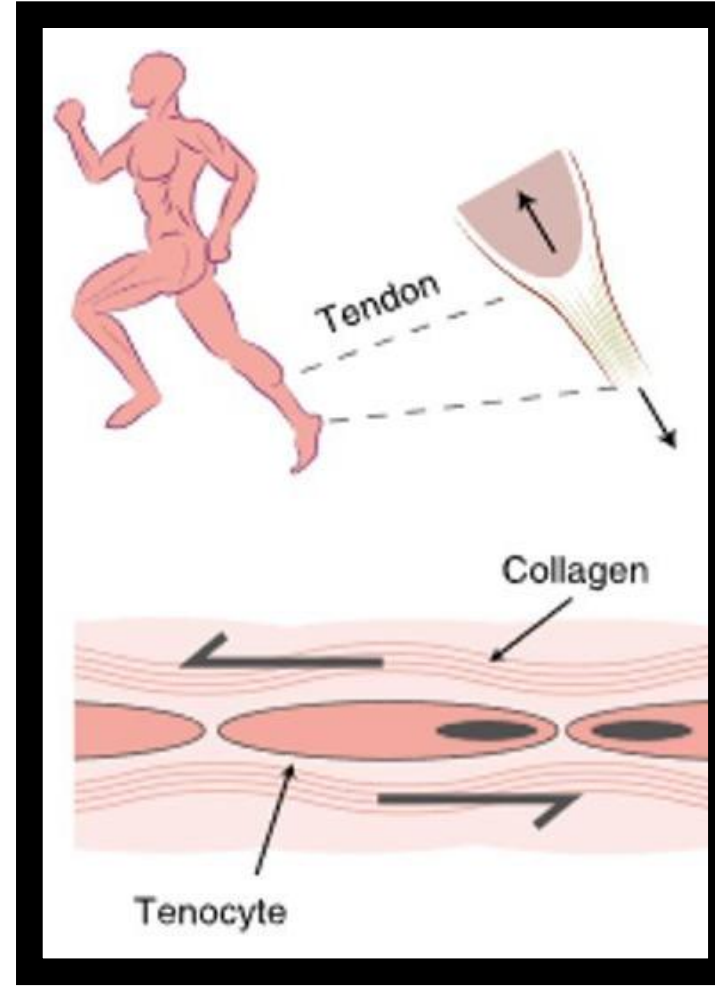


Team Members: Dillon West, Gibson Moseley, Nathan Nelson

Team Sponsors: Joe Stanley, Nathan Schiele **Lead Instructor:** Russell Qualls **Team Mentor:** Ben Morenas

OBJECTIVE

Tendons are connective tissues that transfer forces from muscle to bone and are vital for movement. Tendon injuries heal poorly, are often chronic, and fail to be fully restored by clinical treatments. Researching how shear stress forces affects tendon development may lead to novel therapies.



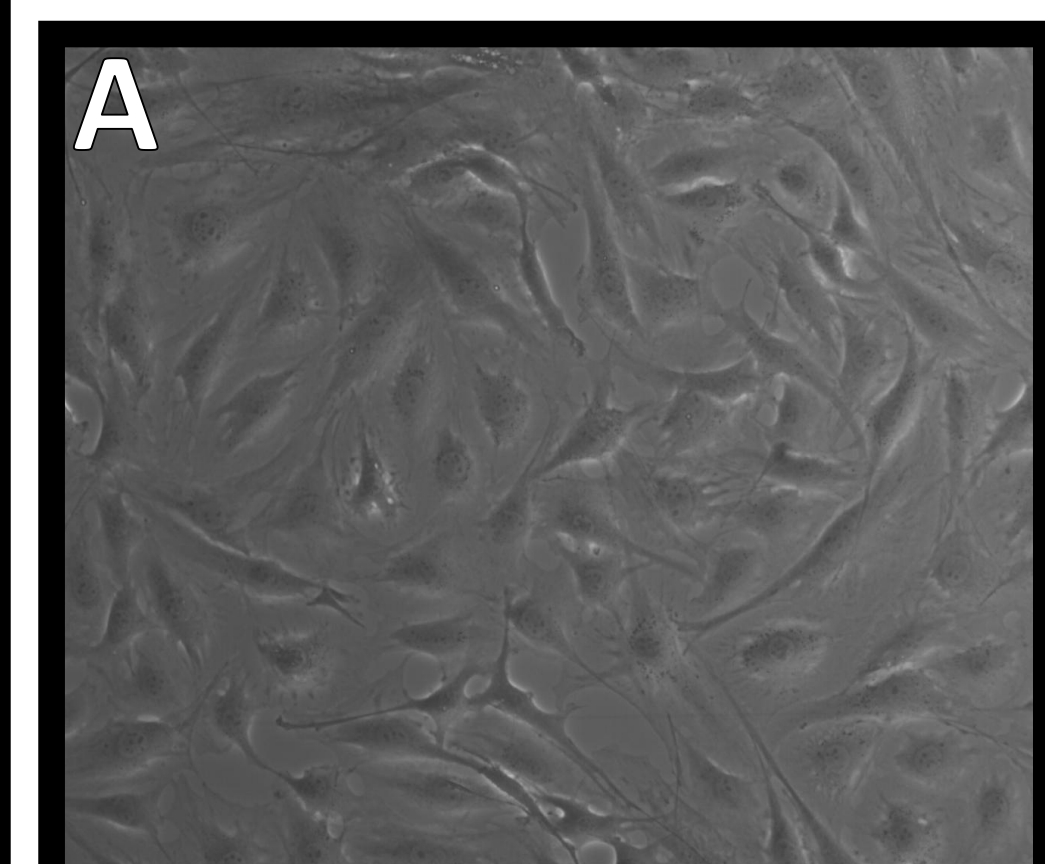
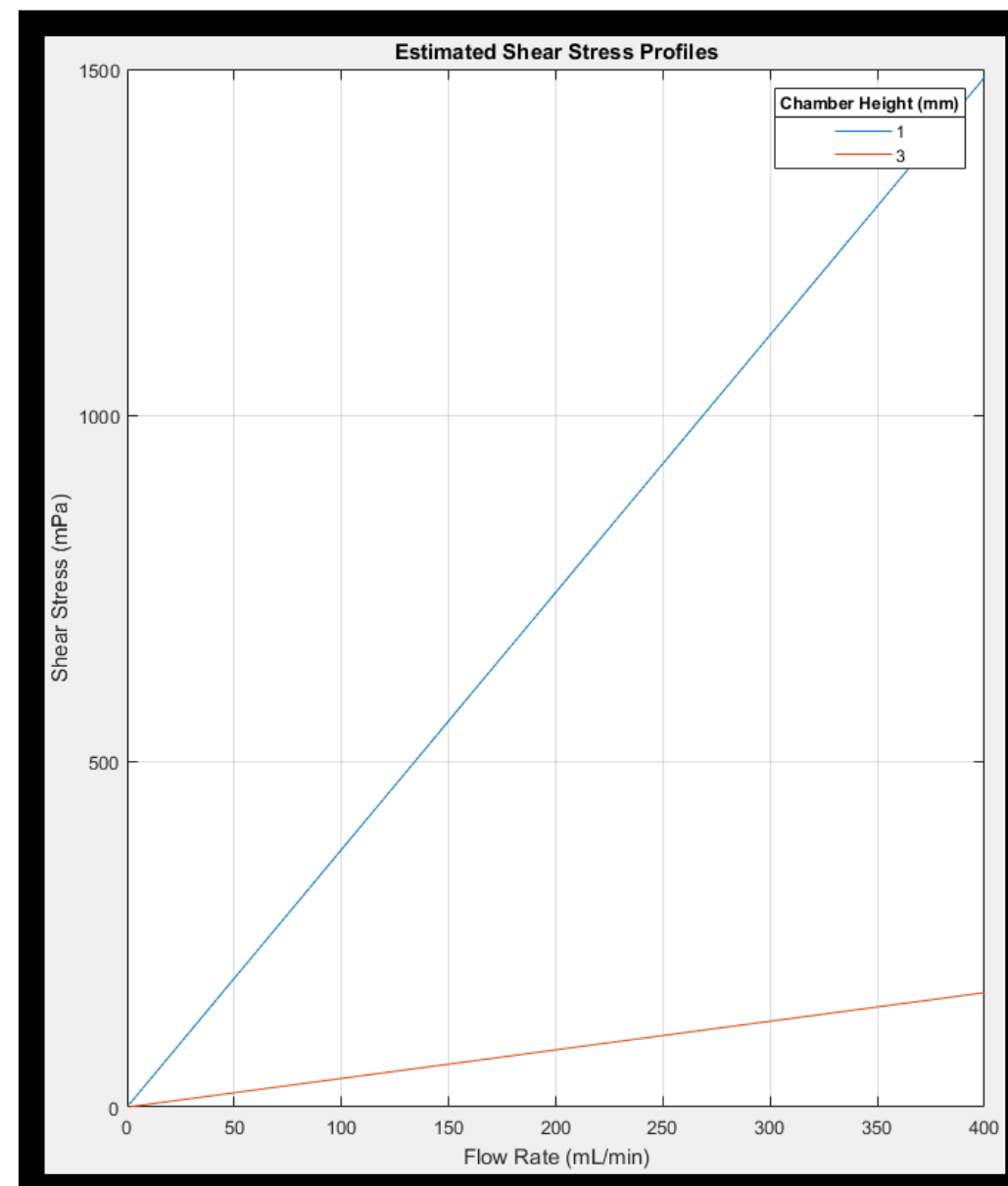
Representation of shear stress in native tendon

Our goal is to design a low-cost and easily assembled fluidic shear stress bioreactor to enable further research in this area.

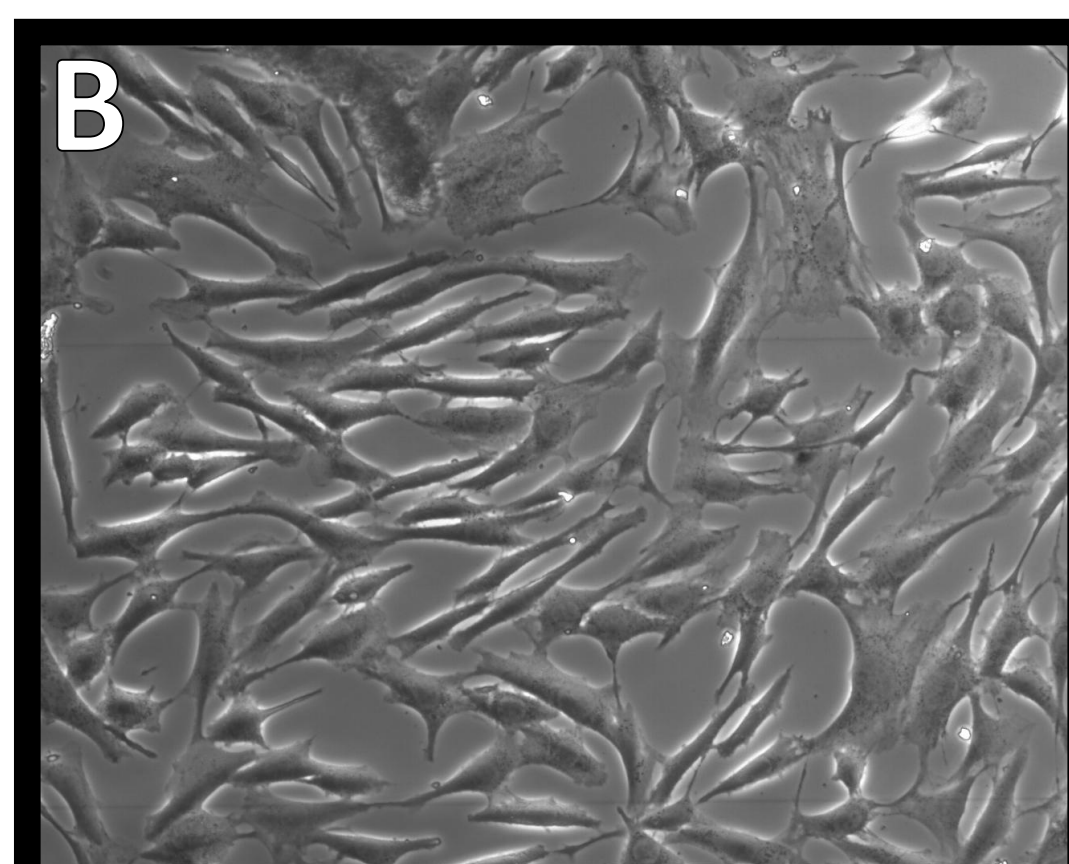
VALIDATION

The modular bioreactor chamber design enables customized shear stress profiles. A feedback control algorithm steadily increase the flow rate to achieve the desired shear stress value.

In vitro experiment with Mesenchymal Stem Cells (MSCs) validates the design's biocompatibility. A) MSCs cultured on static microscope slide. B) MSCs subjected to 40 mPa shear stress for 4 hrs. Elongated cell morphology is indicative of early differentiation into tendon cells.



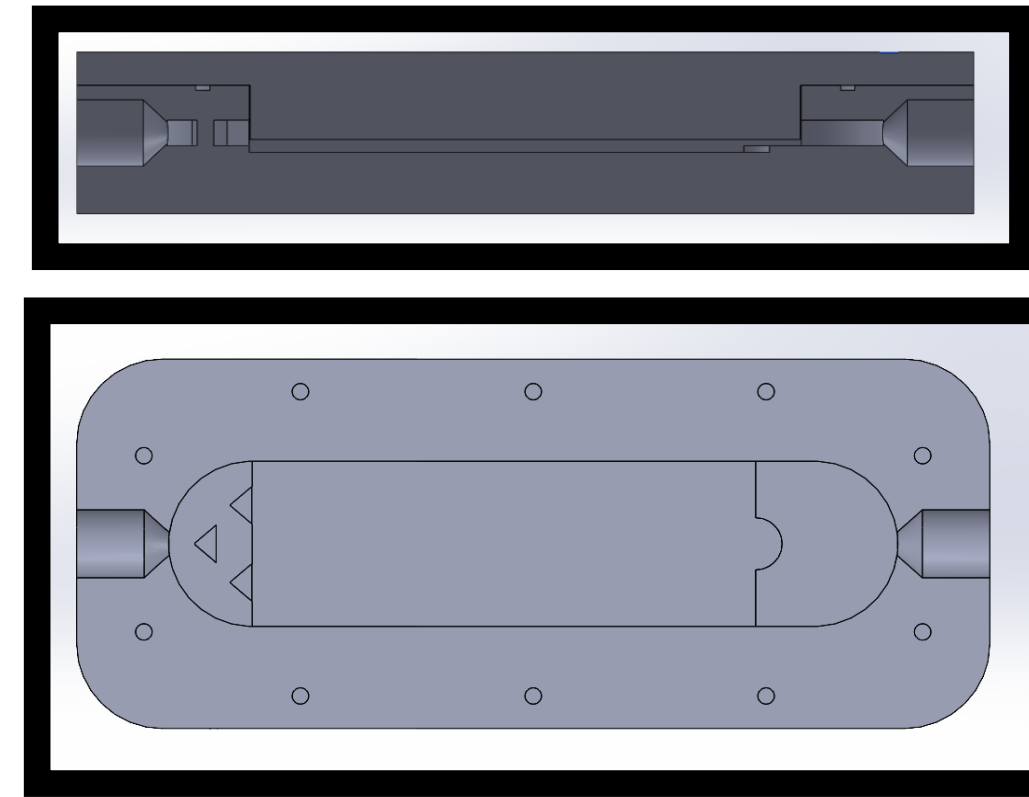
MSCs Before Experiment



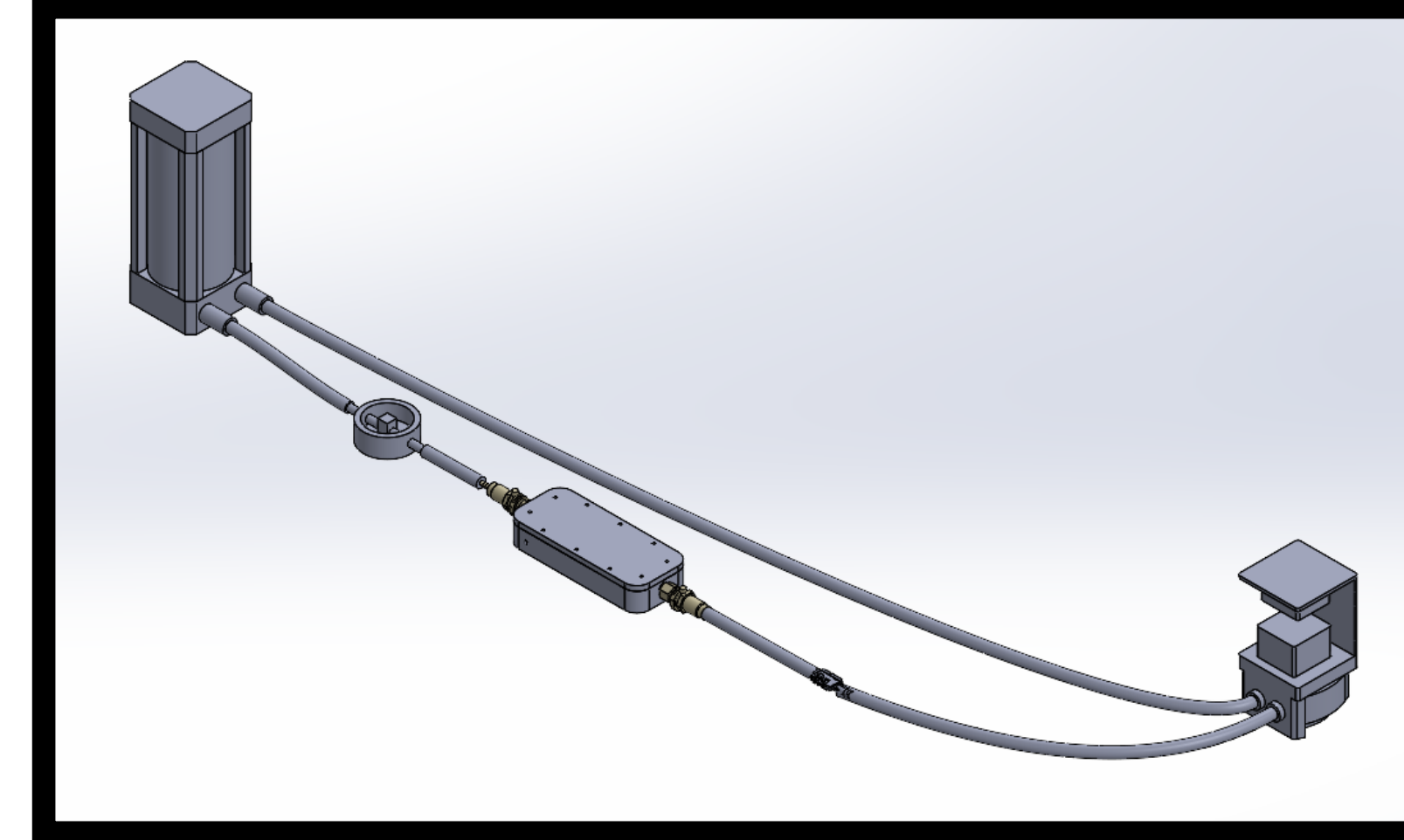
MSCs After Experiment

HARDWARE

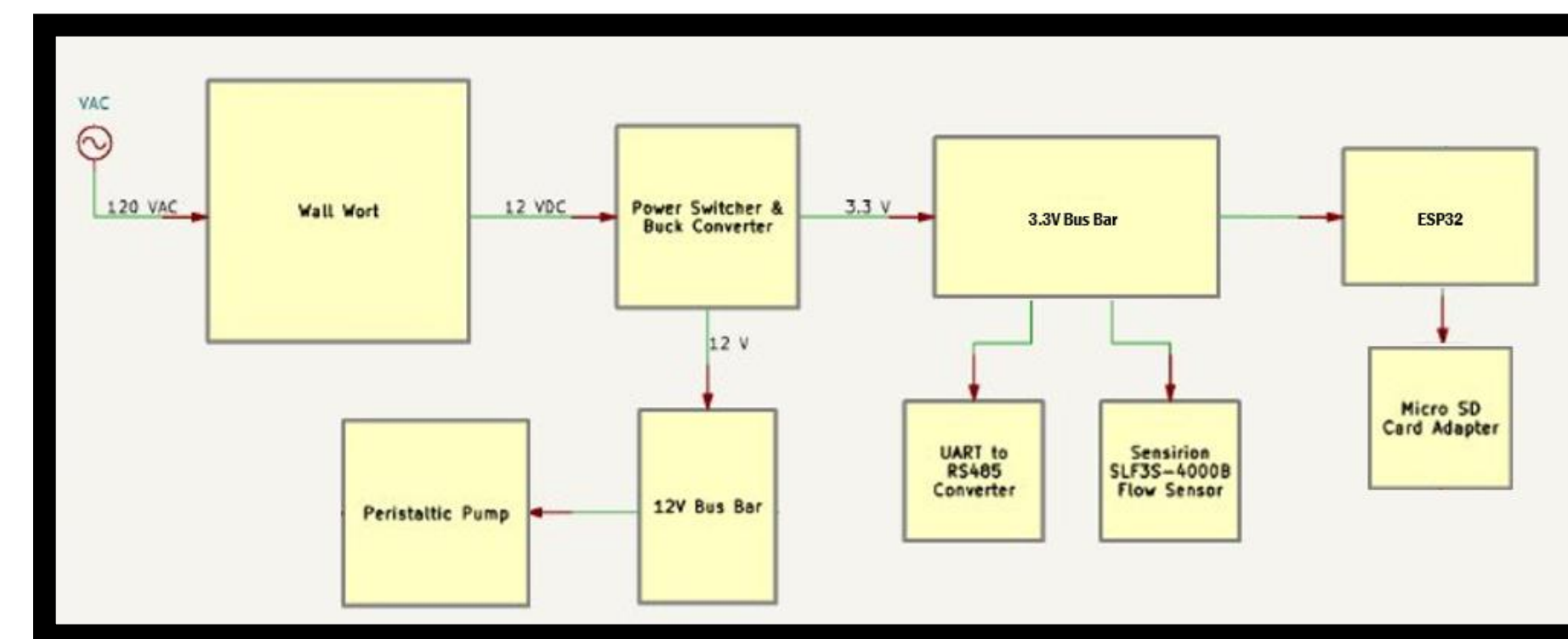
The new bioreactor system utilizes a modular design with interchangeable chamber lids to vary chamber height and applied fluidic shear stress



Side and top sectioned view of bioreactor chamber



Isometric view of fully assembled system



Power block diagram for the system

The circuitry is designed to be replicated and assembled with ease and minimal technical skills, while still ensuring secure connections and an intuitive layout.

SOFTWARE

Bioreactor Website

Current Status & Data

Waiting for pump data...
Waiting for time data
Waiting for flow data...
Waiting for Shear Stress data...

Running Paramaters

Shear Stress:
Shear Stress:
Run Time:
Break Time:
Number of cycles:

Bioreactor Paramaters/Settings

Current Seetings

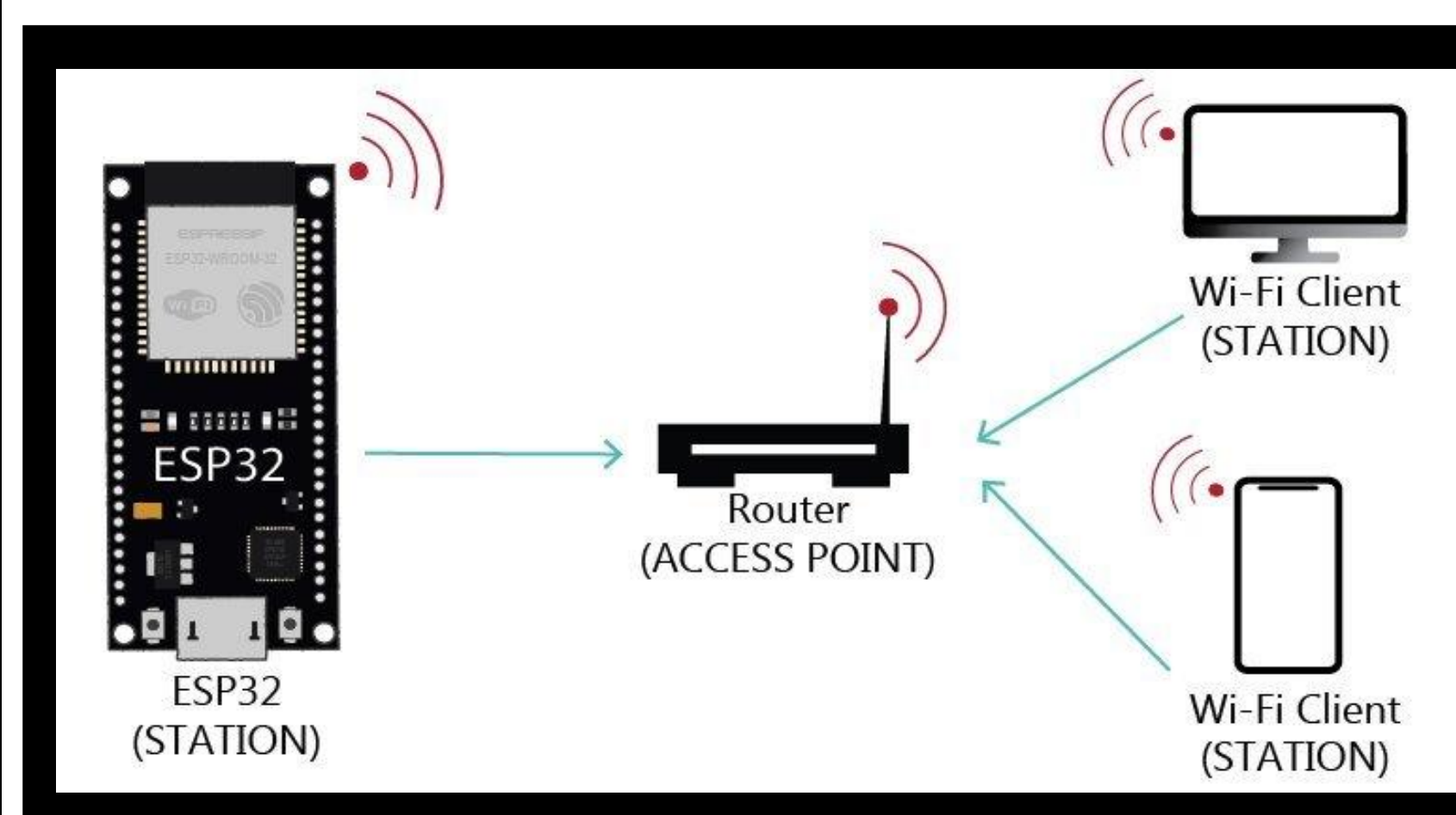
Waiting for Height data...
Waiting for Width data
Waiting for MU data...
Waiting for RHO data...

Set New Settings

Channel Height:
Channel Width:
MU:
RHO:

The interface to the left is powered by an ESP32 microcontroller, which enables remote control over bioreactor settings and experiment parameters.

The website hosted by the ESP32 is accessed by connecting to a shared Wi-Fi router. All experimental data from routines are also stored on a microSD card for later analysis.



Link to
GitHub
Repository



SYSTEM PARAMETERS

- Fully sterilizable and biocompatible components
- Cheap, easily-replicated design (~\$1,500 per unit)
- Laminar fluid flow profile inside bioreactor chamber
- Apply up to 150 mPa shear stress for short-term experiments, and up to 2 Pa for long-term experiments
- Precise and automated control of applied shear stress
- Operate continuously with no issues for 21+ days
- Remote interfacing for control and data visualization
- Thorough documentation for assembly and operation

CONCLUSIONS

This new bioreactor system meets many of the goals, and while long-term (21+ days) testing has not yet been investigated a 24-hour *in vitro* test was conducted. The system is inexpensive and user-friendly to assemble. Different swappable chamber heights enable custom shear stress profiles. The validation experiment was initialized and surveyed via the website, and the system self-corrected the flow rate to achieve set shear stress.

Future work includes long-term experiments to ensure design viability. The system needs an upgraded peristaltic pump for smoother flow and medical grade resin for the chamber. Additionally, current assembly and operation documentation needs to be consolidated.

ACKNOWLEDGEMENTS

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- Joe Stanley for his funding and mentorship
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- The Weinhart Lab at Leibniz University Hannover and Freie Universität Berlin for sharing their slide chamber designs



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2025 Capstone Project