

# Microfluidic Tectonics: A comprehensive construction platform for microfluidic systems

## Team 5

Stefan Bewley

Theresa Bly

Caroline Hon

Nina Singhal

- Microfluidic Techtonics

- Benefits
- Construction
- Limitations
  - Fabrication
  - Pressure/Diffusion
  - Hydrogel Durability
- Applications

- IV Design

- Value
- Concerns
- Fabrication

- Next Steps

## Quick Production Time

- Can make device in 10 minutes

## Construction of Functionally Complex Systems

- One production platform
- Variety of polymers

## 10 Second Response Time in Microscale

## Self-Regulated Flow Control

- Hydrogels as automatic sensors and actuators

## Microscale Eliminates Heat of Polymerization Concerns

## Liquid Phase Polymerization

- Polymerize light-sensitive polymer using photomasks
- Parallel vs. sequential polymerization
- Minimum object spacing of 100  $\mu\text{m}$

## Laminar Flow

- Coat channel walls with polymer
- Allows design flexibility

## Resolution of Polymerization

- Photomask fidelity failure
  - depth > 150  $\mu\text{m}$ 
    - ~ lighting
    - ~ polymerization diffusion
    - ~ optical properties
  - 10% max. variance in side wall
- Laminar flow

## Time Response

- Functional structures - decreases time from 30 min to 10 sec
- Porosity - 10 fold improvement

## Pressure Limitations

- Too heavy → pressure sensitive hydrogel responds to pressure from its own weight
- Collapse

## Diffusion through Gel

- Small molecules through large pores → diffusion negligible
- Large molecules through small pores → temperature important at phase transition

## Encapsulated Cell Transplant for Treatment of Type I Diabetes

- Last lifetime of patient
- Immune system may destroy

## Controlled Drug Release Devices

- Ingested by patient
- Degredation is slow and can be controlled

## Other Applications of Hydrogel Material, Durability is Wear-based

- Cartilage replacement
- Arterial grafts
- Contact lenses
- Wound care dressings

## Possible Stimuli

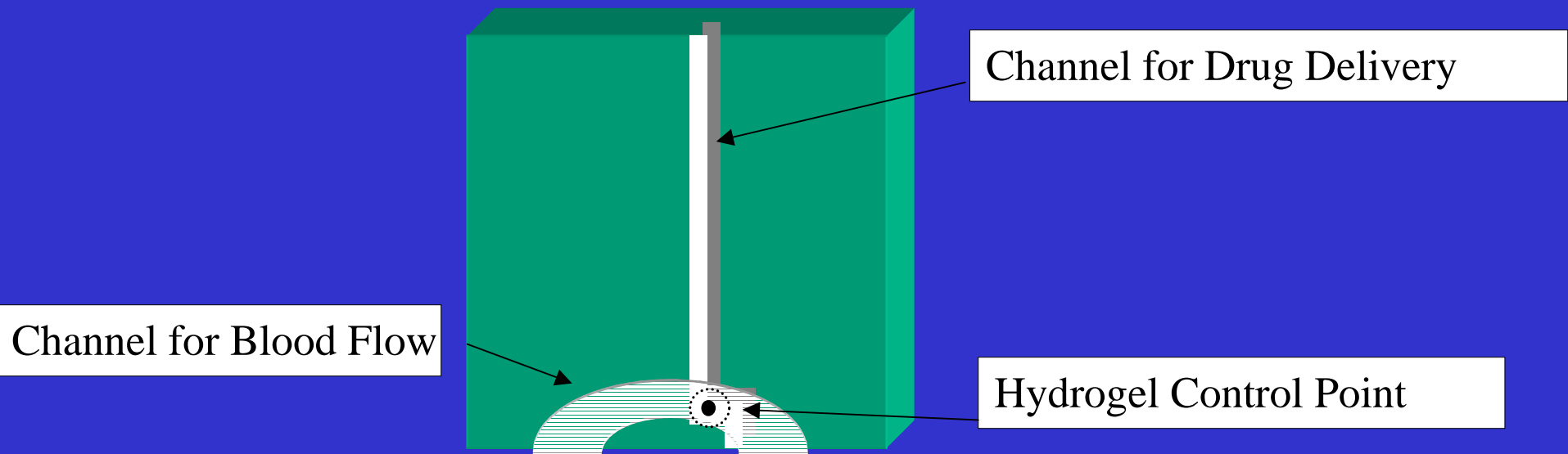
- pH
- Temperature
- Electric fields
- Light
- Carbohydrates (glucose)
- Antigens

## Current Applications

- Biosensors
- Micro-reactors
- Autonomous flow regulation

## Concept: Portable, Automatic IV

- Patient comfort, mobility
- Reduced manpower



## Concerns

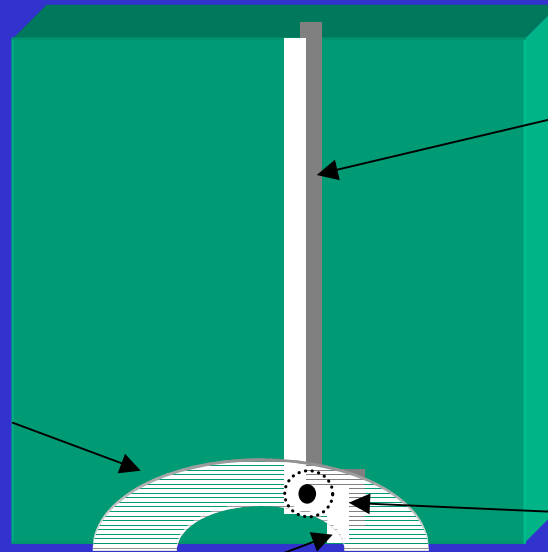
- Receptor to react with drug
  - Bindings on hydrogel  
similar to binding molecules in the brain
- Flow rate of drug
  - Channel size and blood flow rate
- Hydrogel Response time
- Hydrogel Size

## Limitations

- Controlled range of swelling of hydrogel
- Blood cycle time: concentration changes will only be able to be measured once per cycle

# Layout of Micro-Reactor

Top View

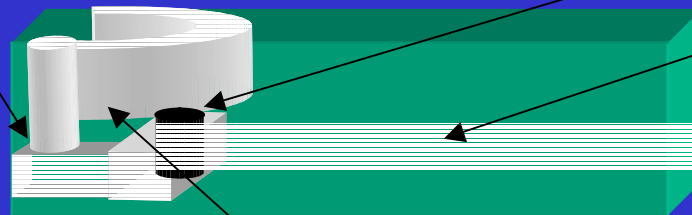


Channel for Drug Delivery

Channel for Blood Flow

Hydrogel Control Point

Side View



Mixing Point

Channel for Drug Delivery

Channel for Blood Flow



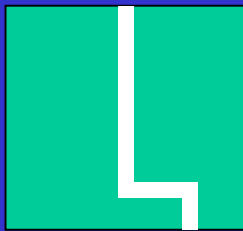
Swelled Hydrogel



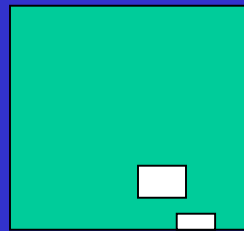
Unswelled Hydrogel

## Start with a PDMS Blank

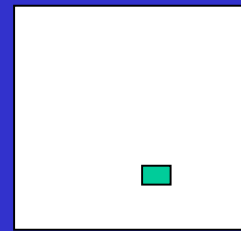
- Create structural channel for drug delivery (mask 1)
  - Seal with packaging tape
- Polymerize and attach structural middle layer - expect hydrogel position and mixing point (mask 2)
- Polymerize functional hydrogel plug in middle layer hole (mask 3)
  - Coat with receptor molecules in bi-phosphid layer
- Polymerize structural channel for blood flow on PDMS blank #2 (mask 4)
  - Turn upside down and attach to allow contact between the blood and hydrogel



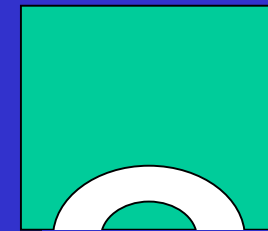
Mask 1



Mask 2



Mask 3



Mask 4

# Next Steps

- Improved Control of Swelling Ratio
  - Unable to determine swelling control precision
- Reduction of Fabrication Time/Cost
  - Prefabricated hydrogel shapes

- Beebe, David et al. Functional hydrogel structures for autonomous Flow control inside microfluidic channels. Nature 404, 588-590.
- Beebe, David et al. Microfluidic tectonics: A comprehensive construction platform for microfluidic systems.” Proc Natl. Acad. Sci., USA, 97, 134888-13494 (2000).
- [www.childrenwithdiabetes.com](http://www.childrenwithdiabetes.com)
  - “Bio Artificial Pancreas News” 2/28/01
- [www.ppti.com](http://www.ppti.com)
  - “PPTI product development: urology applications” 2/28/01