Mechanical Engineering Master's Program Info Session

Prof. Rajat Mittal

Director of Master's Studies

Mike Bernard

Academic Program Manager

JOHNS HOPKINS UNIVERSITY

MSE Degree Requirements

Section A - 8 advisor-approved courses

- 2 must be applied math, numerical analysis, or computational
- 4 (all-course) or 3 (essay) must be 530.xxx or 535.xxx Mechanical Engineering
- No more than 2 from Engineering for Professionals
- No more than 4 from upper-undergrad level (xxx.4xx only)
- No independent research, graduate research, or special studies.

Section B – choose one

- 2 more courses (530.823 MSE Graduate Research can be one)
- Certain Center for Leadership Education courses can count.
- Master's Essay – Research or Co-Op

See Section 3.2 of the Master's Advising Manual

Master's Essay (Thesis) – Research

Conduct original research with world-renowned professors!

1. **Complete 8-10 courses –** 1st-4th semesters
2. **Identify a research advisor –** 1st-2nd semester
3. **Conduct research** – 2nd-4th semesters
   - 6 total credits of 530.823 (equivalent of 2 courses);
   - Prepare and submit a master's essay that summarizes your research (approved by advisor + one other faculty "reader")
   - There is no essay defense

Advantages of MSE Research Essay

- Become part of a research team and learn from a topic-area expert.
- Conduct research that might lead to papers and/or conference presentations.
- Improve your writing/presentation skills.
- Impress potential employers with your expertise.
- Improve chances of entering a PhD program (JHU or others).

Master's Essay (Thesis) – Co-Op

Immerse yourself in a co-operative work experience!

1. **Complete 8-10 courses** – 1st-2nd-3rd semesters
2. **Meet with the Master's Industry Co-Op Office** – 2nd semester
   - Discuss interests and seek employer
   - Create application and resume
   - Interview with companies
3. **Work** – 3rd-4th semester
   - All courses must be completed before beginning work
   - Work at the employer
   - Meet with faculty advisor and employer supervisor every six weeks
   - Write the essay

Advantages of MSE Co-Op Essay

- Get work experience
- Increase potential for continued employment
- Impress potential employers with your expertise.

Frequently Asked Questions about MSE Essay

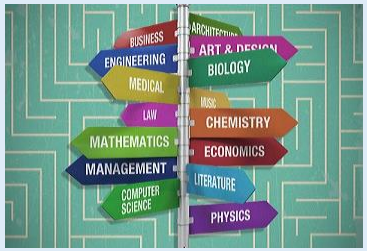
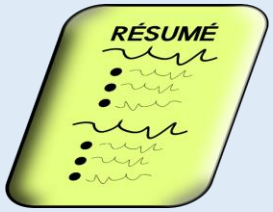
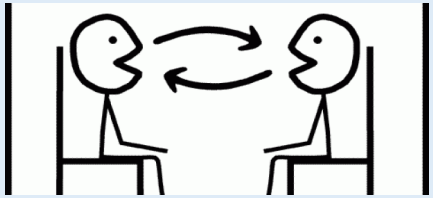
- **How do I find an advisor?**
  - Contact professors in your area of interest and inquire about master's research opportunities.
  - Contact the Director of Graduate Studies or the Academic Program Manager to inquire about potential advisors.
- **What kinds of research projects do Master's students do?**
  - There is significant flexibility on what constitutes a master's essay project, which is decided with your advisor.
  - For example, master's research may be a fundamental scientific investigation involving theory, experiments, computational modeling, or it may involve experimental design and/or testing of a device.
- **How long is the Master's Essay?**
  - There is no recommended length. The essay is a summary of your project and is approved by your advisor and one other reader. Your advisor will usually guide you in the writing of your essay.
- **Research can sometimes be open-ended. What if I cannot achieve my research objectives even after 6 credits of research? Will that delay my graduation?**
  - No! The MS essay is written, submitted and approved at the end of 6 credits of MSE research. As long as your advisor is satisfied that your research effort was appropriate and you prepare an approved essay, you are done.
- **I am thinking of joining the 5th-Year Master's program. Can I do an essay and finish in one year?**
  - Yes! Talk to potential advisors early in your Junior and Senior years so that you can start planning your essay right away.
- **Is there funding available for Master's students who conduct research?**
  - Most MS research is unfunded, but some advisors might have funding available.

LIFE DESIGN LAB
WSE GRADUATE AFFAIRS OFFICE

JOHNS HOPKINS UNIVERSITY

Life Design Educator for Engineering Masters Students
Mark Savage - msavag16@jhu.edu 607-342-3067

FOR DISCUSSIONS / CONSULTATIONS ABOUT CAREER AND/OR JOB SEARCH FOCUSED ISSUES

		
CAREER PATHWAYS	**NETWORKING / CONNECTING WITH OTHERS**	**INFORMATIOAL INTERVIEWS**
CREATING RESUMES & COVER LETTERS	**JOB SEARCH STRATEGIES**	**INTERVIEW STRATEGIES**
		

REGISTER ON HANDSHAKE TO MAKE APPTS, APPLY FOR JOBS, SIGN-UP FOR PRESENTATIONS: https://handshake.jhu.edu

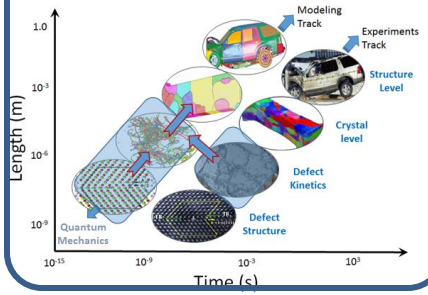
Combining Machine Learning, Multiscale Modeling, and in situ Experiment to Design Materials with Superior Properties

Prof. Jaafar El-Awady
jelawady@jhu.edu

Micro-structure Property Prediction

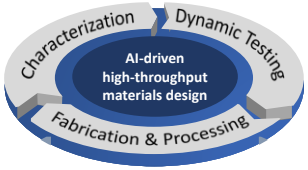
Overview:

- Our group couples ***machine learning*** and ***physics-based multiscale modeling*** tools to design and predict the thermo-mechanical properties, deformation and failure of materials.
- We also develop advanced microscale experiments to: quantify location based properties of advanced metals and alloys.



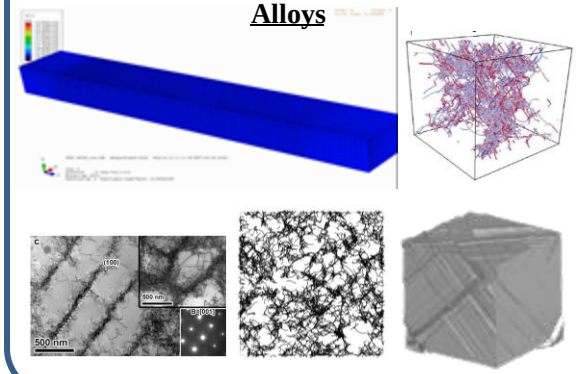
Multiphysics Multiscale Modeling and Machine Learning

AI for Materials Discovery

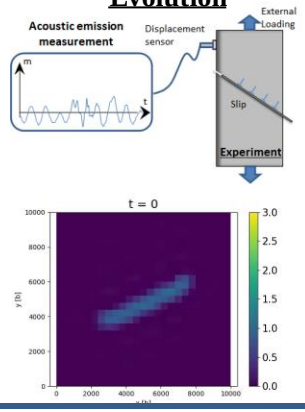


Fully Automated High-throughput Laboratory

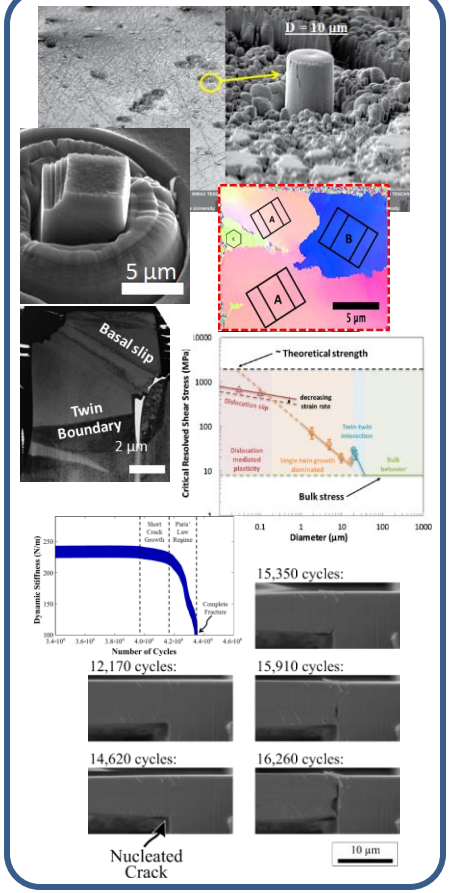
Mechanical Properties and Microstructure Evolution in Additive Manufacturing of Alloys



Machine Learning of Defect Evolution



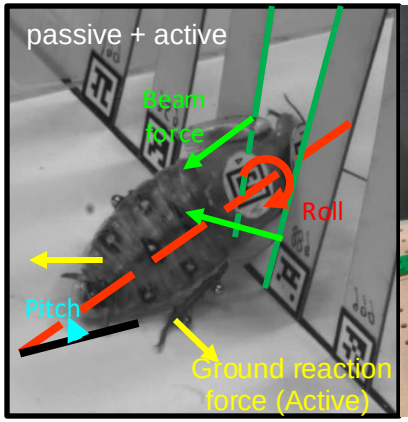
Location Specific In situ High Temp. Testing of Metals

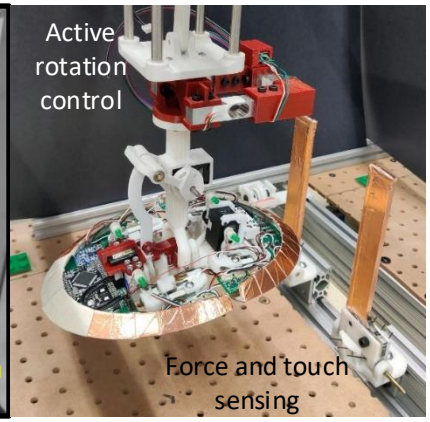


Prof. Chen Li **chen.li@jhu.edu**
https://li.me.jhu.edu/

Terradynamics Lab
Movement Science at the Interface of Biology, Robotics, & Physics

Robot Traversing Beam Obstacles





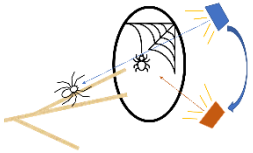
We study how robots can take advantage of active sensing and control to traverse obstacles robustly.

- **Robotic design and experiments**

Spider Predator-Prey Interaction

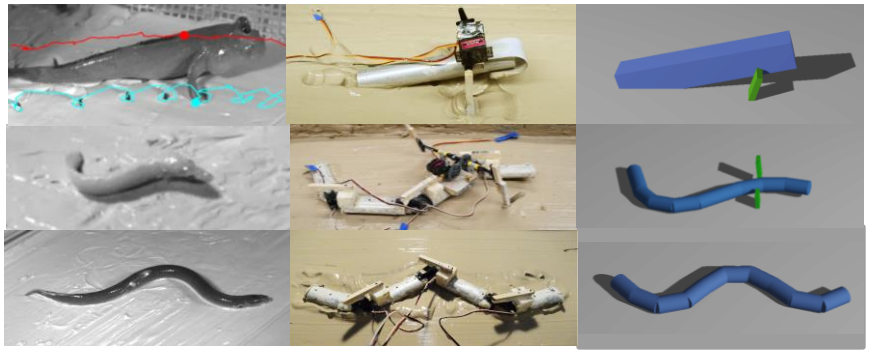
We study how jumping spiders plan a detour in complex environment and invade a web to catch preys.

- **Animal experiments**



Fish Crawling on Mud & Through Vegetation

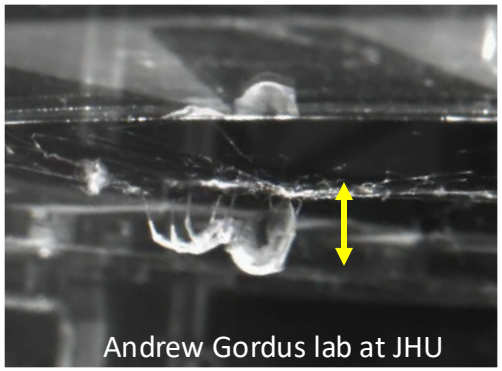
Animal **Robot** **Simulation**

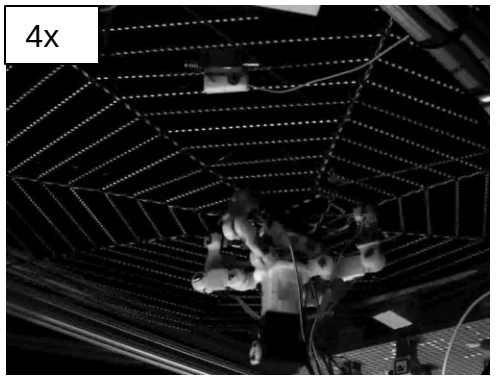


We study how mudskippers, bichir fish, and rope fish moves on muddy terrain to get insights on evolution.

- **Animal experiments**
- **Robotic design and experiments**
- **Physics-based modelling & simulation**

Spider Web Vibration Prey Sensing





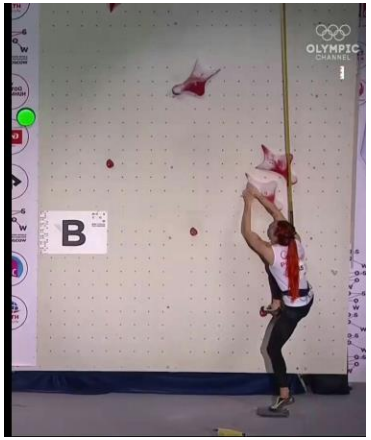
We study how orb-weaving spiders identify and locate prey on their webs through active vibrational sensing using robophysical model.

- **Robotic design and experiments**
- **Physics-based modelling & simulation**

Prof. Chen Li chen.li@jhu.edu
https://li.me.jhu.edu/

Terradynamics Lab
Movement Science at the Interface of Biology, Robotics, & Physics

Human Climbing

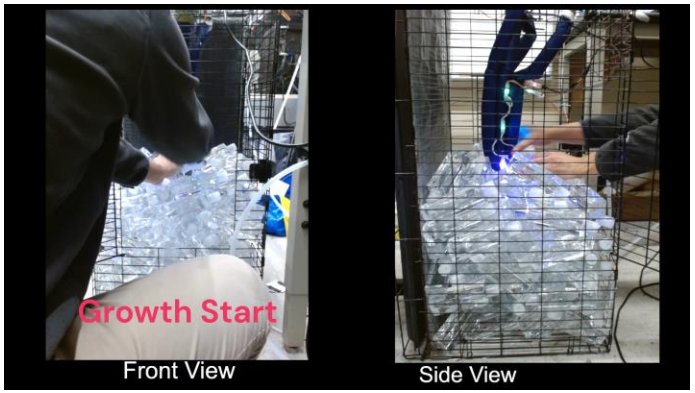


Russell, Zirker, Blemker (2012) *Sports Technol.*

We study how humans climb rocks dynamically

- Video Analysis

Digging into Heavy Rubble

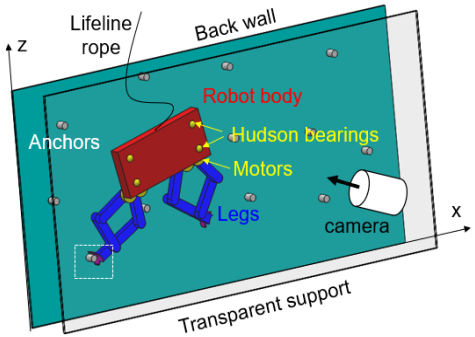


We study how jumping spiders plan a detour in complex environment and invade a web to catch preys.

- Animal experiments

In collaboration with Prof. Elliot Hawkes at UCSB

Goat Climbing on Challenging Terrain

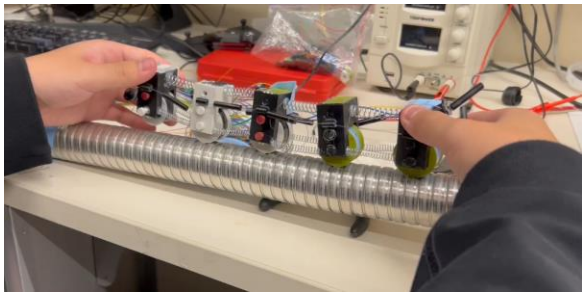


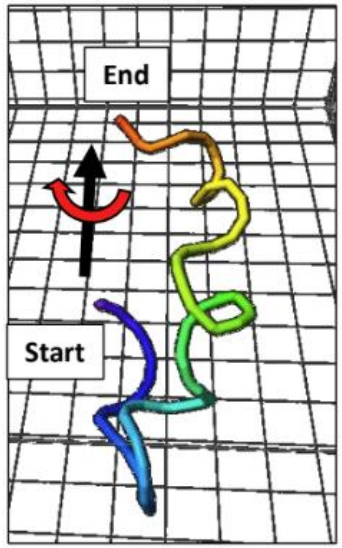
We develop and study a goat-inspired robot climbing steep terrain

- Robotic design and experiments
- Physics-based modelling & simulation

Robophysical Modeling of Malaria

In collaboration with Prof. Yun Chen here





Design and create a robot to imitate malaria parasite movement and understand how it penetrates skin

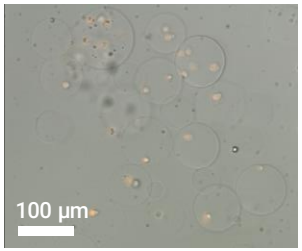
- Robotic design and experiments
- Physics-based modelling & simulation

Student Mentee Achievements

- Have mentored 105 students at JHU (from PhD to high school)
- >40% master, undergraduate, and high school student have earned co-authorship on conference abstracts, >15% on peer-reviewed papers
- 40% have continued onto top PhD, master, or undergraduate programs (MIT, Stanford, Princeton, Berkeley, UPenn, JHU, CMU, Northwestern, UMichigan, UW, Virginia Tech, Columbia, etc.)
- >10% have continued on to top tech companies (Google, Facebook, Amazon, Agility Robotics, etc.)
- >10% of my mentees have won competitive research awards in the department, at local events, and from other universities
  - 5 PhD, 1 master, and 1 undergraduate students won best paper award finalists
  - 1 undergrad won competitive summer research scholarship
  - 5 undergrads won 8 competitive ME departmental research & scholarly and outstanding achievement awards
  - 1 high school student won 2 competitive awards at Science Fair

Learn more: https://li.me.jhu.edu/mentoring/, https://li.me.jhu.edu/join/

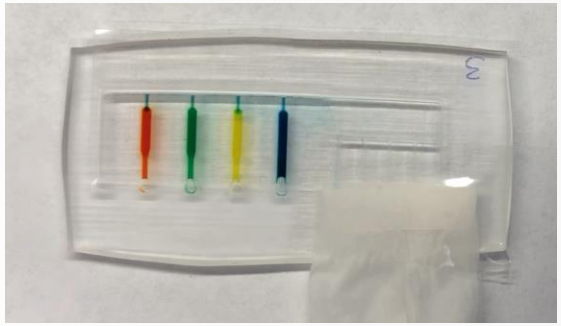
Cell encapsulation in functional gel



Injectable cell-therapy w/
Luo Gu and Sangwon Kim

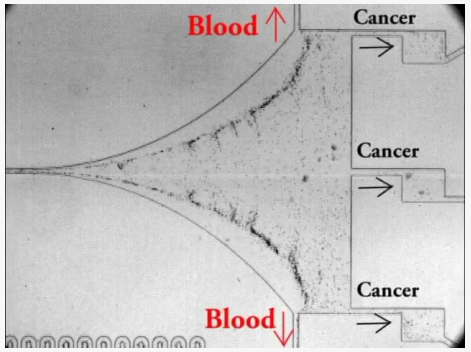
Single-cell secretomics
w/Rebecca Schulman

Pumpless flow control



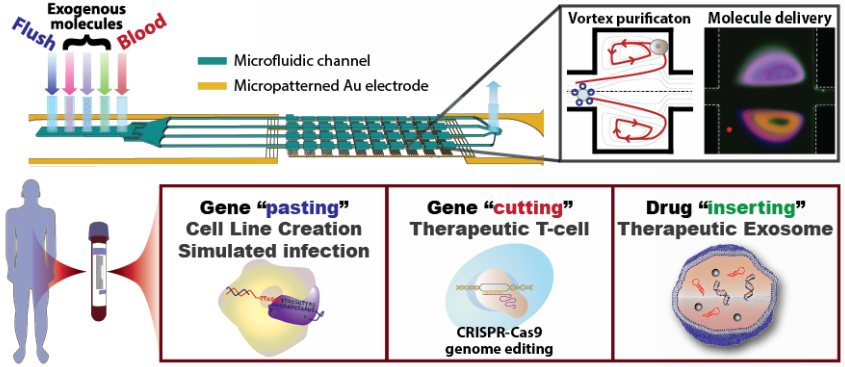
POC diagnostics
w/ Jamie Spangler and Netz Arroyo

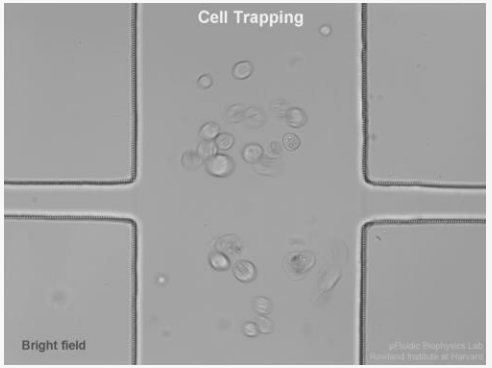
Label-free cell sorting



Retina transplantation w/ Don Zack

Vortex-mediated multi-molecular delivery





µFluidic Biophysics

@fromHurLab

www.IMBiotech.com

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Tissue Morpho & Mechanics Lab (TMML)

Shinuo Weng, Ph.D.
s.weng@jhu.edu
https://sweng.wse.jhu.edu/

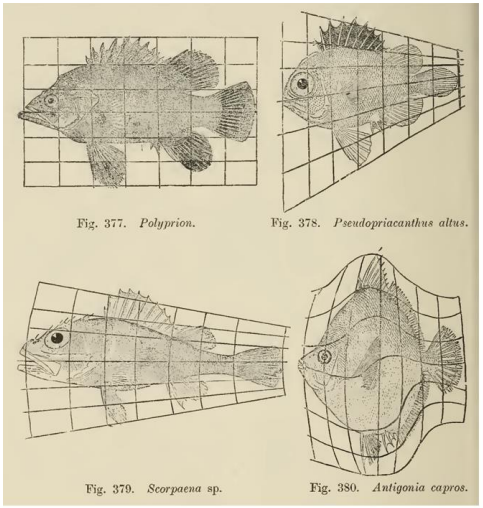
Congenital anomalies are the leading cause of death for children <15 in the U.S.

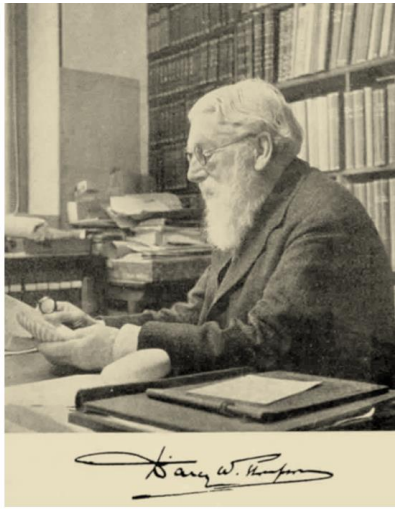
Ages

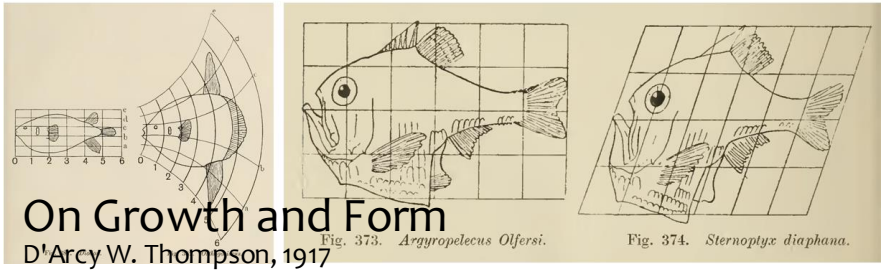
	<1	1-4	5-9	10-14	1-15
1	Congenital Anomalies 4,043	Unintentional Injury 1,153	Unintentional Injury 685	Unintentional Injury 881	**Congenital Anomalies** 4746
2	Short Gestation 3,141	Congenital Anomalies 382	Malignant Neoplasms 382	Suicide 581	**Unintentional Injury** 3913
3	Sids 1,389	Homicide 311	Congenital Anomalies 171	Malignant Neoplasms 410	**Short Gestation** 3141
4	Unintentional Injury 1,194	Malignant Neoplasms 307	Homicide 169	Homicide 285	**Sids** 1389
5	Maternal Pregnancy Comp. 1,116	Heart Disease 112	Heart Disease 56	Congenital Anomalies 150	**Maternal Pregnancy Comp.** 1116

CDC, WISQARS

Formation of shape and function is a mechanical progression







On Growth and Form
D'Arcy W. Thompson, 1917

The form of any particular part of an organism is the result of a balance between the *internal forces* that tend to make it one shape and the *external forces* that tend to make it another.

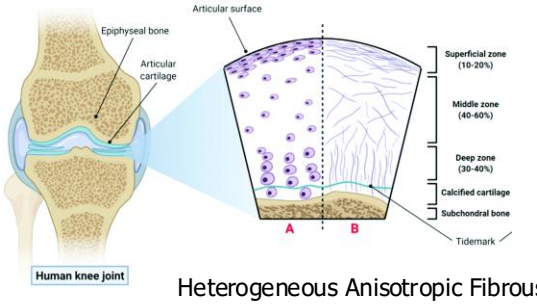
⇨ Harnessing mechanical blueprint *in vivo* to engineer tissues *in vitro*

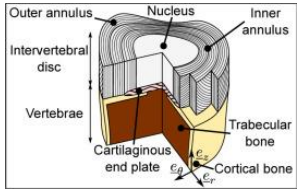
Understanding the Mechanics Associated with Arthritis and Pain

Jill Middendorf
jmidden1@jh.edu

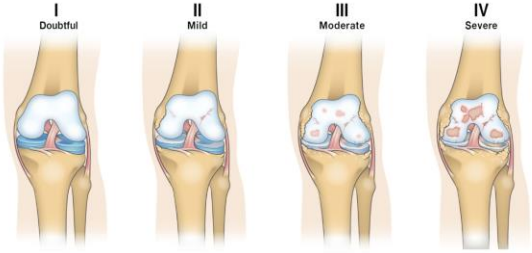
M - TΣAM
Musculoskeletal Tissue Engineering and Advanced Mechanics Lab

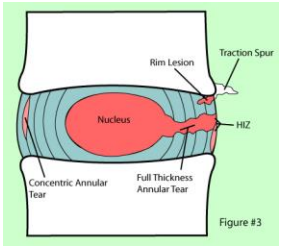
Mechanical Testing of Soft Musculoskeletal Tissues





Heterogeneous Anisotropic Fibrous Structures



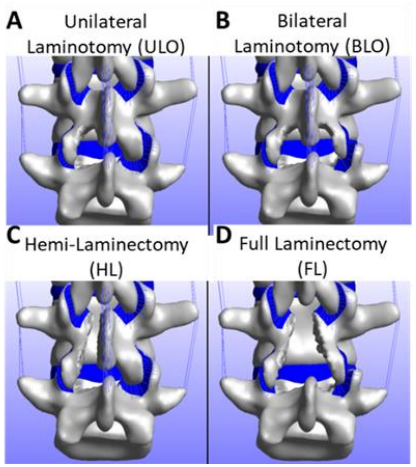


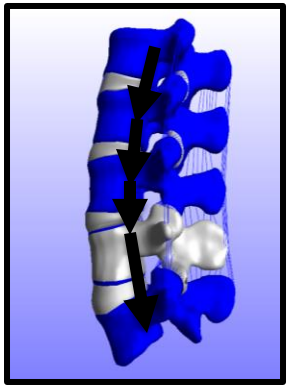
Project: Understand Multiaxial Load Induced Damage

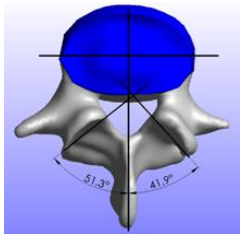
- Design/Run experiments
- Implement finite element models to explain predict damage

Long term goal: Understand structural, cellular, and mechanical changes caused by multiaxial loading of musculoskeletal tissues

Surgical Treatments of Pain





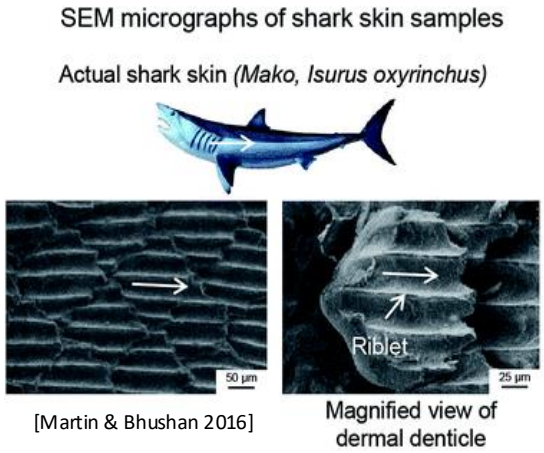


Project: Understand how Patient Specific Factors Affect Surgery

- Build FE model of lumbar spine(ABAQUS)
- Virtually 'perform' laminectomy surgery

Long term goal: Implement results into a virtual simulator that can take many patient specific parameters and many variations in the surgical procedure and provide suggestions to the surgeon to prevent adverse outcomes

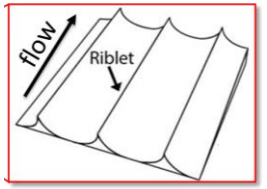
Gayme group projects



[Martin & Bhushan 2016]

Magnified view of dermal denticle

Master's Essay projects staring Fall 2023



[Scientific report, Sungwon Jo, et. al, 2018]

- Bio-inspired investigation of drag reduction techniques
  - Simulation of flow over riblets
  - Model validation through simulation over a range of conditions

- Reduced order wall-turbulence modeling tools
  - Characterizing the role of the physics in refining the model
  - Combine linear systems and simulation oriented tools

- Research tasks and required skills
  - Linear systems (resolvent) analysis of fluid flows (Matlab and Python)
  - Simulations of channel flow using existing codes (CFD)
  - Analysis of results (Matlab and Python)
  - Modification of tools to simulate improved models based on findings (modeling)


[From National Geographic]

Best of luck to you this year!

Questions?