Assessing the Functionality of Microfabricated Devices

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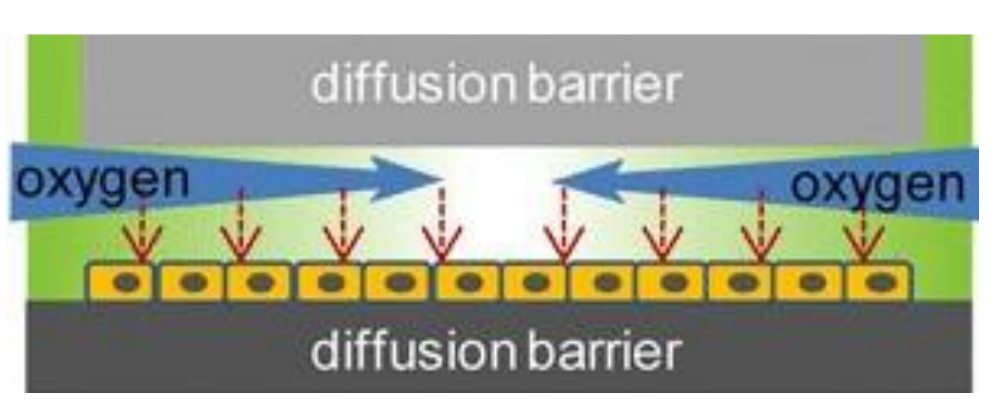
Introduction

Tumor and stem cells grow and interact with a tissue microenvironment, which includes the surrounding tissue cells, blood vessels, immune cells, and signaling molecules. The interactions between the tumor/stem cells and the microenvironment play an important role in the regulation of cell growth and differentiation.

Objective & Impact of Research

- The mission of Professor Keyue Shen's Laboratory for Integrative Biosystems Engineering is to develop *in vitro* models of tumor and stem cell microenvironments.
- These models allow researchers to isolate the individual components of the tissue microenvironment and observe their effects on tumor/stem cells. They are developed using microfabrication, which is the process of manufacturing devices that manipulate substances at the µ scale or smaller.
- By utilizing the models, the lab hopes to discover new targets for drug development and develop more effective tumor/stem cell treatments.

1



Model of microfabricated device designed to replicate hypoxia (lack of oxygen) in tumors. Yellow rectangles represent MCF-7 breast cancer cells. Cells near the edge of the device receive more oxygen than cells near the center.
PC: Yuta Ando [1]

Methods & Results

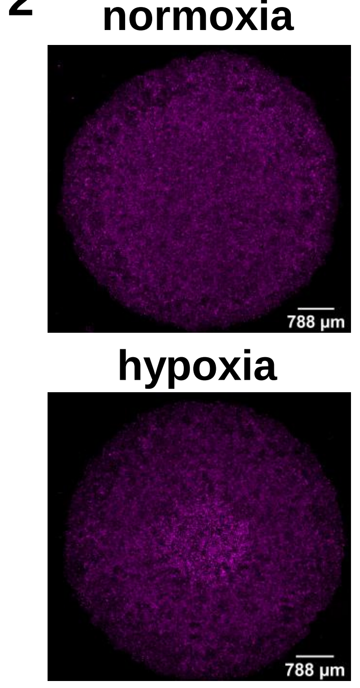
Analysis of Immunofluorescence Images

- Utilized ImageJ and MATLAB to analyze immunofluorescence images **(Figure 2)** of MCF-7 breast cancer cells stained with hypoxic marker Glut-1 that were grown in mentor's hypoxia microdevice platform **(Figure 1)**.
- My program counted 10,018 more objects above a threshold of 165 in the normoxia image vs the hypoxia image **(Figure 3).** Less expression of Glut-1 in normoxia image.
- Mean is slightly higher in hypoxia image due to increased fluorescence in hypoxia image vs normoxia image **(Figure 4).**

2

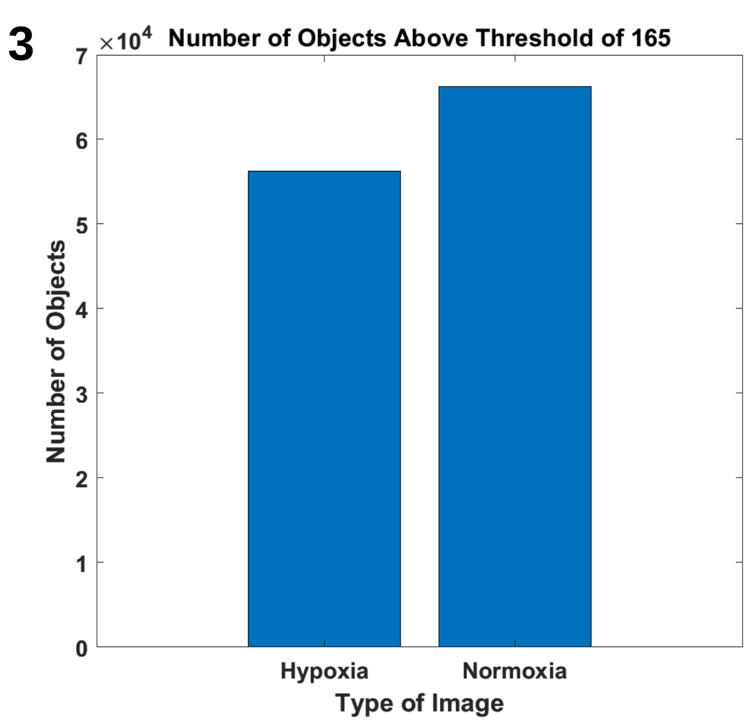
normoxia

hypoxia



PC: Yuta Ando Glut-1

3



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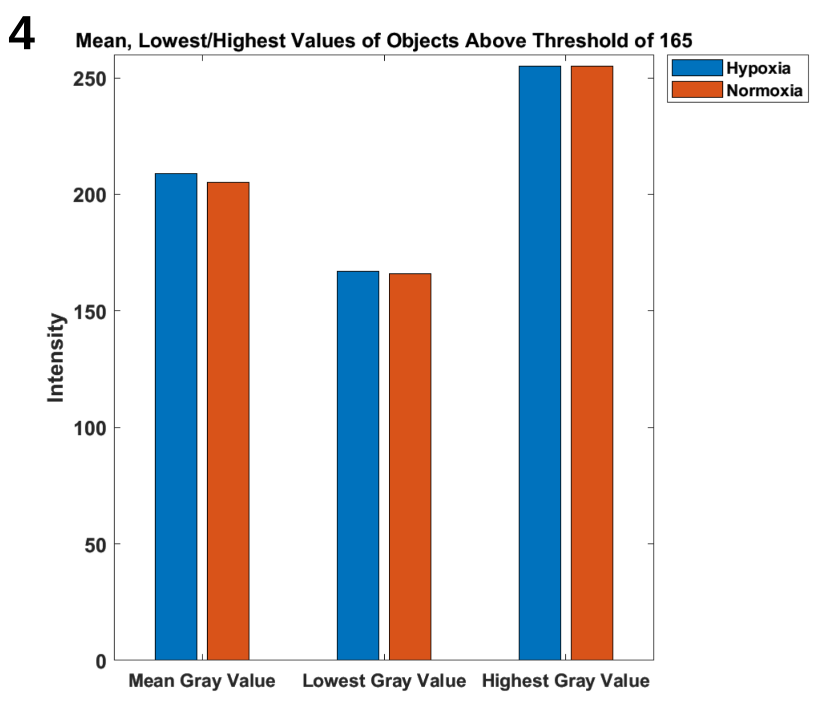

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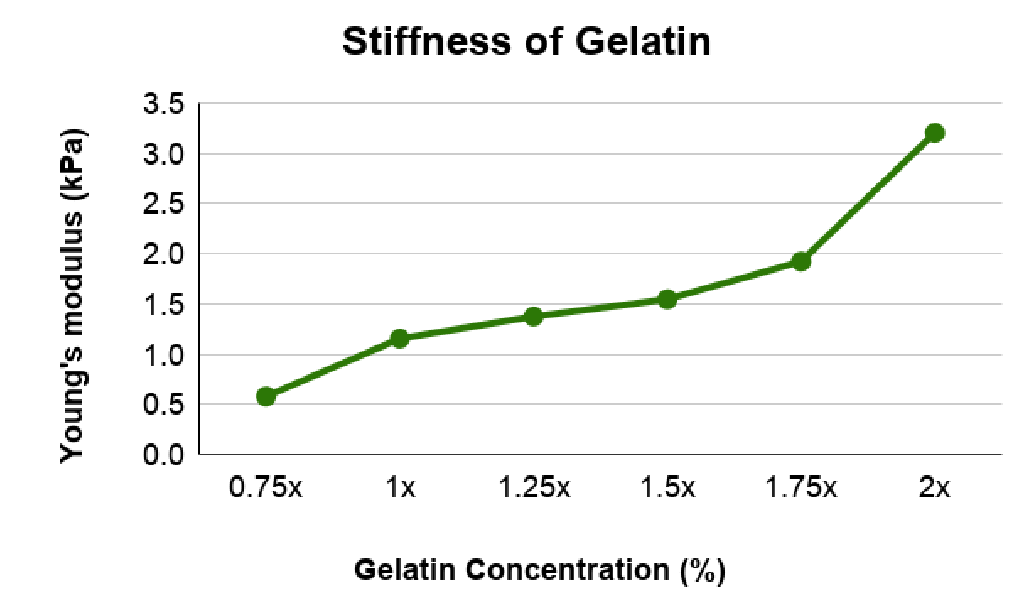
Measuring the Stiffness of Gelatin

- Hydrogels like gelatin are used to mimic biological tissue in microfabricated devices.
- Young's Modulus is a numerical value that describes the stiffness of a material.
- Young's Modulus Formula:
  $\mathbf{E} = (F/A)/(\Delta L/L)$
  $\mathbf{E}$: Young's Modulus F: Force Applied
  A : Area of Section L: Original Length
  ΔL: Change in Length After Force Applied
- Made gelatin in cube mold, placed weight on top of gelatin and calculated $\mathbf{E}$.
- $\mathbf{E}$ increases as concentration increases. Higher $\mathbf{E}$ indicates greater stiffness.



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Food Dye Experiment with Microfluidics Devices

- Conducted experiment with microfluidics devices designed to deliver drugs to cells using food dye **(Figure 5)**.
- Control Device: dyes remain separate. Herringbone Device: dyes mix.
- Assessed functionality of the devices by utilizing the Color Histogram tool in ImageJ software.
- Minimal difference in percentage of RGB values in control device shows food dye did not mix **(Figure 6)**.
- 19% greater percentage of green pixels in end of herringbone device than start shows food dye did mix **(Figure 7)**.

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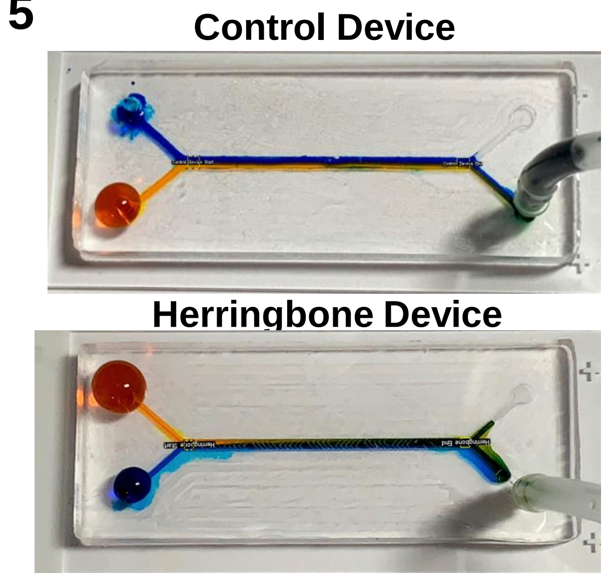
Control Device

Herringbone Device



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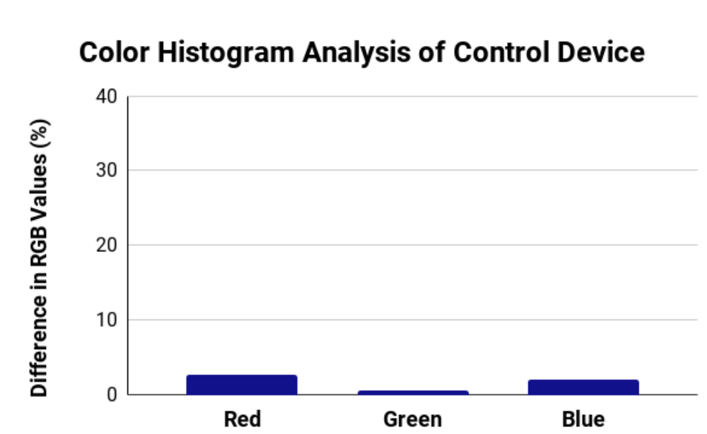

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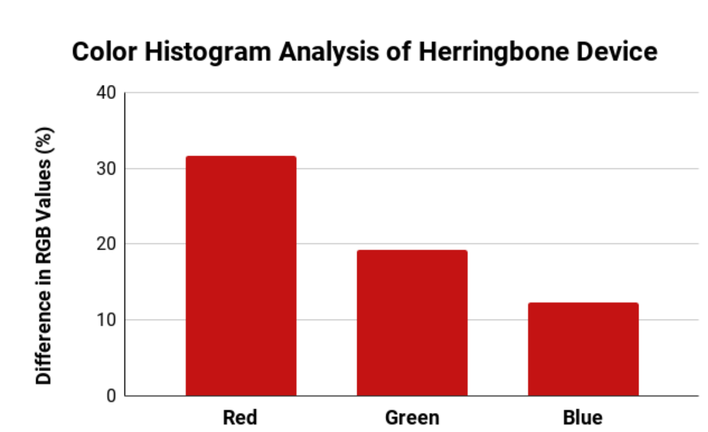

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References

[1] Ando, Y., Ta, H. P., Yen, D. P., Lee, S. S., Raola, S., & Shen, K. (2017). A microdevice platform recapitulating hypoxic tumor microenvironments. *Scientific reports*, *7*(1), 15233.

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