

Microfluidic Device for Artificial Lymph Node Model



DEPARTMENT OF
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Overview

- Background
- Problem Statement
- Design Criteria
- Competing Designs
- Design Matrices
 - Cooling Method
 - Microfluidic Chip
- Selected Design
- Future Work

Background

- Client - Dr. Cristina Sanchez De Diego
 - Post Doctoral Researcher - Microtechnology, Medicine, and Biology (MMB) Lab
 - Prostate Cancer Metastasis
- Why
 - Prostate Cancer has an 8% metastatic incidence at diagnosis [1]
 - Survives the longest in the lymph nodes (31.6 months) vs bones (21.3 months) and lungs (19.4 months) and liver (13.5 months) [1]

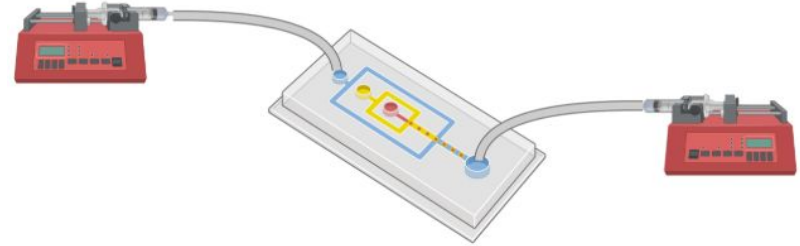


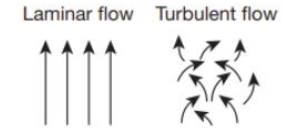
Figure 1. Microfluidic Droplet Generator Example [1]

Sam Kamin

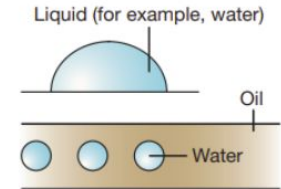
Background

- Microfluidics
 - Highly predictable behavior microscale physics that dominate over macroscale physics [2, 3]
 - Reduces cost and sample size required
 - High scalability [2]
 - When hydrogels polymerize, they create substrates for cell seeding [3]
 - Allows for cell migration [3]
 - Organ-on-a-chip technology

Laminar versus turbulent flow



Surface and interfacial tension



Capillary forces

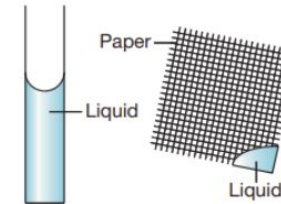


Figure 2. Behavior of Microfluidics [2]

Sam Kamin

Problem Statement

- Prostate cancer commonly spreads through the lymphatic system, but current 2D lymph node models cannot fully capture its complex structure and cellular interactions [1]
- This project will develop a microfluidic device that mass produces collagen microspheres containing B and T cells to build a realistic 3D lymph node model for studying metastasis [1]

Eduardo Usandivaras

Design Criteria and Specifications

- **Performance requirements**

- Target volume of $\sim 0.5 \mu\text{L}$ per droplet, 5-10 minute run time
- Autonomous running, independent of user input

- **Operating Environment**

- Biosafety cabinet, sterilized equipment and environment [4]

- **Materials**

- Resin molds, PDMS chips, Plasma Bound to glass, tubing
- Syringe Pump with two-syringe capabilities, luer lock connectors

- **Size**

- 750 μm -wide collagen channel, 1000 μm -wide oil channels, and 750 μm nozzle [5]

Dylan Libel



Competing Designs

- Micropillar Chips

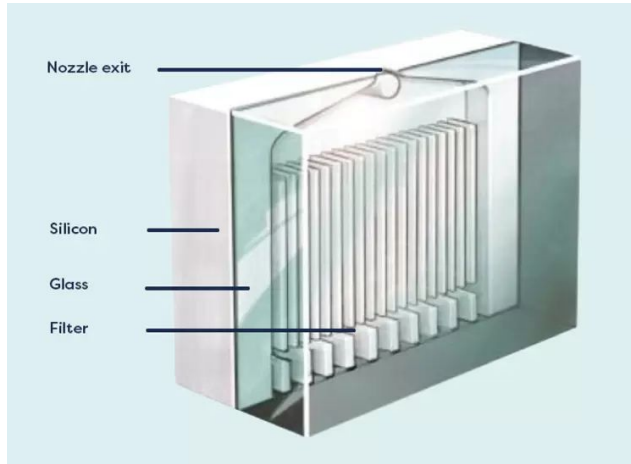


Figure 3: Structural Micropillars used in Specific Chip Design [6]

- Droplet Generator

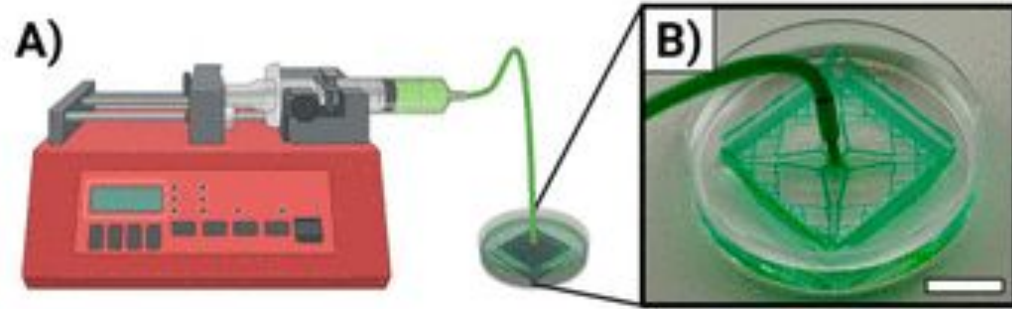
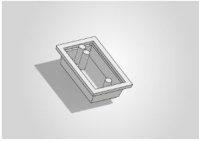
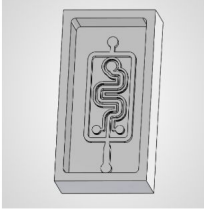
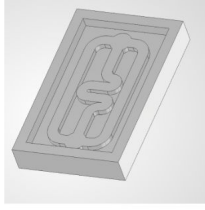


Figure 4: Microfluidic Droplet System with Integrated Syringe Prompt [7]

Dylan Libel

Cooling Mechanism Design

Table 1: Design matrix for the cooling Mechanism

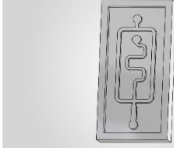
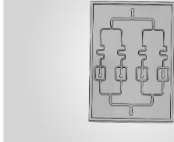
Criteria (Weight)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Design Sketch	Design 1: Ice Cube Mold 		Design 2: Water-Glycerol Channel Adjacent 		Design 3: Water-Glycerol Attached PDMS 	
Cooling Effectiveness (25)	4/5	20	4/5	20	3/5	15
Repeatability (20)	3/5	12	5/5	20	5/5	20
Sterility (20)	3/5	12	4/5	16	4/5	16
Usability (15)	4/5	12	5/5	15	4/5	12
Durability (10)	2/5	4	5/5	10	4/5	8
Ease of Fabrication (10)	3/5	6	5/5	10	5/5	10
Total (100)	66		91		81	

Murphy Diggins



Microfluidic Chip Design

Table 2: Design matrix for the Microfluidic Chip

Criteria (Weight)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Design Sketch	Design 1: Thin No Outlet 		Design 2: Smooth Design 		Design 3: 4-Outlet Design 	
Flow (25)	3/5	15	4/5	20	5/5	25
Accuracy (20)	3/5	12	4/5	16	4/5	16
Usability (20)	3/5	12	4/5	16	4/5	16
Throughput (15)	2/5	6	4/5	12	5/5	15
Reliability (15)	5/5	15	4/5	12	3/5	9
Ease of Fabrication (5)	3/5	3	4/5	5	4/5	4
Total (100)	63		81		85	

Will McGuire



Selected Preliminary Design

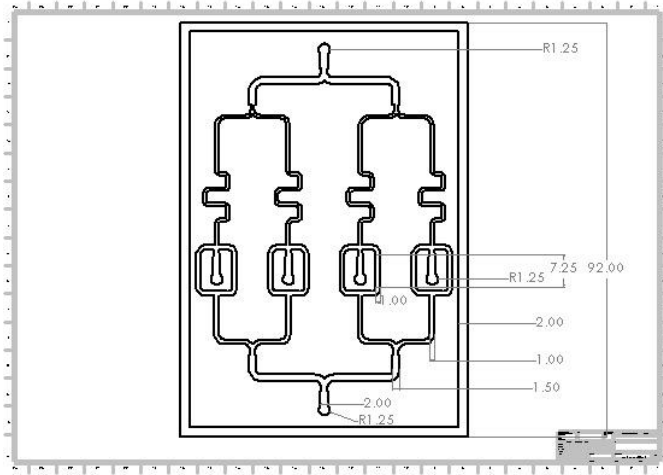


Figure [5] - Preliminary Chip Design

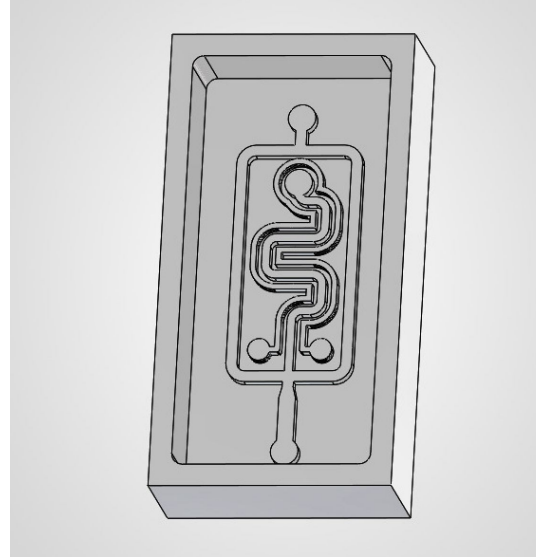


Figure [6] - Preliminary Cooling Mechanism



Will McGuire



Future Work

- Realistic Prototype Testing
 - Fluorescent beads, unpolymerized collagen, cells
- Compatibility of components
 - Specifically cooling with chip design
- Fully Integrated Design
 - Simple, convenient, and organized
 - Collagen Solution → Cell Incubation
- Repeatability
 - Collagen polymerization in tubing and chip.

Vir Jaiswal



Acknowledgements

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Vir Jaiswal



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Questions?

