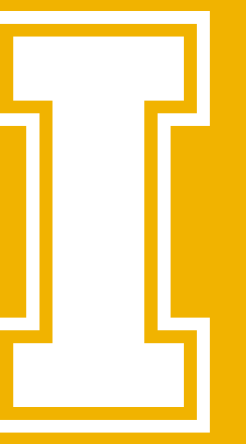


EXPO

engineering ▲ design

BIOREACTOR SYSTEM TO EXPLORE CELL RESPONSE



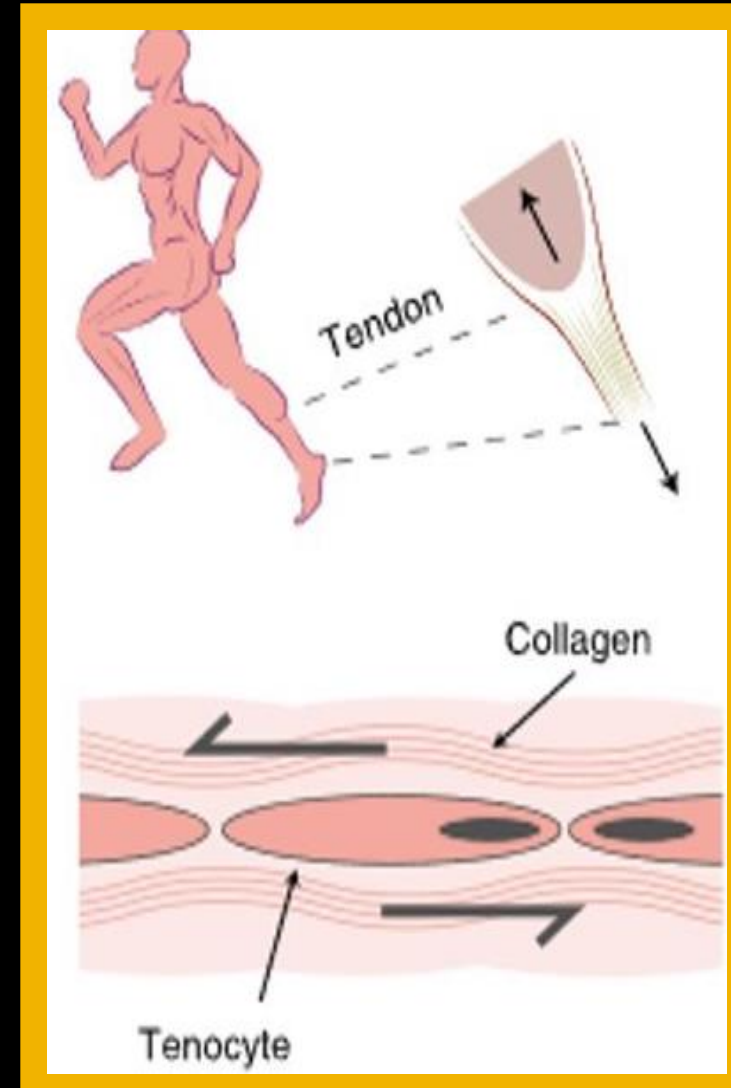
Team Members: Benjamin Morenas, Ishmael Staples, Carson Sloan, Carson Rueber, Chris Bui, Guo Zhonghao

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

OBJECTIVE

Tendon is a tissue in our body that attaches muscle to bone, playing a key role in force transfer and movement. Tendon has poor healing capabilities, making it a vital area to research for health.

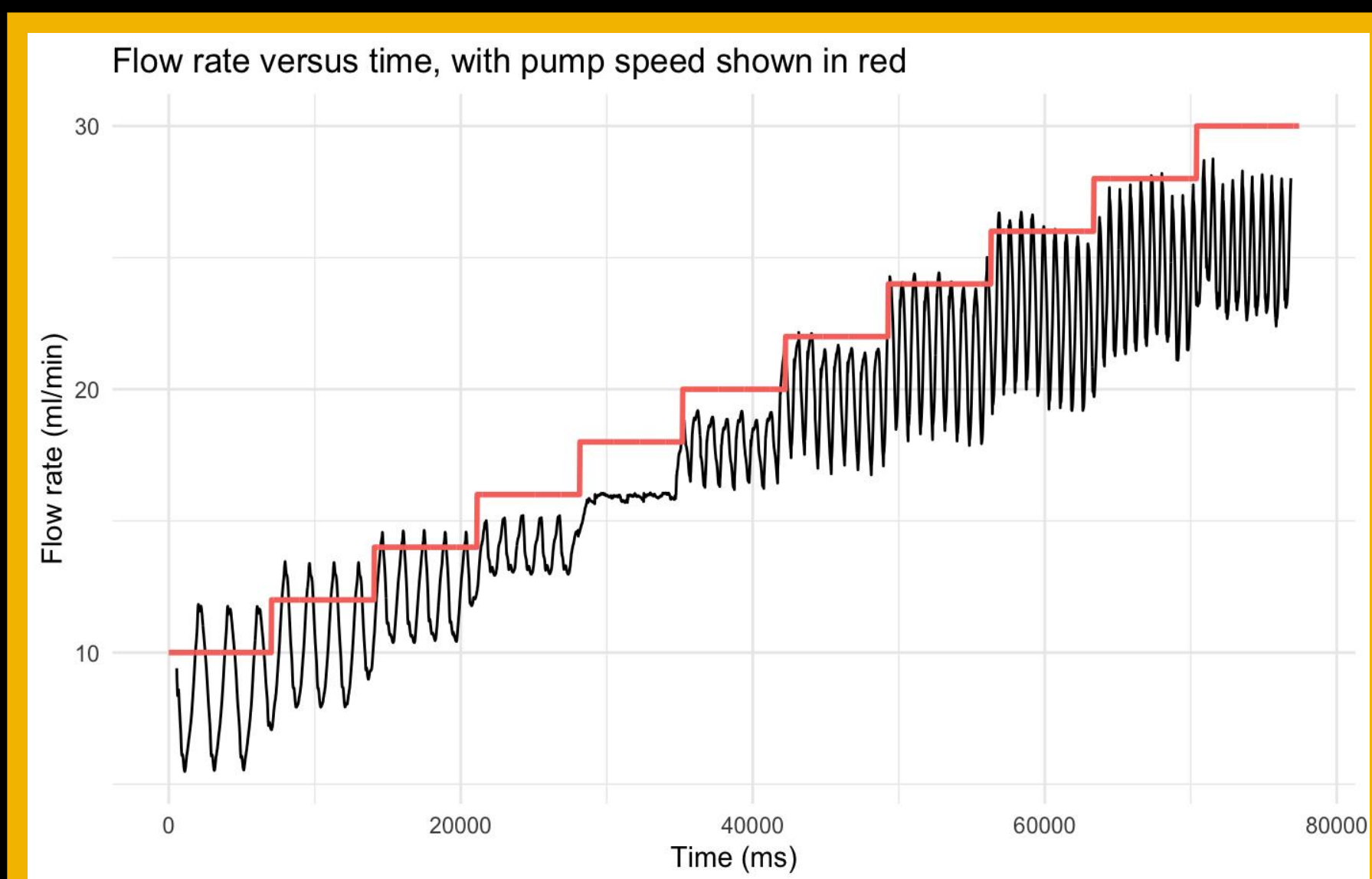
Our goal is to create a low-cost, easily built bioreactor capable of mimicking human body conditions to aid in tendon cell study.



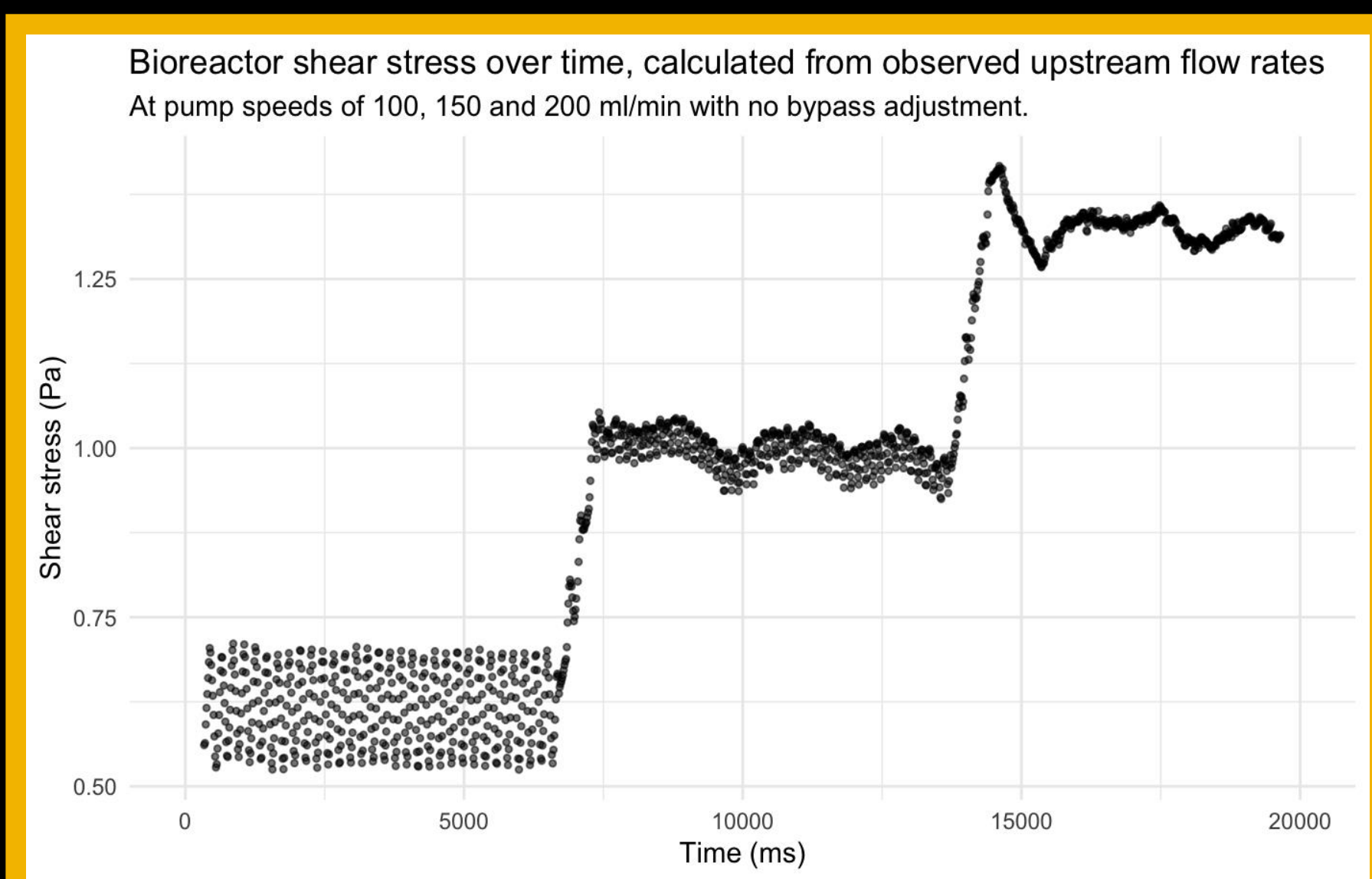
Representation of the effect bioreactor mimics

VALIDATION

The flow rate through the bioreactor is primarily controlled by varying the pump speed. Peristaltic pumps cause oscillations in the flow, which is mitigated by a pulsation damper device at low flow rates. At high flow rates, needle valves are used to precisely control the main and bypass lines based on measurements from two high-precision flow sensors.



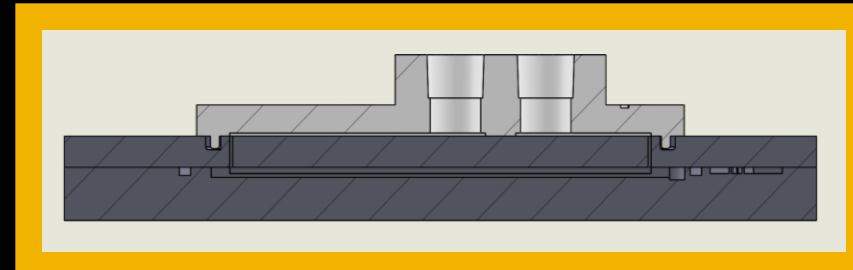
Oscillations are mainly caused by the pump rollers squeezing the tubing and are proportional to the flow rate.



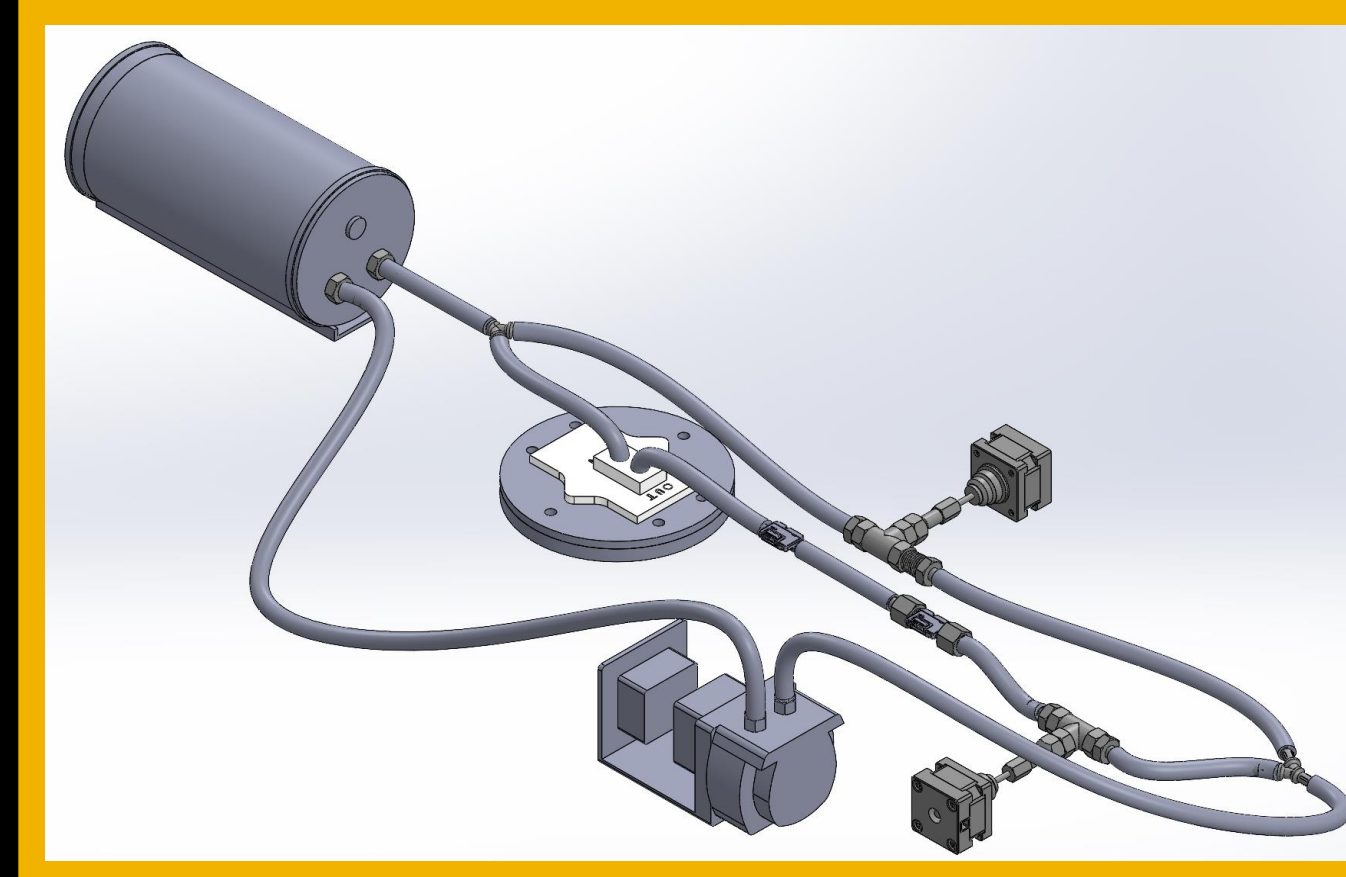
The program calculates the shear stress experienced by the cells based on the flow rate and bioreactor channel dimensions.

SYSTEM

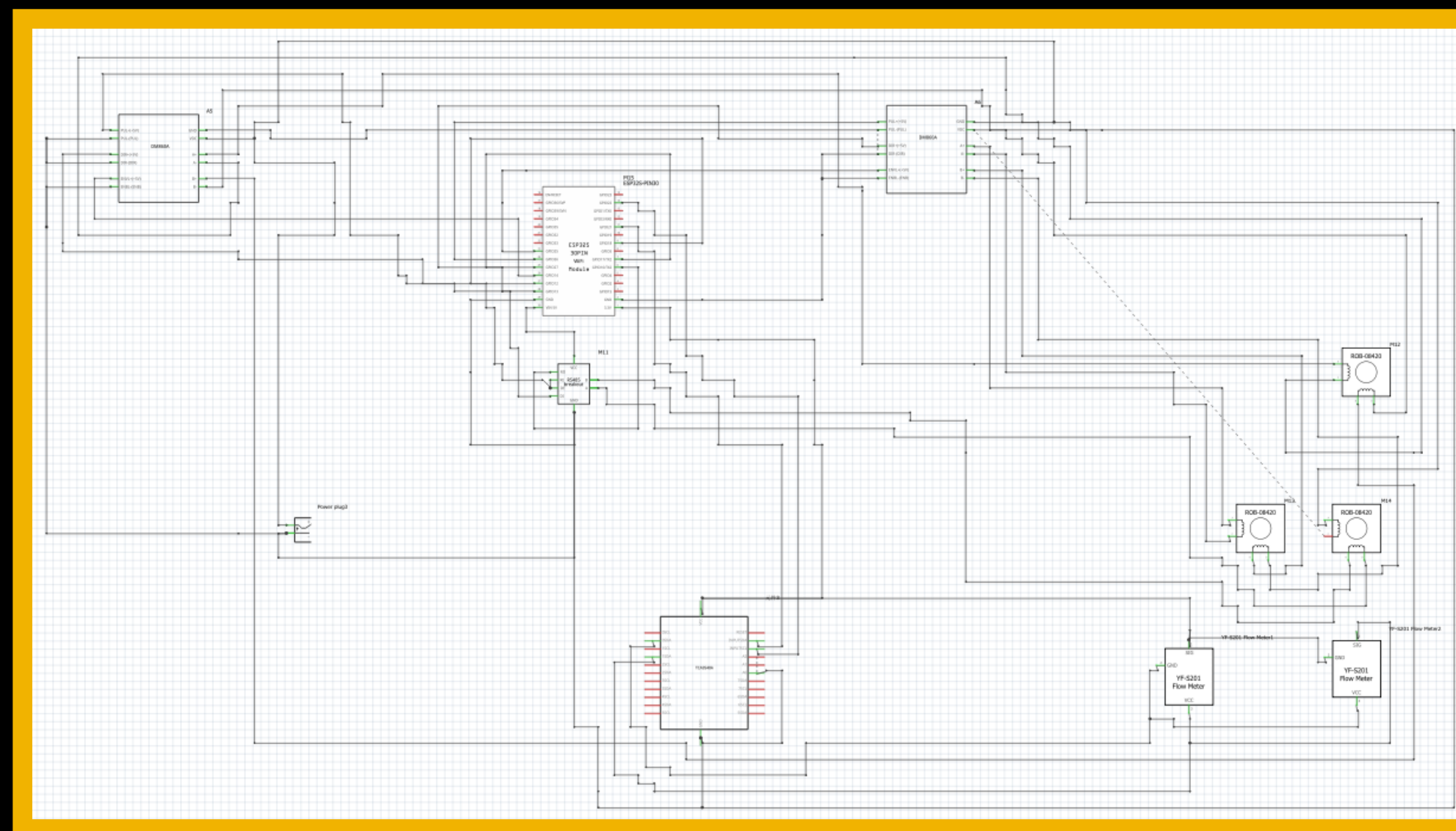
The new bioreactor design allows for modularity and the ability to fully seal the reactor.



Final shear stress reactor design, sectioned view

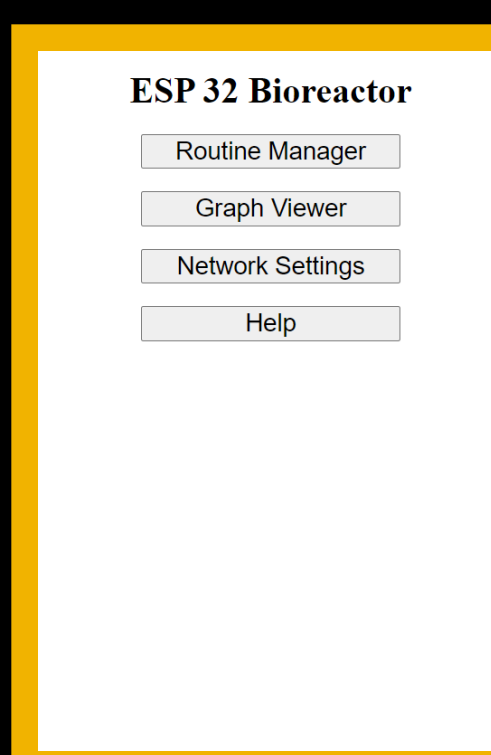
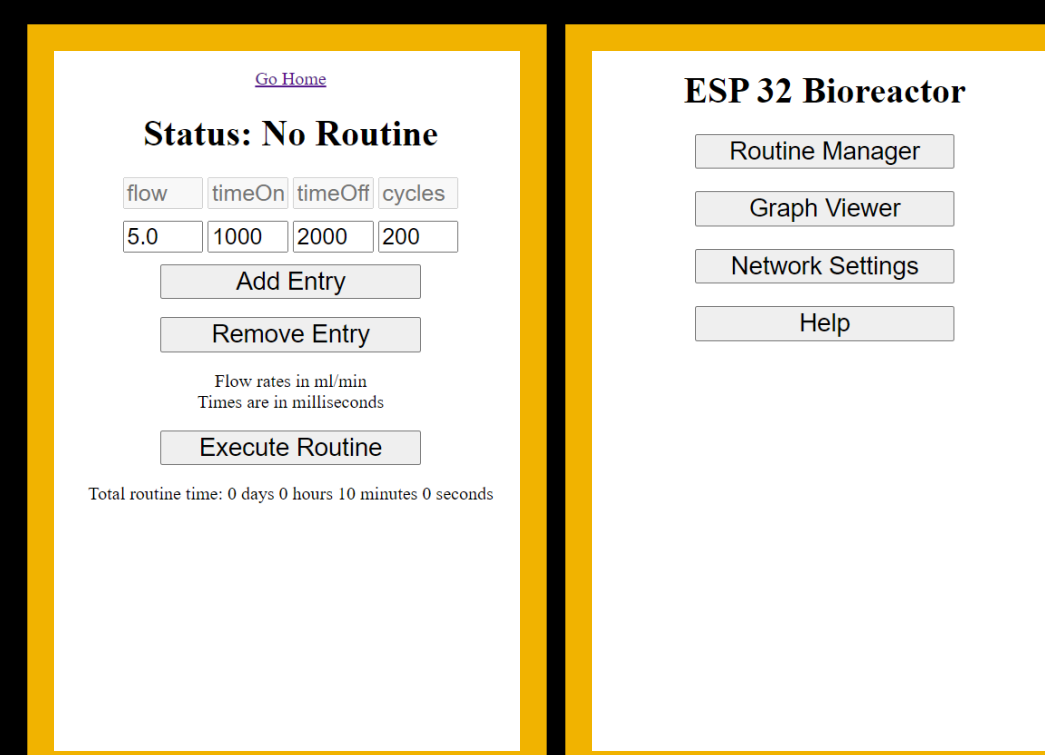


Fully assembled bioreactor system



Finalized controls circuit design

SOFTWARE INTEGRATION



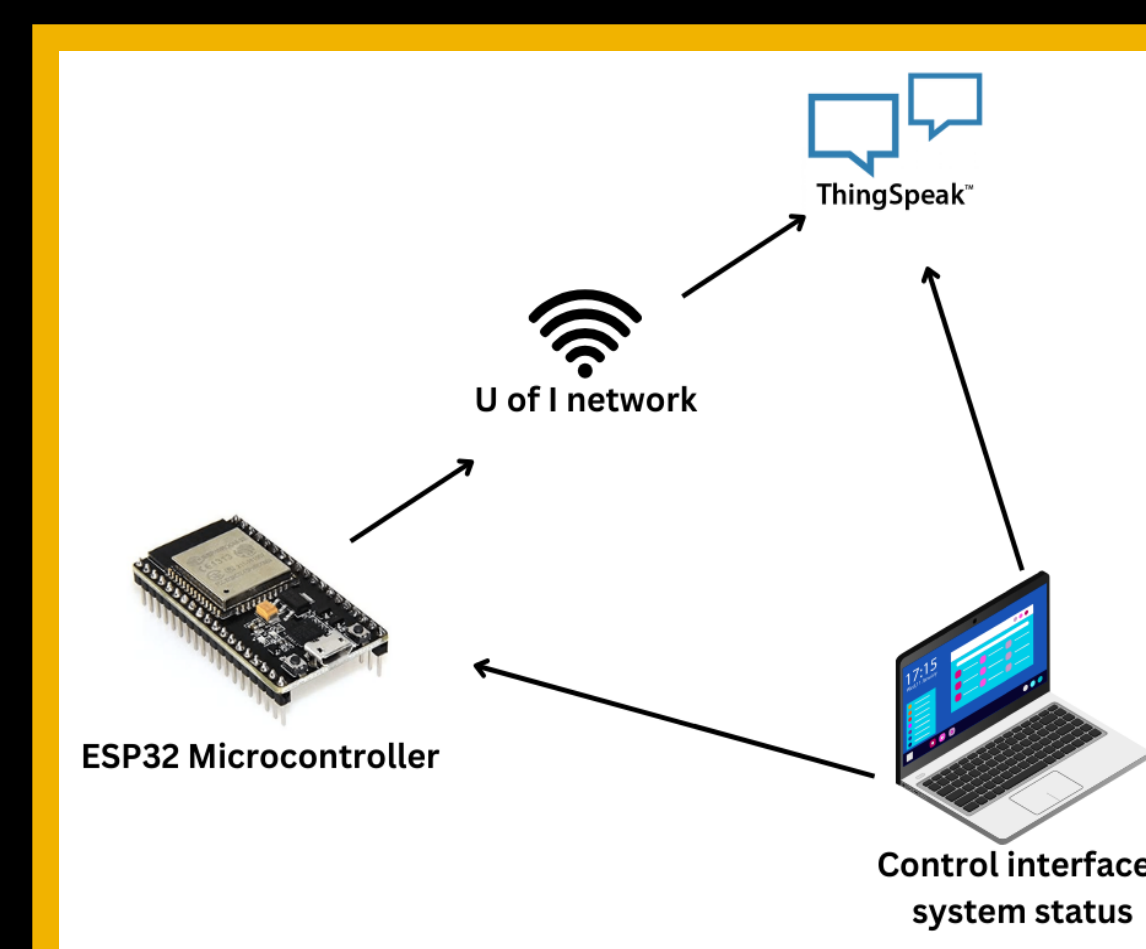
GUI layout

The bioreactor is controlled by connecting directly to the ESP32, while data can be visualized at thingspeak.com, from anywhere, any time.



Link to GitHub repository

The interface, powered by an ESP32, provides advanced control of the bioreactor and connection to Wi-Fi networks to enable real-time data transmission for visualization.



REQUIREMENTS

- Long-term experiments with 0-150 mPa shear stress
- Short-term experiments with 1-2 Pa shear stress
- Flow applied to cells must be laminar
- Parts must be easy to clean
- Less than \$1500 worth of easy-to-get parts
- Easy to use interface for creating experiment protocols
- Remotely visualize system status

CONCLUSIONS

The bioreactor meets most of the requirements listed above in short test cases, including meeting the target flow rates, applying laminar flow to cells, and being able to control and visualize data, all while remaining within our budget.

Future work would include upgrading the peristaltic pump and performing more multi-week testing with cells in the system to make sure it can run for long periods with highly accurate flow and shear rates. Since every part is replaceable, future users can customize the design with different parts if they want. Doing this is recommended, as there may be better options not utilized here that could provide an advantage in precision or ease-of-use.

ACKNOWLEDGEMENTS

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2024 Capstone Project