



FLUID SHEAR STEM CELL BIOREACTOR



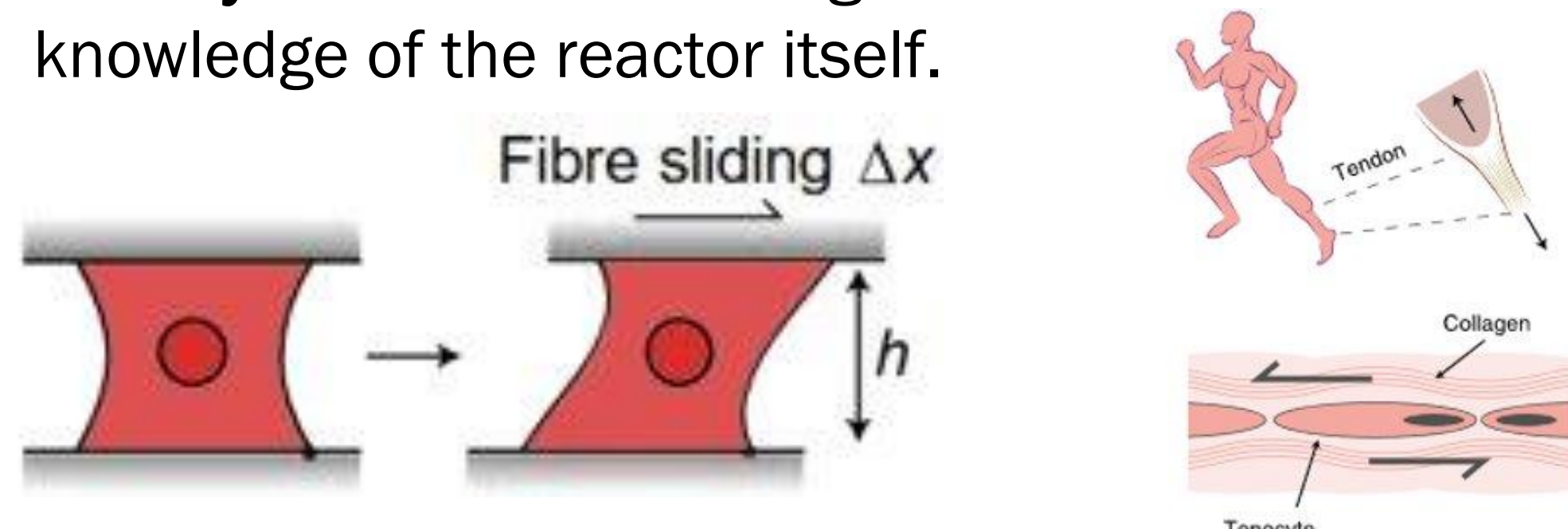
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OBJECTIVE

Design, build, and evaluate a low-cost bioreactor system to apply user-defined magnitudes of shear stress to mammalian cells in culture to explore scientific questions in mechanobiology

BACKGROUND & VALUE PROP

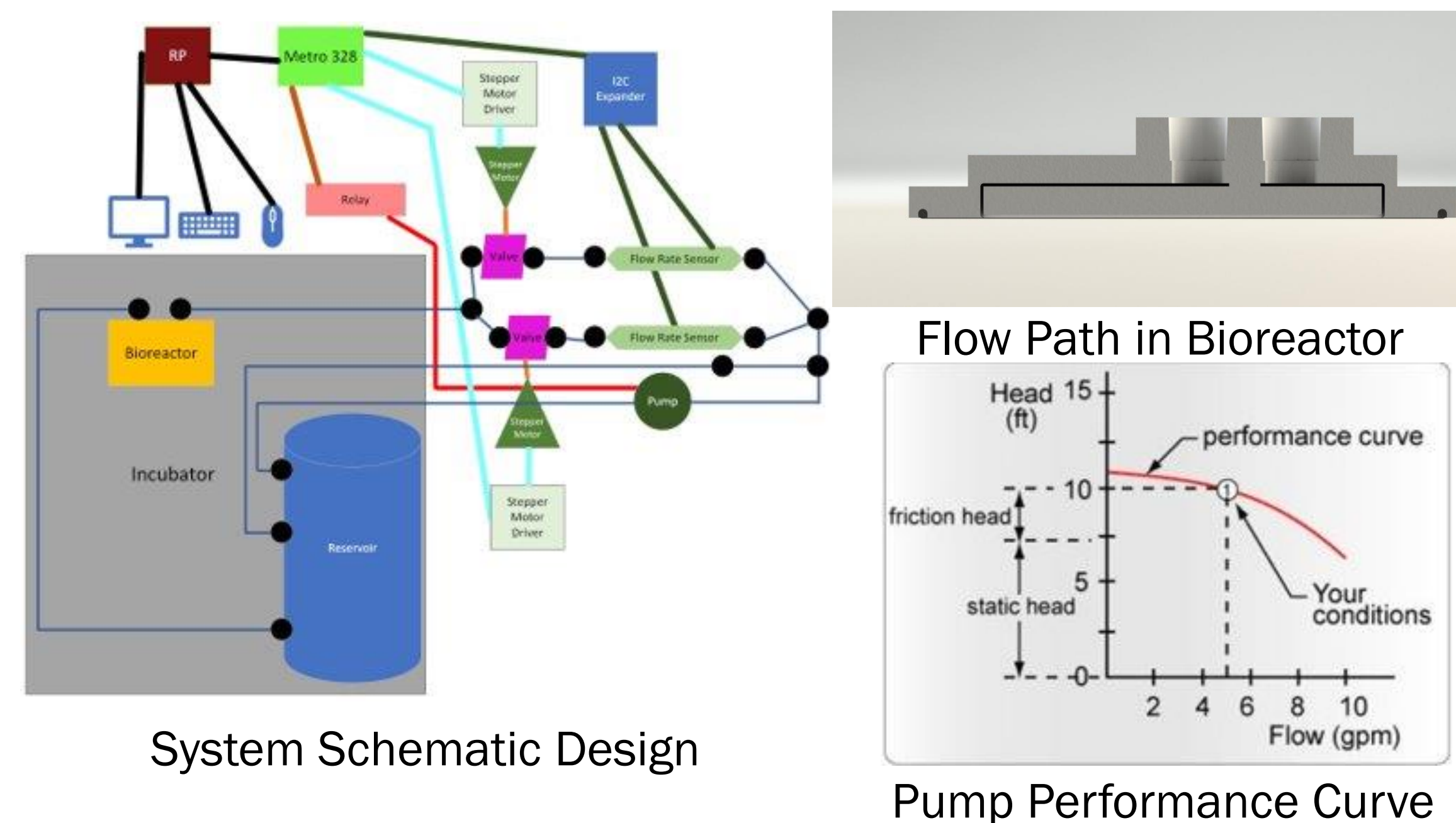
- Cells embedded in tendons experience shear stress as collagen fibers slide past each other
- Dr. Nathan Schiele's lab is interested in studying how shear stresses on stem cells impact tendon lineage and tendon formation
- Aim to create a bioreactor that exposes stem cells to a range of shear stresses that represents mechanical stimuli
- We aim to create a **low-cost** bioreactor for simulating *in vivo* stress conditions of tenocytes in cell culture with a **user-friendly** interface that biologists can use without technical knowledge of the reactor itself.



KEY REQUIREMENTS

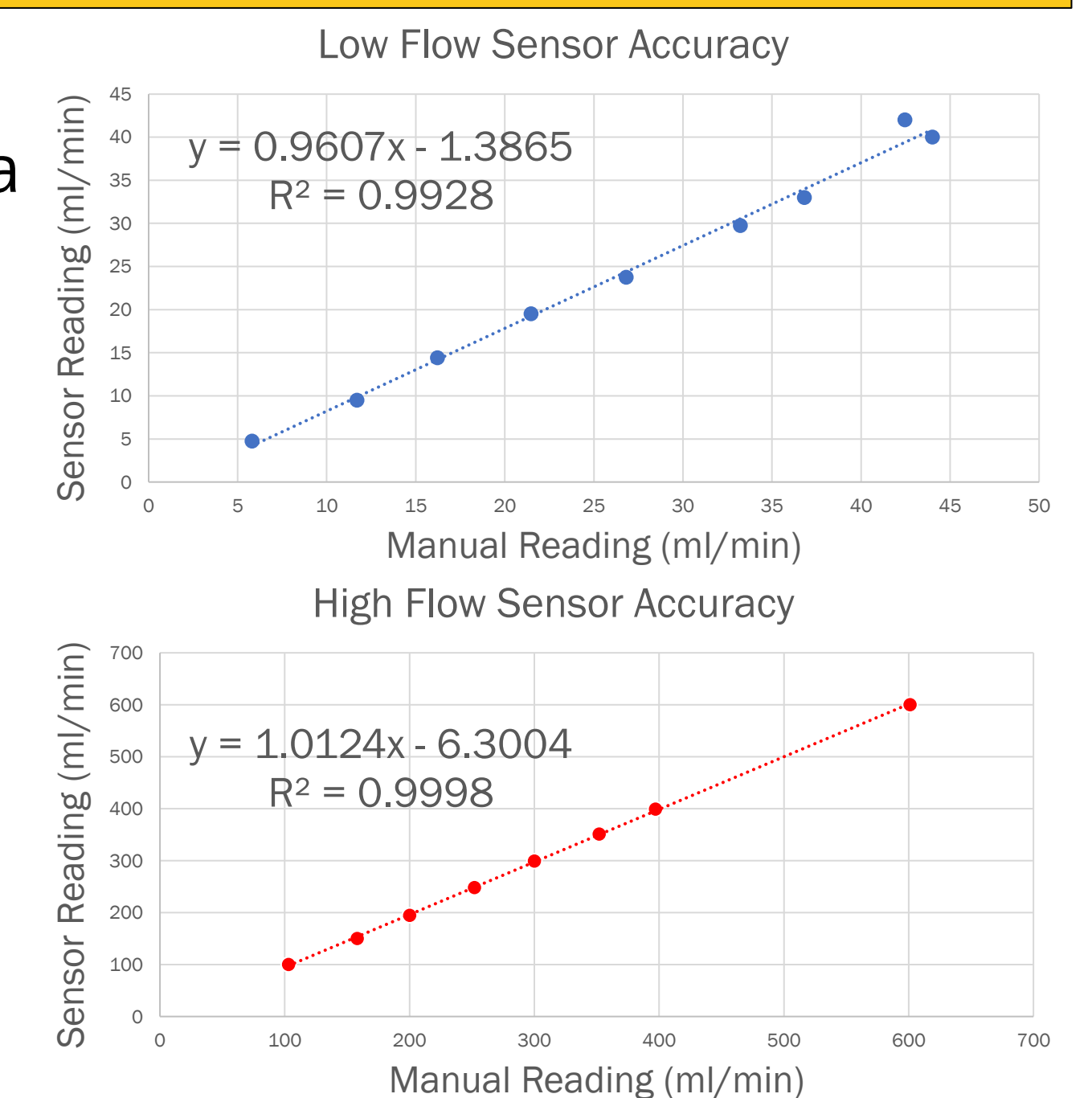
- Withstand incubator conditions for cell cultures
 - Fit inside a 14" x 12" x 12" space
 - 37 °C, 5 % CO₂, & 95% Humidity
- Apply long term shear stress at 0-150 mPa
- Apply short term shear stress at 1-2 Pa
- Low-cost & user friendly
- Components must be autoclavable or ethanol friendly
- Accommodate cell culture plates with minimum cell culture usage

CONCEPT DEVELOPMENT

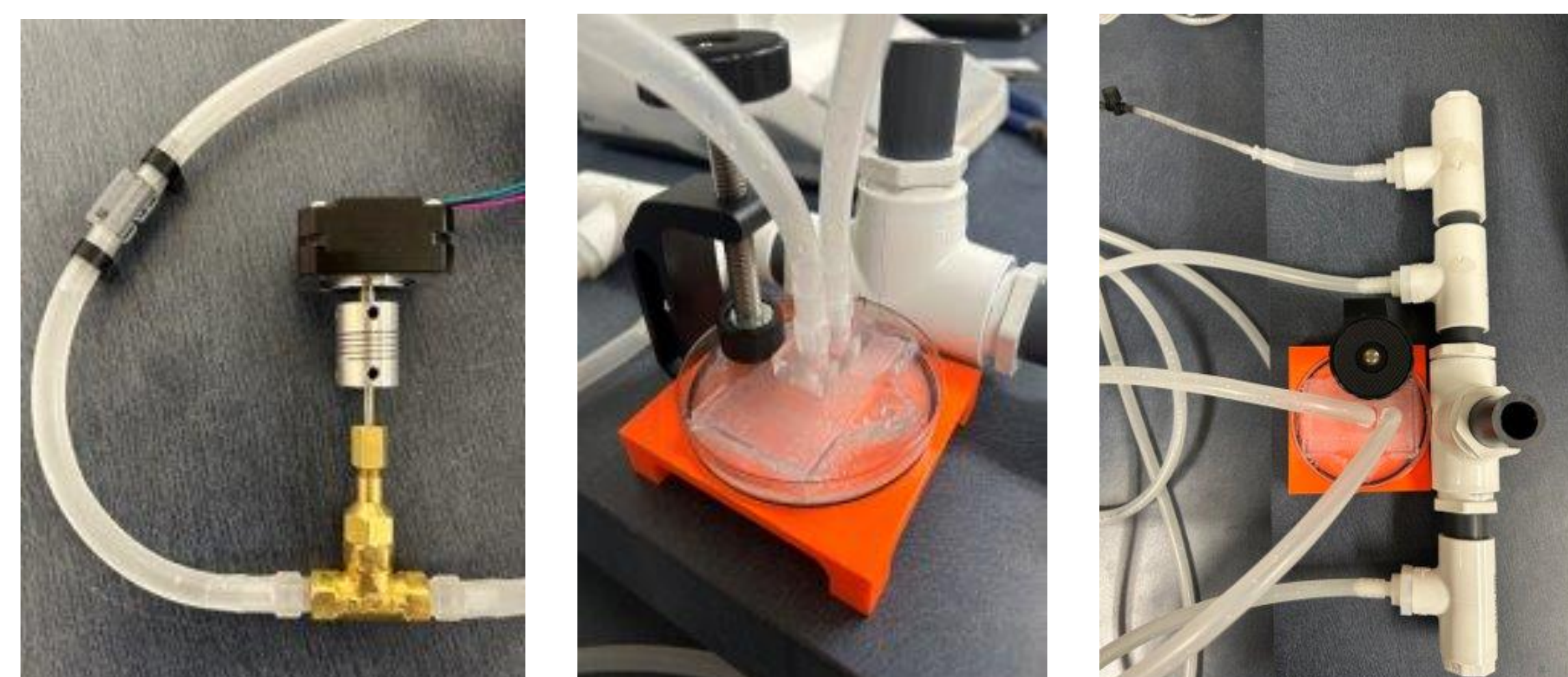


VALIDATION

- Analytical Modeling
 - Using Poiseuille flow, a desired flow rate was found for the bioreactor's channel
- Flow Testing
 - Compared the sensor reading to a manual reading of flow rate to confirm accuracy
- Leak Testing
- Hardware Integration



FINAL DESIGN



Valve, stepper motor and sensor used, full view of resin printed bioreactor, and top view of bioreactor and reservoir unit

Criteria Met

- Two flow paths with different valves and sensors to meet both shear stress ranges specified
- Low total cost even with specialized parts
- Utilization of off-the-shelf products where applicable
- Easy to use GUI interface
- All parts are autoclavable
- Reservoir size and subsequent media usage is minimal
- Withstands incubator conditions
- Fluid flow is completely contained

CONCLUSION

The bioreactor system can deliver fluid shear stresses by controlling the flow rate within the bioreactor system and is able to apply user-defined shear stress(s) for a specified time. The system is operated independently by a Raspberry Pi and Arduino.

In future work, engineers should focus on making a simpler priming process, downscale the size of the footprint of the reservoir, and speed up the time it takes for the valves to be adjusted correctly. More designing is needed to integrate another bioreactor with the current system and increase the number of different experiments the system can run.

ACKNOWLEDGEMENTS

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2023 Capstone Project