Herringbone Microfluidic Device

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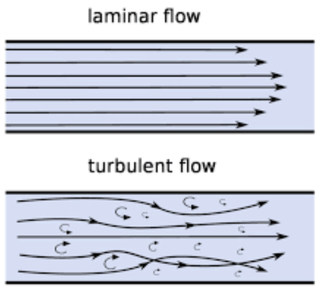
Introduction

Microfluidic devices control and manipulate small amounts (microliters) of liquids. These devices are often used in the screening of drugs, as models to test with. During SHINE, I worked with a herringbone microfluidic device that interrupts the **laminar flow** (fluid particles have order, they follow a smooth flow) in order to obtain a more **turbulent flow** (particles are mixing, characterized as chaotic). This turbulent flow is created by the grooves in the main channel of the device, which allows for the mixing of liquids.



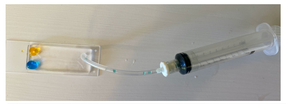
https://diffzi.com/laminar-flow-vs-turbulent-flow/

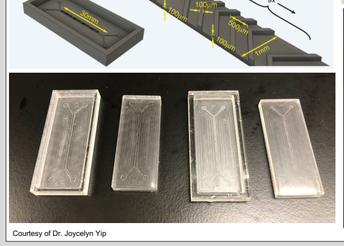
Methods

1. Design a control and a herringbone device in AutoCAD Fusion 360
2. Micromill a mold made of polycarbonate
3. Cast the devices in the mold with PDMS
4. Use a biopsy punch to make holes in three of the four circles at the end of the channels
5. Place the device on a glass slide and apply pressure
6. Insert a syringe with tubing and a barb attached into one of the holes
7. Pipette a drop of colored water on each the two holes that are next to each other
8. Pull the water through the device by pulling the plunger on the syringe

- Steps 1-3 done in lab, by mentors

[1]





Courtesy of Dr. Joycelyn Yip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Results

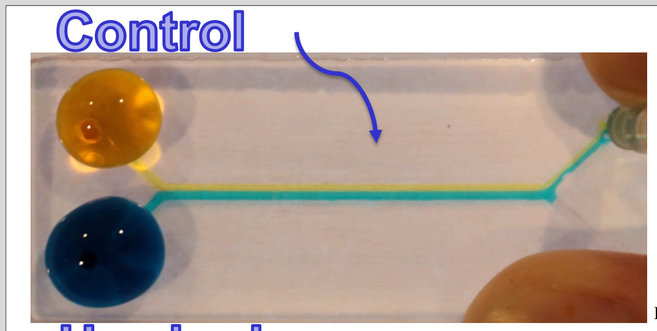


Figure 1

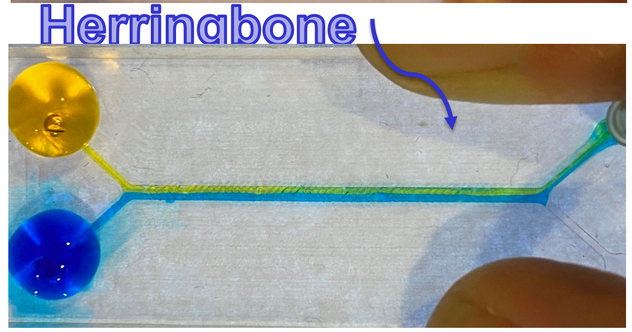


Figure 2

The data collected in Figure 3 was obtained through the analysis of pixels at the beginning and end of each device. ImageJ, an image processing software was used to do this.

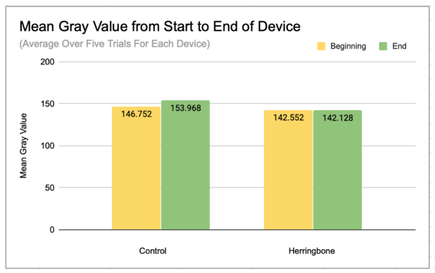


Figure 3

Varying results can be observed. There isn't an identifiable pattern indicating the visual outcome shown in Figures 1 and 2.

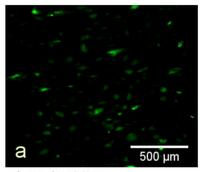
A likely explanation in the variation of the results is the lack of consistency in environment around each trial of the devices. In order to obtain a useable sample size, five trials were conducted, leading to uncontrollable variables, such as the lighting and picture quality.

Next Steps:

Standardization of the lighting throughout tests, and over the devices would help to reduce inconsistent shadows that caused variations in data. Brighter lighting behind the device may help as well. An approach with two syringes, where the water is pushed through instead of pulled, might create more turbulence.

Skills Learned

I was able to become familiar with ImageJ, an image processing software. With ImageJ, I analyzed a video that my mentor, Nina, took of myometrium cells (Figure 4). I created a graph of the cells' calcium activity and oxytocin sensitivity (Figure 5).



Courtesy of Antonia Maxey
Figure 4

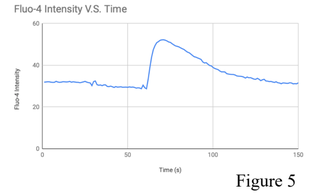


Figure 5

I also learned how to understand scientific literature through reading, and rereading many articles. I improved my literary analysis skills by reading an article about 3D bioprinting components of hearts with collagen. I presented a summary of this article to the LLSE Lab.

Objective & Impact of Professor's Research

The Laboratory for Living Systems Engineering works to design organ-on-chip devices to address existing limitations with drug screening models. Current testing is primarily conducted in rodents or cell culture, both of which have advantages and flaws when compared to microphysiological models.

In vivo


https://www.futurity.org/calnexin-multiple-sclerosis-1698992/lab-mouse-in-hand_1600/

- Whole organism
- Expensive
- Low throughput
- Not a human physiological environment

Microphysiological Systems


https://www.eetindia.co.in/microfluidic-devices-diagnose-worlds-return-to-new-normal/

- More accurate human environment
- Medium throughput
- Flexible for many types of tests
- Systems must be able to be reproduced on chips

In vitro


https://oncologynews.com.au/mini-breast-grown-in-petri-dishes/

- More control over variables
- High throughput
- Cheaper
- Human materials
- Lack of physiological conditions

Acknowledgements

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Citations

[1] Yen, D. P., Ando, Y., & Shen, K. (2016). A cost-effective micromilling platform for rapid prototyping of microdevices. *Technology*, *04*(04), 234–239. https://doi.org/10.1142/s2339547816200041

[2] Yip, J. K., Harrison, M., Villafuerte, J., Fernandez, G. E., Petersen, A. P., Lien, C.-L., & Mccain, M. L. (2020). Extended culture and imaging of normal and regenerating adult zebrafish hearts in a fluidic device. *Lab on a Chip*, *20*(2), 274–284. https://doi.org/10.1039/c9lc01044k