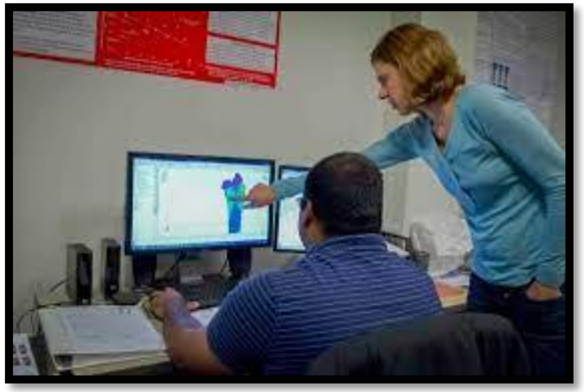
Faculty Introductions and Project Opportunities

New Graduate Student Orientation

August 23, 2023

BME Faculty and Staff

- 19 Faculty (includes research, teaching, and professional practice)
- 3 Administrative assistants
- 2 Lab managers
- 25+ Collaborative Faculty
  - Across 10 departments at WPI plus UMass Medical School

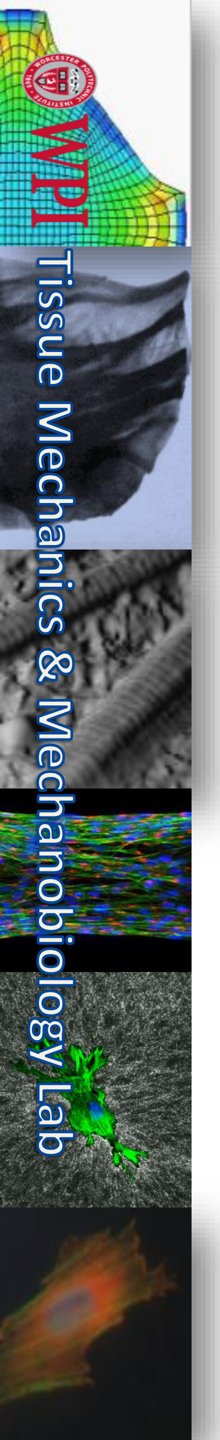


Faculty Research Areas

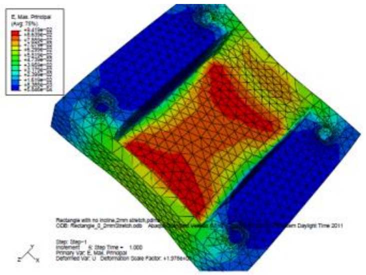
- Descriptions of faculty research on the BME Department web site (www.wpi.edu/+bme)
- Example general research areas (see WPI Grad Catalog and BME Department web site for detailed descriptions):
  - **Bioinstrumentation & Med. Devices** (Albrecht, Mensah, Zhang)
  - **BioMEMS and Microfluidics** (Albrecht, Billiar)
  - **Biomaterials and Tissue Engineering** (Billiar, Coburn, Ding, Mensah, Page, Pins, Whittington)
  - **Biomechanics and Mechanobiology** (Alatalo, Billiar, Ji, Mensah, Troy, Wei, Zhang)
  - **Imaging** (Albrecht, Ji, Troy, Zhang)
  - **Neuroscience** (Albrecht, Lammert)

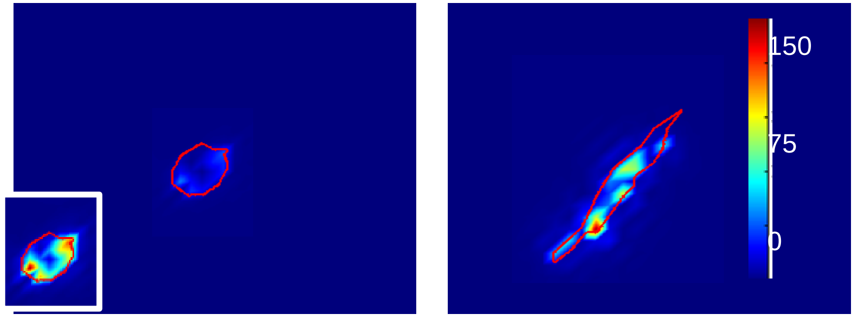
Lineup

1. Billiar
2. Faber
3. Coburn
4. Ding
5. Wei
6. Alatalo
7. Pins
8. Ji
9. Troy
10. Zhang
11. Mensah
12. Albrecht
13. Lammert
14. Whittington



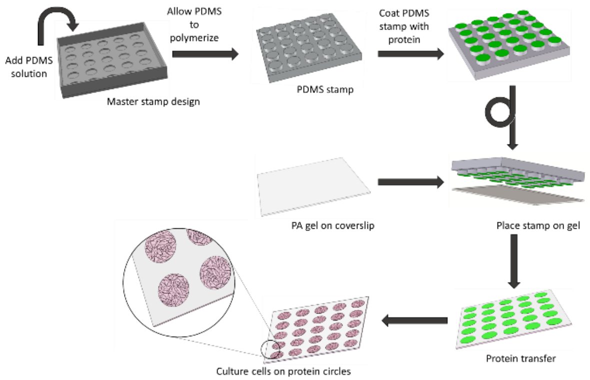
Billiar: Biomech and Mechanobiology Lab

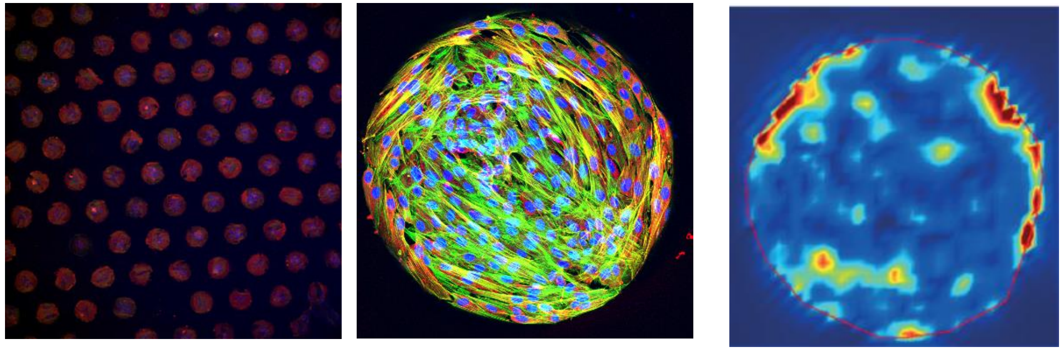




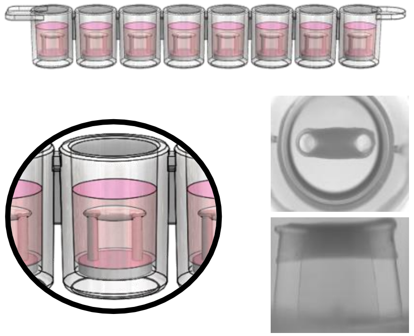
Soft (0.6 kPa) **…stretched**

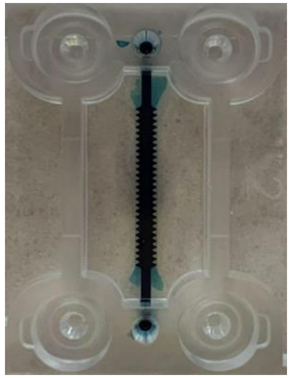
Cirka et al., *Biophys J,* 2016

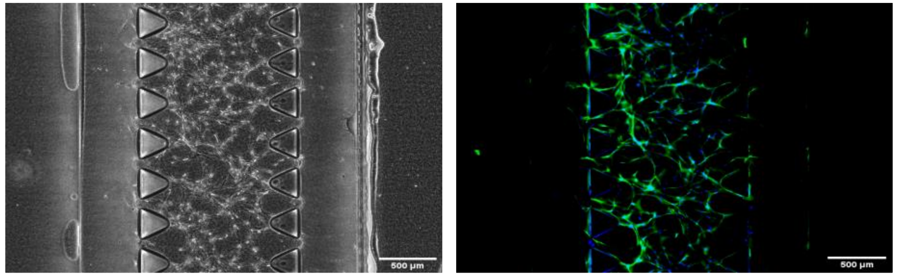




Goldblatt et al., *Biophys J,* 2019







Lineup

Faber Lab: Social Determinants of Health & Clinical Context for Design

Improving Care for Uninsured and Underinsured Patients

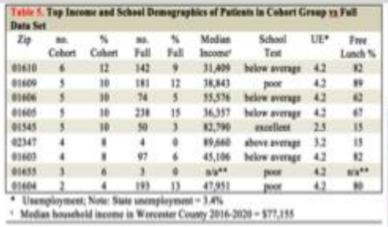


Table 5. Top Income and School Demographics of Patients in Cohort Group vs Full Data Set

Zip	no. Cohort	% Cohort	no. Full	% Full	Median Income¹	School Test	UE*	Free Lunch %
01610	6	12	142	9	31,409	below average	4.2	82
01609	5	10	181	12	38,843	poor	4.2	89
01606	5	10	74	5	55,576	below average	4.2	62
01605	5	10	238	15	36,357	below average	4.2	67
01545	5	10	50	3	82,790	excellent	2.5	15
02347	4	8	4	0	89,660	above average	3.2	15
01603	4	8	97	6	45,106	below average	4.2	82
01655	3	6	3	0	n/a**	poor	4.2	n/a**
01604	2	4	193	13	47,951	poor	4.2	80

* Unemployment; Note: State unemployment = 3.4%
¹ Median household income in Worcester County 2016-2020 = $77,155

We are working with a free urban clinic in Worcester to determine appropriate thresholds for diagnostic testing in vulnerable populations.

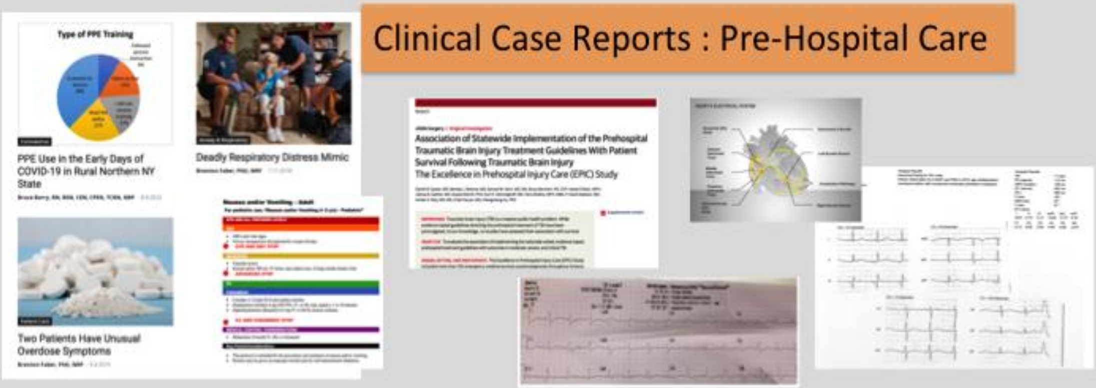
Socioeconomic status (SES) such as income, education, unemployment, and even geographic factors tied to urban design have been associated with greater health risks. How can diagnostic tests better integrate patients' lived experiences and SES?

Alternative systems for healthcare delivery

Can Engineering help design better methods for health care delivery?

It is no secret that the system of American health care is broken. One area that has become particularly problematic is access to primary and urgent care. How can health systems integrate primary care, chronic disease management, behavioral and psychiatric health, emergency services, and social services in cost-effective ways that also ensure access and patient-centered outcomes?

Clinical Case Reports : Pre-Hospital Care



BME & EMS: Examining Pre-Hospital Care

The research informing prehospital care has grown considerably over the past decade and significant RCTs and retrospective data studies are changing practices and protocol development.

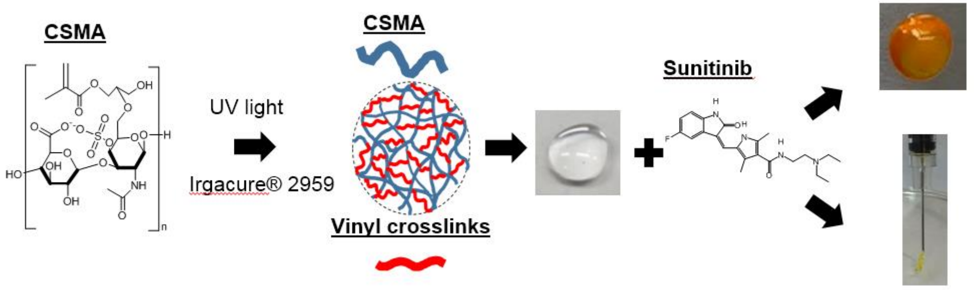
Working with physicians and other out-of-hospital providers, we are interested in case reports and other research than can improve out-of-hospital patient care.

Lineup

bdfaber@wpi.edu

Coburn Lab
on Functional Biomaterials

Materials for drug delivery

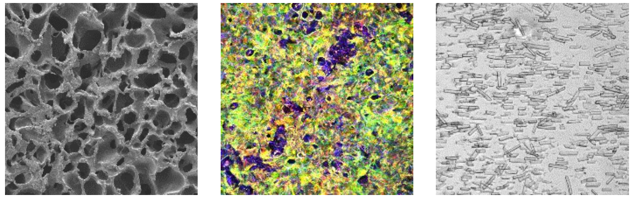



Kate Mistretta


Carolina Villarreal

Scaffold Design for Tissue Engineering and Disease Modeling





Melissa Wojnowski


Kate Mistretta

Designer Bacterial-Derived Cellulose


Elzani van Zyl

Jeannine Coburn
jmcoburn@wpi.edu
labs.wpi.edu/coburnlab

Lineup

WPI

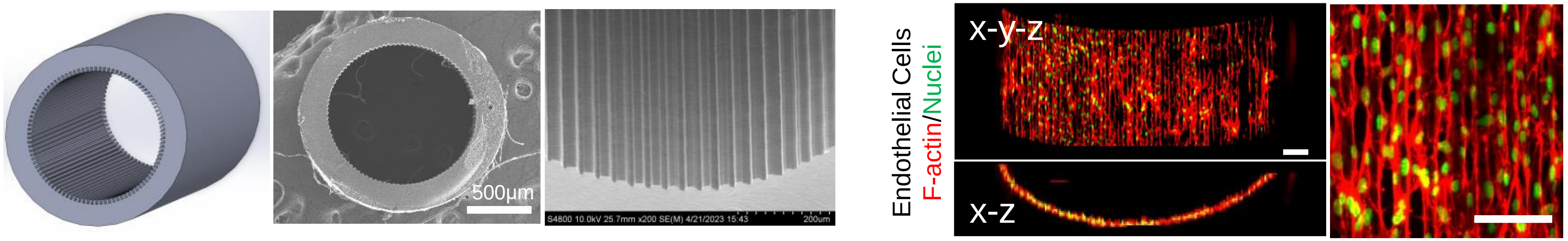
Ding Lab

Additive Manufacturing for Regenerative Engineering

Convergence of regenerative biomaterials, additive manufacturing, and translational strategy for tissue repair and regeneration

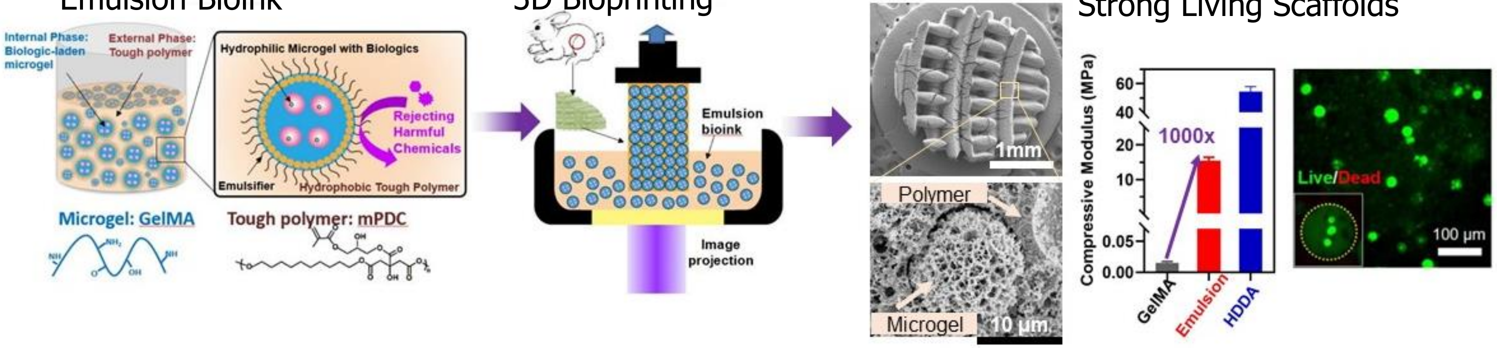
Theme 1: 3D-Printed Scaffolds with Microtopography for Oriented Tissue Regeneration

CAD model | 3D-printed scaffold with surface patterns | Vascular Tissue Regeneration

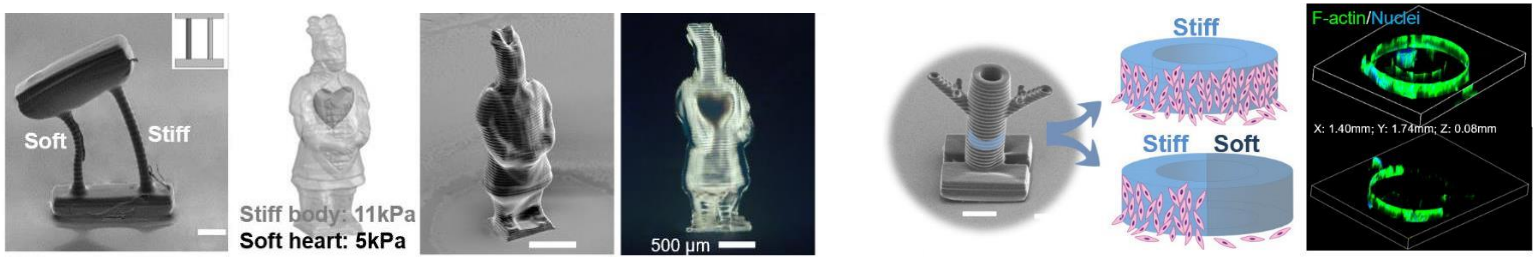


Theme 2: 3D Bioprinting of Strong Living Scaffolds for Load-bearing Tissue Regeneration

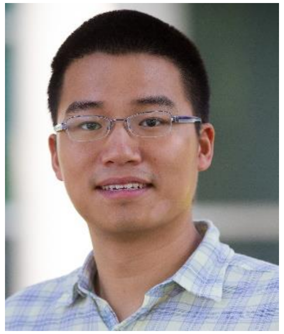
Emulsion Bioink | 3D Bioprinting | Strong Living Scaffolds



Theme 3: 3D Scaffolds with Spatially Programmed Stiffness



Lineup



Professor Zhenglun "Alan" Wei

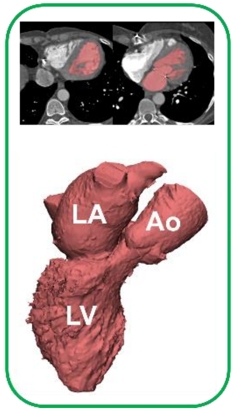
Artificial Intelligence and Modeling Lab for Cardiovascular Diseases (AIMCardio Lab)

WPI

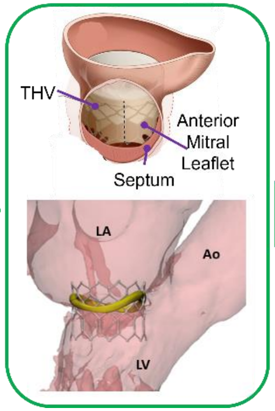
- Cardiovascular Medical Devices; Fluid-structure Interaction; Machine Learning.
- Collaborating with Boston Children's Hospital, Children's Hospital of Philadelphia, Hospital for Sick Children (Toronto), Children's Hospital of Atlanta, Geisinger Medical Center, …
- Collaborating with Apple Inc, Abbott, Medtronic, Boston Scientific, Phillips, …

In Silico Modeling Platform (with Machine Learning)

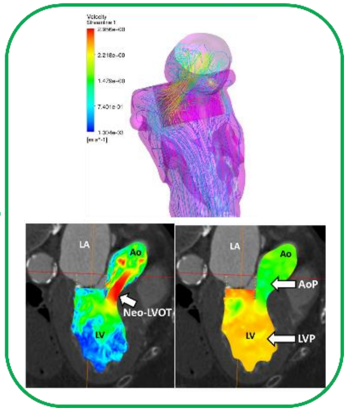
Anatomical Reconstruction



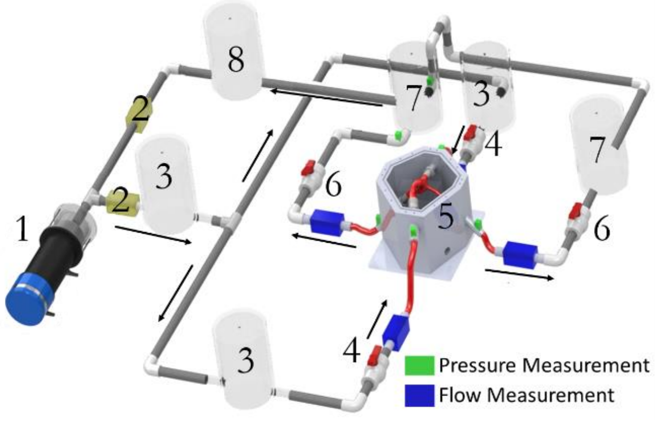
Virtual Device Implantation



Patient-specific Modeling



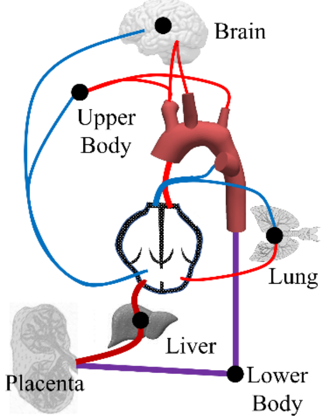
In Vitro Flow Loop (with Particle Image Velocimetry)



Cardiac Stent

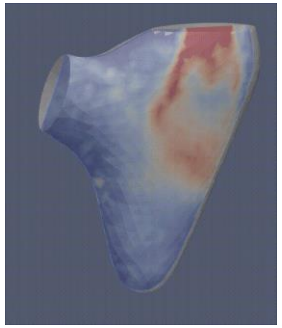
Pediatric Heart Valve

Fetal Circulation



Patient-specific Silicone Phantom

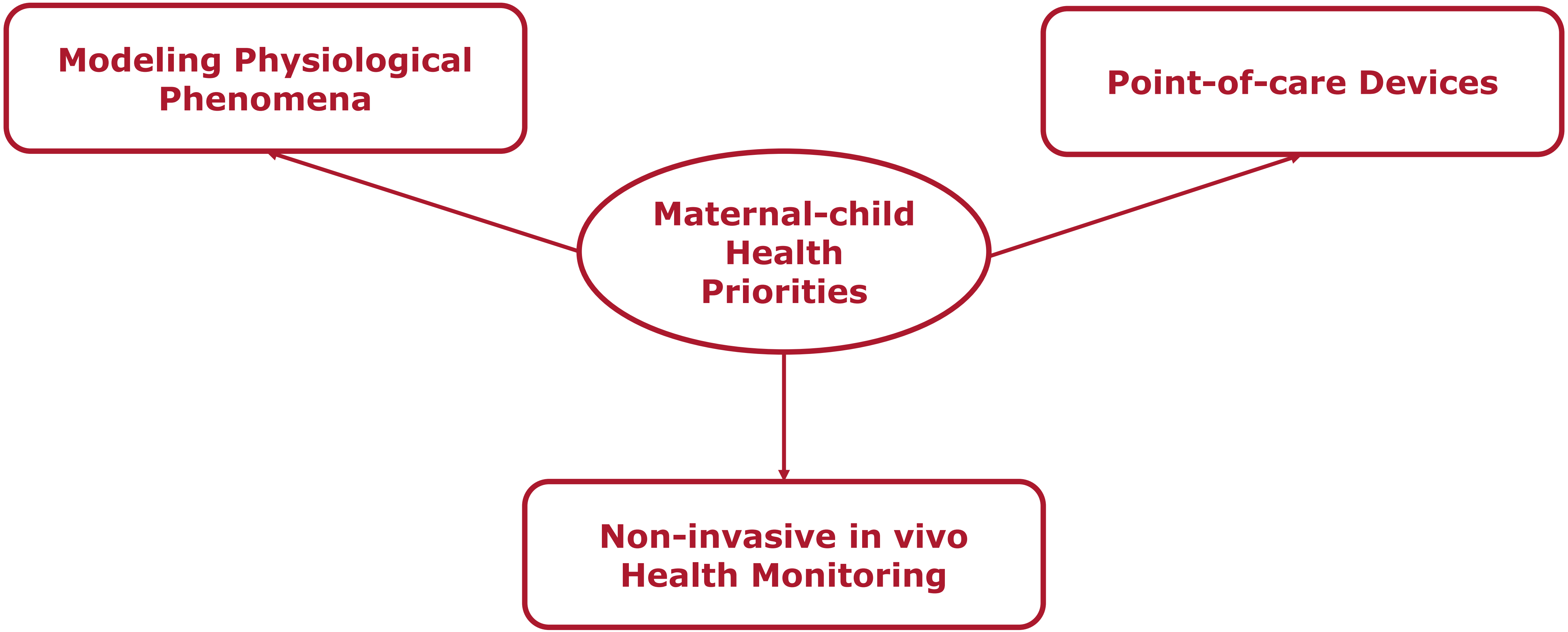
Patient's Vessel Compliance



4D MRI

Lineup

Alatalo Lab



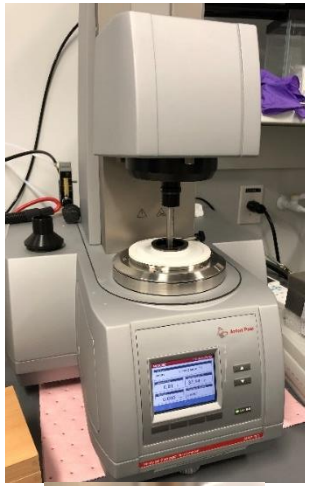
Lineup

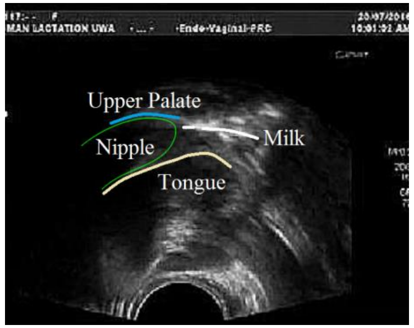
Contact Info: dalatalo@wpi.edu

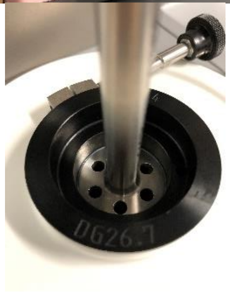
Alatalo Lab

Modeling Physiological Phenomena

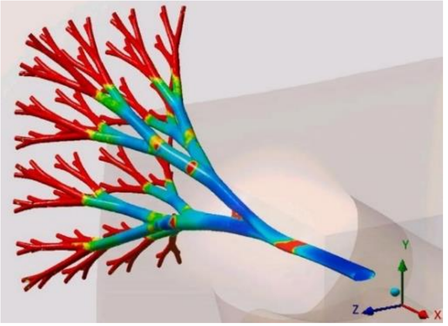
Clinical/Experimental

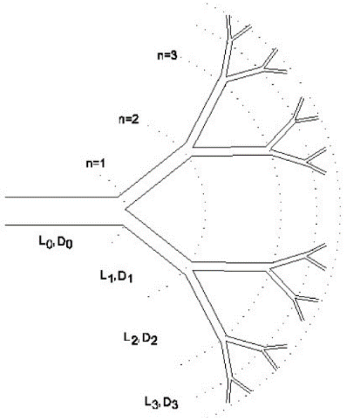






Fluid/Transport Modeling





$$\tau = \frac{r}{2L}\Delta p$$

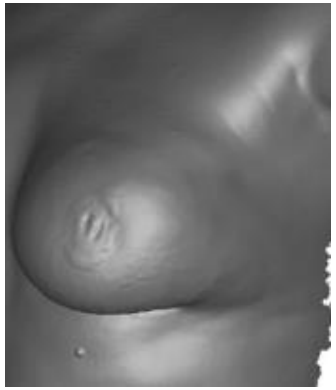
$$L = 38\ mm$$

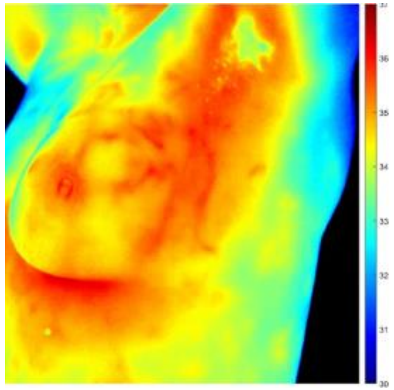
$$r = 3.1\ \mu m$$

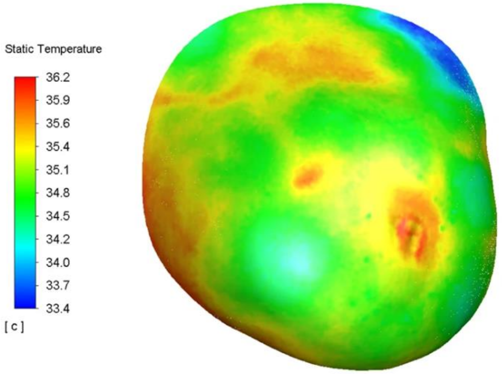
$$\overline{\tau_f} = 0.036\ Pa$$

$$\Delta p = 898\ \text{Pa}$$

Thermal Modeling





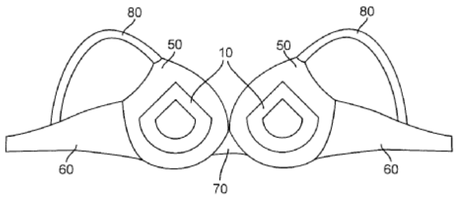


Lineup

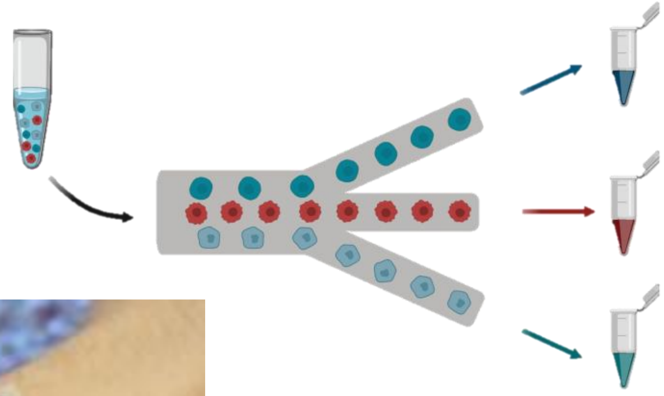
Contact Info: dalatalo@wpi.edu

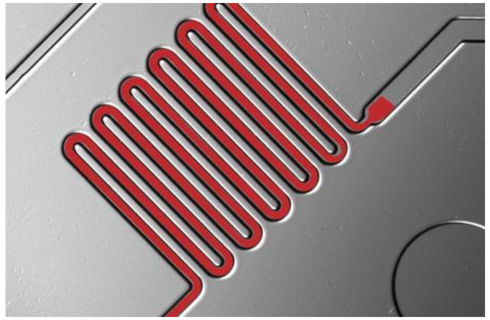
Alatalo Lab

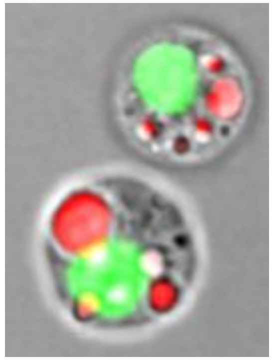
Non-invasive in vivo Health Monitoring



Point-of-care Devices







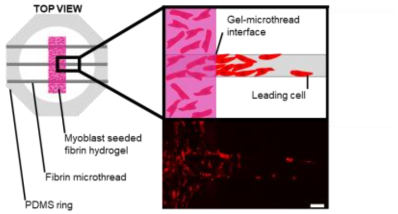
Lineup

Contact Info: dalatalo@wpi.edu

Pins Lab: Regenerative Biomaterials for Multiscale Fabrication of Complex 3D Tissues

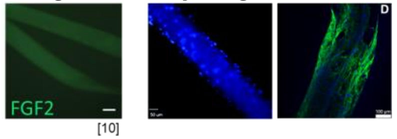
In vitro model systems

1. *In vitro* tissue models of wound healing



Grasman, **Acta Biomater**. 8: 4020, 2012.; ., 10: 4367, 2014
Carnes, **Tissue Eng C**.: 26: 317, 2020

2. Strategic delivery of growth factors and cells

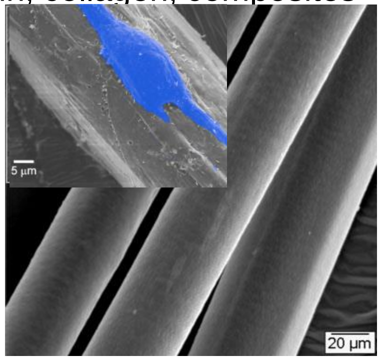


[10]

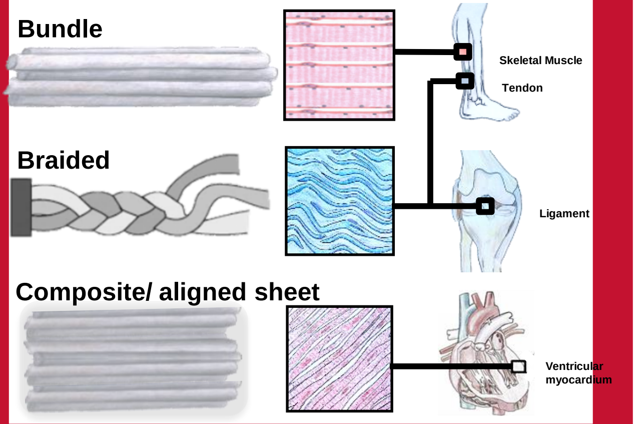
Cornwell, **Tissue Eng.**, 16: 3669, 2010
Grasman, **Tissue Eng.**, 23, 773, 2017
Carnes, **Explor BioMat-X.**, 2023

Biopolymer Microthreads

- fibrin, collagen, composites



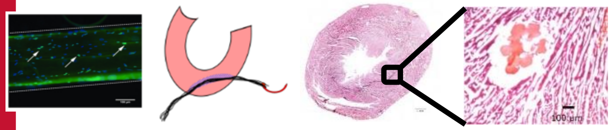
Microthread organization mimics different tissue architectures



O'Brien, **Curr Stem Cell Rep** (2016) 2:147–157

Cardiac Tissue Engineering

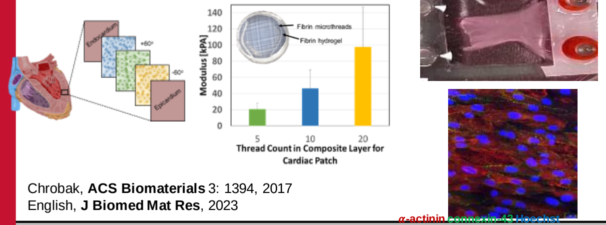
1. Targeted cell (and therapeutic) delivery to the heart



Proulx, **JBMR**, 96A: 301, 2011;
Guyette, **J Biomed Mater Res A**. 101:809, 2013

Tao, **J Tissue Eng Regen Med**. **11: 220,** 2017

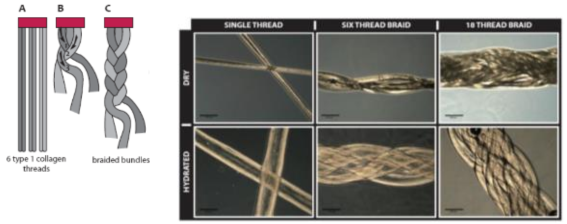
2. Composite patch for myocardial infarct



Chrobak, **ACS Biomaterials** 3: 1394, 2017
English, **J Biomed Mat Res**, 2023

Tendon/Ligament Regeneration

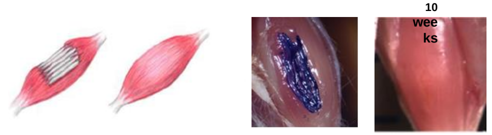
1. Braided collagen threads and composite scaffolds to mimic tendon and ligament regeneration

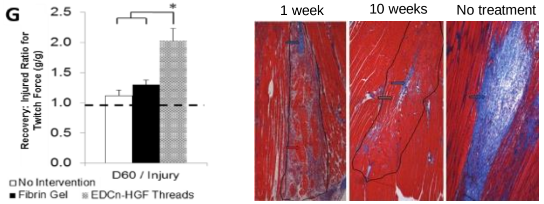


Pins, **Biophys J.**, 73: 2164, 1997
Cornwell, **J. Biomed. Mater. Res.,** 80A:362, 2007
Makridakis, **MS thesis**, WPI, 2007

Skeletal Muscle Regeneration

1. Microthread bundles direct functional muscle regeneration for VML





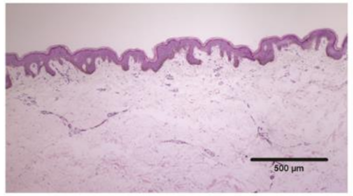
Page, **Tissue Eng.**, 17, 2629, 2011,
Grasman, **Biomater.**, 72: 49, 2015
Grasman, **Acta Biomater.**, 10: 2, 2015
Carne, **Bioengineering**, 7 (3), 85, 2020

Lineup

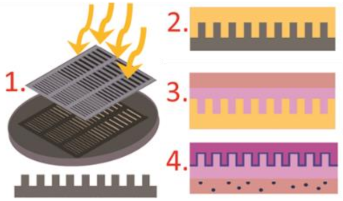
Bioinspired Skin Regeneration Matrices (µDERMs)

Engineering the tissue-wound interface: wound healing models harnessing 3D topography to improve outcomes

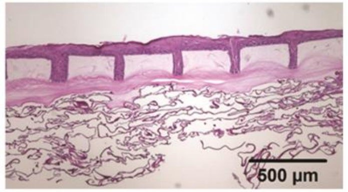
Inspired by topography of native skin



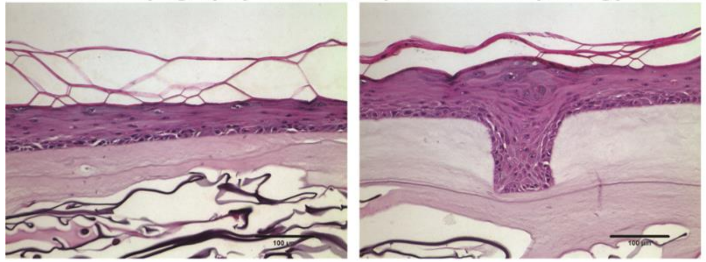
Recreated microenvironment with photolithography

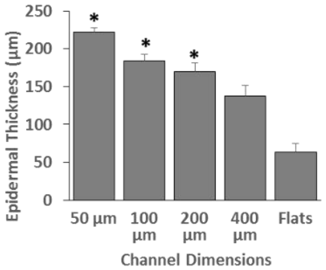


µDERM – 3d Organotypic cultures

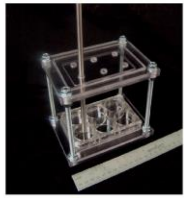


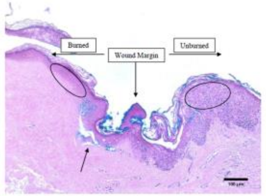
Microtopography enhances epidermal morphology and increases epidermal thickness



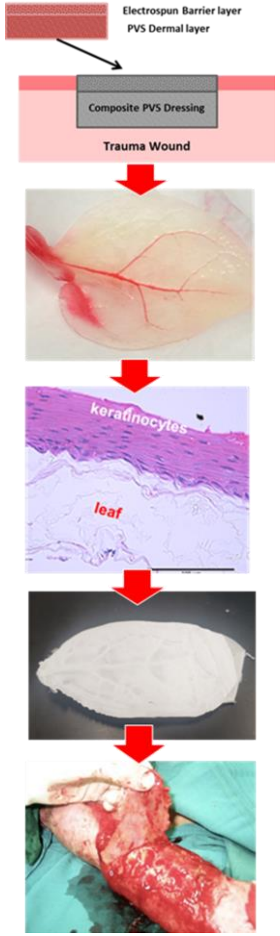


Burn Model System





Composite Wound Care System
with Plant Vascular Scaffolds (LeaVS)

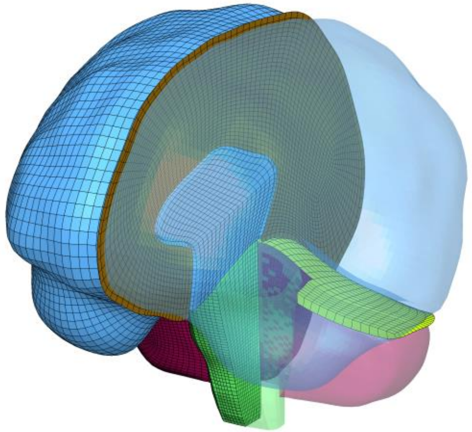
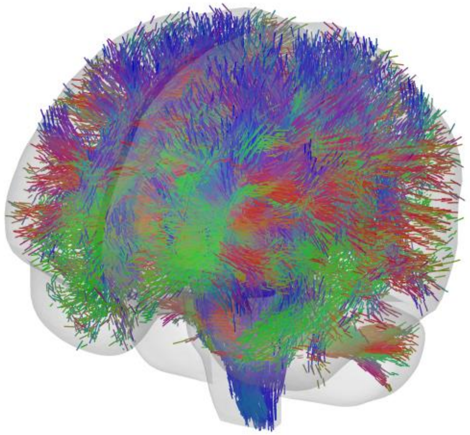
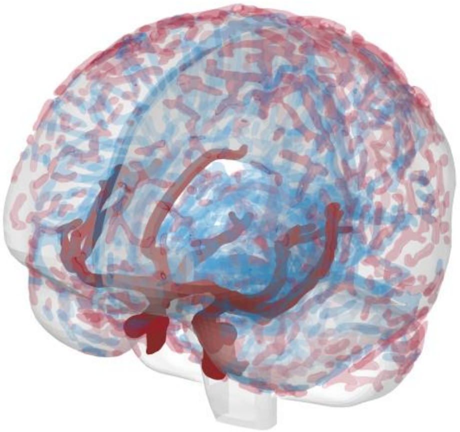
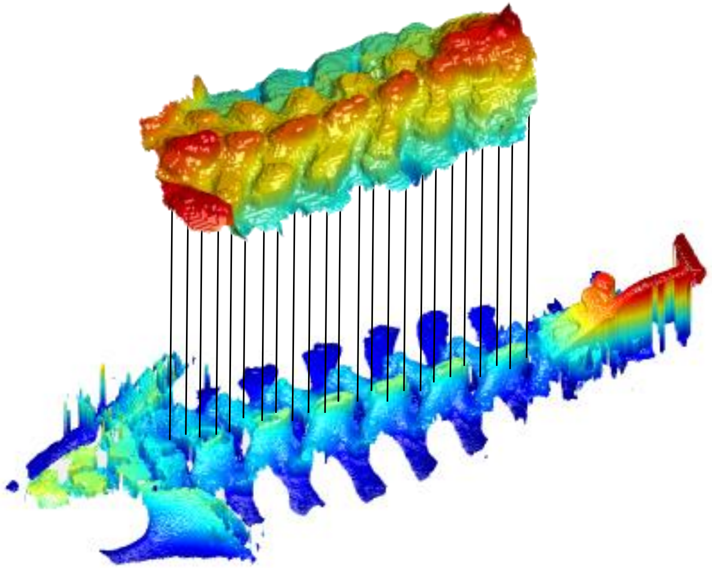


Pins Lab

- *Bush, KA, and Pins GD.* **Tissue Eng Part A.** 2012 Nov;18(21-22):2343-53.
- *Clement, AL, Moutinho, TJ, and Pins, GD*. **Acta Biomater**. 2013 Dec;9(12):9474-84.
- *Clement, AL, and Pins, GD*. **Wound Healing Biomaterials**, Oxford Press, *2016*

The JI lab at WPI – Prof. Songbai Ji

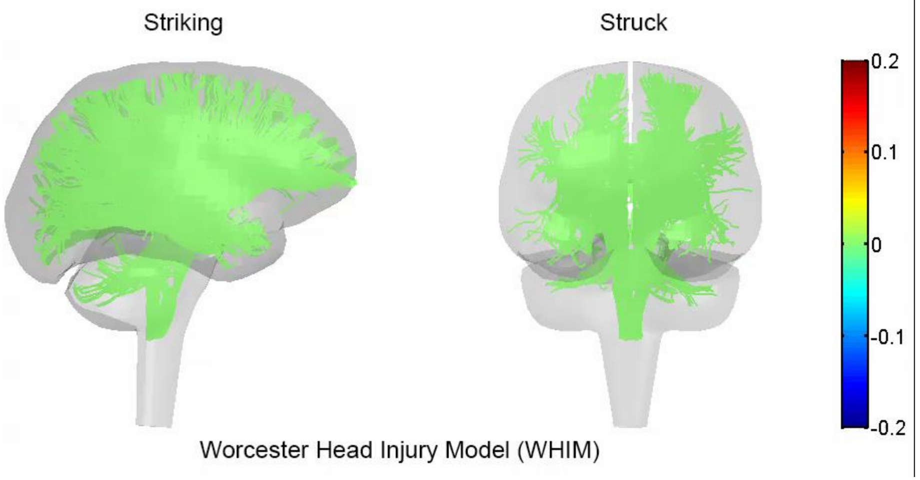
- Concussion Biomechanics
- Surgical image-guidance

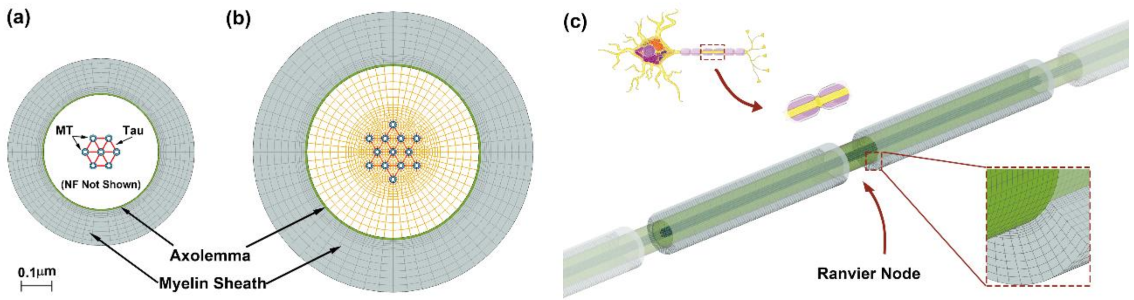





Lineup

Concussion biomechanics: better detection

- Computational modeling
- Medical imaging
- Data science, machine learning and deep learning
- Lots of opportunities to collaborate with other institutions (VT, UBC, Stanford, UU, etc.)
- Work with industry (helmet, mouthguard, etc.)

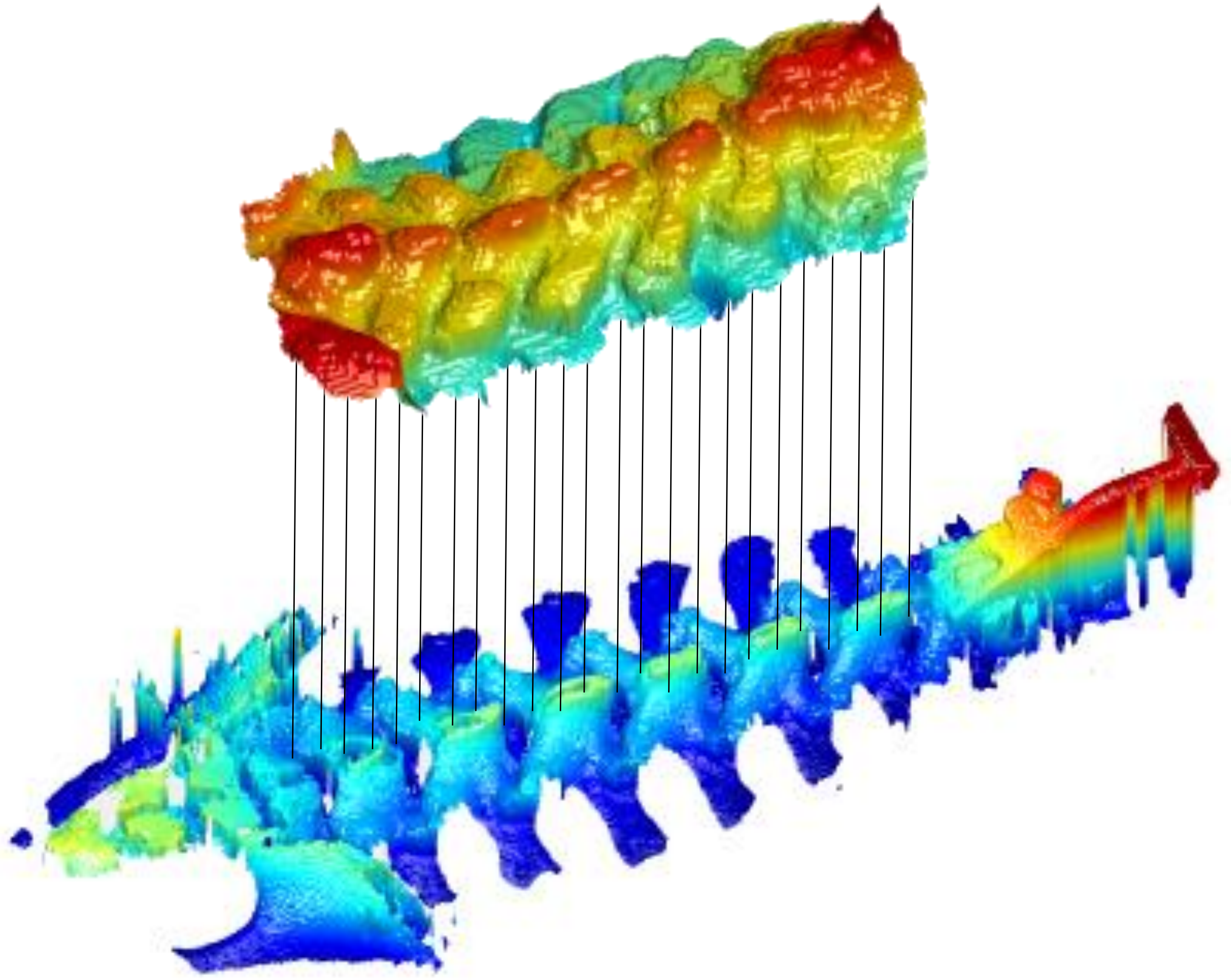




[Lineup]

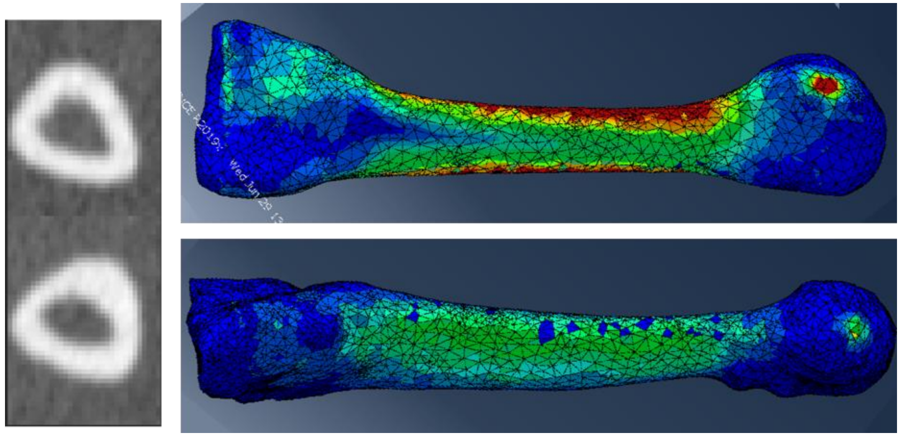
Surgical image-guidance: improve patient outcome

- Help improve surgical accuracy
- Work with lots of medical image data
- Data science techniques
- New collaboration with colleagues at UMASS medical school
- Work with device companies



[Lineup]

Musculoskeletal Biomechanics Laboratory – Karen Troy



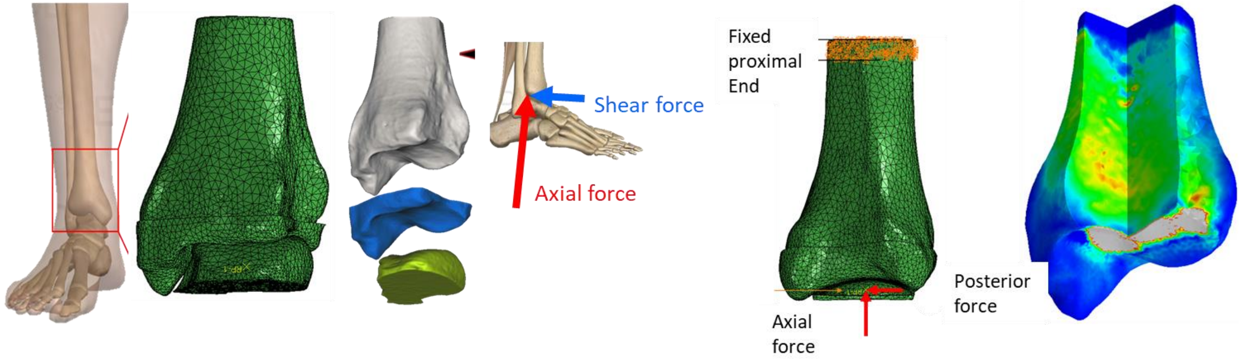
How does musculoskeletal tissue adapt in response to functional activities?

Focus on <u>human</u> injury detection, prevention, rehabilitation.

Techniques:
- *Quantitative image analysis*
- *Finite element modeling*
- *Clinical collaborations*

Musculoskeletal
Biomechanics
Laboratory

Identify structures interacting with the bone(s) of interest	Measure kinematics and kinetics	Calculate joint contact forces	Apply forces and constraints to model



Project Examples
- Quantifying changes in bone strength and stiffness in people with spinal cord injury who participate in exoskeleton-assisted walking
- Fatigue testing of metatarsal bones to predict bone stress injury in runners
- Can we predict what exercises might cause bone adaptation or injury?

Lineup

What are your opportunities?

- Master’s students – directed research experiences, thesis, [limited] projects
- Most projects include quantitative image analysis, computational modeling (sometimes FE), application to musculoskeletal injury and adaptation
- Contact Karen Troy for opportunities – ktroy@wpi.edu

Introduction

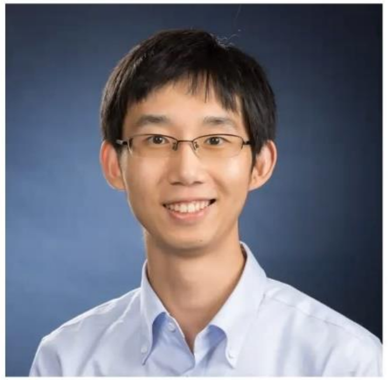
Haichong (Kai) Zhang ***(hzhang10@wpi.edu)***

Assistant Professor

Biomedical Engineering

Robotics Engineering

Computer Science (Affiliate)



Background:

B.S./M.S. – Kyoto University, Japan

M.S./Ph.D. – Johns Hopkins University

Teaching

- BME 4201 Biomedical Imaging
- BME 3014 Signal Processing Laboratory
- BME/RBE 595 Medical Imaging and Robotic Instrumentation

Lab:

50 Prescott 4th floor, Medical FUSION Laboratory

Lineup

PI: Haichong (Kai) Zhang, Contact: hzhang10@wpi.edu

Medical FUSION (Frontier Ultrasound Imaging and Robotic Instrumentation) Lab

- Focuses on interface of medical robotics, sensing, and imaging to create future healthcare.

1. *Robotic assisted imaging systems:* How can a robot revolutionize medical imaging?
2. *Ultrasound and photoacoustic image-guided therapy:* How can advanced imaging revolutionize image guided therapy?

Biological Sensing / Imaging

- Brain recording
- Cancer detection

Medical Robotics

- Co-robotic imaging system
- Robot-assisted intervention
- Point-of-care system

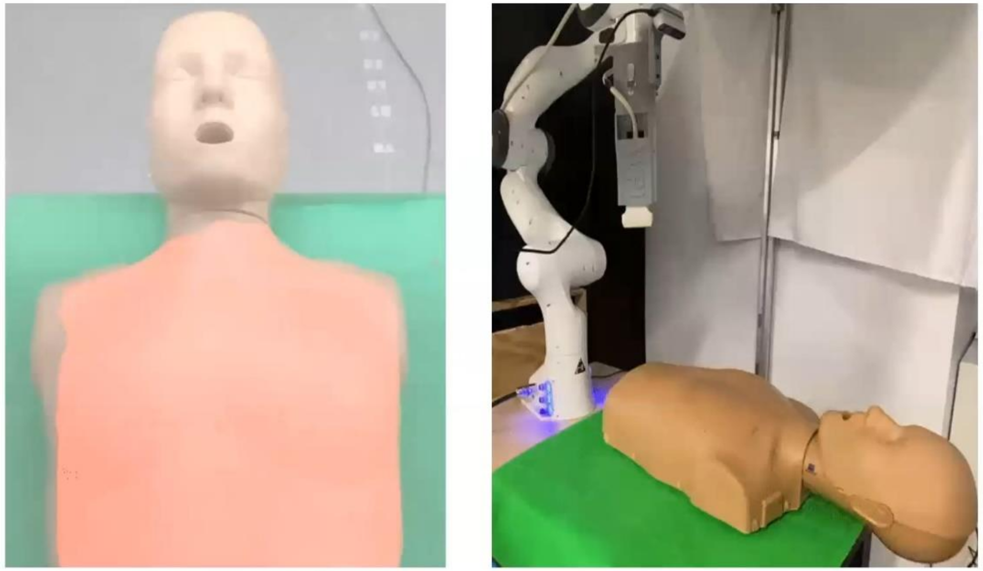
Enabling Technologies

- Image reconstruction
- Advanced signal processing
- Machine learning
- Hand-eye calibration
- Enabling low-cost system

Thrust 1: Robotic Assisted Imaging Systems

Robotic Ultrasound Scanning

- Point-of-care lung ultrasound is a lung diagnostic imaging method to triage COVID-19 patients.
- To counter the shortage of healthcare staffs in rural areas, we develop an autonomous robot-assisted diagnostic platform.



Robot-Assisted Autonomous Lung Ultrasound Scanning

X. Ma, et al., IEEE IROS, 2021

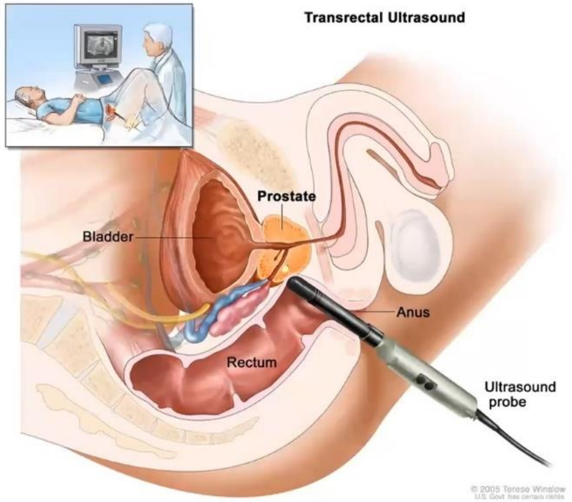
Sponsor: NIH Common Fund Administrative Supplement (DP5OD028162)

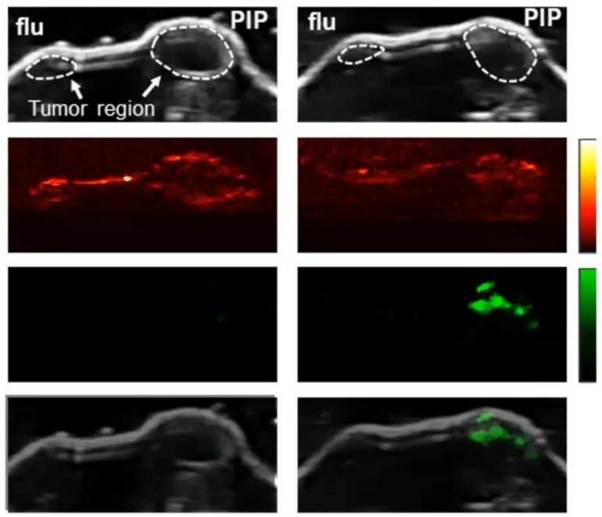
Thrust 2: Ultrasound and Photoacoustic Image-Guided Therapy

Detection: Where should be treated?
Avoidance: Where should not be treated?
Monitoring: When to stop treatment?

Molecular Photoacoustic Imaging of Prostate Cancer

- Photoacoustic (PA) imaging is capable of image targeted molecular contrast agents in vivo.
- We develop an image-guided interventional platform for targeted cancer treatment.





In vivo photoacoustic imaging of PSMA targeted tumor

H. K. Zhang, et al.,
J. Biophotonics, 2018

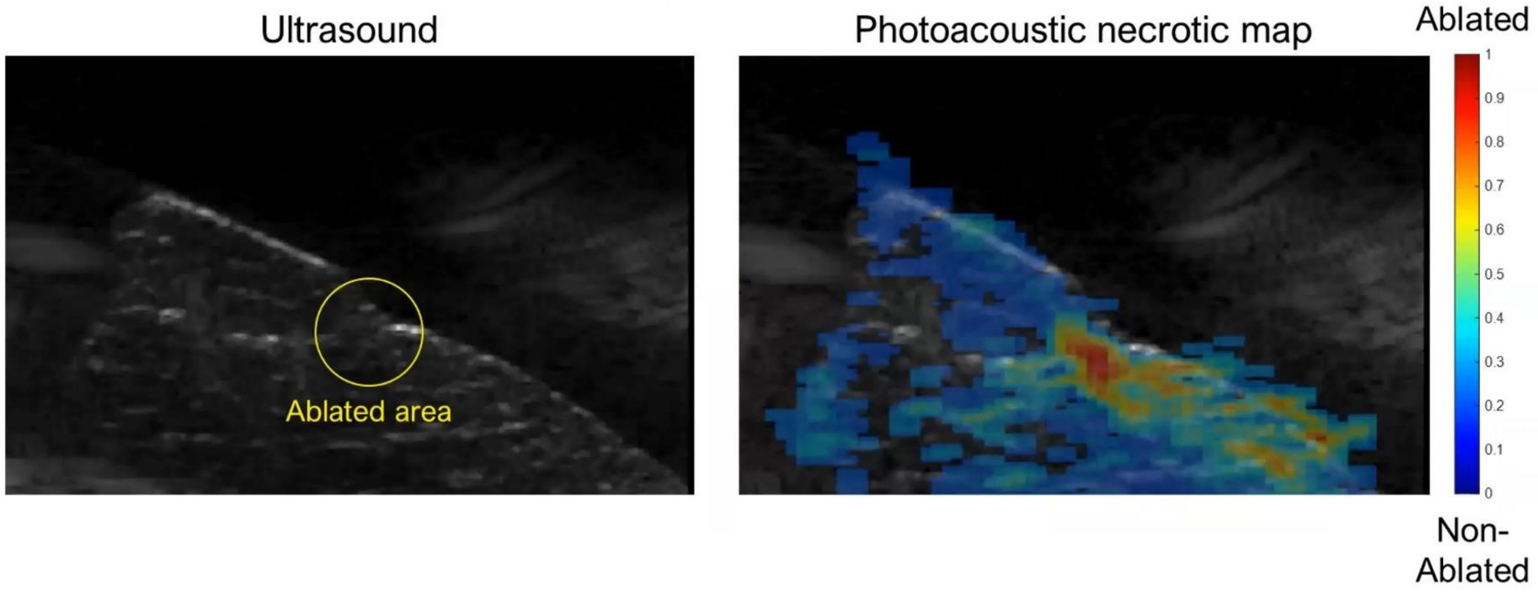
Sponsor: NIH OD028162, CA134675

Thrust 2: Ultrasound and Photoacoustic Image-Guided Therapy

Detection: Where should be treated?
Avoidance: Where should not be treated?
Monitoring: When to stop treatment?

Photoacoustic Necrotic Tissue Visualization for Ablation Monitoring

- We extend the use of photoacoustic imaging for highlighting ablated tissue with respect to the non-ablated counter part.



Photoacoustic Ablation Monitoring
Ablated tissue, highlighted in red.

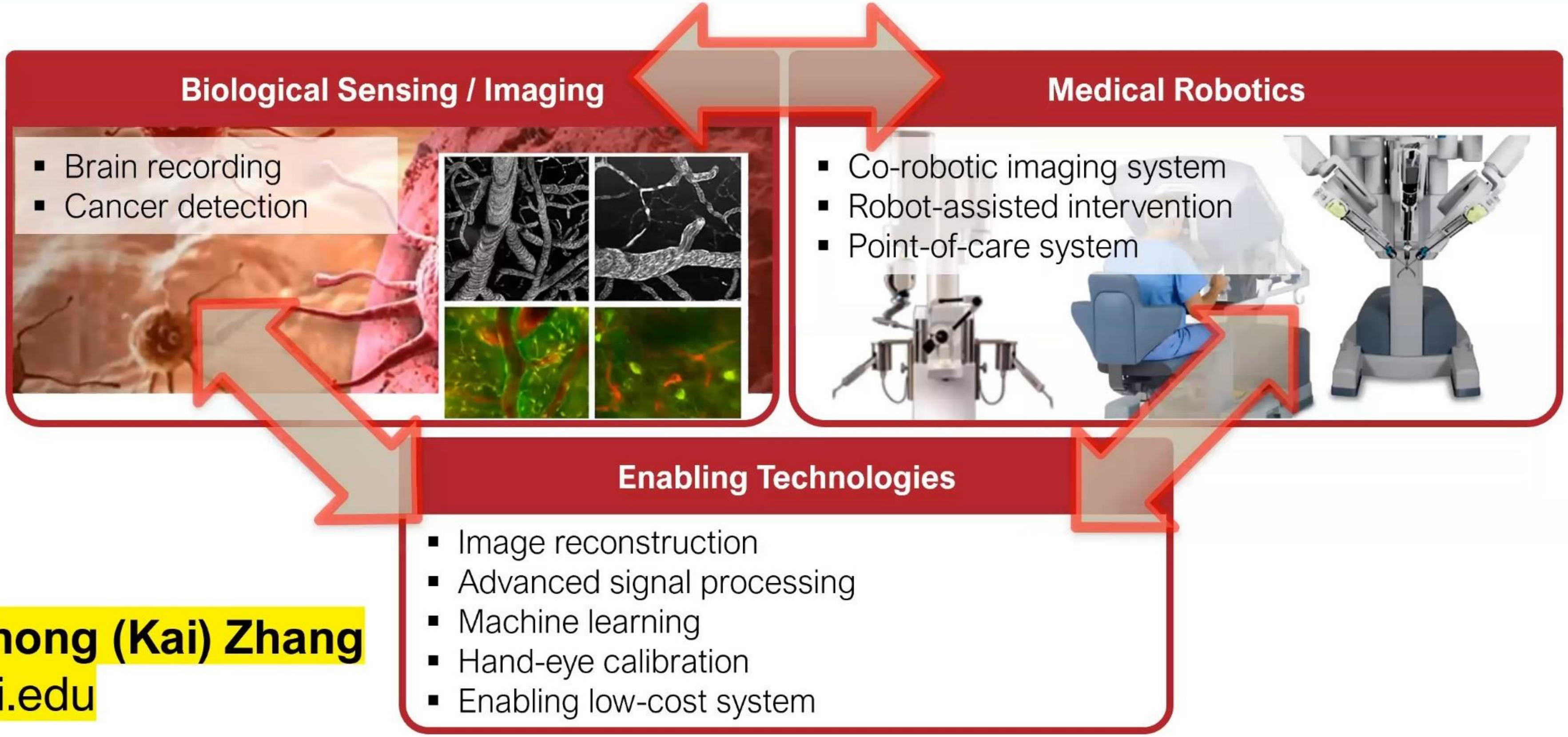
S. Gao, et al., IEEE IUS, 2021

Medical Frontier Ultrasound Imaging and Robotic Instrumentation (FUSION) Lab

Medical FUSION (Frontier Ultrasound Imaging and Robotic Instrumentation) Lab focuses on:

- Interface of medical robotics, sensing, and imaging.

1. *Robotic assisted imaging systems:* How can a robot revolutionize medical imaging?
2. *Ultrasound and photoacoustic image-guided therapy:* How can advanced imaging revolutionize image guided therapy?



Contact: Haichong (Kai) Zhang
hzhang10@wpi.edu

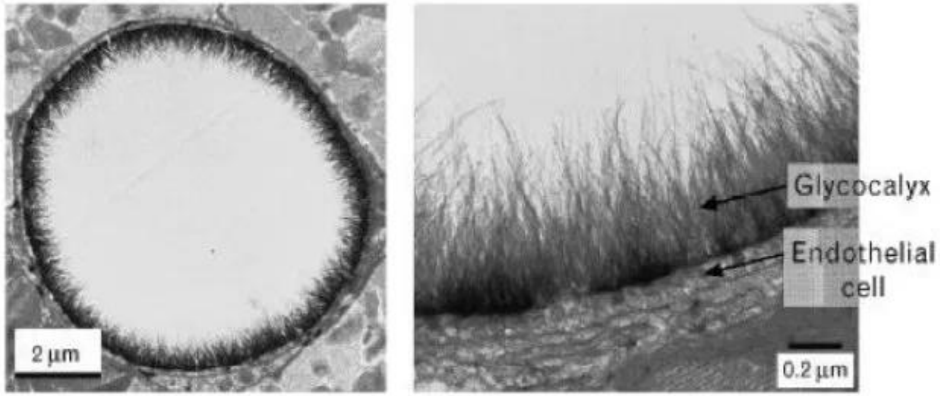
Cardiopulmonary Research and Medical Device Development for Global Health Lab

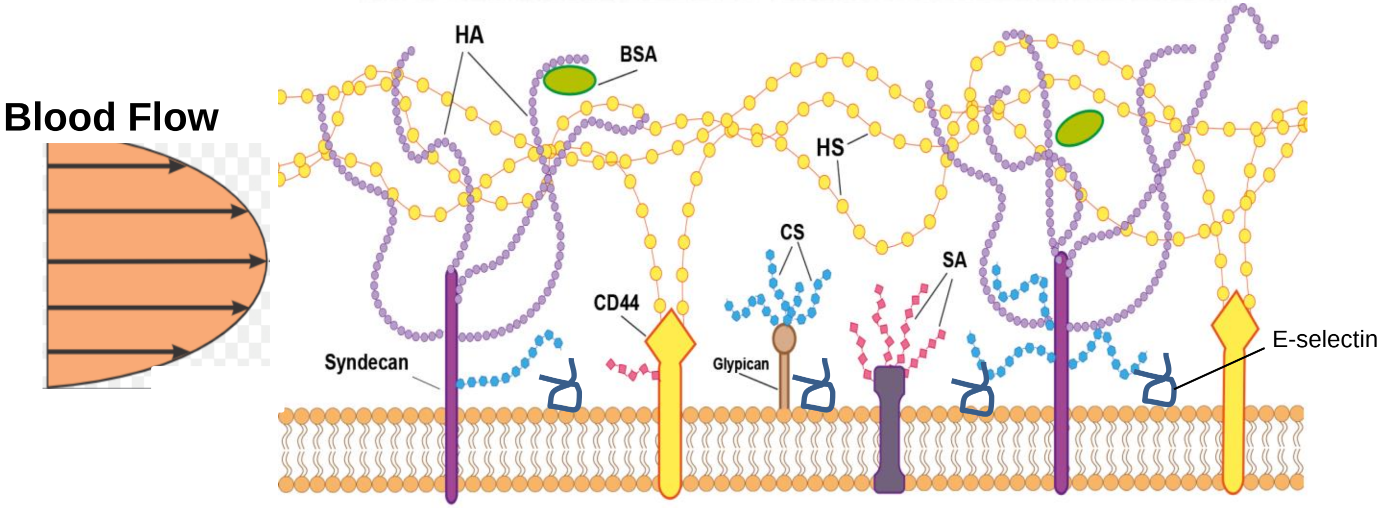
Dr. Solomon Mensah

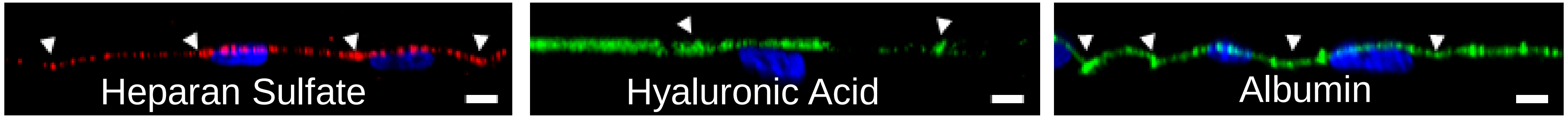
- Research Interests
  - Mechanobiology
  - Intercellular interactions in cancer and immune related diseases
  - *In vitro and vivo* cardiopulmonary models
  - In vitro surgery models
  - Medical Device development for neonatal care

Lineup

Flow Regulated Endothelial Glycocalyx – A Mechanotransducer and Disease Predictor



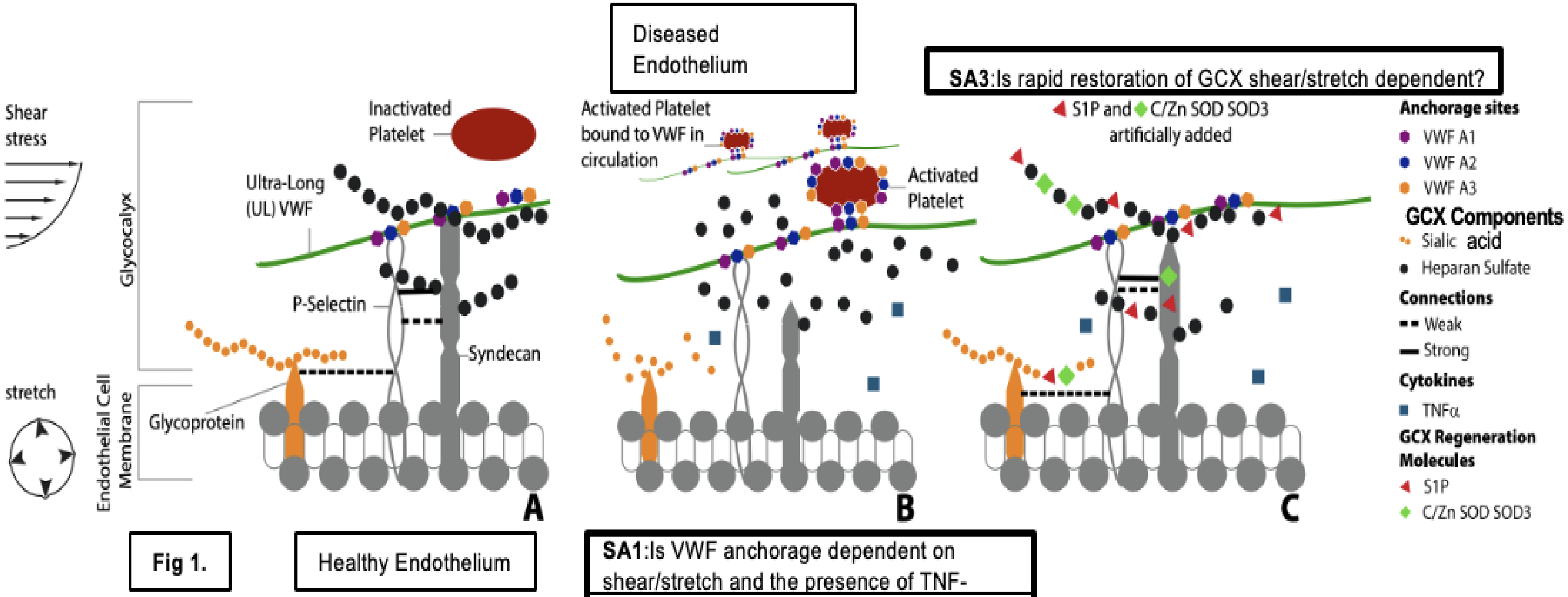




Lineup

1. Ebong et al, ATVB 2011
2. Nieuwdorp et al, Curr Opin Lipidol, 2005
3. van den Berg et al, Circ Res, 2003

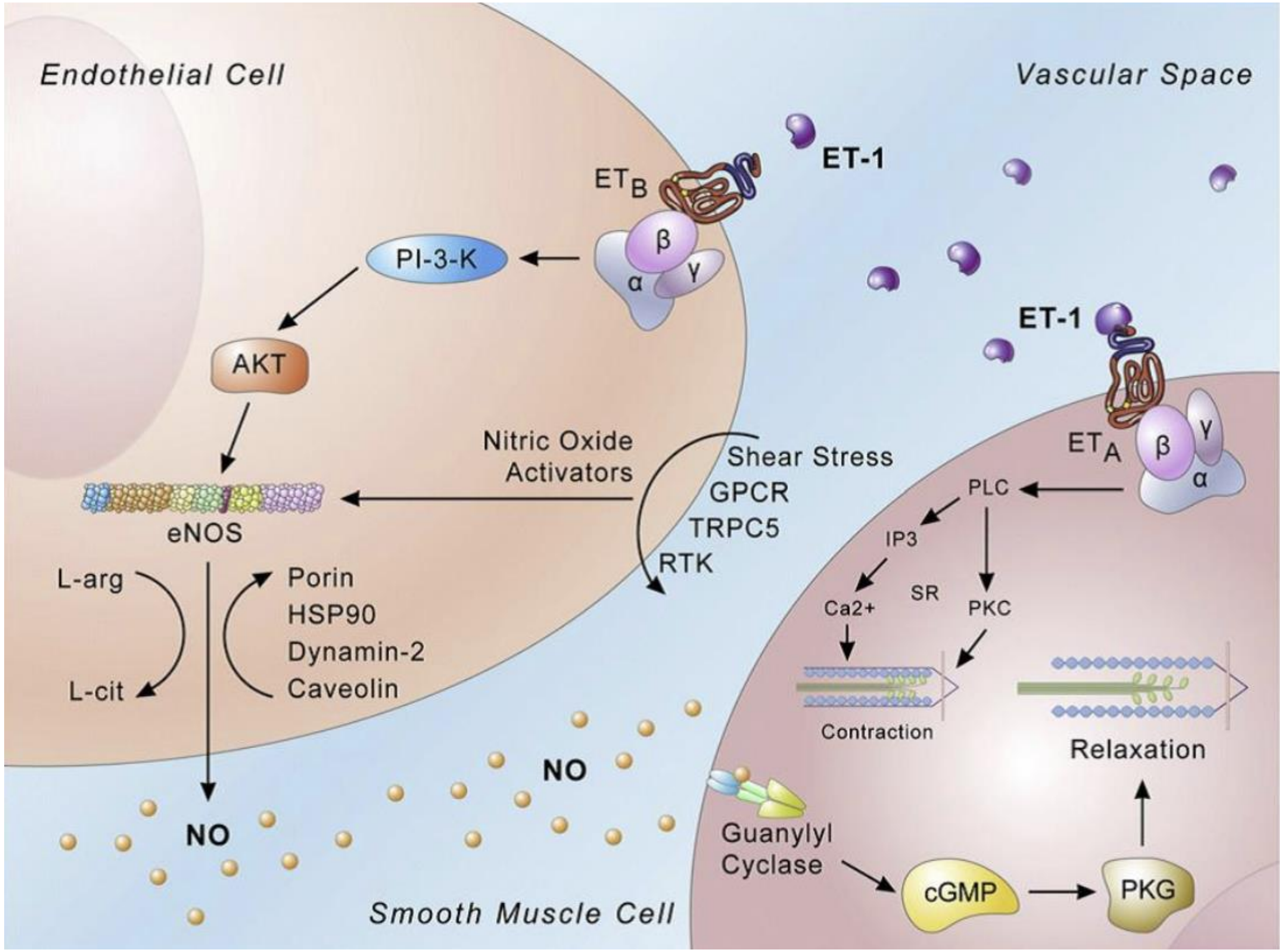
Current Project- Endothelial Glycocalyx and Coagulation



SA1:Is VWF anchorage dependent on shear/stretch and the presence of TNF-alpha?
SA2: Which GCX components help P-selectin
tether VWF?

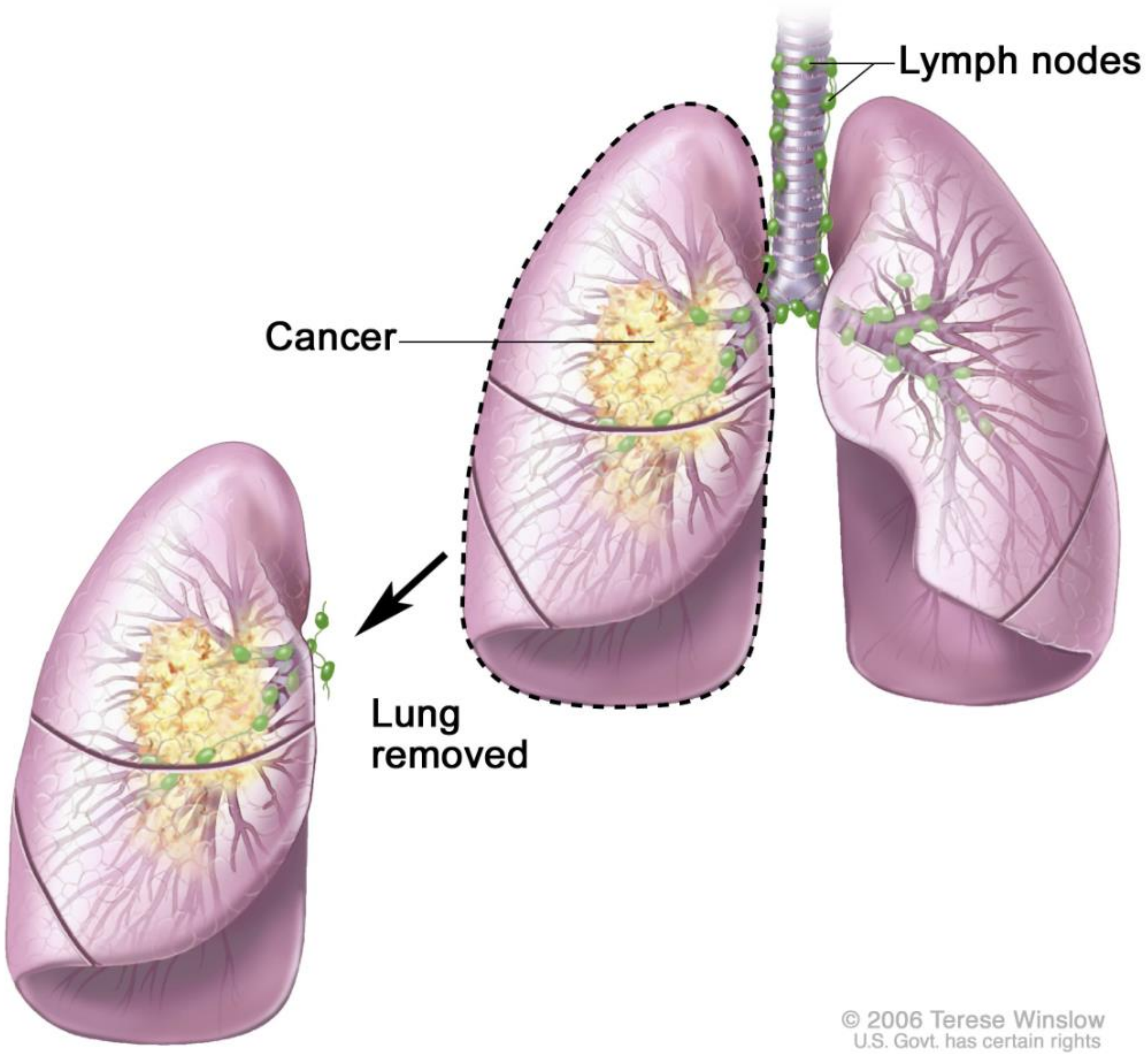
Lineup

Current Project- Endothelial Glycocalyx and Endothelin-1



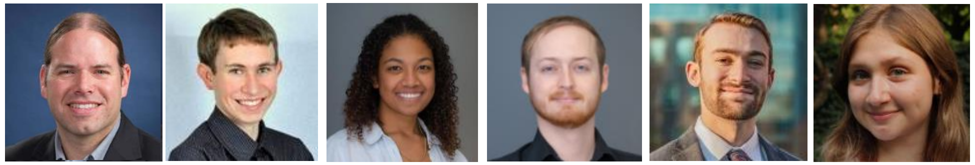
Lineup

Current Project- Endothelial Glycocalyx and Pneumectomy



[Lineup](#)

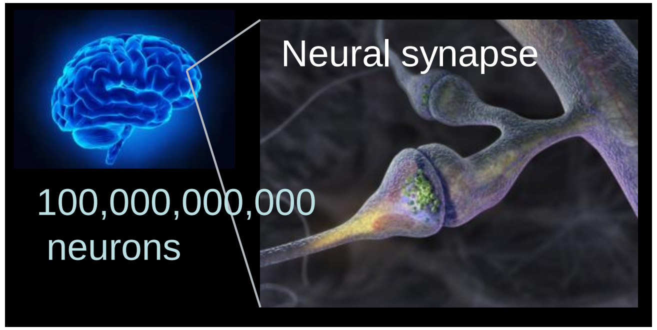
QNTL
quantitative neurotechnology lab



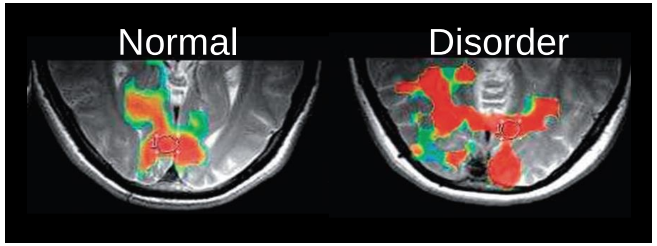
Dirk Albrecht Hamilton Vanessa Fox Daniel Veronika

- Neurological disorders affect >100M
- Many involve **altered neural activity within brain circuits**
- We don't know <u>*how*</u> this activity is altered, by *trauma*, *environment*, or *genetics*
- Toward novel therapeutics

Structure



Function

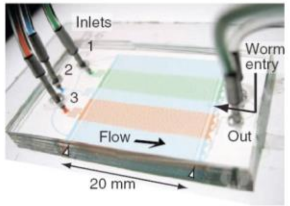


- Our lab engineers new methods to record **living brain function** and identify **regulators of neural activity**

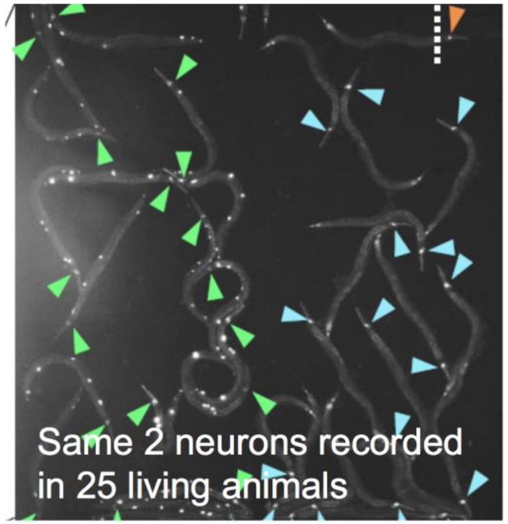
method → **experiment** → **modeling** → **analysis**

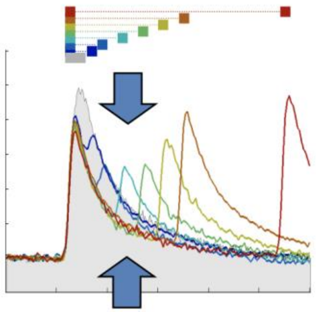
C. elegans
302 neurons

Microfluidics
for precise
stimulation



Fluorescence microscopy to record brain activity changes





Regulated neural response!

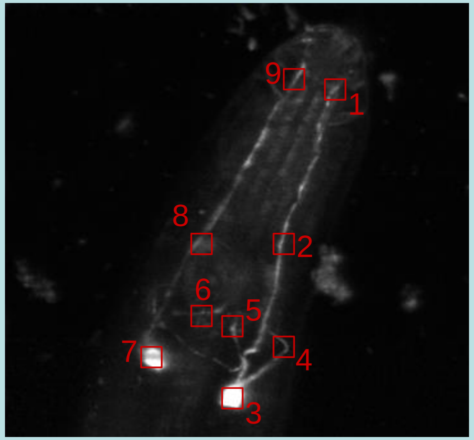
Lineup

QNTL
quantitative neurotechnology lab

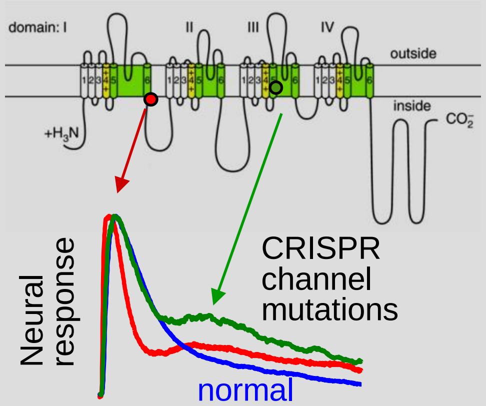
Dirk Albrecht
dalbrecht@wpi.edu
wp.wpi.edu/qntl

- Lab tools and topics: *what will I use and learn?*

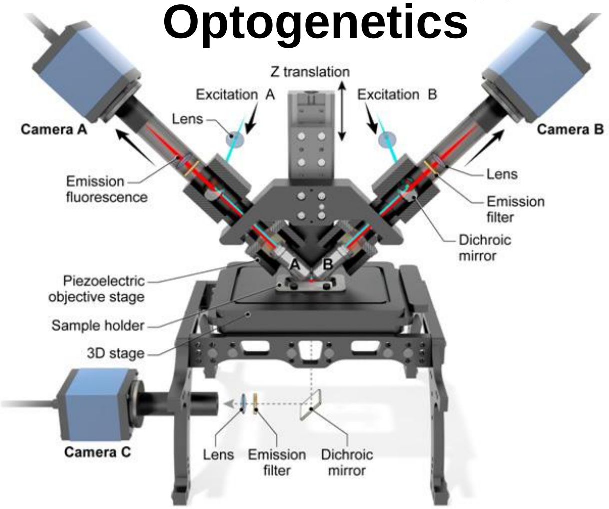
Live Neural Activity, image processing



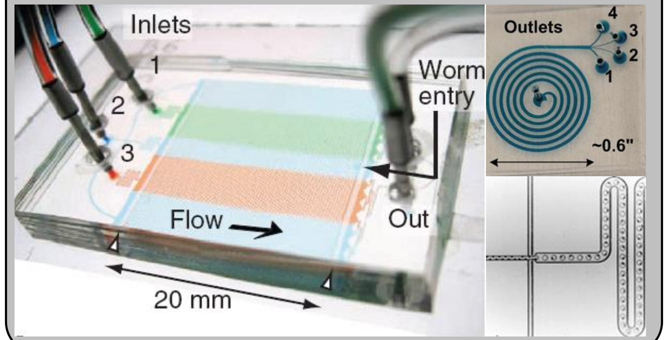
Neural Disorders, Genetics, Behavior (e.g. Sleep, Learning)



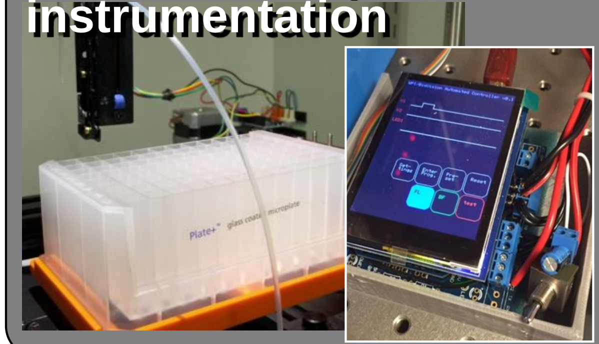
2D/3D Microscopy, Optogenetics



Microfabrication/fluidics



Automated experiments, instrumentation



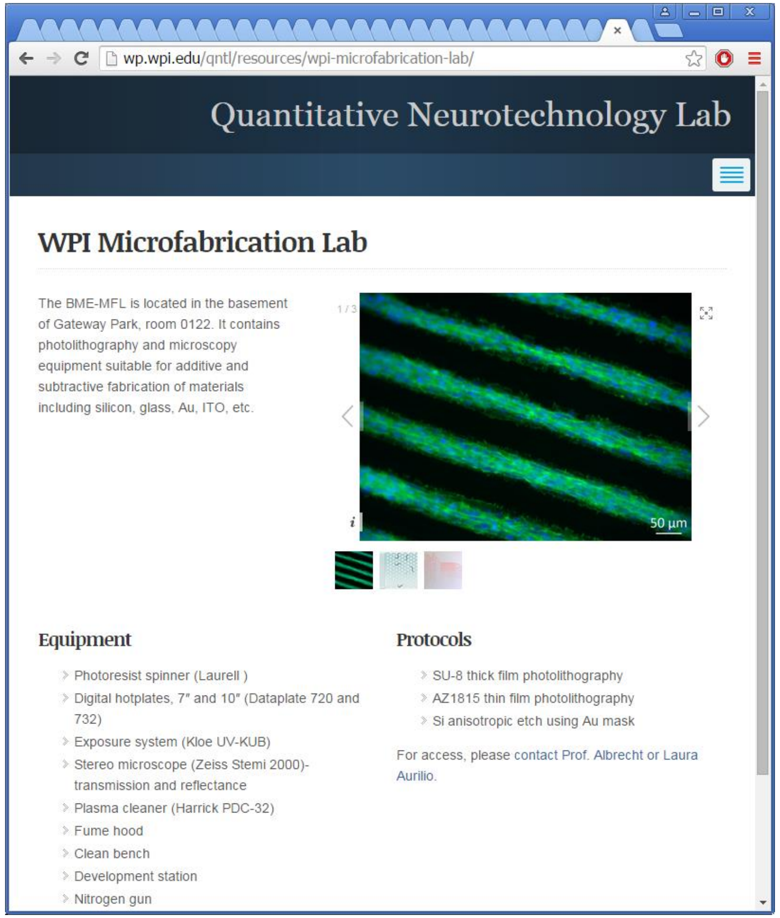
Biomaterials

Lineup

BME-MicroFabrication Lab (MFL)

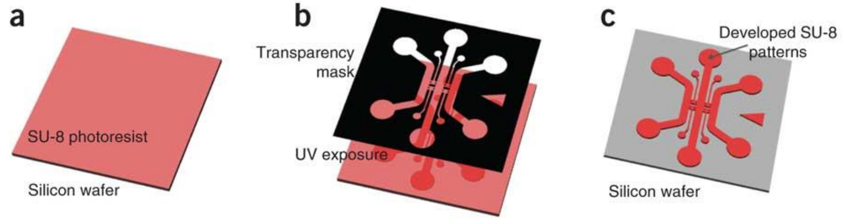
- Also, we run a *microfabrication cleanroom*, available for all grad students to use after training.

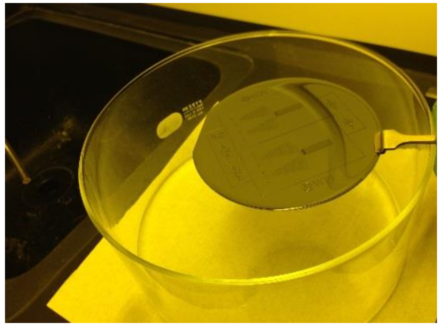
wp.wpi.edu/qntl

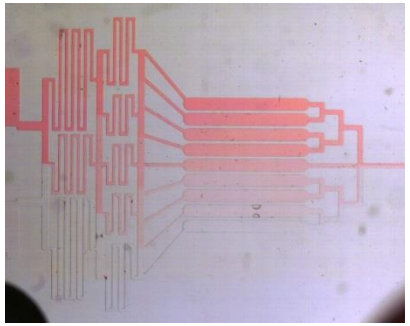


BME555: BioMEMS and Tissue Microengineering, Spring (‘23 next)

- Spin-coat, Photolithography, Etching, Stereomicroscopy, Profilometry, Plasma







- Also: 3D printing, rapid-prototyping microfluidics, etc.

Lineup

QNTL
quantitative neurotechnology lab

Dirk Albrecht
dalbrecht@wpi.edu
wp.wpi.edu/qntl

WPI

- **Lab Questions & Projects:**
  - How does brain activity (excitability) change after:
    - **traumatic brain injury (TBI)**
    - **deep-brain stimulation (DBS)?**
  - And during **learning, sleep, & aging?**
  - Organism **models of human neuropsychiatric disorders** (CRISPR, RNAi) for high-throughput screening (HTS)

- **Available Master's projects, Fall 2023:**

Functional HTS for compounds that alter neural communication *in vivo*

- focus on targeting gap junctions and chemical synapses
- genetic engineering & automation

New methods to study neuropeptide communication, and multisensory attention!

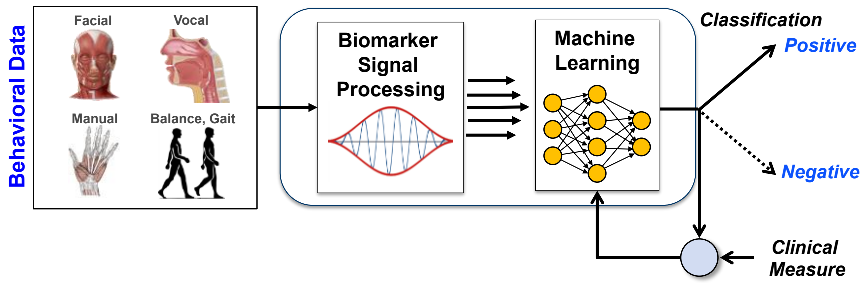
- behavior recording
- hardware / software / microscopy

- other related ideas? let's chat!

Lineup

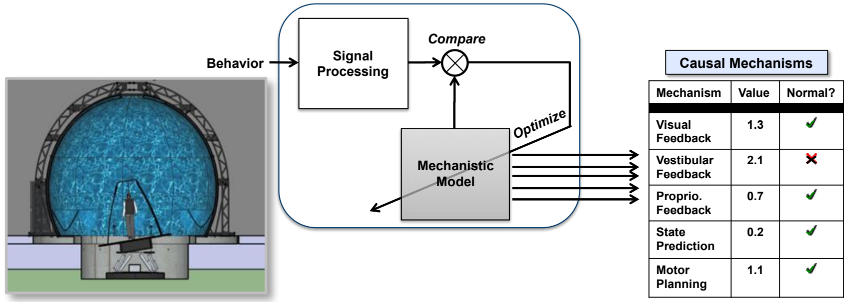
Brain, Behavior & Computation Laboratory

Behavioral Biomarkers of Neurological Disease and Psychological Health



Major Depressive Disorder, Cognitive Fatigue

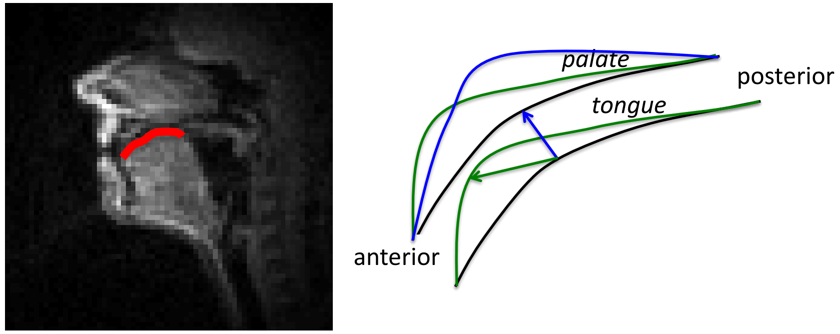
Virtual Reality Testing for Phenotyping of Sensorimotor Impairments



Mechanism	Value	Normal?
Visual Feedback	1.3	✓
Vestibular Feedback	2.1	✗
Proprio. Feedback	0.7	✓
State Prediction	0.2	✓
Motor Planning	1.1	✓

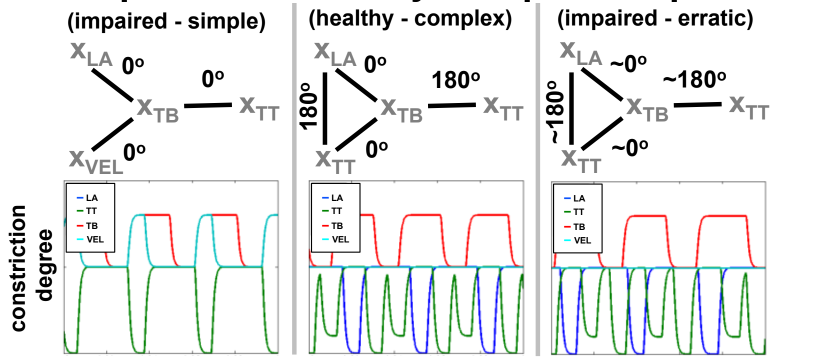
Traumatic Brain Injury, Speech Motor Disorders

Structure & Function in Speech Motor Variability Using Real-Time MRI



Cleft Palate, Cancer-Related Glossectomy

Computational Models of Motor Planning & Adaptation in Healthy & Impaired Speakers



Lou Gehrig's Disease, Speech Motor Disorders

Prof. Adam Lammert (alammert@wpi.edu)

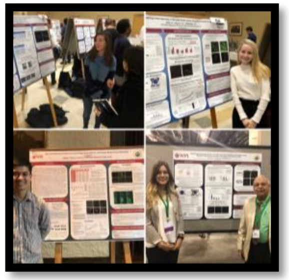
Lineup

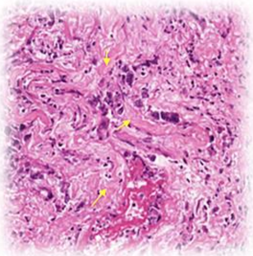
Whittington Laboratory

cfwhittington@wpi.edu;
@cfwhitt; @WPI_BME; @BlackInBME

DynaMITE
Dynamic Microenvironment Tissue Engineering Lab





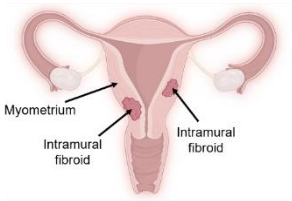


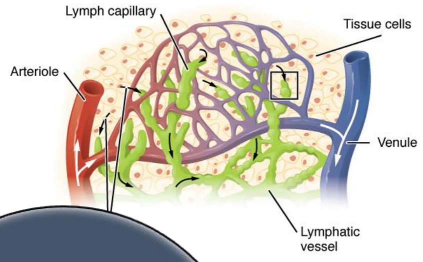
Pancreatic cancer

Fibrosis

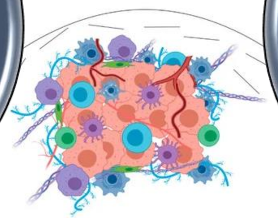
In vitro disease model development

Lymphatic disease





Uterine fibroids

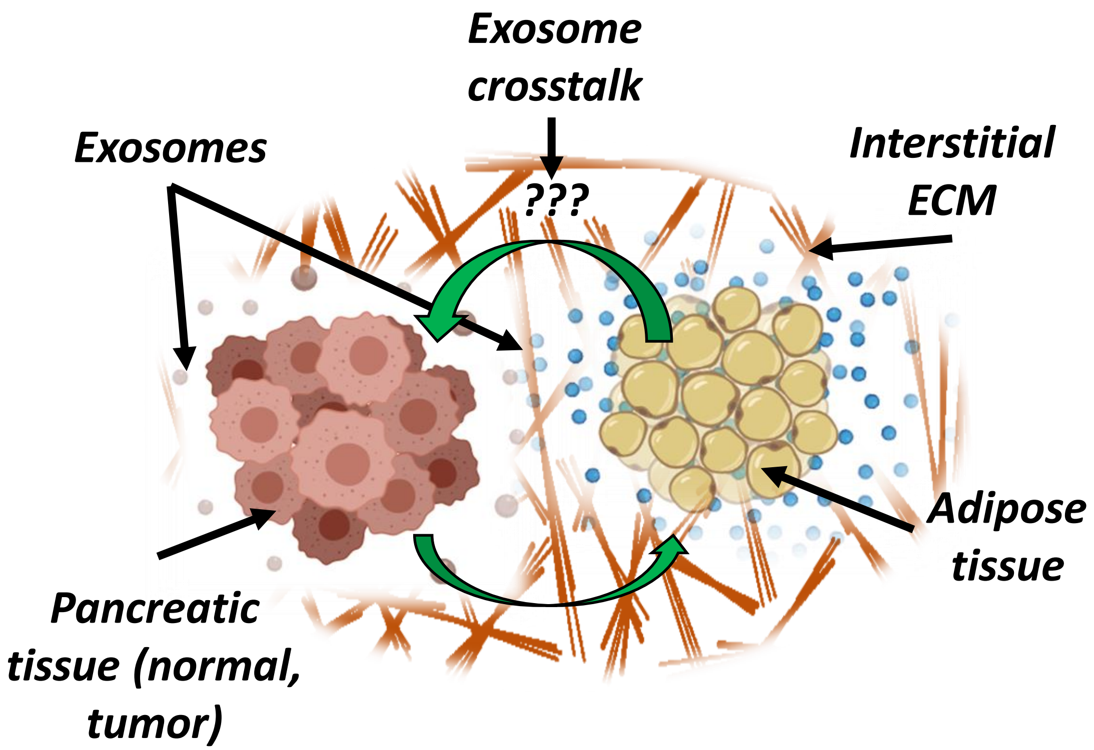


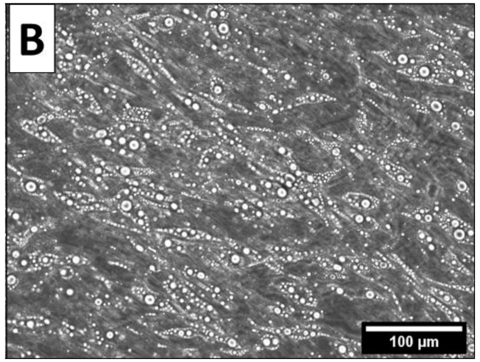
Pancreatic cancer + Lymphatics

Lineup

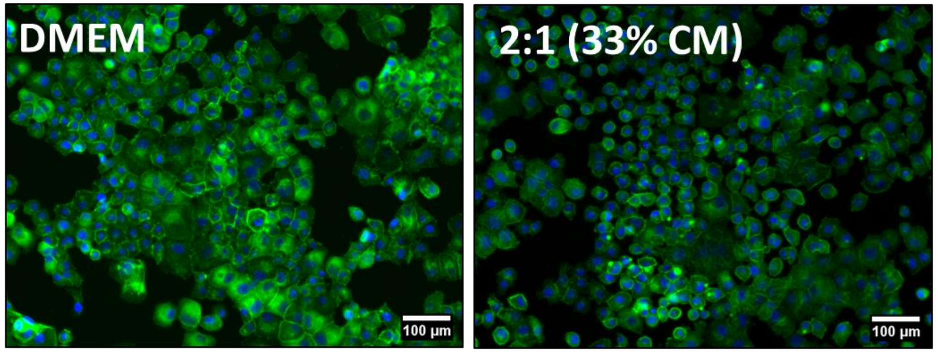
Fibrosis-mediated transformation in pancreatic cancer risk factors in vitro *(focus on obesity)*

PANCREATIC CANCER ACTION NETWORK®





Adipocytes in culture



Pancreatic cancer cells cultured with and without adipocyte conditioned media.

Available MS Thesis Projects

Investigating the role of ECM stiffness in regulating or contributing to:

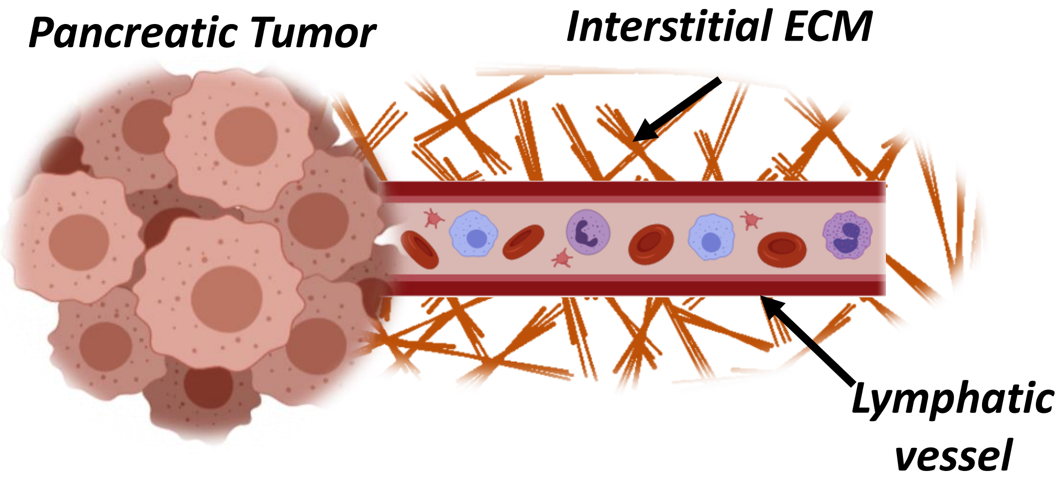
Exosome secretion in pancreatic cells and/or adipose cells.

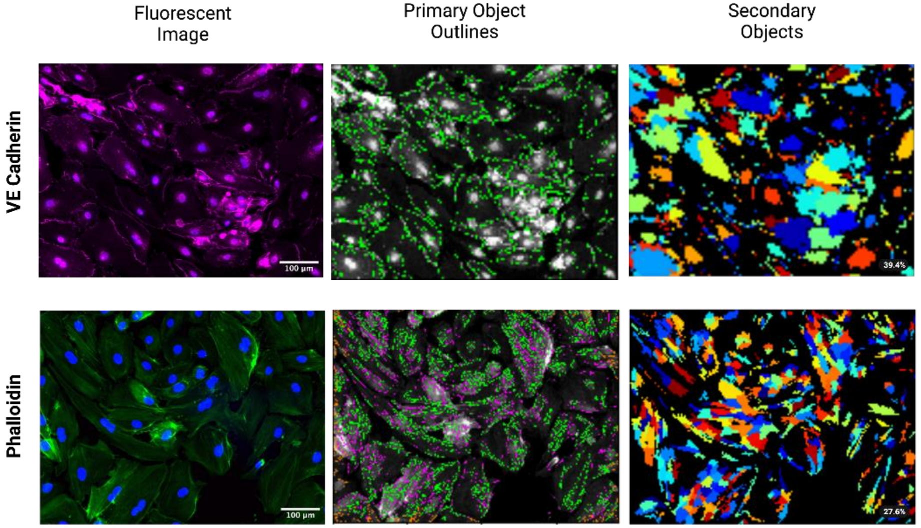
Early malignant transformation of pancreatic cells with KRAS and/or p53 mutations.

Pancreatic-adipose crosstalk and sensitivity to paracrine signals.

Lineup

Using collagen matrices to investigate how progressive stiffening alters lymphatic trafficking in PDAC





Assessing cell-cell coverage as a method of of evaluating lymphatic endothelial cells barrier integrity using VE-Cadherin (cell-cell junction marker) and phalloidin (actin marker) staining and CellProfiler.

Available MS Thesis Projects

Investigating the role of ECM stiffness in regulating or contributing to:

- Adhesion and chemotaxis markers in lymphatic endothelial cells.
- Cell-cell adhesion between lymphatic endothelial cells and pancreatic tumor cells or immune cells.
- Motility of pancreatic tumor cells or immune cells across a lymphatic endothelial cells monolayer.
- Barrier integrity of lymphatic endothelial cells (i.e., migration of pancreatic tumor cells or immune cells across the vessel wall).

Lineup