age. Therefore, we investigate the motor adaptation mechanisms available to older adults during locomotion. To this end we will use an innovative split-belt treadmill paradigm, which can be used in the laboratory to create novel environmental conditions by moving the belts independently under each foot. While young adults can adapt their gait during split-belt walking and learn new locomotor patterns, it is not clear if these abilities change with age. This is relevant because if we understand the learning mechanisms available to older adults we will use them to optimize the use of the split-belt treadmill as a rehabilitation tool in older clinical populations.

Understanding Generalization of Locomotor Learning

A primary issue in rehabilitation robotics is the fact that devices like exoskeletons and treadmills correct patients' movements while using the device but not without them. Several clinical trials have reported limited efficacy of robotic aid in gait rehabilitation -possibly because patients cannot improve their mobility during 'real-life' situations off of the training devices. To address this challenge our objective is to identify key factors that regulate the generalization of locomotor learning after stroke. Our *rationale* is that once factors mediating the generalization of learning are identified, they could be harnessed to develop interventions that would improve the mobility of stroke survivors beyond the clinical setting. In these projects we use a computational framework and experimental approaches that analyze step-to-step changes when subjects transition between treadmill and overground walking. Our results allow us to generate predictions on how to train patients to maximize the positive effects of treadmill-assisted learning to real-life situations.

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Jonathan Vande Geest, PhD

Professor

Principal Investigator Brief Biography

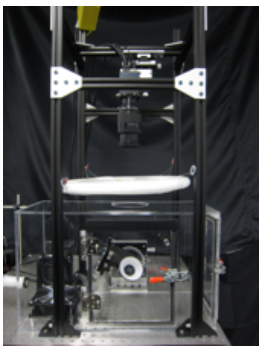
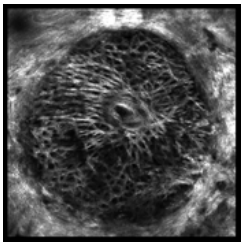
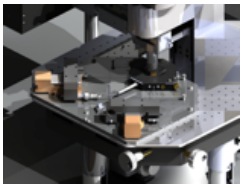
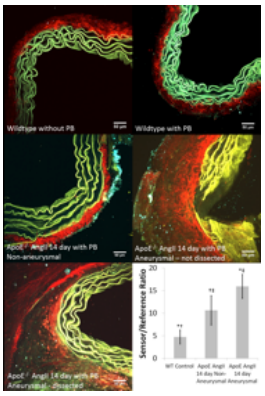
Dr. Jonathan Vande Geest is a Professor in the Department of Bioengineering and holds affiliate faculty positions in the McGowan Institute for Regenerative Medicine, the Louis J. Fox Center for Vision Restoration, the Vascular Medicine Institute, and the Department of Mechanical Engineering and Material Science. He received his BS in Biomedical Engineering from the University of Iowa in 2000 and his PhD in Bioengineering from the University of Pittsburgh in 2005. Dr. Vande Geest joined University of Pittsburgh in January of 2016.

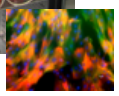
Dr. Vande Geest is a currently a member of the Biomedical Engineering Society (BMES), the American Society of Mechanical Engineers (ASME), the Association of Research in Vision and Ophthalmology (ARVO), the American Heart Association (AHA), the International Society for Applied Cardiovascular Biology (ISACB), and the American Physiological Society (APS). He currently serves as the Chair of the ASME Bioengineering Division Solids Technical Committee and as an Associate Editor for the *Journal of Biomechanical Engineering*.

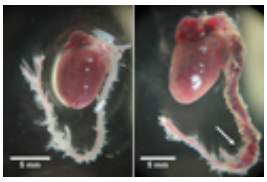
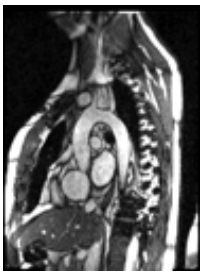
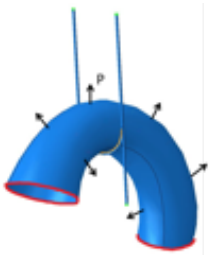
Soft Tissue Biomechanics Laboratory

The primary goal of the Soft Tissue Biomechanics Laboratory (STBL) is to develop and utilize novel experimental and computational bioengineering approaches to study the structure function relationships of soft tissues in human growth, remodeling, and disease. These relationships are then used to develop and fabricate the next generation of novel endovascular medical devices and bioactive drug therapies.

The STBL achieves this goal by seamlessly bringing together state-of-the-art techniques in tissue characterization, device fabrication, nonlinear optical microscopy, finite element modeling, and cell mechanobiology. This multifaceted approach allows members of the STBL and its interdisciplinary collaborators to expedite the mechanistic understanding and therapeutic treatment of human disease.



Current Active Projects

- Assessing the role of the extracellular matrix and cell mechanobiology in primary open angle glaucoma
- Development of a functional biopolymer-based compliance matched tissue engineered vascular graft using human tropoelastin and blood derived endothelial cells
- Assessing the role of aortic compliance in the onset of idiopathic vocal fold paralysis
- Experimental and computational optimization of patient specific endovascular medical devices
- Experimental, analytical, and computational modeling of the multiphasic and chemo-mechanically driven growth and remodeling of soft tissues
- Extracellular matrix remodeling of murine aneurysm

David A. Vorp, PhD

Associate Dean for Research
Professor of Bioengineering, *Cardiothoracic Surgery, Surgery, and the Clinical and Translational Sciences Institute*
Director, *Vascular Bioengineering Laboratory*

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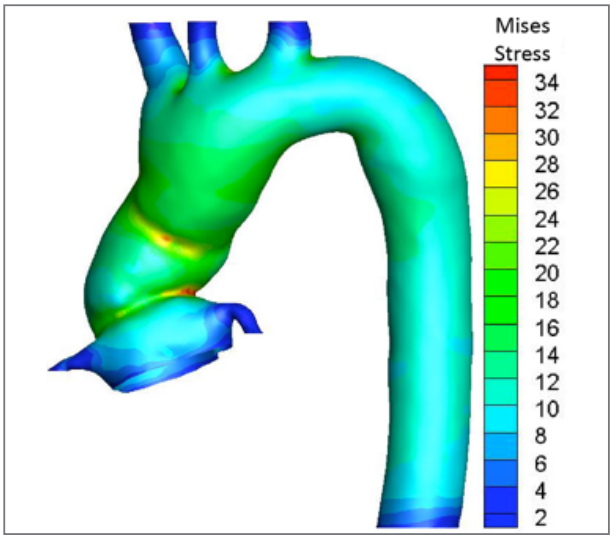
Vascular Bioengineering Laboratory Mission

Pathologies of the vascular system are tightly linked to biomechanical alteration of the vessel wall during disease. By applying our strengths in computational and experimental biomechanics, image analysis, cellular and molecular biology, and tissue engineering, our research mission is *to develop regenerative treatments for vascular diseases such as aortic aneurysm and coronary heart disease*. In addition to our research mission, we aim to train the researchers of tomorrow using the most cutting-edge technology available. Ongoing projects in the lab include:

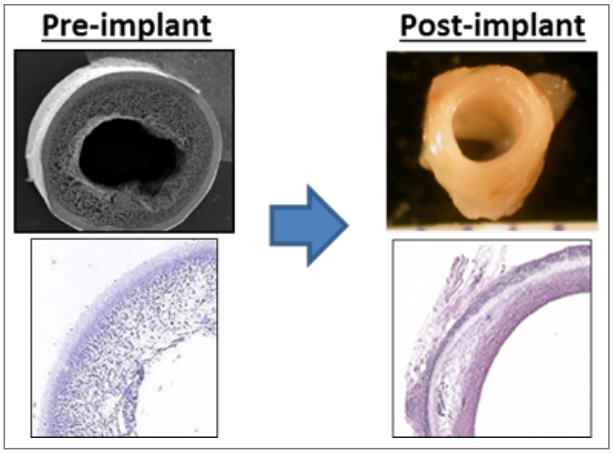
- Assessing the mechanopathobiology of thoracic and abdominal aortic aneurysm
- Creating a novel regenerative therapy for abdominal aortic aneurysm
- Developing a human stem cell-based tissue engineered vascular graft
- Characterizing the biomechanics of cerebral aneurysms, including changes that occur with coil embolism therapy
- Using a novel ex-vivo perfusion system to simulate the biomechanical milieu of vascular diseases
- Extending our biomechanical analysis to other tubular structures such as the urinary tract, intestine, and esophagus

Our best assets for collaboration pertain to the thrusts of ***vascular biomechanics*** and ***vascular tissue engineering***.

Vascular Biomechanics: Our group performs both experimental and computational biomechanics studies on tubular tissues; recent studies have focused on aneurysms of the aorta (thoracic and abdominal) and cerebral arteries but we also have experience with the ureter, esophagus, and intestine. On the experimental end, we perform extensive mechanical testing of tissues including tensile and compression tests, indentation tests, perfusion tests, and dynamic mechanical tests. Using mechanical properties determined from experimental testing we build strain energy function models of these tissues and computationally analyze the progression of degenerative disease. We also work with imaging collaborators at the School of Medicine to obtain structural information on human blood vessels; the geometries of these tissues have allowed us to computationally model stress distributions and develop rupture potential indices.



Vascular Tissue Engineering: Our group is developing an autologous tissue engineered vascular graft (TEVG) utilizing adipose-derived mesenchymal stem cells (AD-MSCs) seeded into tubular porous synthetic scaffolds. Utilizing our novel cell seeding device which applies rotation and vacuum to a lumenally infused cell suspension, we are able to seed our vascular grafts rapidly, evenly, and efficiently. Our TEVG has remained patent during rodent implantation, remodeling extensively in vivo towards a blood vessel-like architecture. A unique slant to our investigation in recent years has been testing AD-MSC from patients at high cardiovascular risk, such as diabetics and the elderly; determining if these patient populations will be suitable for autologous therapy will be critical in designing the next generation of vascular grafts.



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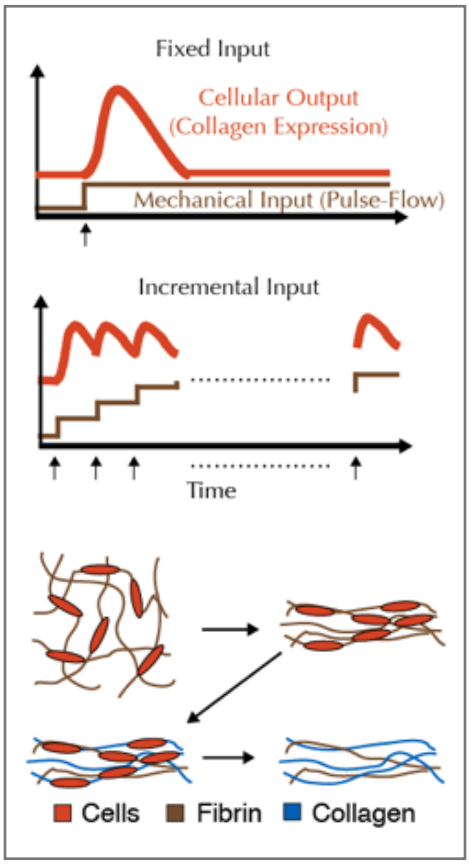
Justin S. Weinbaum, PhD

Research Assistant Professor
Director, *Vascular ECM Dynamics Laboratory*
Associate Director, *Vascular Bioengineering Laboratory*

Vascular ECM Dynamics Laboratory

Our laboratory uses a multidisciplinary approach. At the fundamental biological level, we are dedicated to understanding how the native extracellular matrix orchestrates tissue regeneration. As bioengineers, we use this information to innovate strategies to combat vascular disease. Our most recent work has focused on fabricating small-diameter vascular grafts and slowing the progression of abdominal aortic aneurysms.

Our primary areas of expertise are in extracellular matrix biology (particularly with respect to components of the elastic fiber and matricellular proteins), cell-matrix interactions, matrix modulation of growth-factor signaling, non-invasive reporters of matrix turnover, three-dimensional biological scaffolds, and vascular engineering.



Multiple opportunities for collaboration are available for future lines of research. Potential topics of interest include:

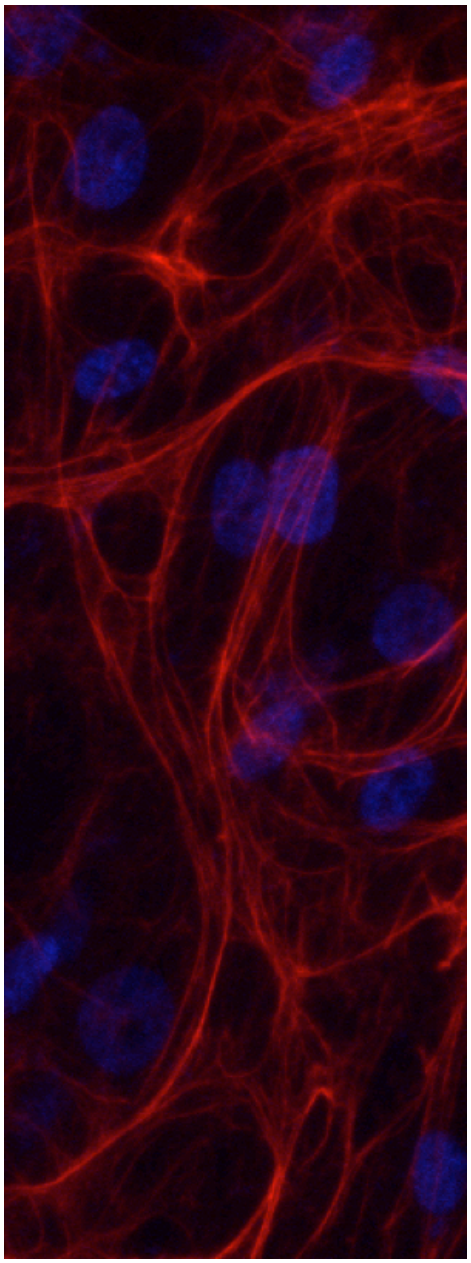
1) Designing novel degradable scaffolds functionalized with matricellular protein domains to guide the behavior of host cells (adhesion, migration, differentiation)

2) Using cellular "reporter" technologies to optimize ECM remodeling in the context of a dynamic chemical/mechanical environment (e.g. varying growth factors, stretching regimes)

3) Improving decellularization techniques to preserve an ECM rich in matricellular proteins; thereby enhancing downstream remodeling and recellularization

4) Establishing three-dimensional models for studying vascular physiology and pathology

5) Modulating growth factor activity in the context of wound healing to reduce scar formation



Smooth muscle cells (pictured) and fibroblasts are experts at assembling an extracellular matrix rich in elastic fibers (red). Using methods that we are developing to monitor elastic fiber production noninvasively, we are increasing the production of elastic fibers in tissue-engineered arteries.

Selected Publications

Krawiec JT*, Weinbaum JS*, Liao H-T, Ramaswamy AK, Pezzone DJ, Josowitz AD, D'Amore A, Rubin JP, Wagner WR, Vorp DA. In Vivo Functional Evaluation of Tissue Engineered Vascular Grafts Fabricated Using Human Adipose-Derived Stem Cells from High- Cardiovascular Risk Populations. Tissue Eng Part A. 22(9-10):765-75 (2016) *=equal contribution

Krawiec JT, Liao H-T, Kwan L, D'Amore A, Weinbaum JS, Rubin JP, Wagner WR, Vorp DA. Evaluation of the Stromal Vascular Fraction of Adipose Tissue as the Basis for a Stem Cell-Based Tissue Engineered Vascular Graft. J Vasc. Surg. 66(3):883-890 (2017)

Savio L-Y. Woo, PhD, D.Sc., D.Eng.

Distinguished University Professor Emeritus
Director, *Musculoskeletal Research Center*

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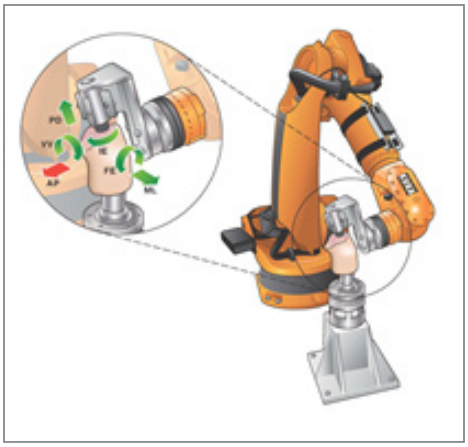
Knee Joint Biomechanics & Robotics Laboratory

Tissue Mechanics Laboratory

Mechanobiology Laboratory

Dr. Savio L-Y. Woo is a Distinguished University Professor Emeritus of Bioengineering and the Founding Director of the Musculoskeletal Research Center (MSRC). Dr. Woo is a pioneer in bioengineering and is renowned for his 50+ years of translational research in healing and repair of tissues. Together with hundreds of students, residents, fellows and junior faculty members, the teams have published 311 original research papers in refereed journals as well as 158 book chapters and review articles. The outcome of their work has directly impacted the management of ligament and tendon injuries including clinical paradigm shifts that has led to significant improvement in patient outcome.



Dr. Woo's research has focused on: 1) accurate measurement of the biomechanical properties of ligaments and tendons and *in-vitro* and *in-vivo* joint mechanics and function, and 2) using functional tissue engineering (FTE) strategies to biologically accelerate the healing and regeneration of ligaments and tendons. Dr. Woo is the inventor of the robotic/UFS testing system, or "Smart" Robot, to determine joint kinematics under unrestricted, multiple degrees-of-freedom (DOF) motion and *in-situ* forces of soft tissues and their replacements in a non-contact way. The system collects data of ligaments and their replacement grafts from the same specimen; thus eliminates interspecimen variations and increases statistical power (repeated measures ANOVA). This powerful apparatus has been adopted by more than 30 other laboratories.

Dr. Woo has worked in collaboration at the Steadman Philippon Research Institute on using a bi-planar fluoroscopy system that can capture bone motions to within 0.2mm/0.2° accuracy. Thus, this new system can obtain *in-vivo* kinematic data to help characterize the function of the anterior cruciate ligament (ACL) and understand mechanisms of ACL injury that could lead to better ways for injury prevention.

More recently, Dr. Woo and his team have designed biodegradable and bioresorbable magnesium (Mg) devices. These devices can aid soft tissue (e.g. ACL) healing and then programmed to degrade so that the healing tissue would take over the loads so that it could become better and stronger. The devices can also be used together with extracellular matrix scaffolds and hydrogels to further accelerate the healing process.

Selected Referenced Journal Articles

Woo, S.L-Y., Fox, R.J., Sakane, M., Livesay, G.A., and Rudy, T.W.: Biomechanics of the ACL: Measurements of *In Situ* Force in the ACL and Knee Kinematics. Knee, 5:267-288, 1998.

Torry, M.R., Shelburne, K.B., Peterson, D., Giphart, J.E., Krong, J., Steadman, J.R., Woo, S.L-Y.: Knee Kinematic Profiles During Drop Landings: A Bi-Plane Fluoroscopy Study. Medicine & Science in Sports & Exercise, 43(3):525-532, 2011.

Farraro, K.F., Kim, K.E., Woo, S.L-Y., Flowers, J.R., McCullough, M.B.: Revolutionizing Orthopaedic Biomaterials: The Potential of Biodegradable and Bioresorbable Magnesium-Based Materials for Functional Tissue Engineering. J. of Biomechanics, 47(9):1979-1986, 2014.

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Ioannis Zervantonakis, PhD

Assistant Professor
UPMC Hillman Cancer Center

Tumor Microenvironment Engineering Laboratory

Understanding cell behavior in native tumor microenvironments and developing new strategies to deliver therapeutics directly to tumor cells are critical in improving and extending patients' lives. Our lab employs a quantitative approach that integrates *microfluidics*, *systems biology modeling*, and *in vivo experiments* to investigate the role of the tumor microenvironment on breast and ovarian cancer growth, metastasis and drug resistance. Our goal is to develop bioengineered tumor microenvironment platforms and apply them to improve understanding of tumor-stromal signaling mechanisms in order to: (1) discover biomarkers that guide new drug development and improve prognosis, (2) develop new strategies to improve existing treatment protocols and (3) engineer microfabricated tools that enable screening and personalization of cancer therapies.

Research Projects

1. Cellular dynamics in stroma-rich breast cancer microenvironments

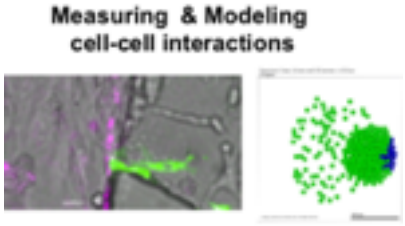
Advanced HER2+ breast cancer has a poor prognosis; improving patient outcomes will depend on elucidating mechanisms of therapy resistance. Motivated by our in vitro co-culture studies, we hypothesized that fibroblasts activate tumor cell pro-survival signaling and contribute to drug resistance. To dissect mechanisms of fibroblast-mediated therapy resistance we measure the dynamics of breast cancer cells to HER2-targeting therapy using microfluidic tumor slice cultures and controlled co-culture assays. By integrating live cell death measurements with mathematical modeling we explore mechanisms of cell-cell communication and develop an integrative framework to predict therapy resistance in breast tumors that exhibit different stromal fibroblast densities.

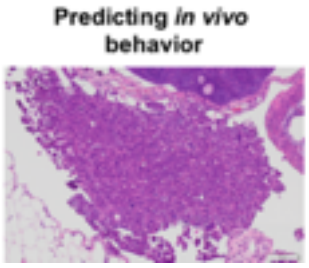
2. Microfluidic models of ovarian cancer metastasis

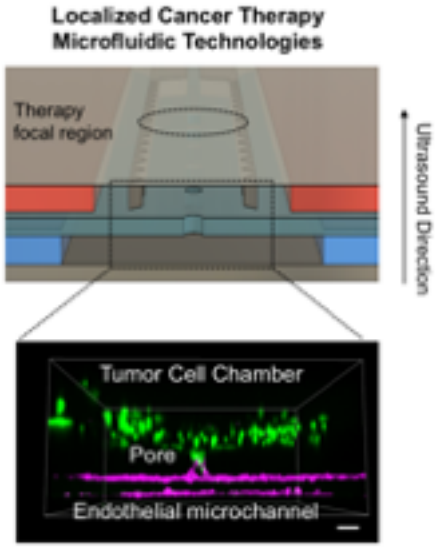
Ovarian cancer is oftentimes not detected until after metastases have occurred. The mechanisms of tumor cell survival during metastatic spread and the role of biomechanical and biochemical factors on ovarian cancer invasion remain poorly understood. We have developed a microfluidic device to control the interactions of ovarian cancer cells with a mesothelial barrier and macrophages under fluid flow. The goal of this project is to determine the role of fluid flow-induced forces and biochemical factors secreted by macrophages on ovarian cancer invasion.

3. Localized drug release and single-cell technologies in cancer therapies

We have developed a 3D acoustofluidic platform to monitor heating-induced localized drug release and study mechanisms of thermal cytotoxic therapy enhancement in invasive ovarian cancer. To improve therapies targeting heterogeneous ovarian cancers we are engineering single-cell microwell assays that enable screening of patient-derived cells and xenograft models.







RESEARCH LABORATORIES, CENTERS, AND INSTITUTES

Office of Industry and Economic Partnerships

https://oiep.pitt.edu

Associate Vice Chancellor
Cynthia Sweet *cynthia.sweet@pitt.edu*

Director of Partnerships
Brian Vidic *vidicba@pitt.edu*

Mission

Created in 2015, Pitt's Office of Industry and Economic Partnerships (OIEP) was formed to create and implement an economic development framework that enhances the University's mission to advance teaching, research, and public service. The framework is designed to increase Pitt's ability to partner on economic opportunities, connect the University to the global economy, and accelerate growth in the regional economy. The framework is built on several strategies.

Corporate Engagement

OIEP functions as an ambassador to the business community, helping companies leverage Pitt's world-class resources to gain a competitive advantage. That includes research services, product development, licensing our IP, recruiting Pitt students, developing employee training programs, increasing brand visibility on campus and participating in community development.

Global Partnerships

Currently, the University of Pittsburgh has 235 cooperation agreements in 73 countries aimed at finding answers to global challenges through cutting-edge research and problem-solving. Partnership models include research, commercialization centers, collaborations, faculty exchange, joint research agreements, clinical research support, community engagement and strategic philanthropy.

Venture Capital

OIEP promotes Pitt startups to venture capital funds, facilitates introductions and opens doors for funding opportunities. One resource for OIEP supports is LifeX Labs, a life science accelerator that provides resources and expertise to help entrepreneurs quickly move their ideas from the benchtop to the bedside.

Key Initiatives

Access to Core Facilities and Labs

The fee-for-service partnership program helps businesses access Pitt's world-class research, facilities, and faculty expertise to make their businesses more competitive. That, in turn, facilitates knowledge transfer from Pitt to industry, government and non-profits in the fields of science, technology and health, as well as generates additional revenue for the university.

GRID Institute

Pitt's Energy Grid Research and Infrastructure Development (GRID) Institute is a global consortium focused on modernizing the power grid and energy infrastructure in Pittsburgh, the U.S. and ultimately the world. OIEP helped launch the project in 2016 with $5 million in funding and 20,000 square feet of laboratory space at the Energy Innovation Center in Pittsburgh's Hill District.

Life Science Opportunity Analysis

As part of its goal of develop Pittsburgh's potential as a biotech hub, OIEP engaged an economic development consulting firm to analyze the region's current strengths and weaknesses in the life sciences and develop a growth strategy. The report concluded Pitt's strength in healthcare and research can be amplified by expanding the region's life sciences ecosystem.

Brookings Report

The Brookings Institute studied alternatives for growing the biotech industry in the Pittsburgh region and it recommended developing innovation clusters, supporting high-growth entrepreneurs and increasing workforce development efforts. InnovatePGH, a public private partnership, is now working to implement the Brookings recommendations.

Innovation District

OIEP has played an active role in founding The Pittsburgh Innovation District, which is centered on the Oakland neighborhood and bridges innovation assets in the Strip District, Lawrenceville, East Liberty + Bakery Square, Hazelwood Green, the South Side, Uptown, Downtown, the North Side and beyond. InnovatePGH is working to advance the Brooking's Innovation District project.

Biomedical Computing Laboratory

PI
Liang Zhan, PhD
liang.zhan@pitt.edu

Mission

My Lab is interested in the bio signal modeling and computing. We collaborate with many other researchers in medical school and use the bio signals (e.g. EEG, MRI) to study different brain diseases (Alzheimer's disease, Parkinson disease, bipolar disorder, 22qDS, depression, TBI and stroke etc). Our mission is to identify the possible non-invasive imaging biomarkers to assist the clinical diagnosis and lower the healthcare costs.

Objective 1

Big Data for Healthcare

To build novel tools to fuse all available clinical biomarkers, images, genomes, across data types, diseases and continents worldwide to discover optimal biomarkers for different brain diseases.

Objective 2

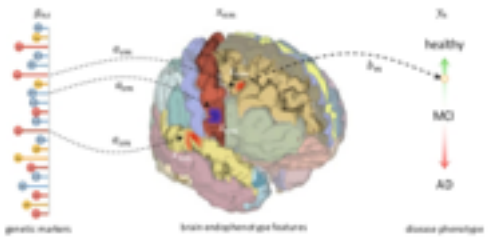
Mapping Brain Modular Longitudinal Pattern

Mapping brain functions, activities and clinical measures to each modular structure and create a thorough modular progression model for different brain diseases and normal aging for each gender

Objective 3

Build Genetics-Modular-Function Correspondence

Traditional imaging genetics focus on finding the genetic correlations with some measures from voxel level or ROI level. To develop a computation framework for mapping the high dimensional genetic-modular correspondence and associate this correspondence with brain functions and diseases.



Center for Medical Innovation

www.engineering.pitt.edu/cmi

Executive Director
Alan D. Hirschman, PhD

PITT | SWANSON ENGINEERING
CENTER FOR MEDICAL INNOVATION

The Center for Medical Innovation (CMI) is an interdisciplinary program housed within the Department of Bioengineering. The Center's purpose is to stimulate, guide, and promote the development and commercialization of technological innovations to improve health care. The CMI provides an organizational structure that links faculty, students, and clinicians across the University of Pittsburgh through collaboration among the Swanson School of Engineering (SSoE), Schools of the Health Sciences, the Katz Business School, the School of Law, the Coulter Translational Research Partnership, and the Innovation Institute. As of 2018 more than 60 early-stage projects have received seed funds totaling $1.2 million from CMI out of 240 competitive proposals considered since program inception in 2012. Nine of these clinical translation projects have attracted significant external investment for commercialization, and all have resulted in significant intellectual property development. Other projects have successfully competed for large external awards from government and private foundations as a result of the CMI Early Stage Seed Grant Funding Program. A few projects have resulted in new company formation.

CMI's research mission is to serve as a "matchmaker" between the engineering faculty in the Swanson School and the clinical faculty of the Schools of Health Sciences. CMI catalyzes the development of such partnerships between engineers, clinicians, and students who have interests in translating their applied research into commercial products meeting the needs of healthcare delivery.

CMI's educational mission to train the next generation of medical product innovators, managers, and developers is met through the Master of Bioengineering/ Medical Product Engineering curriculum. The 30-credit MS program, established in 2012, is aimed at providing clinical project experience, introduction to new product methodologies considered state of the art in industry, and networking opportunities with regional players in the medical product development industry. Most of our program graduates go on to careers in medical product development, marketing, regulatory affairs, consulting, and entrepreneurship.

Projects identified and funded by CMI have resulted in partnerships between most of the engineering departments at SSoE and many of the clinical disciplines at the Schools of Health Sciences. Additional outreach efforts have resulted in partnerships with Carnegie Mellon University and the Allegheny Health Network. The CMI has contributed to career development of our graduates by collaborating with industry partners to place students in jobs and internships.

Dr. Alan D. Hirschman, Professor of Bioengineering, serves as CMI's Executive Director. After a career of more than 30 years in research and industry, Dr. Hirschman joined the faculty of the Department of Bioengineering in 2011. He and his colleague, Dr. Kilichan Gurleyik, Assistant Professor of Bioengineering and CMI's Associate Director of Education, have primary responsibility for guiding the research and educational missions of CMI. They are assisted by a multidisciplinary team of engineering faculty, clinical faculty, and representatives of the Innovation Institute. An industry Board of Advisors provides input into CMI's direction.

Dr. Alan D. Hirschman, PhD Dr. Kilichan Gurleyik, DSc

Coulter Translational Research Partners II Program

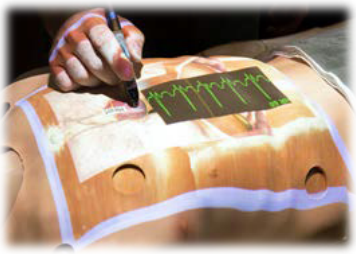
http://www.engineering.pitt.edu/coulter/

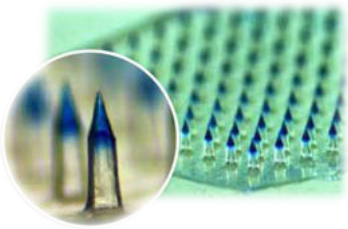
Vision

To provide the anchor for translating University of Pittsburgh biomedical and engineered technologies to commercialization. The Coulter Translational Research Program (Coulter) envisions itself playing a key leadership role in translational biomedical research, education, and commercialization, making significant contributions to enhancing healthcare, educating future innovators and entrepreneurs, and promoting economic development in our region.

Mission

- To identify, select, develop, and commercialize promising technologies originating from faculty sponsored biomedical research that address significant unmet clinical needs and promise to improve patient care worldwide.
- To create a culture of innovation and entrepreneurial thinking across the biomedical engineering community by uniting faculty and students from engineering or the physical sciences with clinicians from the Schools of Health Sciences, students from the Joseph M. Katz Graduate School of Business (Katz) and the School of Law, and members of the business community.





Objectives

Translational Research and Commercial Preparedness. Since the Program's funding by the Wallace H. Coulter Foundation in 2011, along with additional matching funds from the Swanson School of Engineering (ENGR), the Schools of the Health Sciences, and the Innovation Institute, Coulter has accelerated the translation of new technologies to improve healthcare and address challenging unmet clinical needs. Our primary objective is to advance projects toward commercial endpoints by way of a unique risk reducing process comprised of business and stakeholder analysis, mentorship, and hands-on project management.

Competitive Grants. The Program also awards competitive grants to deserving research teams that have advanced their technologies to the point where they may be considered for license or new business formation. Coulter aims to further reduce technical and business adoption risk by funding pre-clinical and clinical work that may pave the way for commercial and clinical adoption.

Collaboration. We view ourselves as part of the continuum of innovation from basic research to commercial translation. Housed within the Bioengineering Department of the Swanson School of Engineering, we collaborate closely with the Center for Medical Innovation (CMI) and the Clinical Translational Science Institute (CTSI) that support pilot projects, which often then advance through the Coulter Program. Ultimately, we work with the Innovation Institute to help assure a successful transition to commercial enterprises. Our objective is to continue to strengthen these relationships and partner with other programs across campus.

Education. Our educational objective is to engage faculty and students in the process of innovation and entrepreneurship by way of our rigorous and immersive process. Scientific and clinical PI's work together with fellows and students to develop regulatory, reimbursement, IP and business strategies. We also recruit graduate students from ENGR, Katz and Law schools to assist project teams during 14-weeks of Coulter Coaching intended to align the technology-based solutions with real world needs.

Summary

Since its inception, the Coulter Program has established a new model to assure that Pitt's world-class biomedical research ideas become commercial solutions to real-world problems. In its short history, the Coulter Program has:

- Attracted over **218 applications** covering medical devices, drug delivery systems, and diagnostics
- Funded 36 projects and 71 principal investigators with an awarded total of over $3.5 million in direct grant support
- Enabled formation of **SEVEN companies with $13 million in professional funding**
- Enabled granting of **FOUR licenses**, and four additional licenses expected before end of FY2019
- Generated an additional **$14 million in follow-on grant funding** to the University
- Directly and indirectly impacted **125+ students and 35 departments across Pitt**

Human Movement and Balance Laboratory

http://engineering.pitt.edu/hmbl/

Investigators

April Chambers, PhD
Rakié Cham, PhD
Kurt Beschorner, PhD
Mark Redfern, PhD

Mission

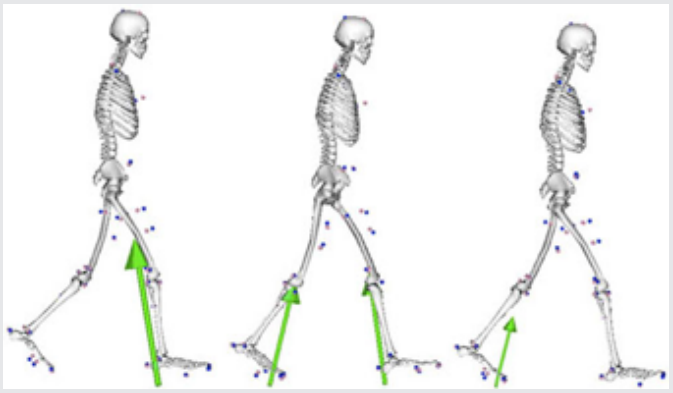
The mission of the Human Movement & Balance Laboratory (HMBL) is fall and musculoskeletal injury prevention in healthy and clinical young/elderly adult populations. We achieve these goals by gaining a thorough understanding of the biomechanical and postural control principles that govern human movement, balance during standing/walking, and performance of occupational tasks. A multidisciplinary group of researchers including biomechanical engineers, physicians (geriatricians, neurologists and psychiatrists), and physical/occupational therapists work in close collaboration to achieve our research goals. HMBL is a state of the art space designed and equipped to analyze the dynamics of human motion.

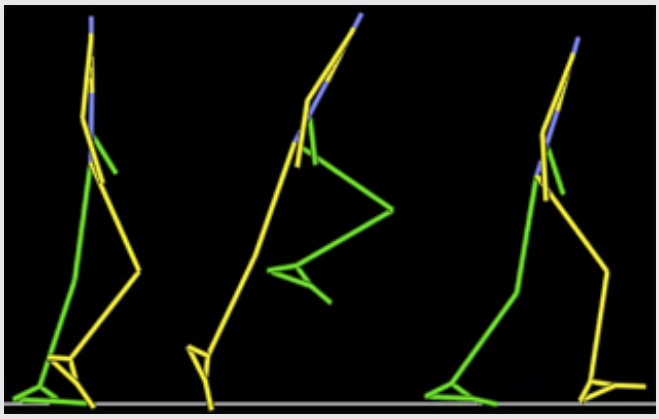
Objectives

Current research projects include a wide range of experimental studies examining fall prevention following external disturbances such as slipping or tripping, prosthetics, ergonomic-related research, cognitive research and imaging applications in various population types. In conjunction with experimental studies, biomechanical computer modeling is used to gain a greater understanding of the impact of environmental and human factors on the risk of falls and injury.

Summary

Our laboratory is a full gait analysis facility specifically designed to conduct locomotion studies related to postural control but also capable of capturing small finger movements involved in typing. Three dimensional motions and foot forces as well as electromyographic data can be collected during walking or other daily tasks including activities such as stopping, turning, multitasking, etc. We are also equipped with an electromyography and accelerometer system, a Biodex strength machine, a Biolog heart rate and skin conductance monitor. The motion data is collected and synchronized with ground reaction forces and other biomechanical data. Thus, this system allows the collection of all gait variables required to provide a complete description of whole body biomechanics. Motion capture is possible on our level walkway, uneven walkway, ramp, uneven ramp, or stairs. We are also able elicit perturbations of slips, stumbles, and trips.





The two images above are examples of the biomechanical analysis and computer modeling able to be done to better understand the factors involved in normal gait, slips, trips, and falls.

McGowan Institute for Regenerative Medicine

www.mcgowan.pitt.edu

Director
William R. Wagner, PhD

Executive Director
John Murphy

Mission

The McGowan Institute serves as the focal point for the University's leading engineering, scientific and clinical faculty who are working in the areas of tissue engineering, cellular therapies, and medical devices.

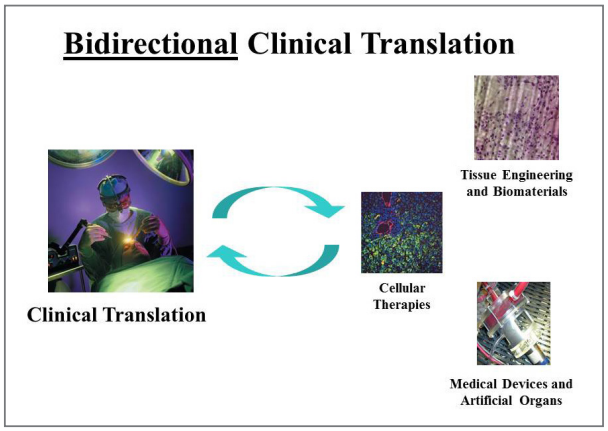
The Institute's mission is

- To provide a national center of expertise in regenerative medicine focused on developing and delivering therapies that reestablish tissue and organ function impaired by disease, trauma or congenital abnormalities;
- To foster the generation of scientific knowledge in regenerative medicine and to share that knowledge with researchers, clinicians and the public through educational activities, training and publications;
- To educate and train scientists and engineers to pursue technologies related to regenerative medicine, and train a generation of clinicians in the implementation of regenerative therapies, and;
- To support the commercialization of technologies in regenerative medicine and thereby accelerate the translation of research discoveries to clinical implementation and patient benefit.

Objectives

There are over 255 McGowan affiliated faculty, all of whom are independently recognized for their respective expertise, who have elected to work in multidisciplinary teams for the advancement of the core sciences, the development of innovative devices, procedures and clinical protocols, and the pursuit of rapid commercial transfer of new technologies related to regenerative medicine.

Many McGowan affiliated faculty are clinically active, seeing patients every day. These clinicians work with the collaborating engineers and scientists in the identification of research needs and the pursuit of solutions for such needs. This bidirectional clinical translation helps keep projects "on-target" and expedites the adaptation of new technologies in the clinic.



Also critical to the mission is the education and training of the next generation of scientists, clinicians and engineers who will be carrying the field forward toward the ultimate goal of improving the quality of life and the reduction in health care costs. Graduates who are mentored by McGowan faculty are eagerly recruited by commercial, academic and governmental entireties. Training includes opportunities in the laboratory as well as in clinical settings, a combination that is not available at many other institutions.

Technologies developed by McGowan affiliated faculty has resulted in the formation of 28 companies. These start-ups now employ over 480 people and have raised over $600 million in external funding. These companies are an essential component of the McGowan Institute commitment of rapidly moving technologies from the lab bench to the bedside.

Summary

The McGowan Institute eagerly seeks opportunities for collaboration with academic, governmental and commercial partners. The Institute Director is William R. Wagner, PhD, who is a professor in the Department of Surgery at the University of Pittsburgh, with joint appointments in the Departments of Bioengineering and Chemical Engineering. For more information, please see www.mcgowan.pitt.edu.

Orthopaedic Robotics Laboratory

genesis1@pitt.edu

Co-Directors
Volker Musahl, MD
Richard E. Debski, PhD

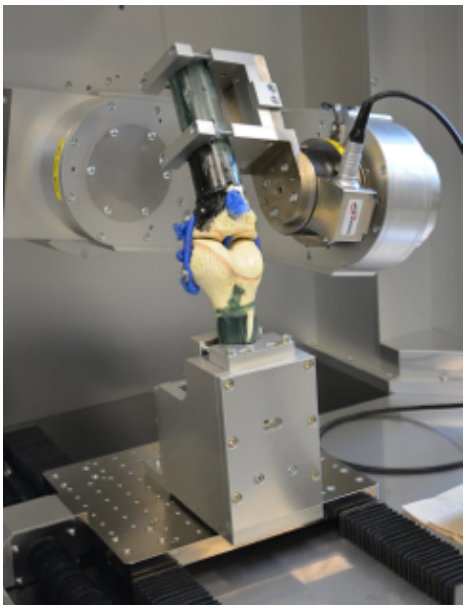
Mission

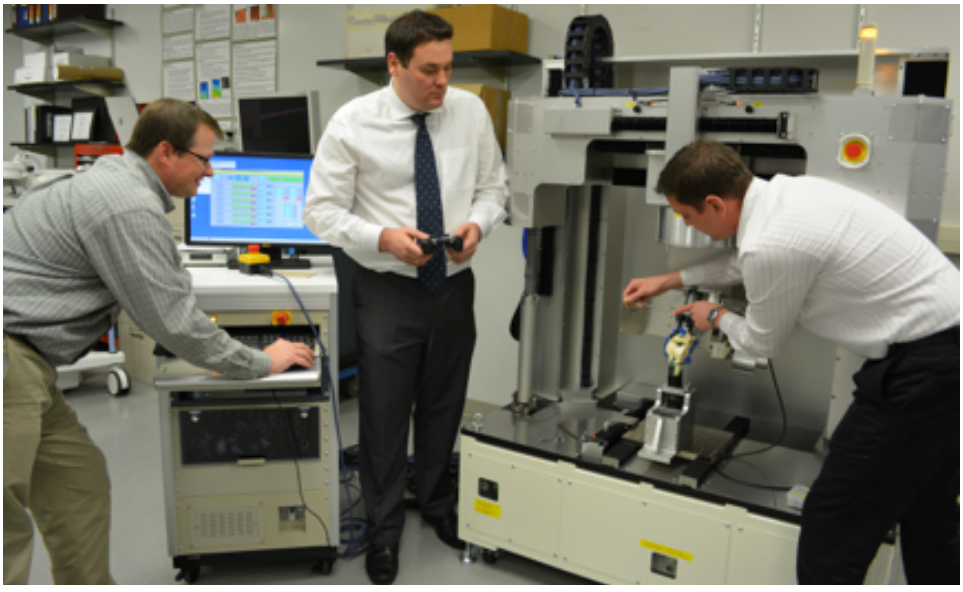
The mission of the Orthopaedic Robotics Laboratory is the prevention of degenerative joint disease by improving diagnostic, repair, and rehabilitation procedures for musculoskeletal injuries using state-of-the-art robotic technology. Thus, diarthrodial joint function will be elucidated and the roles of the bony and soft tissues assessed. The technology in the laboratory includes novel robotic systems and the lab serves as a multi-disciplinary CORE facility with collaboration promoted between investigators. The Orthopaedic Robotics Laboratory occupies 1800 sq ft in the Center for Bioengineering (CNBIO) and is a collaboration between the Department of Orthopaedic Surgery and Department of Bioengineering.

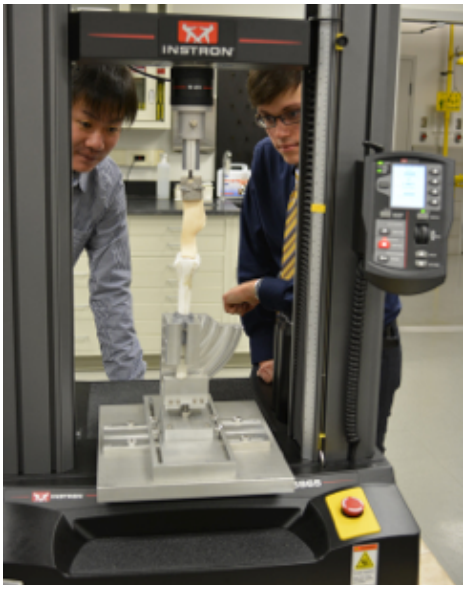
Robotic Technology

The MJT Model FRS2010 is a six-axis test robot with a compact workspace and high stiffness. The hybrid control system that uses position and force feedback is quite robust and allows a wide range of applications. Operators can modify every control parameter for their desired purpose. Thus, the MJT can be customized easily. Other advantages of the MJT Model FRS2010 are portablility, low maintenance costs, universal programming language, and realistic loading conditions. This robotic technology can also be used to examine the function of multiple joints such as the knee, glenohumeral joint, acromioclavicular joint, spine, elbow, hip and ankle.

These capabilities are enhanced by supporting equipment that can measure joint contact pressures; tissue deformations and forces during joint loading; and tissue properties. State-of-the-art fluoroscopy, ultrasound, and arthroscopy systems are available. In addition, the laboratory includes the Shoulder Testing Apparatus r4 (STAR4) that allows simulation of muscle forces at the glenohumeral joint and measures resulting motion and joint contact forces. Recently, this device has been upgraded to include the capability to test knees.







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BIOENGINEERING

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