UNIVERSITY OF CAMBRIDGE

Hydrogel Bioprinting:

An Interactive Introduction

June 23, 2023

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Dyson Day

- Thank you all for your attention and coming out here today.
- My name is Noah Gordon. I was a recipient of a Dyson Award 2023 for my part IIB project on multi-material bioprinting.

Agenda

1. Introduction to Hydrogels
2. Preparing Hydrogels
3. Introduction to Bioprinting
4. Printing with Hydrogels

- We’re going to have an exciting day packed with learning and hands-on activities.
- We will start off by introducing hydrogels - what they are and why they’re important in bioprinting.
- After we learn about hydrogels, we will move on to an activity where we prepare our own hydrogels. It’s going to be messy but fun.
- Once our hydrogels are ready, we’ll shift our focus to bioprinting, learn about its importance and the science behind it.
- Finally, we’ll conclude the day with the most exciting part - printing with hydrogels using a real bioprinter! You will see firsthand how the theory we learned applies to real-world science.
- I can’t wait to get started, and I hope you’re all as excited as I am.

Introduction to Hydrogels

What are Hydrogels?

- Hydrogels are three-dimensional, hydrophilic, polymeric networks capable of absorbing large amounts of water or biological fluids.
- Due to their significant water content, they resemble natural living tissue more than any other class of synthetic biomaterials!
- They are used in a variety of applications: wound dressings, contact lenses, diapers, drug delivery systems, and more.

- Hydrogels are fascinating materials that have unique properties due to their high water content.
- We’re going to explore what makes these materials so special and how they’re used in bioprinting.

Preparing Hydrogels

Making Hydrogels

- Now let’s dive into the process of making hydrogels.
- We’ll discuss the steps involved and how different variables can affect the properties of the hydrogel.

- Start with measuring the right amount of agarose powder.
- Dissolve the powder in a buffer solution by heating it up.
- Once dissolved, allow it to cool and form a gel.

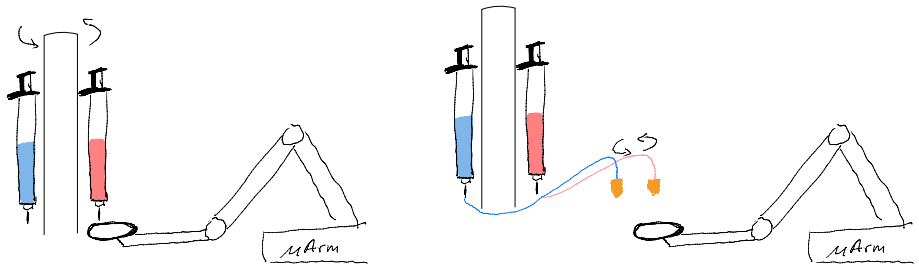
Introduction to Bioprinting

Bioprinting: Building with Biology

- Bioprinting is a method of 3D printing with biological materials.
- It’s used to create structures that imitate natural tissues and organs.
- Scientists hope to use bioprinting to address the shortage of transplant organs.

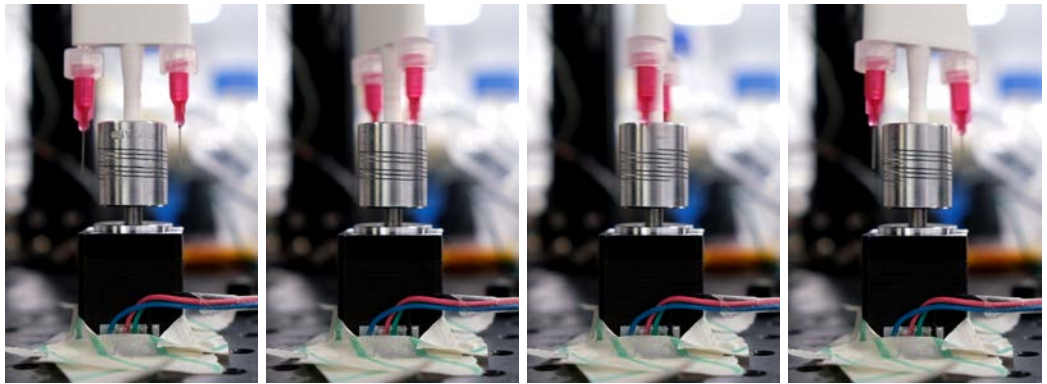
- Bioprinting is a revolutionary technology that’s pushing the boundaries of science and medicine.
- We’ll explore how it works and why it’s so important.

Mechanism Concept Designs



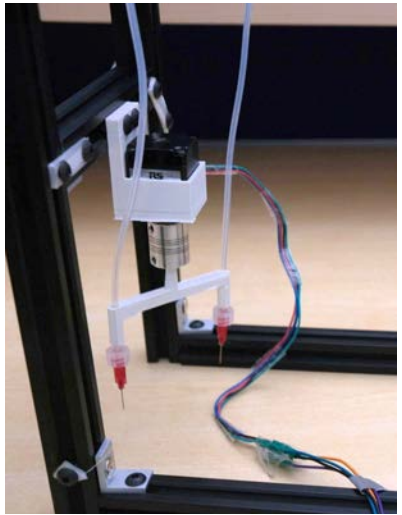
- The initial design concept for BioArm 2's multimaterial functionality was a carousel-like system with two large syringe modules mounted back to back.
- However, this design had potential issues regarding weight manipulation, high power demands, and torque during quick material switches.
- The revised design leveraged the fluid dynamics of different materials flowing through tubes. This allowed for greater control over material selection and deposition, offering an elegant solution to our initial design challenges.
- This tube-based concept formed the foundation of our Stage 1 mechanism design and our first mechanism viability prototype.

Design Stage 1



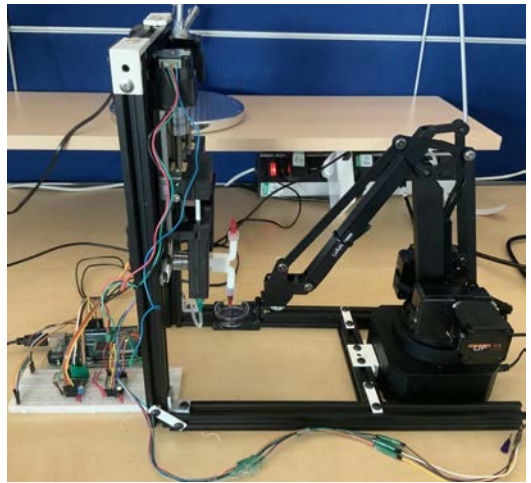
- The first design of the mechanism viability prototype aimed to couple the rotation of the motor axis to the rotation of the tubing.
- Initial designs used a set screw design to secure the part to the motor shaft. However, this proved to be inferior to having the shaft integrated into the part.
- The part was lengthened to better manipulate the tubing and had a protruding rod to ensure a secure connection with the motor.
- This prototype marked a significant milestone in the project, validating our tube-based mechanism.

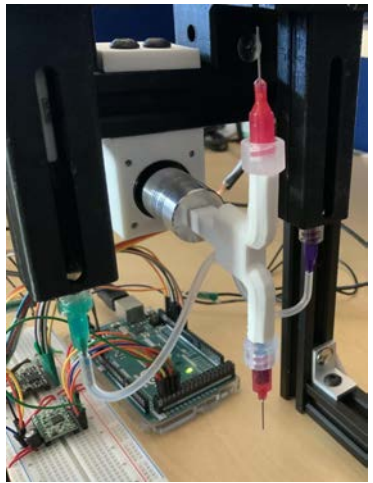
Design Stage 2



- As we evolved into the full prototype stage, the focus extended beyond just the mechanism design.
- The rotor was redesigned to ensure the printhead could traverse a larger surface area without disrupting the print.
- In addition, we had to consider the role of the mount and its attachment to the frame.

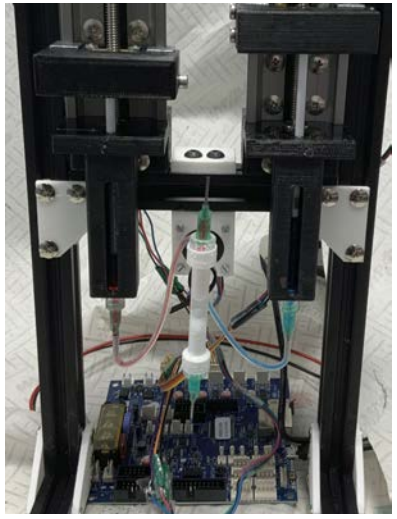
Design Stage 3





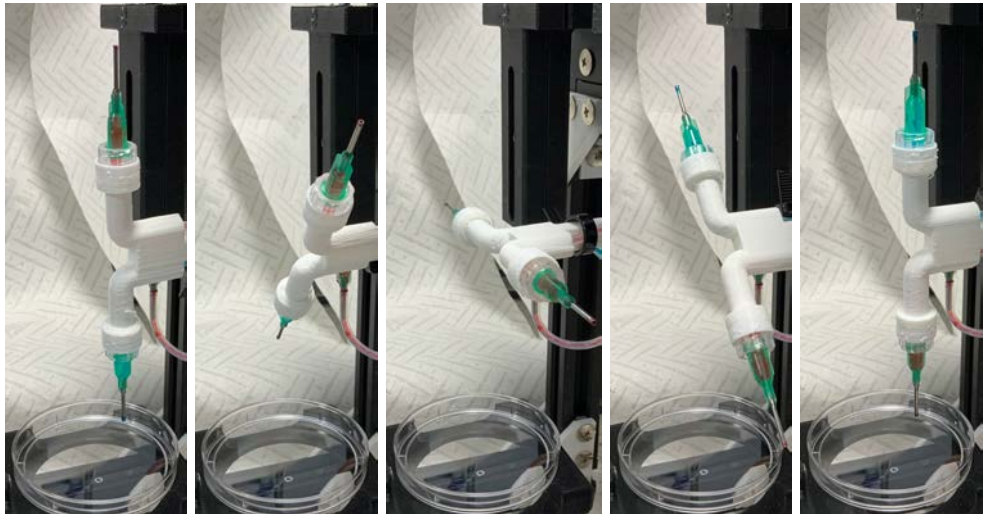
- Here, we refined the rotor and mount design further, optimizing for print quality and ease of use.
- Each iteration of the design brought us closer to a robust, reliable multi-material bioprinting solution.

Final Design



- We present our final design, incorporating all the improvements from previous stages.
- This design features optimized rotor and mount components for efficient material manipulation and precise bioprinting.

Final Design



- These are detailed views of our final design.
- Our success in creating a multimaterial manipulation mechanism and a reliable bioprinter gave us the confidence and motivation to further develop the BioArm 2.

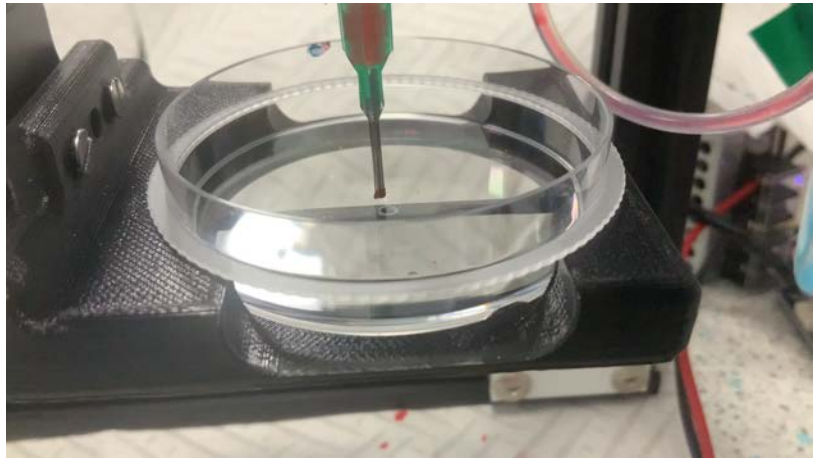
Printing with Hydrogels

Hydrogel Printing

- Hydrogels can be used as a ”bio-ink” in bioprinting to create 3D structures.
- They provide a supportive structure that allows cells to maintain their shape and alignment.
- The main challenge in bioprinting with hydrogels is controlling their mechanical properties - too soft and they cannot support the structure, too hard and they can harm the cells.
- Ongoing research aims to create hydrogels with the right balance of properties to effectively support cell growth and tissue formation.

- We’re now going to see hydrogels in action in the 3D bioprinting process.
- We’ll discuss how hydrogels can be used as ”bio-inks” and what challenges we face when printing with them.

Printing demonstration



Activity time

Go!

Acknowledgements

Thank you Dr. Roebuck and Dr. St. Leger for organizing Dyson Day 2023!

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Thank you!