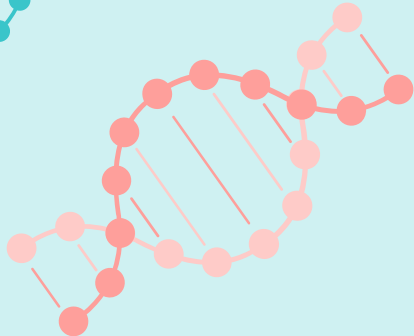
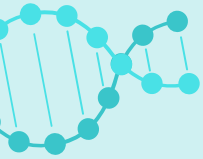
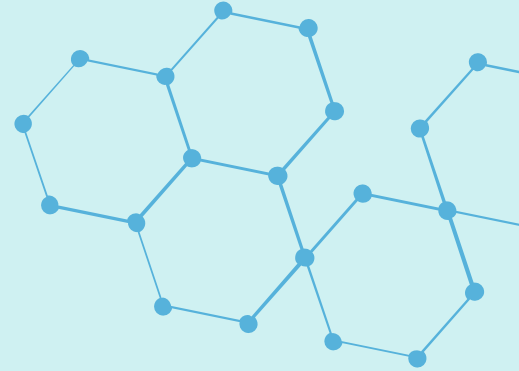




# The Messersmith Lab

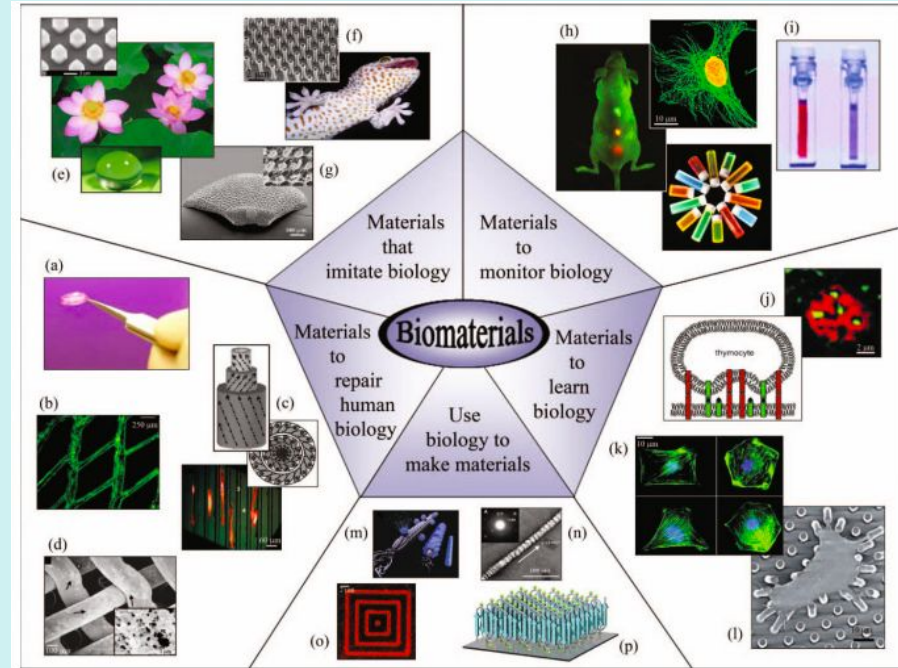
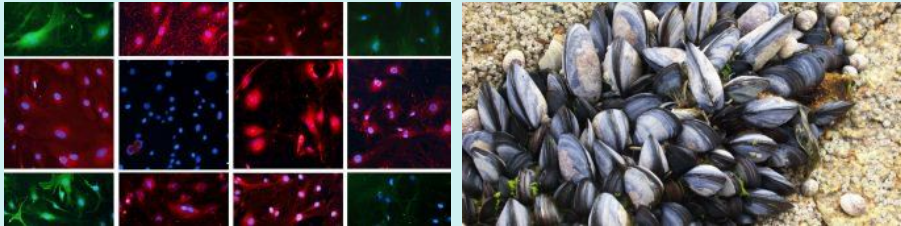


Melody Ghaffari and Berwyn Phan  
2022



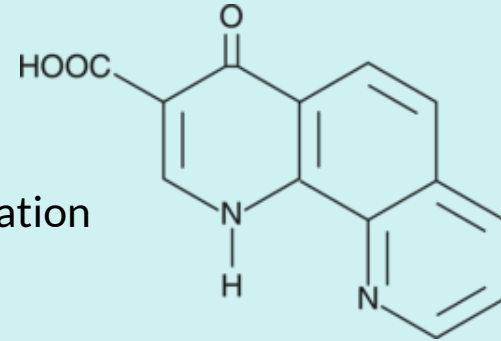
# What Are Biomaterials?

- Biomaterials are any material that has been engineered to interact with a biological system
- This lab uses biomaterials for regenerative medicine and adhesive applications



# Regenerative Medicine

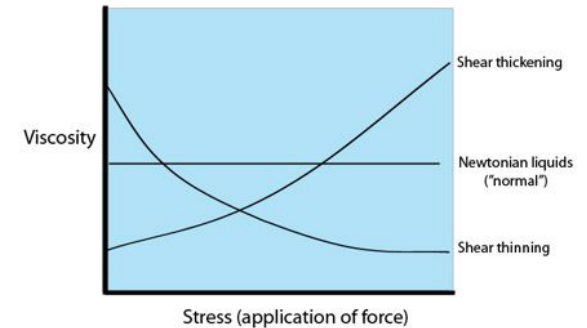
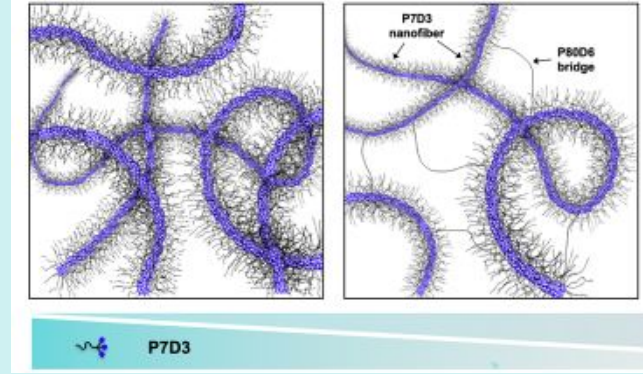
- Healing vs. Regeneration
  - Healing is the **sealing** of wounds/formation of scars
  - Regeneration is the **replacement** of differentiated tissue
- How the lab treats this:
  - Use a molecule drug called **DPCA** (pictured right) to induce regeneration in mammalian cells
  - DPCA upregulates **HIF-1 $\alpha$**  which is correlated with regeneration
- Drug delivery
  - DPCA is attached to the end of a **PEG** (polyethylene glycol) molecule (1-3 per PEG)
  - DPCA is hydrophobic, PEG is hydrophilic



*DPCA - pro-regenerative drug*

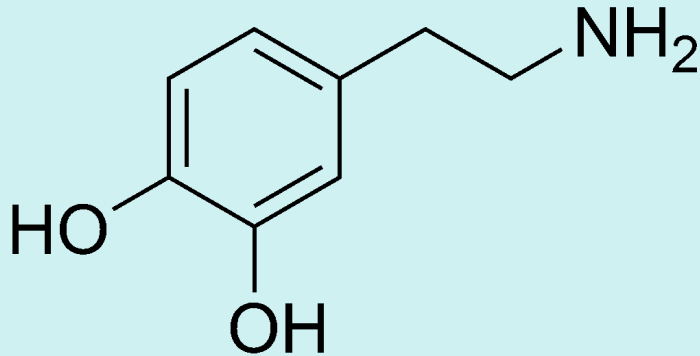
# Regenerative Medicine (cont.)

- P7D3 forms long, micelle-like fibers in water (see right →)
  - Noncovalent interactions promote **self-assembly**
- Mechanical properties
  - Shear thinning, starts viscous but gets thinner
    - Weak attraction breaks apart under stress
- Drug release
  - **Heat** or **stress** causes the fibers to break apart and release the drug
  - Ideal for long-term release of DPCA

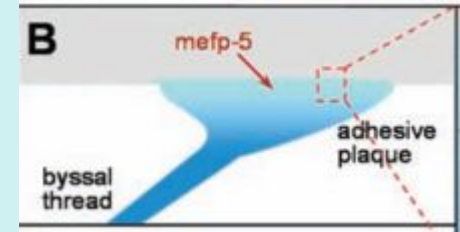


# Adhesives and Mussel-Inspired Chemistry

- Mussels → small feet used to attach to rocks and each other
  - Build fibers with adhesive on the end
  - Can stick to almost anything and interact with nonpolar and polar



- **Dopamine (DOPA)** – a bioinspired building block for surface coatings – is used to mimic this behavior
  - 2 OH groups, + amine
  - Also has a nonpolar region



# Adhesives and Mussel-Inspired Chemistry (cont).

- DOPA spontaneously forms polymers upon submersion in a marine-like solution (pH 8.5 buffered), forming polyDOPA
  - Mimics the adhesive qualities of the mussels
- Applications
  - Simple controlled adhesive
    - Surgical adhesive
    - Works underwater too





# **Our Lab Experiences**

# Main Project We Followed

- Goal: Combine regenerative medicine research + adhesives to create drug delivery systems for the treatment of **ulcerative colitis (UC)**
  - Attach *mussel-inspired polymer* to the surface of a nanoparticle to adhere to the intestines and deliver *DPCA*.
- Experiment: Evaluate performance in mouse UC model
  - Dextran sodium sulfate used to cause damage to mouse intestine
  - Examine tissue **damage** and **scarring**

Healthy Intestine



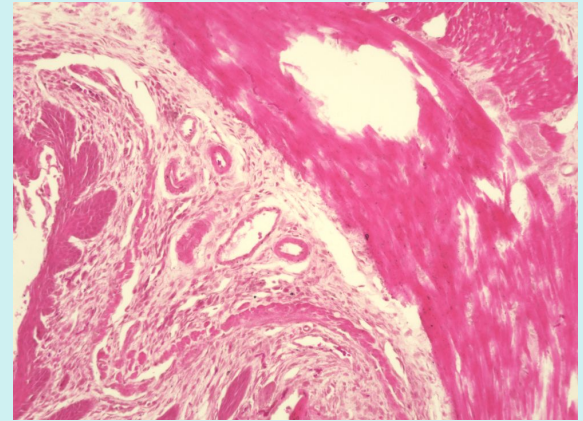
**UC** is a chronic disease causing lesions to form in the colon

Ulcerated intestine



# Histology

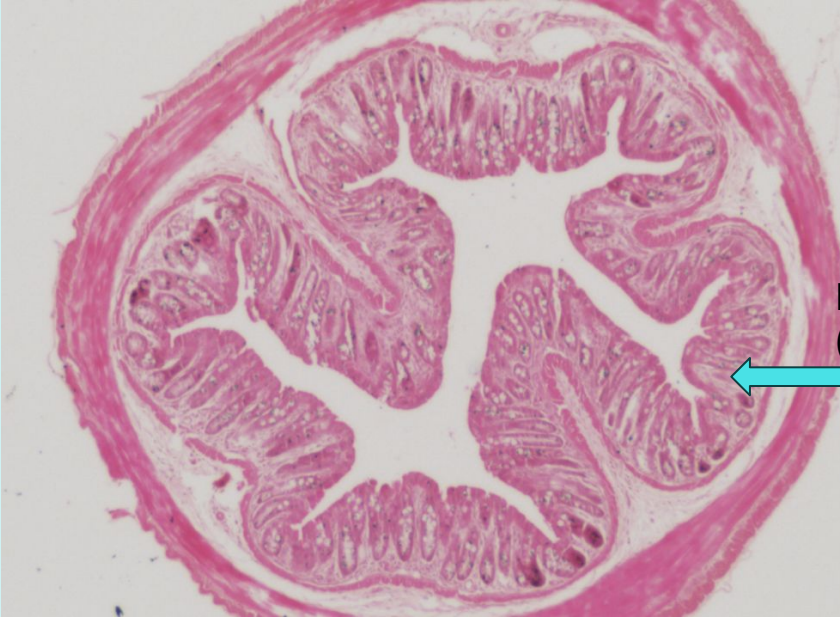
- Histology is the study of **tissue structure**
- Slice tissues and mount on slides, then stain them to look under a microscope
- H&E staining:
  - Hematoxylin and Eosin → stain nucleus and proteins respectively
  - Helpful in allowing us to see the presence of **immune cells**



H&E stain  
(Layers are easier to see)

# H&E Staining

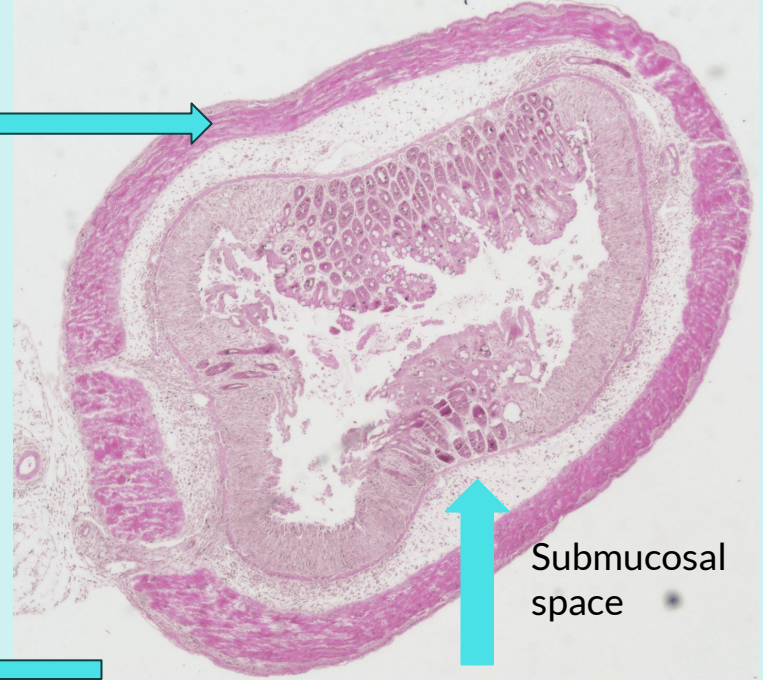
Healthy Mouse



Muscle

Epithelium  
(folded)

Sick Mouse Colon



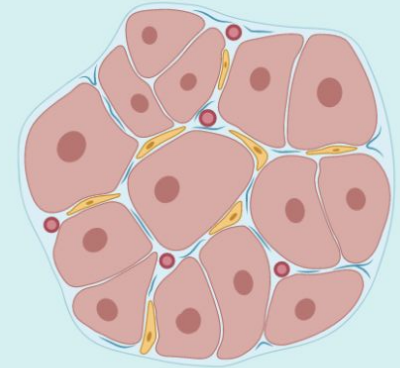
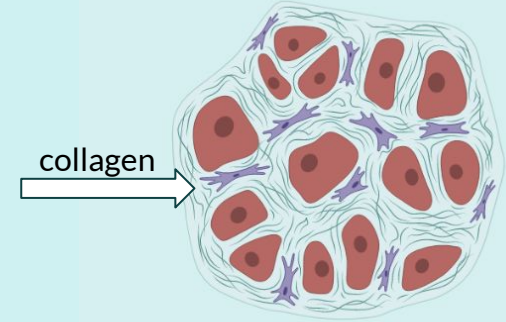
Submucosal  
space

- More **immune cells** in sick submucosal space
- **Torn** muscles
- Epithelium disrupted (less goblet cells)

# Masson Trichrome Staining

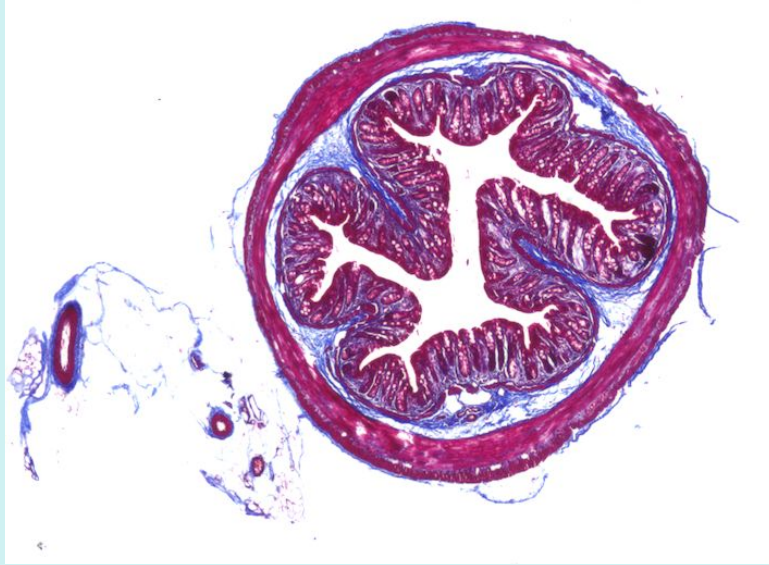
- Masson Trichrome is used to assess scar tissue formation by staining collagen
  - **Collagen** shows scarring
  - Hematoxylin, Aniline Blue, Acid Fuchsin
- Immune cells **harder to spot**, same space as collagen

Scarred (fibrotic) tissue



Healthy Tissue with organized matrix

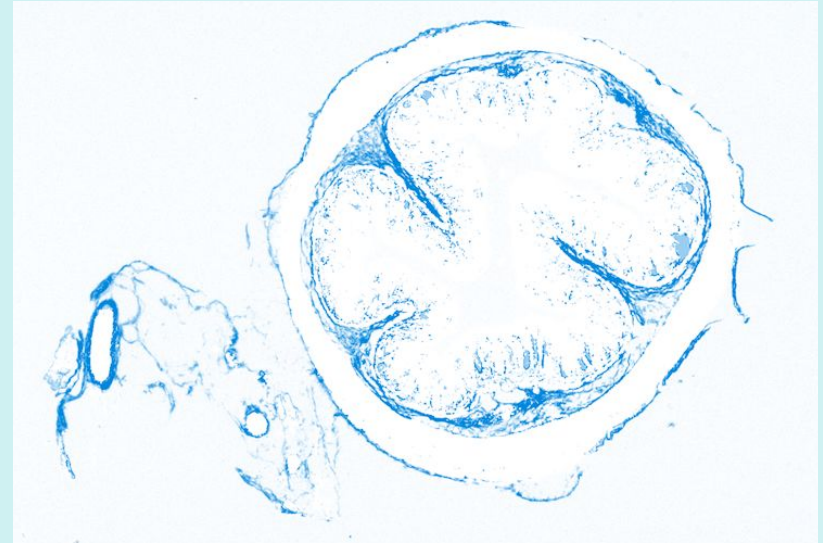
# Image Processing



← Masson Trichrome of a tissue slice

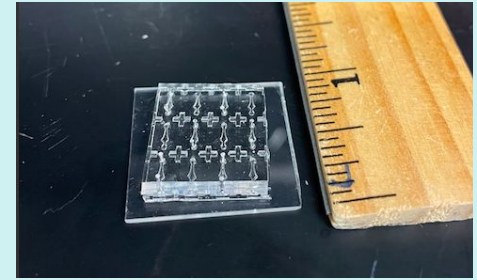
Isolated collagen and contrast →

- **Only dyed pixels** are highlighted to calculate the % of collagen vs a healthy sample



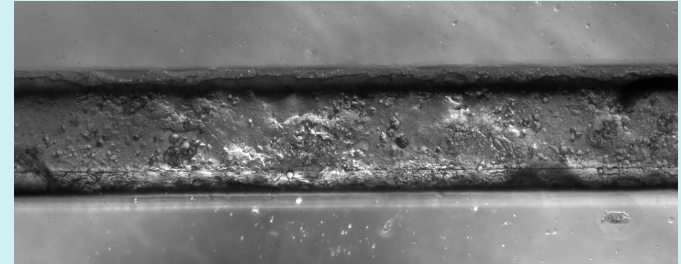
# Microfluidic Devices

- Can be used to simulate biological environments at a **smaller scales**
  - High throughput
  - Less expensive
  - Biologically relevant nutrient: cell ratios and flow rates
- Our Project - use chips with mucus-producing gut cells to determine nanoparticle adherence



(above) microfluidic device  
on glass slide

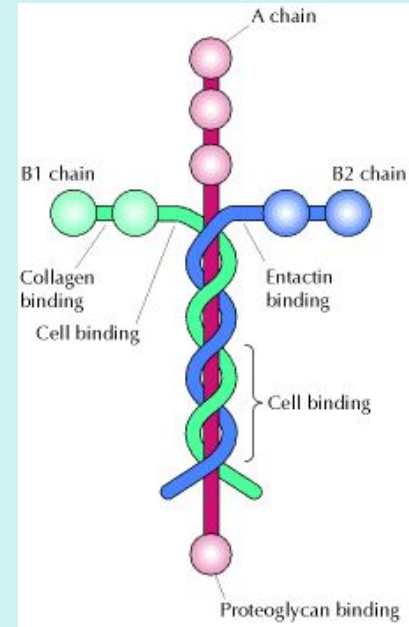
(below) microscope image  
of chip channel + cells





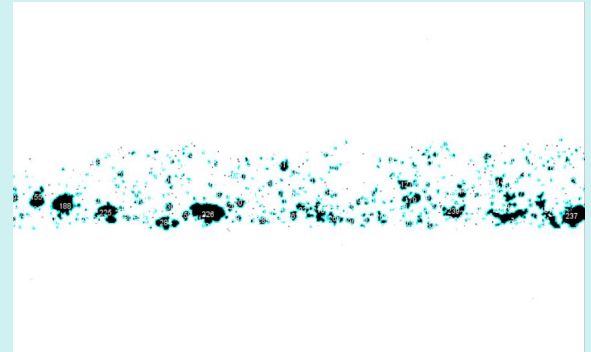
# Microfluidic Device Fabrication

- **Silicon** chips used to make channels on polymer
- **PDMS** is used for its biocompatibility
  - High viscosity, can be modified for various functions
  - **UV** activate, then cure with temperature
- Attach onto glass with plasma
  - Oxygen flooded into a chamber, then turned to plasma
  - Reacts with the PDMS, making it adhere to glass
- Treat chip, then adhere cells
  - Flush with **laminin** →
    - Cells adsorb onto the channels



# Particle Analysis

- Microscope used to take image of **fluorescent tags**
- Enhance contrast and turn into B&W
- Set binary and parameters for detection
  - Detect only suitable darkness/particle size
- Software identifies particle count/area
- Example had **275 particles** of 10+ pixel size

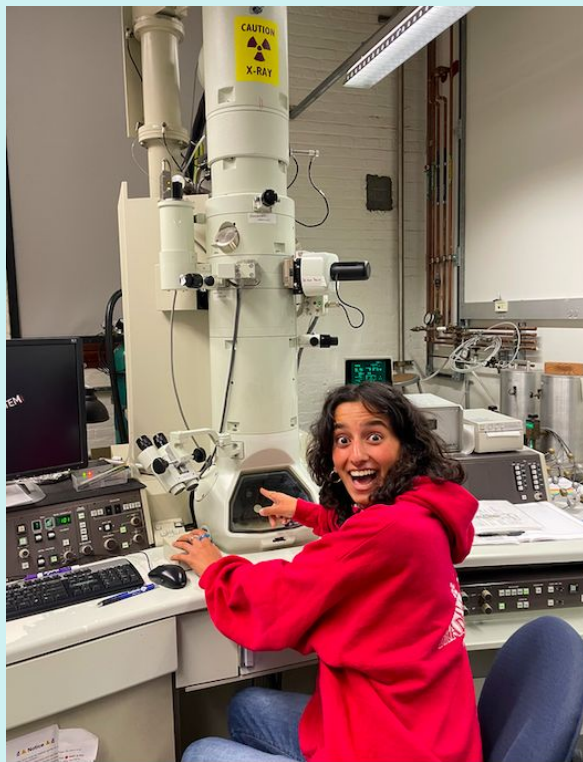




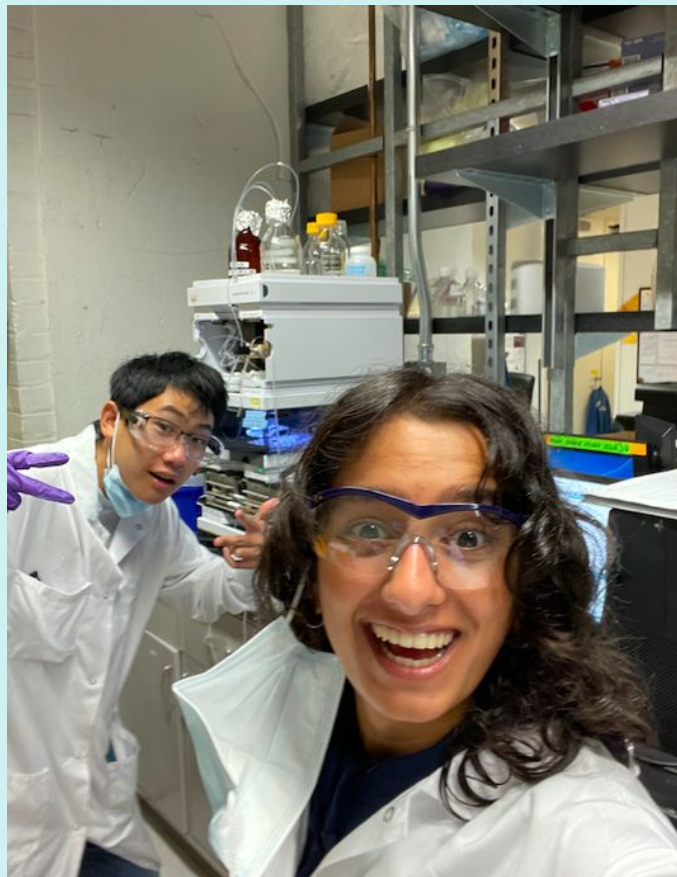
# Lab Pictures



TEM Machine

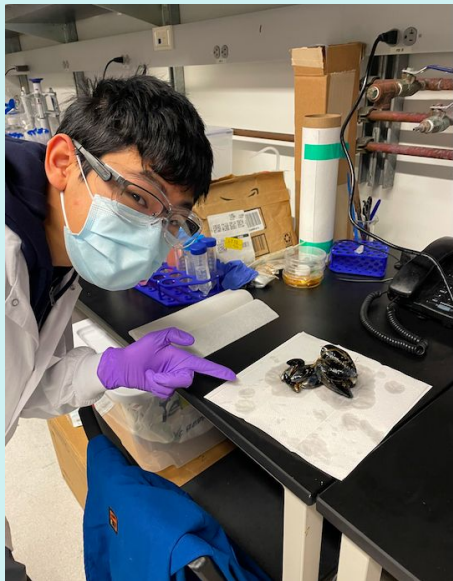
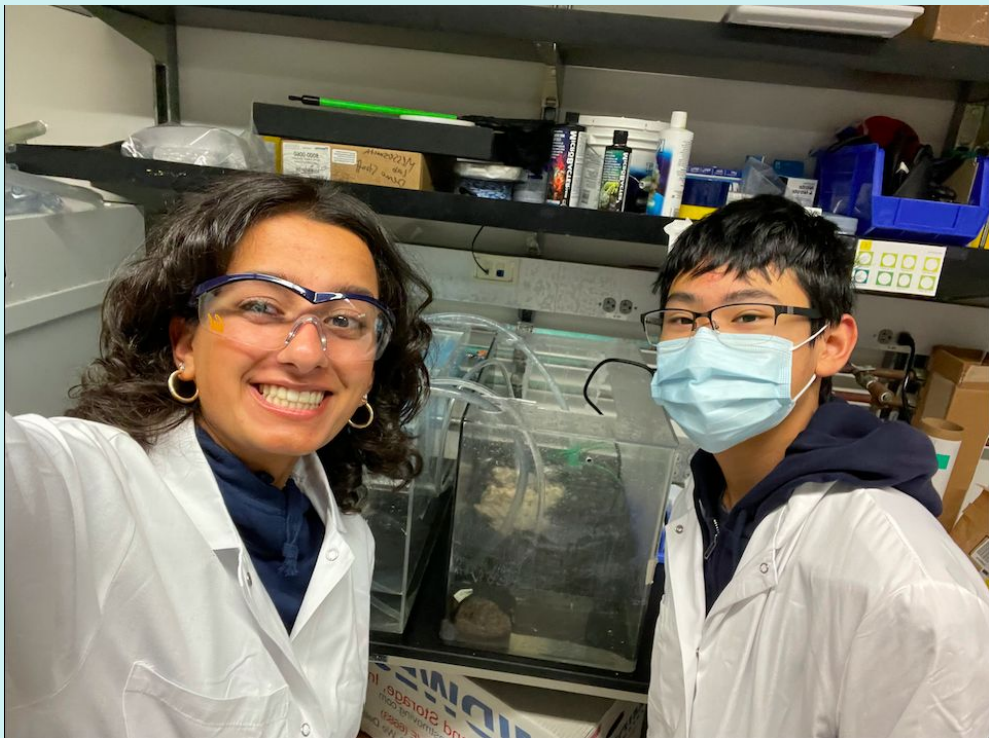
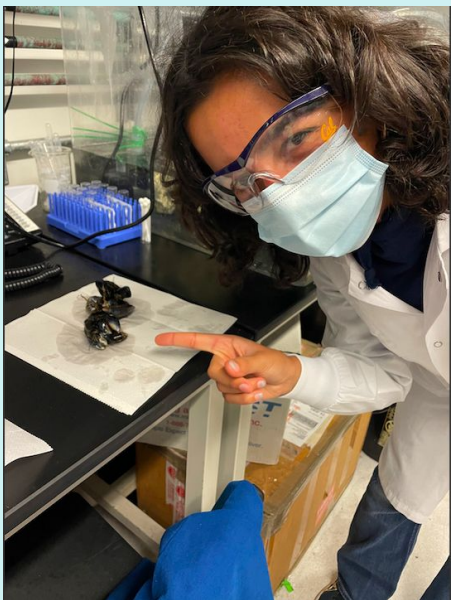


HPLC machine

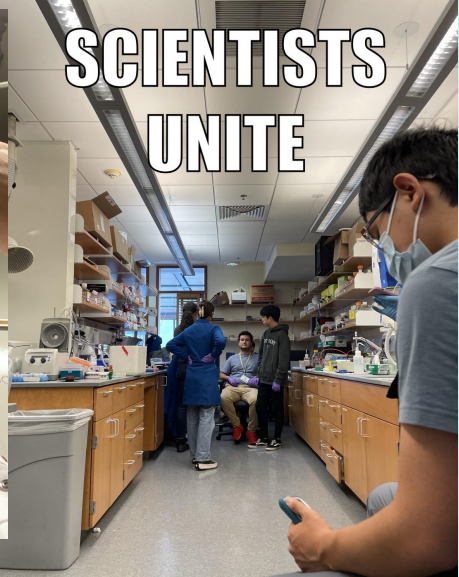
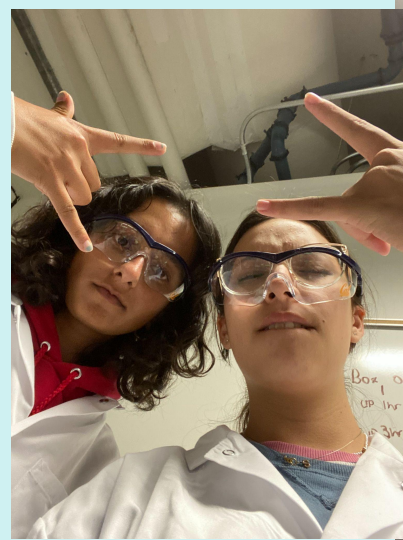
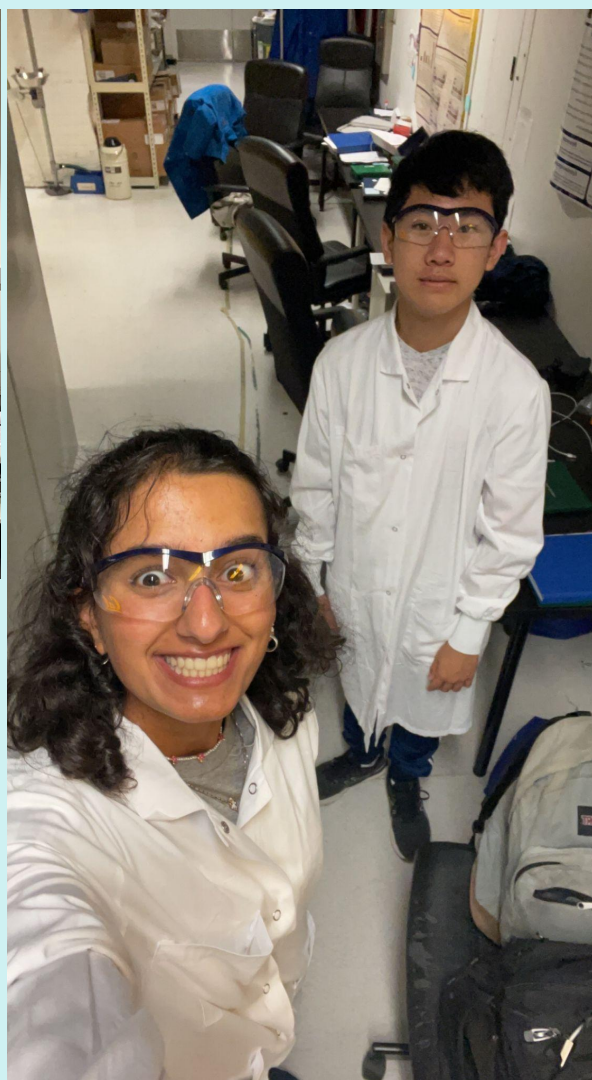


TEM Machine

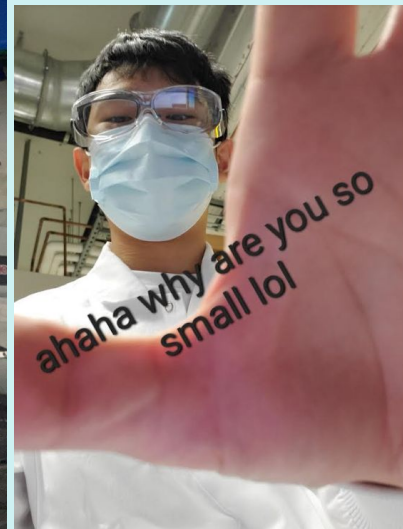
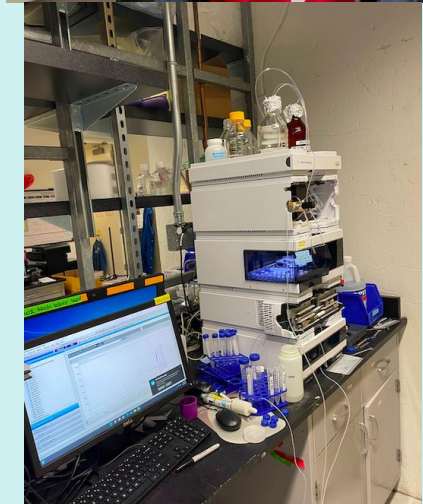








**SCIENTISTS  
UNITE**





# Outside of Lab Experiences



# Group Activities!

## BAMPFA Museum



## San Francisco :)



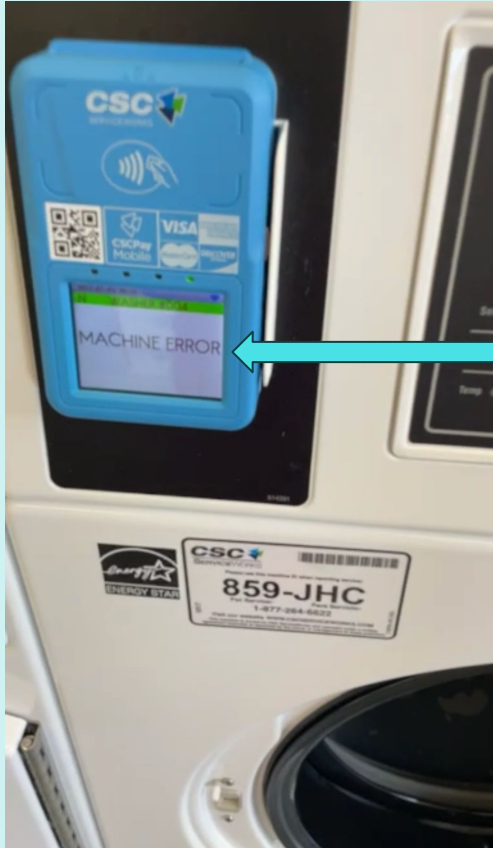


# More Group Activities!

## Campanile trip



# Great Laundry Experiences



Not good, not good at all

# Foothill Cafeteria Food

Certainly was food



# References

1. Chang, J., Amin, D., Latona, J., Heber-Katz, E., & Messersmith, P. B. (2019, May 8). *Supramolecular polymer hydrogels for drug-induced tissue regeneration ...* ACS Nano. Retrieved August 1, 2022, from <https://pubs.acs.org/doi/10.1021/acsnano.9b00281>
2. Zhang Y;Strehin I;Bedelbaeva K;Gourevitch D;Clark L;Leferovich J;Messersmith PB;Heber-Katz E; (2015, June 3). *Drug-induced regeneration in adult mice*. Science translational medicine. Retrieved August 1, 2022, from <https://pubmed.ncbi.nlm.nih.gov/26041709/>
3. Lee, H., Delatorre, S. M., Miller, W. M., & Messersmith, P. B. (2015, June 3). *Mussel-inspired surface chemistry for multifunctional coatings*. Science Translational Medicine. Retrieved August 1, 2022, from <https://www.science.org/doi/10.1126/science.1147241>

# Thanks for listening!





**Any  
Questions?**