FIU | Engineering & Computing

Biomedical Engineering

BIOMEDICAL ENGINEERING

UNDERGRADUATE RESEARCH CELEBRATION

FALL 2023

DISCOVER | DESIGN | DEVELOP | DELIVER

Presented through the generous support of the Wallace H. Coulter Foundation.

FIU Engineering & Computing

Biomedical Engineering

14th Annual
UNDERGRADUATE RESEARCH CELEBRATION

November 3, 2023 — MMC, GC 243

8:30-9:00 AM	**Breakfast**
9:00-9:05 AM	**Opening Remarks:** Dr. Kevin Boutsen, Dr. Vladimir Pozdin, and Dr. Wei-Chiang Lin
9:05-10:30 AM	**Seminar by Dr. Song Li:** "Mechano-Epigenetic Engineering For Cell Reprogramming"
10:30 AM-12:00 PM	**MME Seminar by Dr. Pranjal Nautiyal:** "Mechanically-Assisted Manufacturing of Structural Alloys and Ceramics"
10:30 AM-12:00 PM	**Meeting with BME Alumni in GC 305**
12:00-2:00 PM	**Joint Poster Session with Lunch**
2:00-3:30 PM 3:30-	**Joint Oral Session**
4:30 PM	**Career Development Seminar by Dr. Tzung Hsiai:** "Integrating Wearable Sensors, Omics, and Data Science to Ameliorate Cardiometabolic Disorders"
4:30-5:00 PM	**Joint Award Ceremony:** Dr. Arvind Agarwal and Dr. Jorge Riera

Department of Biomedical Engineering (BME) bme.fiu.edu | @fiubiomed

ORAL PRESENTATION SCHEDULE

2:00 PM **Katrina Jabech:** Innovative Hydrogels for Cardiovascular Applications

2:15 PM **Zion Michaell (MME):** Biomechanics of Biogenic Termite Structures

2:30 PM **Lorimar Santiago:** Exploration of Connection Between Cardiovascular Disease, Chronic Kidney Disease, and Alzheimer's Disease Through GM3

2:45 PM **John Marcial (MME):** Conductive Traces for Biodegradable Electronic

3:00 PM **Katherine Lopez:** Isolation Of Cerebral Microvascular Networks To Investigate Capillary-Mediated Neurovascular Coupling

3:15 PM **Nicholas Espinal (MME):** Design Improvements for H-Canyon Wall Crawling Platform: Semi-Autonomous Controls

MESSAGE FROM THE CHAIR

Congratulations Biomedical Engineering Undergraduate Researchers! Today marks a milestone in your undergraduate education, where you showcase your self-motivated contributions to research. You set a great example to all, that learning does not end in the classroom and research is a vital component of your undergraduate experience.

I am delighted that there has been a steady increase in the number of undergraduate students participating in research. Each of you has a vital role in your research projects, no matter how big or small your contributions are. The Undergraduate Celebration presentations reflect your ability to work both individually and in teams, to converge information and ideas to discover the unknown, and to find innovative solutions. During this special day, we also recognize our outstanding students in the Coulter Undergraduate Research Excellence (CURE) Program. The BME Wallace H. Coulter endowment allows us to support students in the CURE Program as they participate in a tiered research experience alongside a faculty mentor and participate in career development workshops.

As you move forward in your undergraduate education, continue motivating yourself and others around you to enhance your knowledge, remain inquisitive, and continue to grow in all aspects of learning. Thank you to all our BME Alumni for their active participation in our Undergraduate Celebration and for sharing their real-life experience as medical students, graduate students, academicians, or industry/corporate members. This truly reflects your enthusiasm to give back to the next generation of biomedical engineers!

Best wishes for continued success,

Jorge Riera Diaz, Ph.D.
Associate Professor, Interim Chair of Biomedical Engineering

BME KEYNOTE SPEAKER

MECHANO-EPIGENETIC ENGINEERING FOR CELL REPROGRAMMING

Song Li, Ph.D.

Professor and Chair of Bioengineering
University of California, Los Angeles

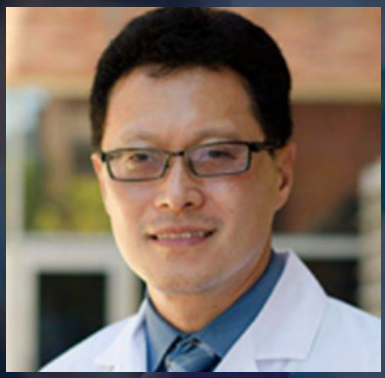
SHORT BIO: Dr. Song Li's research is focused on cell and tissue engineering. He has contributed to the understanding of how biophysical factors regulate stem cell differentiation and cell reprogramming, and has developed multidisciplinary approaches for engineering biomaterials, stem cells, and immune cells for tissue regeneration and disease therapy. Dr. Li's contributions to bioengineering have earned him numerous awards and honors, including being elected as a Fellow of the American Institute of Medical and Biological Engineering, the Biomedical Engineering Society, and the International Academy of Medical and Biological Engineering.

ABSTRACT: Our research focuses on cell and tissue engineering, with the goal of utilizing the potential of stem cell differentiation, cell reprogramming, and synthetic biology to improve regenerative medicine and disease therapy. At this seminar, I will discuss our work on mechanoepigenetic engineering for cell reprogramming. While cell reprogramming allows for the transformation of cells into a different lineage, the impact of biophysical factors on this process is not yet fully understood. Our work has revealed that micro-structured materials can influence the shape of cell nuclei and epigenetic state, leading to improved cell reprogramming efficiency. Furthermore, reducing intracellular tension and cell adhesion increases chromatin accessibility and enhances cell reprogramming. We have also discovered that applying active forces, such as a millisecond squeeze on the cell nucleus using microfluidic devices, can overcome epigenetic barriers and facilitate cell reprogramming. These findings have significant implications for the field of mechano-genomics and may lead to the creation of new cell engineering technologies.

CAREER DEVELOPMENT SEMINAR

INTEGRATING WEARABLE SENSORS, OMICS, AND DATA SCIENCE TO AMELIORATE CARDIOMETABOLIC DISORDERS

SHORT BIO: Dr. Tzung Hsiai's research focuses on advanced imaging sensors to elucidate mechanotransduction underlying tissue injury and repair. Dr. Hsiai received his undergraduate education from Columbia University and his medical training from the University of Chicago. He received his PhD in BioMEMS at UCLA, and was recruited to the University of Southern California Schools of Engineering with an Early Career Endowed Chair. In 2014, he was recruited back to UCLA to promote team science, which led to the LA PRISMS Center connecting UCLA Bioinformatics and Microbiome Research with USC's Environmental Health Sciences Center.



Tzung Hsiai, Ph.D.

Professor of Medicine and Bioengineering and Maud Cady Guthman Endowed Chair in Cardiology
University of California, Los Angeles

ABSTRACT: While cardiovascular-related deaths in the U.S. have fallen, cardiometabolic disparities remain in our multi-ethnic community. Our central focus is to integrate data science and non-invasive wearable sensors to better engage individuals at high-risk for cardiometabolic disorders (CMD). We will address the unmet clinical challenges for early detection of individuals for CMD. We will present our collaboration to leverage transcriptomics to confront nonalcoholic fatty liver disease (NAFLD) as an emerging risk factor for poor cardiovascular disease outcomes. We will further demonstrate our AHA Network to address science in diversity of clinical trials to improve cardiometabolic health, and our AHA and NIH training programs to provide the next generation of bioengineers, clinicians and scientists to embrace advanced sensors, OMICS, and social determinant of health for personalized intervention.

ORAL PRESENTATION - 2:00 PM

Innovative Hydrogels for Cardiovascular Applications

Authors: Katrina Jabech and Alexi Switz
Faculty Advisor: Anamika Prasad, Ph.D.

Approximately 250,000 Americans live with advanced heart failure and yet only 2,000 patients receive a donor heart each year. In light of this donor heart shortage, researchers seek alternate long-term solutions for heart failure. Cardiac tissue engineering offers two promising solutions: injectable hydrogels and cardiac patches. Pre-clinical studies demonstrate that these solutions can regenerate nonfunctional cardiac contractile tissue. A cardiac patch is composed of a layer of electrospun fibers embedded in a cell-seeded hydrogel scaffold. The fibers are created when an electrospinner utilizes a large voltage gradient to stretch a polymer solution into the fine fibers. The hydrogel scaffold is made when an extrusion-based bioprinter systematically ejects bioink from a syringe. The bioprinting process can be paused to insert the electrospun fibers. To optimize cardiac patch performance, this research aims to improve the properties of the hydrogel component. Hydrogels are highly soluble, three-dimensional polymer networks. Those derived from natural biomaterials are highly biocompatible and have non toxic degradation products, but exhibit poor mechanical properties. Commonly used natural polymers for bioink include gelatin and methyl cellulose. Hydrogels derived from synthetic biomaterials have superior mechanical properties and customizability but poor biological activity and biocompatibility. Some examples of synthetic polymers for bioink include poly (oligoethylene glycol methacrylate) (POEGMA), and poly (Ethylene Glycol) (PEG). The goal is to synthesize a novel hydrogel with optimal properties to support cardiac tissue regeneration.

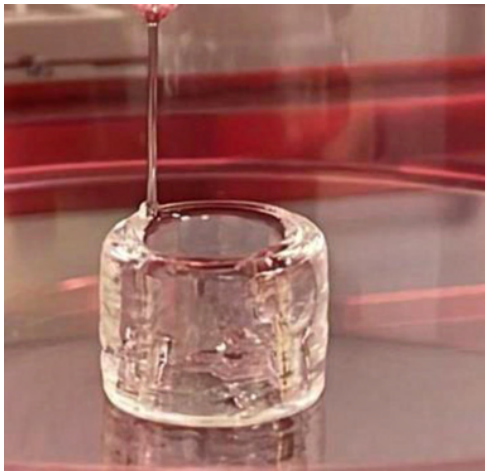


Fig 1. Cylindrical structure composed of Pluronic bioink printed using the Allevi 3 bioprinter.

ORAL PRESENTATION - 2:30 PM

Exploration of Connection Between Cardiovascular Disease, Chronic Kidney Disease, and Alzheimer's Disease Through GM3

Authors: Lorimar Santiago and Sophie K. Ashbrook
Faculty Advisor: Joshua Hutcheson, Ph.D.

Cardiovascular disease is the leading cause of mortality worldwide. Vascular calcification, the pathological formation of calcium mineral within arteries, significantly predicts cardiovascular risks in chronic kidney disease (CKD) patients. Patients with CKD are also at an increased risk for cognitive disorders such as Alzheimer's disease. Calcification and Alzheimer's both increase with age, and accelerated aging mechanisms caused by CKD may explain the shared increased risk. Renal failure in CKD causes decreased levels of klotho, an anti-aging protein produced in the kidneys [2]. Reduced klotho can result in the buildup of GM3, a glycosphingolipid in cell membranes in the brain which contributes to the development of Alzheimer's. GM3 has also been associated with arterial medial calcification. In this study, we tested the effect of arterial GM3 in adenine-induced CKD in male and female (n= 9 to 10 per group) mice. GM3 content in the aortic arch was determined after study endpoints through immunostaining followed by quantification using a custom MATLAB script to normalize the area of GM3 to total cellular area. Mice on the adenine diet exhibited a larger concentration of GM3 compared to mice on the control chow diet. The results, while not statistically significant, suggest that GM3 levels are higher in a state of renal failure, potentially caused by lack of klotho production associated with the condition. Ongoing studies will explore how klotho and GM3 levels influence the degree of calcification in the aorta and how these changes are reflected in the brain in CKD.

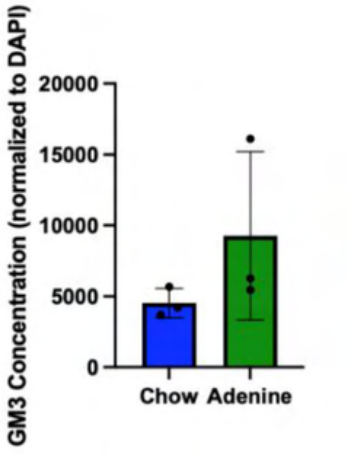


Fig 1. GM3 immunostaining results.

ORAL PRESENTATION - 3:00 PM

Isolation Of Cerebral Microvascular Networks To Investigate Capillary-Mediated Neurovascular Coupling

Authors: Katherine Lopez and Karen Colmenares
Faculty Advisor: Nikolaos Tsoukias, Ph.D.

Blood flow regulation in the brain is essential for delivering oxygen and nutrients to active neurons. Neurovascular Coupling links neural activity to changes in cerebral blood flow, a process often impaired in neurodegenerative disorders like dementia and Alzheimer's. Recent research indicates that direct communication occurs between neurons and the smallest blood vessels, capillaries, in addition to established signaling with feeding arterioles. This study aims to investigate a novel mode of neurovascular communication by adapting a capillary- arteriolar ex-vivo preparation. The experiments involve using a C57BL6 mice and genetically modified Kir2.1 knockout mice. Brain isolation is performed following euthanization, and the middle cerebral artery is dissected to isolate pial arteries and parenchymal tissue containing capillary networks. The isolated vascular network is stretched and transferred for electrophysiology and fluorescence microscopy. The ex-vivo preparation offers a valuable tool for understanding capillary dynamics and signaling in blood flow regulation. The study focuses on the electrical properties of capillary networks, including signaling dynamics and communication with upstream arterioles, with a specific interest in the Kir 2.1 channel. Preliminary work indicates the feasibility of isolating and characterizing long capillary networks. The Kir-KO mice will help explore the role of the Kir 2.1 channel in neurovascular coupling. This ex-vivo model offers insights into the electrical properties of the capillary network and its significance in neurovascular regulation, with implications for both normal brain function and neurovascular disorders.

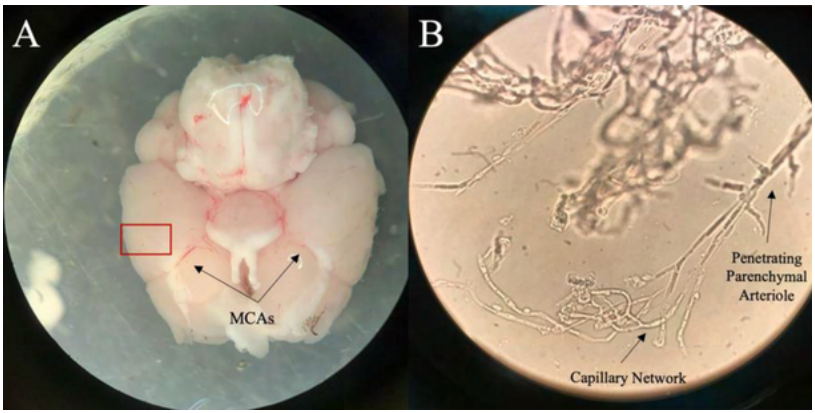


Fig 1. Isolated Mouse Brain and Capillary Network A) Basal view of an Image of the isolate mouse brain showing the depicting Circle of Willis and the Middle Cerebral Arteries (MCA) from which stems isolate capillaries. A pial artery branching out of the MCA and surrounding tissue is dissected (red box.) B) An Image of penetrating PAs branching out of MCA and stemming into isolated capillary networks with its feeding Parenchymal arteriole. The arrow points to the capillary network branching out of the PA.

POSTER PRESENTATION

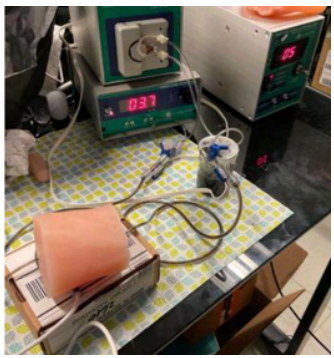
The Development of a Dynamic Phantom for PPG Signal Validation with Skin tone and Obesity Variations

Author: Marianne Porras Bouzas, Amanda Sanchez, Tananant Boonya-ananta, Andres J. Rodriguez, Ajmal, Eddie Tomas-Baute, and Ernesto Rodriguez
Faculty Advisor: Jessica Ramella-Roman, Ph.D.

Cardiovascular disease (CVD) is a leading global cause of death, responsible for 31% of all fatalities in the world. A key risk factor for CVD is hypertension. Novel non-invasive point-of-care health technologies have been designed to allow for hypertension detection and continuous monitoring, offering a proactive approach to managing CVD. Central to these technologies is Photoplethysmography (PPG), which measures blood volume changes and creates cardiovascular activity waveforms. However, when PPG is used to probe deeper arteries, variables like skin tone and obesity can affect the accuracy of the signals. To address this challenge, we developed a dynamic phantom replicating pulsating fluid flow, mimicking blood circulation in the radial artery at the wrist. We used rapid prototyping and mold casting to control the mechanical and geometric properties of the phantom precisely. Additionally, we incorporated features to manipulate the optical properties of the medium. A pressurized flow system generated controlled continuous flow at various pressures, ranging from 30mmHg to 200mmHg. We recorded PPG signals under different pressure conditions, assessing them for pulsatile patterns in line with the peristaltic pump cycle frequency, while considering optical properties, interfaces, and geometric shapes. In the next research phase, we will focus on enhancing the manipulation of optical properties within the phantom to more accurately simulate skin, flesh, and pulsating vessels. This development will provide a reliable and effective means to test and analyze the impact of skin tone and obesity on PPG signals, further advancing cardiovascular health technology.

3D Model of Human hand/wrist.

Casting of the silicon hand/wrist.



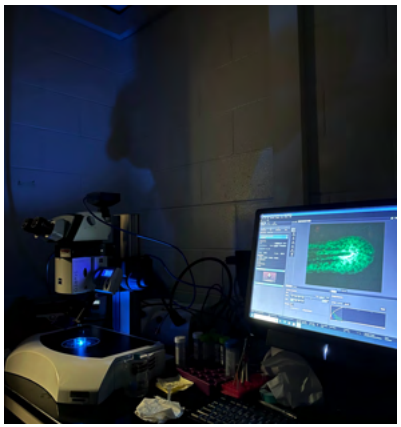
Phantom attached to pulse flow system.

POSTER PRESENTATION

Revealing cellular electric activity in the Danio rerio (zebrafish) caudal fin folds via Voltron, a genetically encoded voltage indicator

Authors: Erbol Nishanov
Faculty Advisor: Nikolaos Tsoukias, Ph.D.

Growing evidence suggests that bioelectricity modulates embryonic development, tissue regeneration, and congenital diseases. Recent invention of genetically encoded voltage indicators (GEVIs) surmounted the challenge of non-invasive in vivo assessment of cellular electric potential. Voltron, a novel genetically encoded voltage indicator, implements the HaloTag protein complex to bind to the bright and photostable synthetic fluorophore ligand dyes. The functional versatility of these dyes makes Voltron a superior indicator, allowing for brighter, high-resolution, prolonged imaging. The goal of our research is to investigate regeneration biology of the zebrafish caudal fin. A previously established transgenic Voltron zebrafish line with UAS promoter was bred with Tg(and1: Gal4FF) to image the bioelectric activities of zebrafish larva caudal fins. The embryos at the early development stage were incubated in the working solution of the selected ligand dye and then paralyzed and mounted in low-melting agarose for imaging. Movies of various duration were obtained to document the change of the fluorescence intensity in the fish's caudal fin. The fluorescence data were quantified using Image J and analyzed via MATLAB and Minitab. Resulting data will be used to assess the behavior of the electric potential in the embryos. Upon successful application of the Voltron GEVI, the imaging technique can be used to reveal the role of bioelectricity in the fin development and regeneration and its relationship with calcium signaling.



Optimization of a Mouse Aortic Valve Leaflet Tensile Testing Method

Authors: Andrea M. Rivera, Daniel Chaparro
Faculty Advisor: Joshua Hutcheson, Ph.D.

Calcific aortic valve disease (CAVD) is the most prevalent valvular disease in the United States. It is distinguished by the deposition of calcium in the leaflets of the aortic valve (AoV) that render it stiffer, preventing it from opening and closing properly. The role of biomechanics in CAVD initiation and progression remains unclear. Mouse models present the unique opportunity to measure temporal changes as the disease progresses. However, due to their microscopic size, standard uniaxial and biaxial tensile testing modalities are not suitable to assess mouse aortic valve leaflet (MAVL) tissue mechanics. Our lab came up with a novel method of quantifying the tensile properties of MAVLs by resecting the tissues, placing them on a silicone rubber membrane, stretching the composite and tracking its deformation1. However, the stiff elastomer used previously can mask subtle differences in tissue properties. Therefore, an elastomer that is more compatible with the elastic modulus of mouse aortic valve leaflets is necessary to improve the sensitivity of the analysis. We have manufactured polydimethylsiloxane (PDMS) membranes using commercially available elastomers that have a lower apparent stiffness ($P < 0.0001$) than the standard membranes we have used so far for this method. Current studies aim to assess the sensitivity of these membranes by conducting tensile testing of MAVL on the PDMS membranes and the standard membranes before and after fixing the tissues with paraformaldehyde. Completion of this project will improve the sensitivity of our tensile testing method, allowing us to identify subtle changes during disease progression.

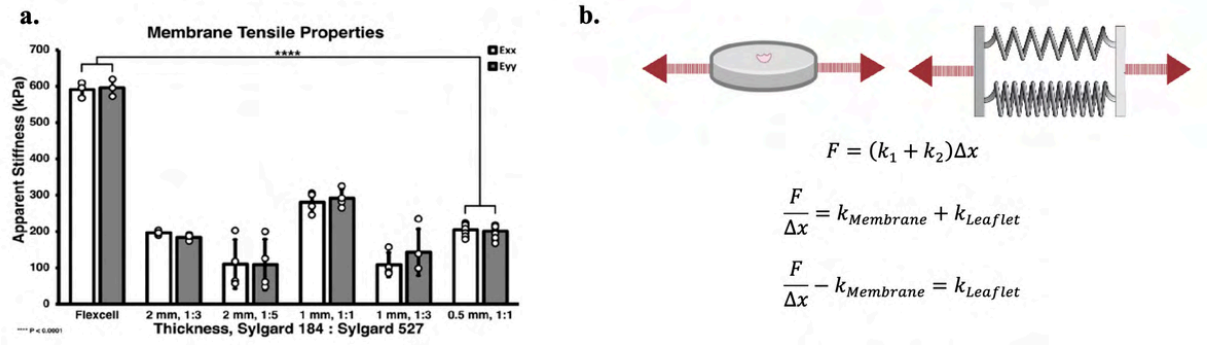


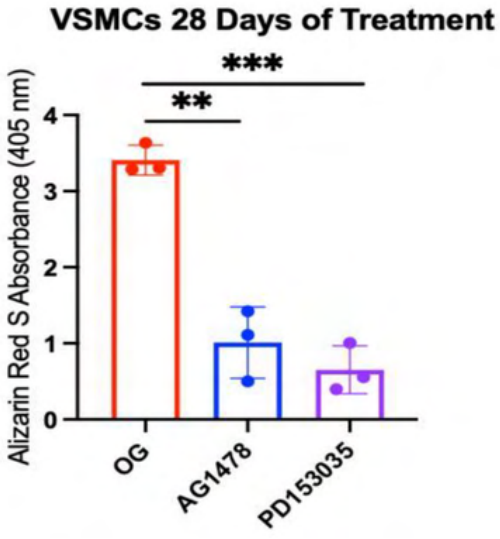
Fig 1. **a.** Apparent stiffness of standard Flexcell membranes and manufactured PDMS membranes. **b.** Model of tissue-membrane composite tensile testing.

POSTER PRESENTATION

Dose dependency of PD153035 to treat vascular calcification

Authors: Alexandra Rodriguez and Sophie K. Ashbrook
Faculty Advisor: Joshua Hutcheson, Ph.D.

Cardiovascular disease is the primary contributor to global mortality. Vascular calcification (VC) increases cardiovascular risks by altering the mechanics and function of the arterial wall. Inflammation and altered calcium and phosphate levels in the blood cause vascular smooth muscle cells (VSMCs) to differentiate into osteoblast-like cells inducing VC. Our lab established that the scaffolding protein, caveolin-1 (CAV1), and the epidermal growth factor receptor (EGFR) regulate VC mechanisms. EGFR tyrosine kinase inhibition reduced VSMC calcification in vitro by altering CAV1 trafficking through the cell. These previous studies were performed with single dosage of the EGFR inhibitor AG1478. In the present study, we examined the effects of an additional EGFR inhibitor, PD153035, at 5 different doses to assess the specificity of our observations and to find the most effective dose at decreasing calcification identified via alizarin red staining. We found that PD153035 ($p < 0.001$) and AG1478 ($p < 0.01$) both reduce calcification compared to positive controls cultured in osteogenic media for 28 days. However, PD153035 exhibited a slightly higher efficacy compared to AG1478. The PD153035 treatment was most effective at a concentration between 2.5 uM and 4 uM. Our study established that the tyrosine kinase inhibitors effectively mitigate VSMC calcification, with an optimal PD153035 dosage of 2.5 uM. Future studies will explore the in vivo efficacy of these treatment strategies.



POSTER PRESENTATION

The Cellular Heterogeneity in Valvular Elastinogenesis of Albino and K-5 Endothelin3 Mice

Authors: Rosali Nodarse and Daniel Chaparro
Faculty Advisor: Joshua Hutcheson, Ph.D.

The aortic valve (AoV) ensures that blood flows in one direction from the left ventricle of the heart to the rest of the body. Aortic valve disease is characterized by pathological extracellular matrix (ECM) remodeling that stiffens the AoV leaflets. The AoV ECM is a highly organized trilaminar microarchitecture of collagens, elastin, and glycosaminoglycans. Valvular interstitial cells (VICs), a heterogenous population of cells, are responsible for producing and maintaining ECM components. Within the AOV interstitium, fibroblasts, melanocytes, immune cells, neurons, and glial cells populate the tissue. Though little is known about how non-fibroblast VICs affect tissue function a strong positive correlation has been shown between melanocytic pigmentation and the elastic fiber abundance and organization in the AoV. Compared to wild type (WT) controls albino mice are void of pigment on the AoV and have significantly reduced elastic fiber abundance. In contrast, hyperpigmented K5-Edn3 mice have hyperpigmented AoVs and overabundant and disorganized elastin network1. Though there is a striking phenotypic correlation between elastic fiber presence and melanocytic pigmentation we have not identified melanocyte-specific elastin fiber synthesis pathways. Elastin fiber maturation may be influenced by more than one cell type in a cell non-autonomous manner. We have designed an experiment to assess cellular heterogeneity in the different mouse models of pigmentation and determine how these different cell types are involved in elastic fiber maturation through immunofluorescence techniques. We hypothesize that phenotypically distinct cell types will express different proteins necessary for mature elastic fiber synthesis such as elastin binding protein and fibulin 5.

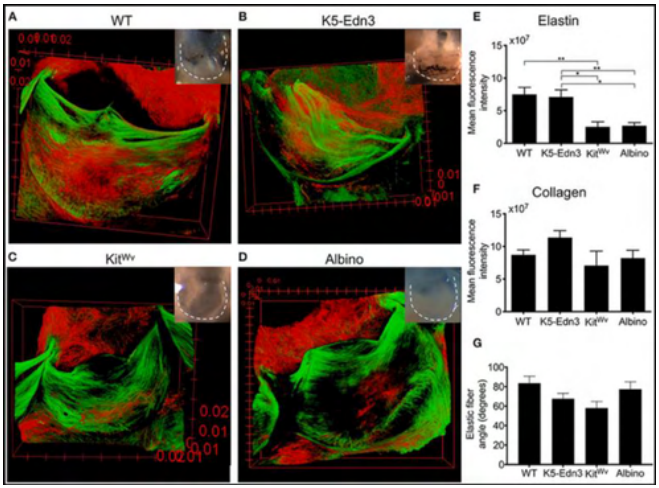


Fig 1. Relationship between pigment variation and ECM in the AoV leaflet.

POSTER PRESENTATION

Optimizing Biomimetic Scaffold Design and 3D Printing Strategies for Bone Regeneration

Authors: Shanai Wilks and Paula Gustin
Faculty Advisor: Anamika Prasad, Ph.D.

Osteosarcoma most commonly affects the long bones of the hand and leg, peaking in occurrence in adolescence and early adulthood. One of the biggest challenges in reconstructing these bones following tumor removal is that younger patients' developing bones must be considered. In these applications, using a biocompatible scaffold that resembles those in nature and has a variety of purposes, including enhancing cell adhesion, proliferation, and differentiation, is crucial. Our research aims to create scaffolds capable of transmitting signals to cells that promote regeneration and develop a relationship between porosity and pore size to compressive strength and elasticity of a biomimetic scaffold. To achieve this aim, trabecular bone scaffolds were designed using Voronoi lattices as the basis for bone scaffold design. Rhinoceros 5 Modeling Software was then used to create the 3D scaffold structure, and the Grasshopper Algorithm Editor was used to develop algorithms that generate and customize the structure to develop precise and tailored scaffold designs. The created designs had varying levels of porosity and pore size diameters. Porosity ranged from 30% to 70% in increments of 10%, while pore sizes were 5mm, 12mm, and 36mm. A Creality Ender 5 Plus 3D printer was used with 3DX Tech's SimuBone bone modeling filament to produce physical models from the software designs. Each porosity level was printed with a different pore size to produce a range of scaffolds. Before cell seeding, computational fluid analyses will be carried out to evaluate each 3D-printed scaffold.

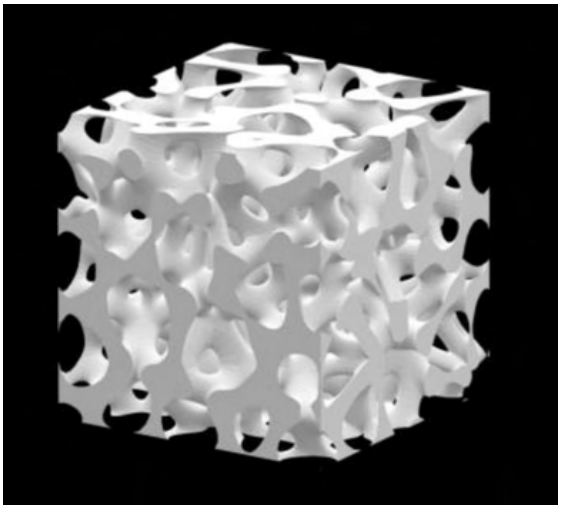


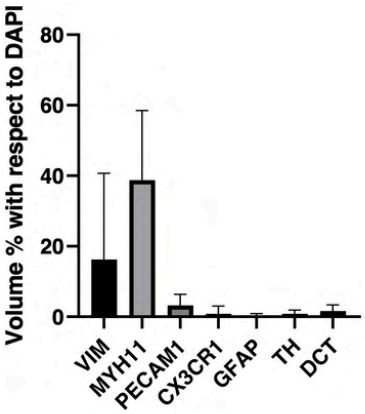
Fig 1. Bone scaffold with 30% porosity and 5 mm pore size.

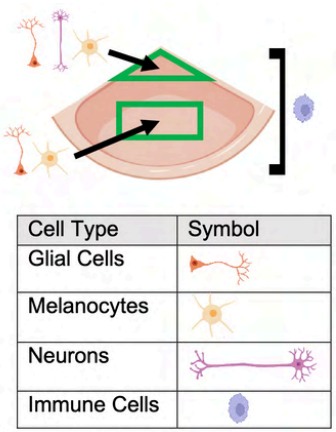
POSTER PRESENTATION

Differences in Cellular Heterogeneity between Bicuspid Aortic Valve and Tricuspid Aortic Valve

Authors: Lucas Menendez, Paula Everts, and Daniel Chaparro
Faculty Advisor: Joshua Hutcheson, Ph.D.

Recent studies have provided new insight into the mechanisms of aortic valve (AoV) physiology and disease. Most studies, however, have focused on the contributions of fibroblasts, a predominant cell type that persists in culture. The aortic valve also contains melanocytes, immune cells, neurons and glial cells, but their contribution to valve function remains largely unknown. In this study, we used immunofluorescence to determine the spatial location and abundance of these cell types within the AoV leaflets. In normal AoV leaflets, we observed immune cells distributed throughout the leaflets, which composed 0.8% of the total AoV volume. Neurons, melanocytes, and glial cells were mainly observed near the edge and belly region with abundances of 0.8%, 1.6%, and 0.4%, respectively. These data were collected from mice with tricuspid aortic valves (TAV). However, the most common congenital heart defect is the bicuspid aortic valve (BAV) malformation, where the AoV contains two leaflets instead of three. Individuals with BAV exhibit a higher risk of developing AoV disease earlier in life. Ongoing research seeks to compare the distribution and abundance of these under-studied cell types in BAV and TAV. The outcome of these studies will help determine if the differences in these cell types contribute to BAV development.



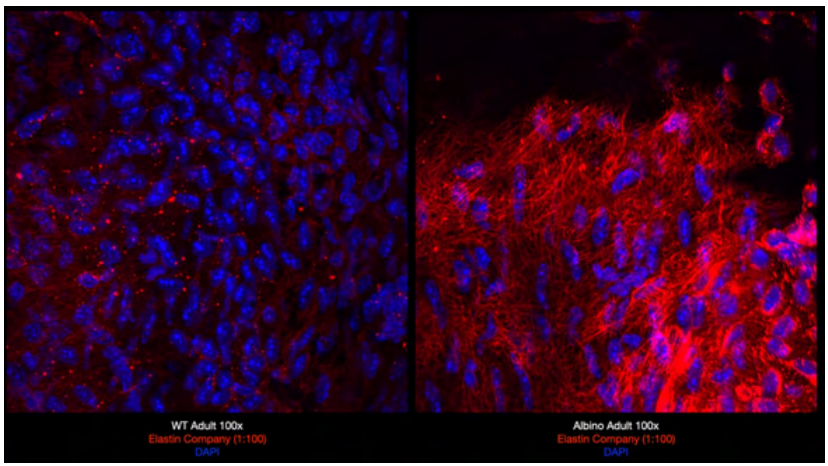


POSTER PRESENTATION

Differential Elastin Distribution in Murine Aortic Valve

Authors: Alexandra Coba and Perôny Nogueira
Faculty Advisor: Joshua Hutcheson, Ph.D.

The aortic valve (AoV) ensures unidirectional blood flow from the left ventricle of the heart to the body. The proper opening and closing of the AoV leaflets depend mostly on the proper organization of the extracellular matrix (ECM) components, such as elastin. The process of elastin formation involves a series of complex events, from the synthesis of its precursor, tropoelastin to the maturation of the elastic fibers within the extracellular environment. Previous studies have shown a correlation between pigment production and elastogenesis, where hypopigmented mice are largely devoid of mature elastic fibers. Using immunofluorescence, we investigated the distribution of tropoelastin within the AoV leaflets of adult Wild Type (WT) and hypopigmented Albino mice. The immunofluorescent images showed intracellular tropoelastin in WT mice but did not detect elastin in mature elastic fibers. In the Albino mice, we observed tropoelastin staining within fiber structures. These data may indicate that the antibody used for immunofluorescence only detects elastin in the immature tropoelastin form and that the Albino mice synthesize tropoelastin but cannot form mature fibers. Future experiments will analyze other mediators of elastic fiber synthesis, such as fibrillin-1 and fibulin-4 to determine potential differences in the fiber maturation process. This study will contribute to our understanding of the correlation between elastic fiber formation and pigmentation and its implications in the development of aortic valve disease.



POSTER PRESENTATION

Battery-less and Wireless Multichannel System for Pigs Neuronal Recordings

Authors: Daniel Parrado, Melany Gutierrez- Hernandez, and Sally Duarte
Faculty Advisor: Jorge Riera, Ph.D. and John L. Volakis, Ph.D.

Neural signals encompass vital data for evaluating brain function and diagnosing neurological disorders. While wireless implanted systems are commonly utilized for neuronal recording, current technologies relying on batteries pose potential risks, including brain heating and nervous tissue damage. To address the constraints of battery-dependent implantable systems, our team has devised a minimally invasive, passive wireless neurosensing system (mWiNS). This system facilitates multichannel neuropotential recording using the RF backscattering technique. Comprising an external interrogator and an implanted neuropotential recorder equipped with an impedance matching network and a multiplexer, our system has undergone rigorous validation through in vivo measurements. Specifically, we conducted tests on pigs, with the neuropotential recorder fully implanted subcutaneously, to evaluate one and eight channels of neural somatosensory cortex activity. Two distinct paradigms were explored during the assessment. The first involved recording somatosensory evoked potentials, achieved through electrical hind and fore limb stimulation. The second paradigm centered around a comprehensive behavioral examination, utilizing a stereotaxic cap to meticulously align the antennas, ensuring optimal RF transmission. Moving forward, our research endeavors will concentrate on the development of an induced epilepsy model. This will involve the utilization of RF-liberated capsules containing an epileptogenic glutamate activator. This pioneering initiative promises to revolutionize the landscape of neurosensing and provide unprecedented insights into neurological disorders.

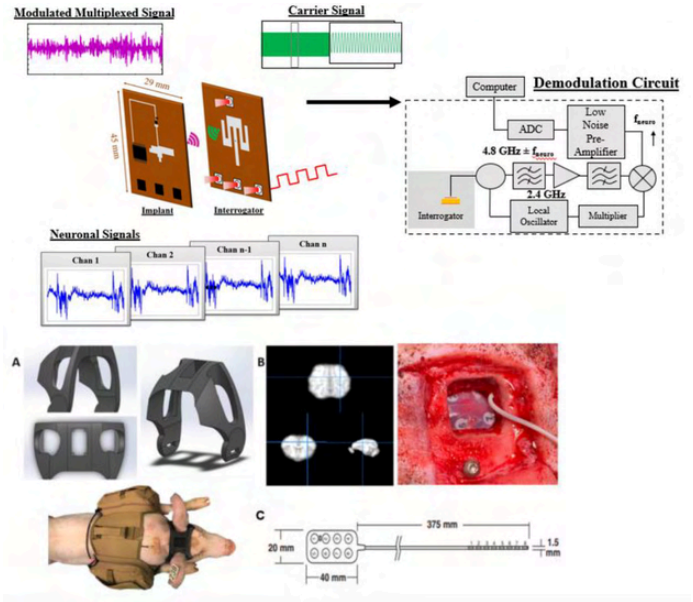


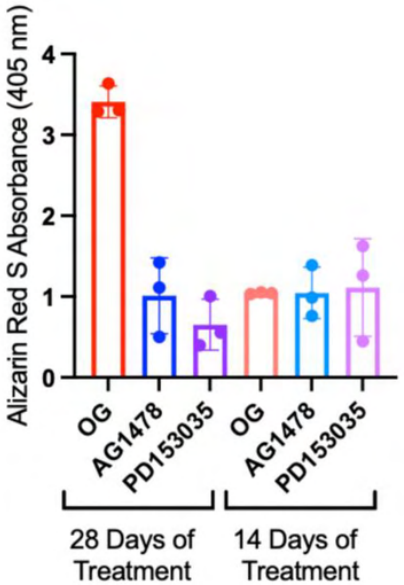
Fig 1. **Top -** Wireless Neurosensing System (WiNS), **Bottom - a.** 3D modeled stereotaxic cap and 3D printed cap for behavioral recordings
b. Hind limb somatosensory cortex with implanted electrode **c.** FDA-approved 8 channel stereo and strip electrodes (AD-TECH)

POSTER PRESENTATION

Investigating the potential of EGFR inhibition as to reverse vascular calcification in vitro

Authors: Jazlyn Hernandez and Sophie K. Ashbrook
Faculty Advisor: Joshua Hutcheson, Ph.D.

Cardiovascular disease is the leading cause of death worldwide, and vascular calcification is the most significant predictor of cardiovascular events. Currently, there are no therapeutic treatment options for vascular calcification. In diseased arterial tissues, vascular smooth muscle cells (VSMCs) develop an osteoblast-like phenotype and release calcifying extracellular vesicles (EVs), mimicking bone mineralization. Caveolin-1 (CAV-1), a membrane scaffolding protein linked to the biogenesis of calcifying EVs, plays a critical role in this process. The epidermal growth factor receptor (EGFR) modulates CAV-1 trafficking, making EGFR a promising target for preventing vascular calcification. This study investigated the potential of EGFR inhibition to reverse calcification in vitro using VSMCs cultured in an osteogenic media, which mimics osteogenic conditions for 28 days. EGFR tyrosine kinase inhibitors (AG1478, 2.5 uM, N=3 and PD153035, 2.5 uM, N=3) were added to the media after 7 and 14 days of osteogenic culture and continued for the duration of the 28 days. Alizarin red staining was used at the endpoint to observe the degree of calcification. Although calcification did not decrease compared to the osteogenic group, we observed that the addition of EGFR inhibitors prevented further development of calcification. Future studies will determine the effects of the inhibitors in reversing phenotypic changes in VSMCs and in arresting and reversing calcification in vivo.



POSTER PRESENTATION

Development and Standardization of Agar-Based Gel Phantoms Mimicking the Dermis

Authors: Maria Hernandez, Sonu Durgappa, Arundhathi Arun, Anarelis Galvez, Daniela Leizaola, and Fernando Chiwo
Faculty Advisor: Anuradha Godavarty, Ph.D.

Diabetic foot ulcers are a common complication in people with diabetes. It typically occurs due to reduced blood flow, and/or nerve damage. Early monitoring and treatment of these foot ulcers can reduce the potential for future amputations. Recently, our lab developed a smartphone-based optical imaging device to monitor the healing status of wounds. The current focus is to validate our smartphone-based imaging device via systematic imaging studies on different skin phantoms. Hence, the objective of our study is to develop and standardize skin-mimicking phantoms that can be used to validate our imaging devices. Initially, we focused on the dermis layer of human skin tissue with optical properties that replicate the actual tissue. Gel phantoms of 152×127×5 mm were prepared with bacteriological agar (base), aluminum oxide (scattering), and India ink (absorption), similar to the properties of the dermis. Reflectance and transmittance spectra of the two standardized phantoms were obtained using a custom-developed integrating sphere system that uses an inverse adding doubling technique to determine the absorption (μa) and reduced scattering coefficients (μs'). Preliminary results across 5 repeated measurements of the 2 sample phantoms provided μa = 1.016+0.155 cm-1 and μs'= 2.871+0.181 cm-1, at 690nm wavelength. Ongoing efforts are to determine the precision of these measurements via repeated studies on several standardized phantoms. Future work is to standardize a multi- layer skin phantom of varying skin colors.

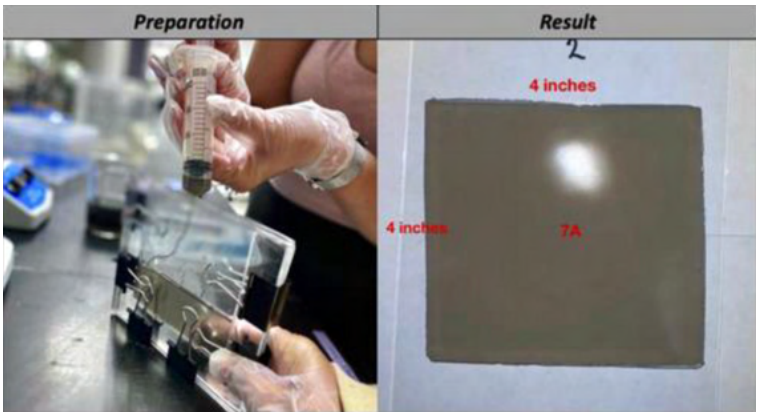


Fig 1. **a.** Set up and preparation of gel phantoms **b.** The 5mm thick dermis mimicking gel phantom

POSTER PRESENTATION

Modeling Blood Flow Dynamics and Hematocrit Distribution in Cerebral Microvascular Networks by Tracing Red Blood Cell Movement in Capillary Networks

Authors: Michelle Wiese
Faculty Advisor: Nikolaos Tsoukias, Ph.D.

A complex microvascular network supplies the brain with nutrients and oxygen. It incorporates several hundred miles of blood vessels, the majority of which are capillaries. Multiple mechanisms control blood perfusion in the brain including signaling from active neurons (i.e. neurovascular coupling) that can affect tone and diameter in arterioles but also in capillaries. Neurovascular coupling and proper blood flow control is critical for normal brain function and may be compromised in neurodegenerative diseases, such as Alzheimer's and Dementia. Tissue perfusion by red blood cells will depend on local blood flow and hematocrit (HD) levels that can dynamically vary as vessels react to stimuli. Absence of red blood cells can often be observed in capillaries (capillary stalling) and this could impair surrounding tissue oxygenation, viability and proper function.

The relative inaccessibility of the cerebral microcirculation to experimental observation makes modeling an invaluable tool for understanding regulatory mechanisms of brain perfusion in health and in disease. In this study we use computational tools to predict dynamic changes in blood flow and hematocrit distribution in reconstructed microvascular networks of the mouse cerebral cortex. We apply a novel approach of tracing individual Red Blood Cells (RBCs) through the capillary network to predict transient changes in hematocrit, viscosity and flow as arterioles and capillaries react to vasoactive signals. The proposed model of capillary flow dynamics will be utilized to explore mechanisms of capillary stalling and assist in multiscale analysis of cellular signaling, vessel mechanics and blood flow control in the brain.

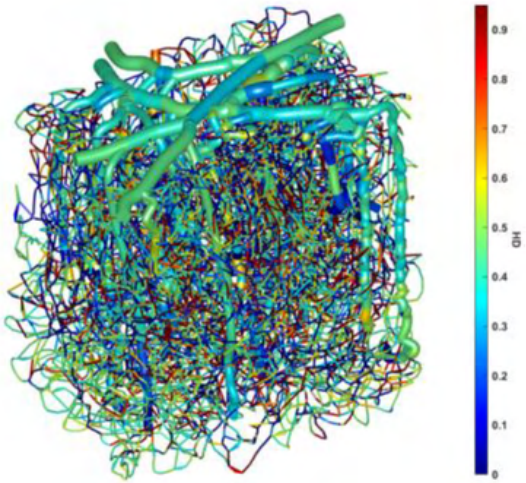
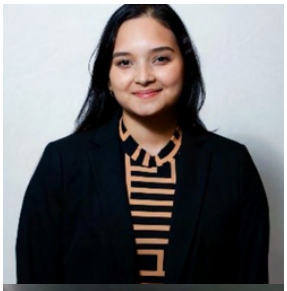


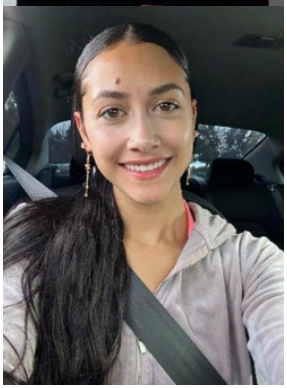
Fig 1. Predicted Hematocrit Distribution using the RBC Tracing Method.

POSTER PRESENTATION

An Ex Vivo Capillary-Arteriole Preparation To Investigate Neurovascular Coupling

Authors: Karen Colmenares, Ela Nunez, and Katherine Lopez
Faculty Advisor: Nikolaos Tsoukias, Ph.D.





Neurovascular Coupling (NVC) is a multifaceted mechanism that links neural activity to changes in cerebral brain blood flow, playing a pivotal role in maintaining normal brain function. This interplay between neurons and the vasculature is often impaired in neurodegenerative disorders and stroke, underlining its significance in neurological health.

In response to neuronal activity, various mediators are released to influence arteriolar smooth muscle tone and local blood flow. Understanding of capillary-mediated NVC is limited due to the inaccessibility of capillaries for experimental observation and the scarcity of suitable experimental assays. Our aim in this study is to advance a recently proposed ex vivo isolated Capillary-Arteriole preparation for quantifying Kir-mediate signaling in the cerebral microcirculation.

The experiments involve using a C57BL6 mice and genetically modified Kir2.1 knockout mice. Kir-KO mice are generated by crossing mice expressing CRE recombinase under an endothelial-specific promoter Cadherin 5 with a Kir 2.1 floxed Tg mice, where exon 1 of the Kir 2.1 gene is flanked by LoxP sites. A homozygous LoxP mouse with CRE is obtained after two generations of breeding. Brain isolation is performed following euthanization, using micro-forceps, the Middle Cerebral artery (MCA) is excised from the Circle of Willis and traced until reaching smaller pial vessels at the top of the brain. A small piece of tissue at the end of the isolated vasculature is preserved and carefully disrupted using forceps. The isolate is placed on the surface of aCSF solution. Surface tension enhances the removal of parenchymal tissue and stresses the isolated capillary-arteriole network. We plan to utilize the CaPA prep to:

Investigate the determinants and quantify electrical propagation in brain capillaries, and test the role of Kir channel in electrical signaling in the brain capillaries. This will allow us to determine stimulatory requirements, electrical propagation distances and resistivities in WT and Tg mice. We will deduce parameters to inform the model and test model predictions.

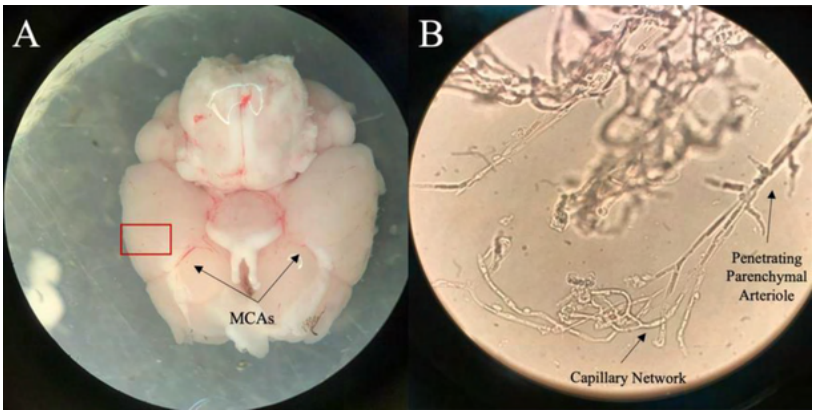


Fig 1. Isolated Mouse Brain and Capillary Network A) Basal view of an Image of the isolate mouse brain showing the depicting Circle of Willis and the Middle Cerebral Arteries (MCA) from which stems isolate capillaries. A pial artery branching out of the MCA and surrounding tissue is dissected (red box.) B) An Image of penetrating PAs branching out of MCA and stemming into isolated capillary networks with its feeding Parenchymal arteriole. The arrow points to the capillary network branching out of the PA.

CURE PROGRAM

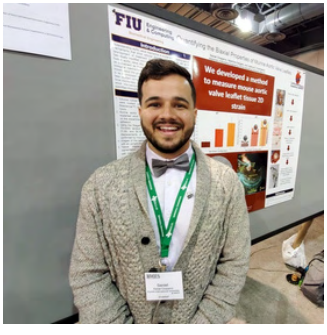
The Coulter Undergraduate Research Excellence (CURE) Program was established by support from the Biomedical Engineering Wallace H. Coulter Endowment. Through the CURE Program, biomedical engineering undergraduate students perform research under the supervision of a faculty mentor. The three-tiered program allows students to begin as volunteer "Trainees," where they can learn more about working in a research laboratory. CURE Trainees attend laboratory meetings and shadow other researchers. After completing this volunteer phase, students can receive a stipend for their work in the "Researcher" and "Fellow" tiers. Students in these tiers receive an immersive research experience, which supplements didactic coursework. CURE Researchers work closely with their mentors to develop independent projects. CURE Fellows are expected to perform high level research and present findings at national research conferences. Funds are also provided through the CURE Program for career development activities. All CURE students take a pledge to achieve academic excellence, perform research and scholarly activities with integrity to promote global well-being, and serve as an ambassador for FIU Biomedical Engineering. Participation in the CURE Program allows students to learn technical skills in the laboratory while also strengthening abilities in critical thinking, communication, time management, and collaboration. CURE students are well-prepared to meet the challenges of life after graduation!

Presented through the generous support of the Wallace H. Coulter Foundation.

Thank you

To Our Alumni/Panelists

Angelica Cobo, PhD is an engineer passionate about development of medical devices.

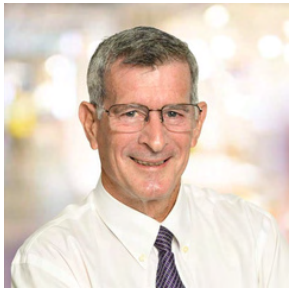


Daniel Chaparro, PhD focuses on aortic valve tissue mechanics and the involvement of neural crest derived cells in tissue homeostasis and disease.

Jorge Barter is an R&D Engineer at Cordis, a global leader in cardiovascular technologies.

SomafaBailey is a Senior Quality Engineer at Medtronic in the Mechanical Circular Support division.

Manuela Tamayo holds a B.S. as well as a M.S. in Biomedical Engineering from Florida International University and she is certified as a project management professional (PMP) by PMI.



OferAmit, MSEM, CHRC.

Oferhas more than fifteen years of experience in establishing and managing research programs in clinical and academic settings.

ABOUT OUR PROGRAM

The Department of Biomedical Engineering (BME) is part of the College of Engineering and Computing at FIU and is a prime resource for biomedical engineering education, training, research, and technology development. BME is an ever-evolving field that uses and applies engineering principles to the study of biology and medicine in order to improve healthcare.

Located in Miami, Florida, our College of Engineering and Computing is ranked #1 for bachelor's degrees awarded to Hispanics, #1 for Bachelor's degrees awarded to Underrepresented minorities by total, #2 for master's degrees awarded to underrepresented minorities by total, and #56 among graduate programs in the country*. Nationally, we are among the Top 30 to award undergraduate degrees and Top 80 for research expenditures*. Florida International University is designated a Carnegie Highest Research (R1) and Carnegie Community Engaged Institution.

*US News 2023 *ASEE 2022 and NSF HERD 2019-2021

Presented through the generous support of the Wallace H. Coulter Foundation.

FIU Engineering & Computing
Biomedical Engineering

Department of Biomedical Engineering **bme.fiu.edu**

Florida International University College of Engineering and Computing
10555 West Flagler St. Room EC 2610 Miami, Florida 33174