

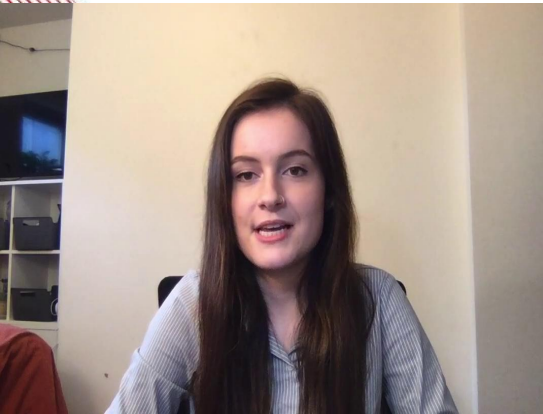


Teaching Model for Ventilation and Perfusion Mismatching

Client: Dr. Chris Green
Advisor: Dr. Amit Nimunkar

Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski,
Jenna Eizadi

10/02/2020



Outline

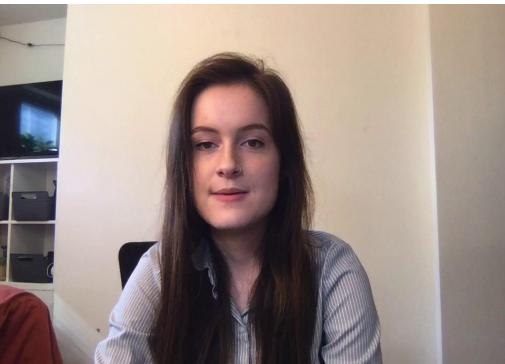
- Introduction
- Background
- Competing Designs
- Design Specifications
- Preliminary Designs
- Design Matrices
- Future Work
- References and Acknowledgements

Introduction

Our client, Dr. Christopher Green, is a pediatric pulmonologist and requested the creation of a model representing the mechanisms underlying ventilation/perfusion (V/Q) mismatching and its various complications, such as hypoxemia and dead space ventilation, to help medical students understand this concept.

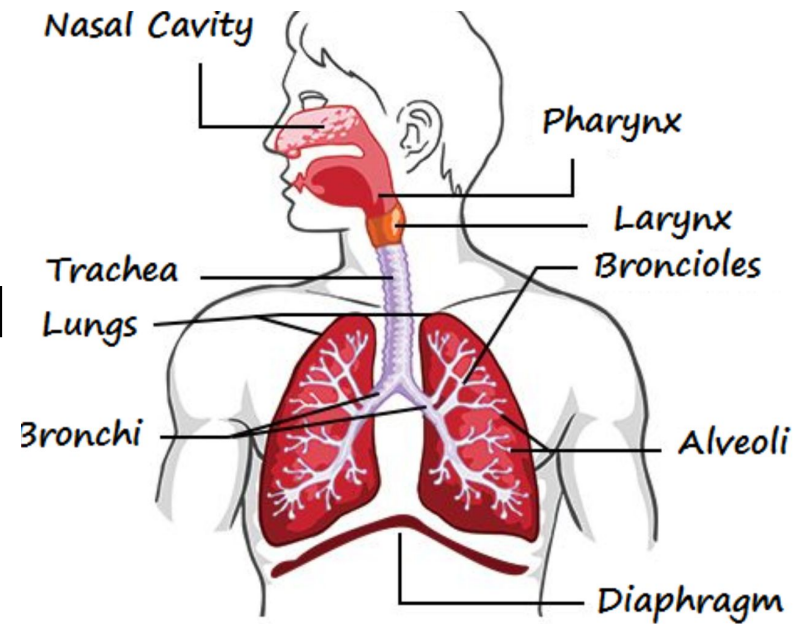
Features:

- An alveolus and corresponding bronchiole
- Capillary tube for perfusion
- Multiple ratios (High V/Q to low V/Q)
- Large enough to be seen on a projector of a lecture hall containing at least 180 people

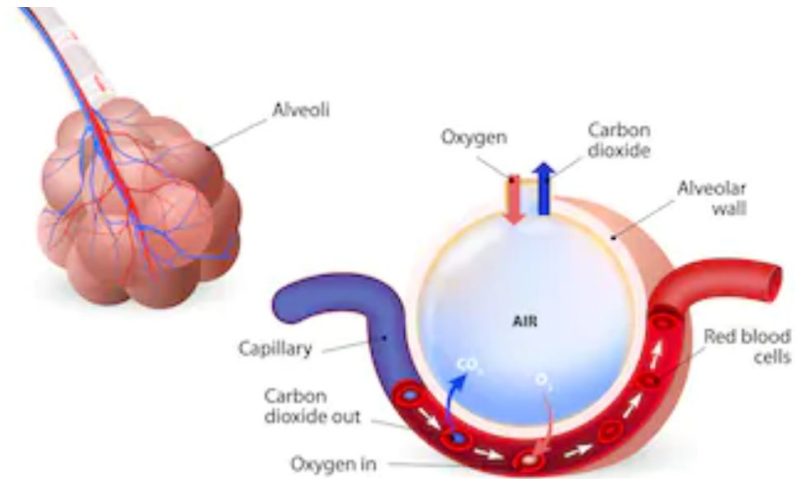


Background

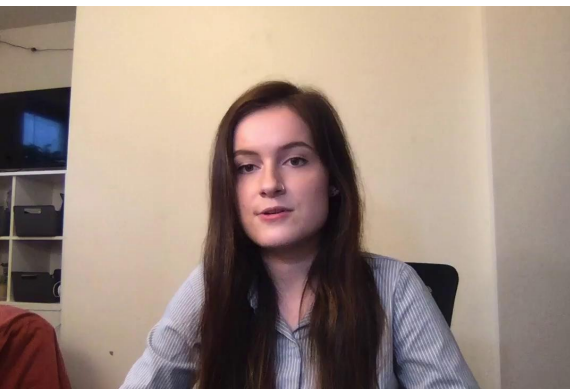
- Air Flow
- Gas exchange occurs in the alveolus [1]
 - Ventilation (V)
 - Perfusion (Q)
- High V/Q
 - Dead space ventilation [2]
- Low V/Q
 - Shunt
- Common diseases can cause mismatching [3]
- Mismatching can lead to hypoxemia [4]



Lung Anatomy [5]

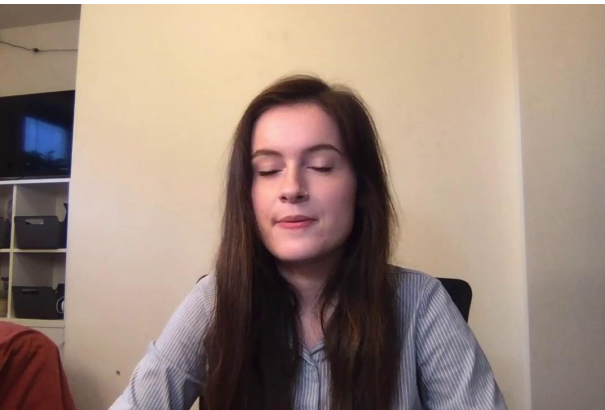
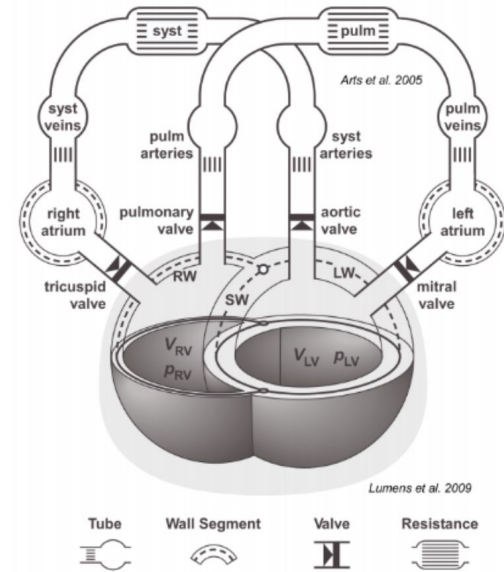
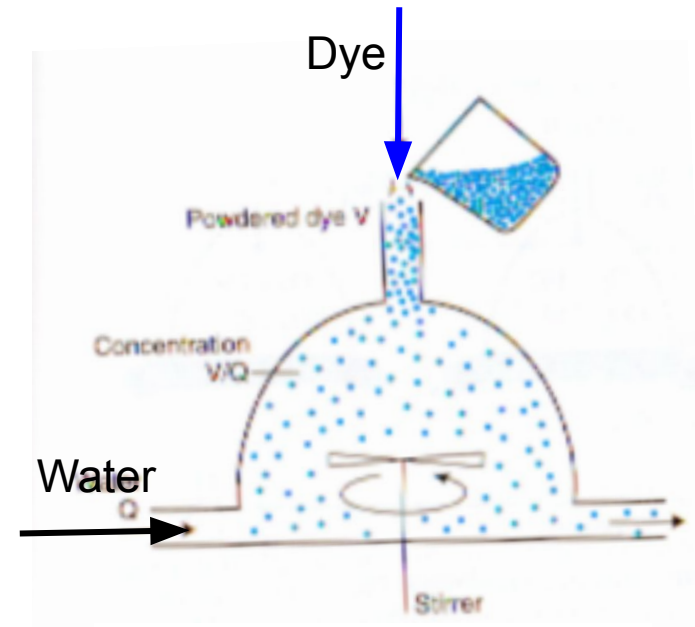


Gas Exchange [6]



Competing Designs

- Water Model
 - Powered Dye (ventilation)
 - Water (blood flow)
 - Concentration (V/Q) [7]
- Circ-Adapt
 - Computational (online) model of heart and circulation
 - Adjustable parameters
 - Focused on cardiac disease [8]



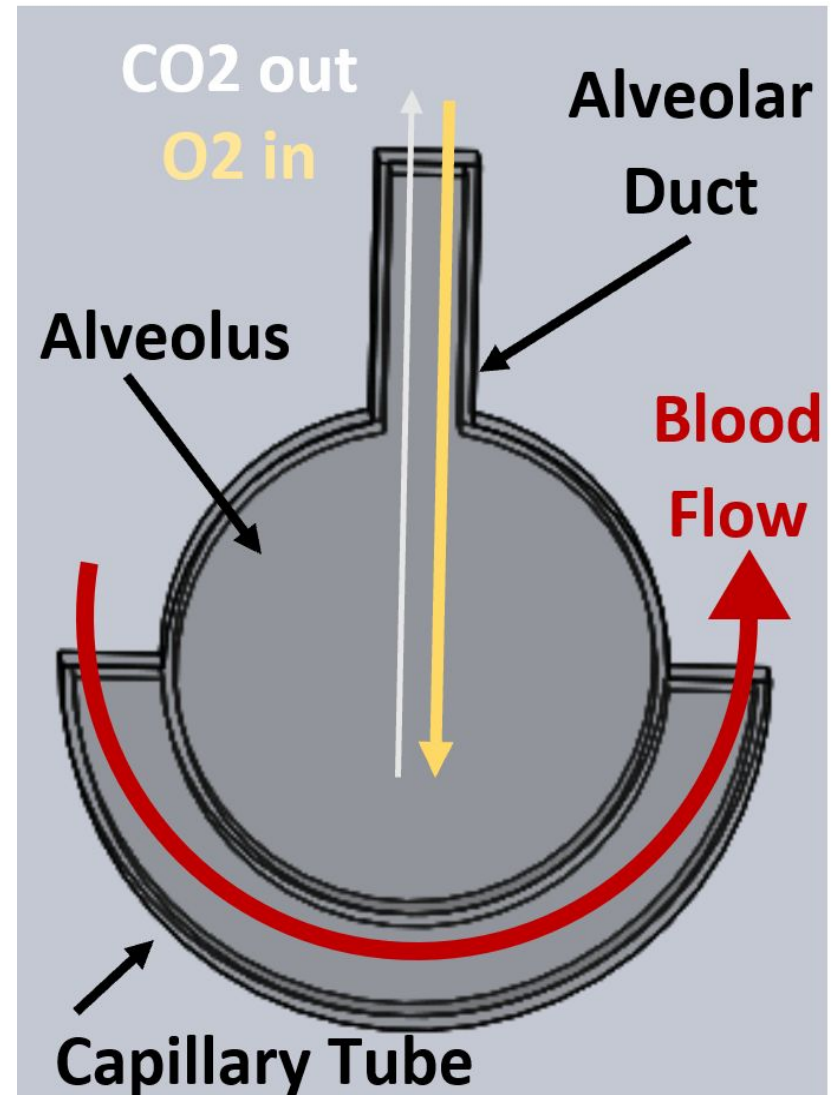
Design Specifications

- Model ventilation/perfusion mismatching within the respiratory system
- Interactive component for the user to change the V/Q ratios
 - Minimum of 5 different ratio settings
- The device should be able to be used multiple times within a lecture
- Large enough for a classroom of 180 people to see with the use of a projector
- Must be able to withstand storage for long periods of time
 - Life in service of at least five years
- Must weigh less than 6.8kg (15 lbs) for easy portability and

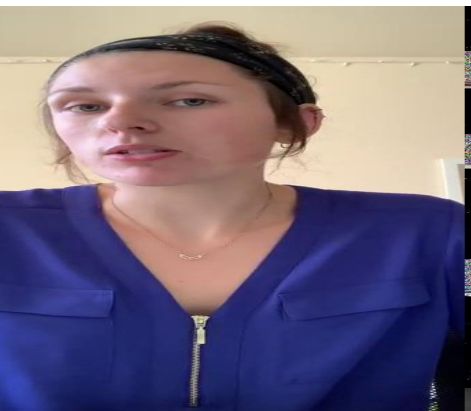
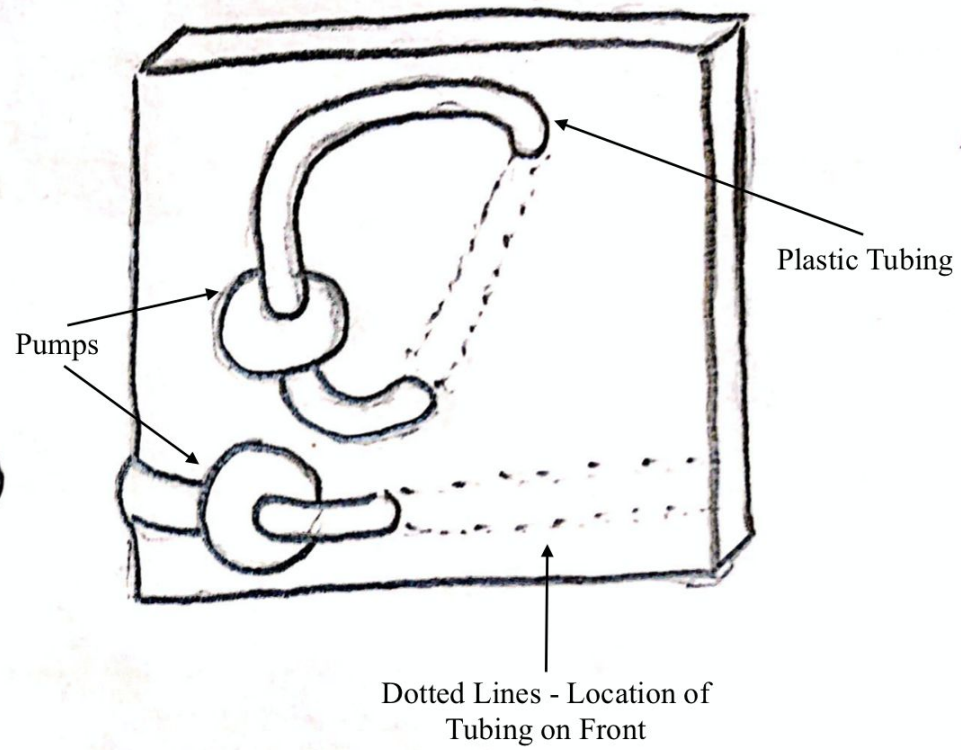
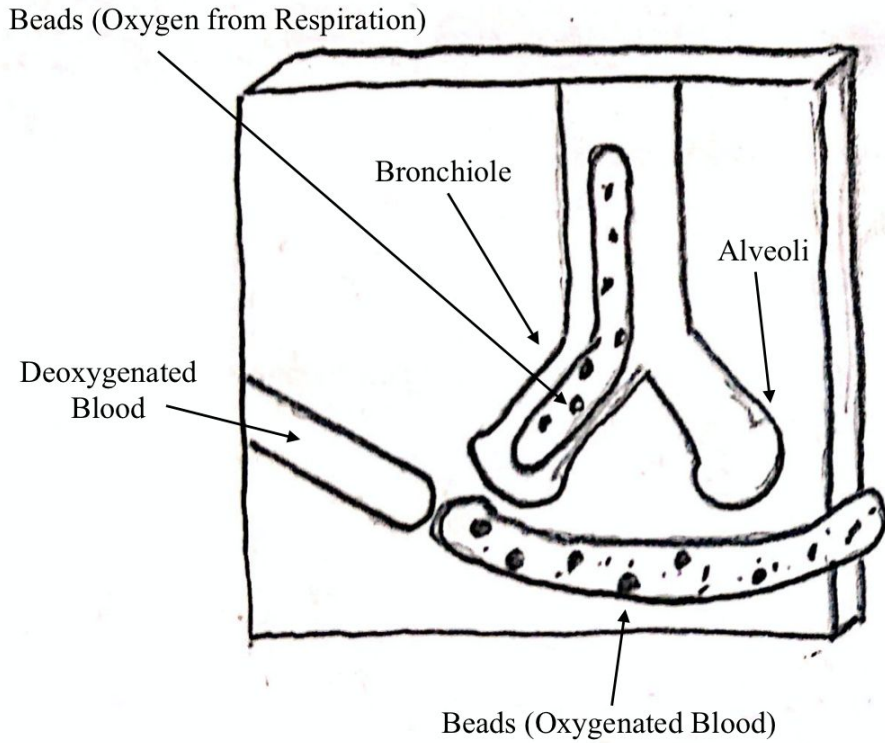


1. LED Model

- Pros
 - Easy Fabrication
 - Greater variability with color, shades, and brightness
 - Great range of ratios that can easily be differentiated by the user
- Cons
 - No branching of alveoli



2. Bead Model

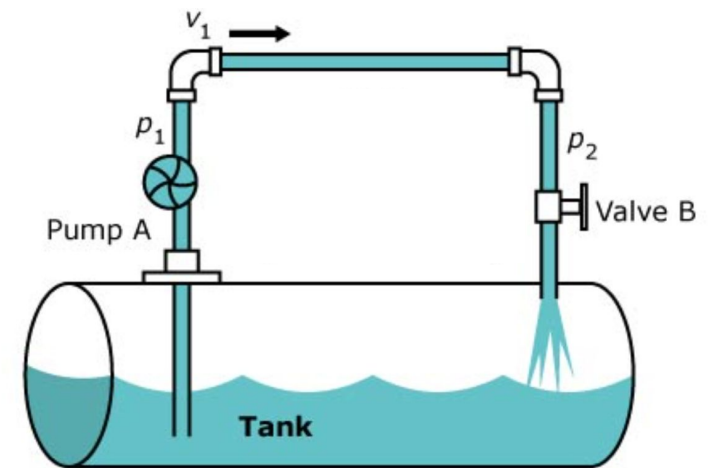
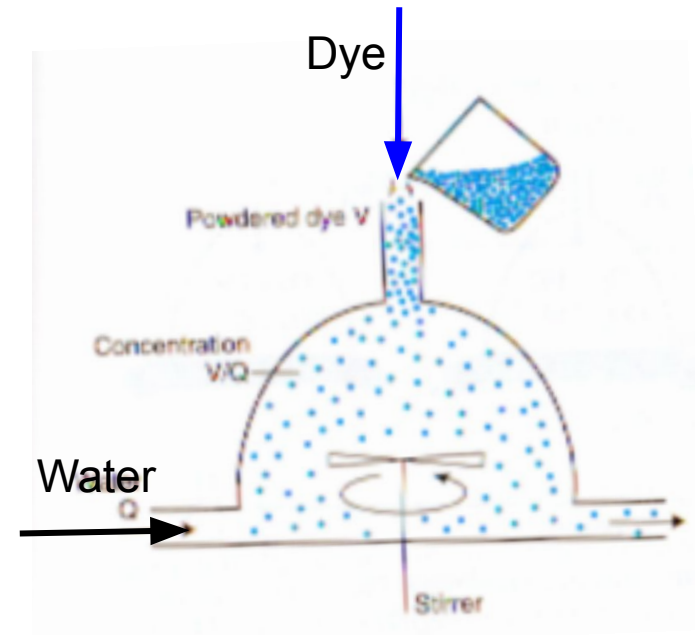


Front View

Back View

3. Water Model

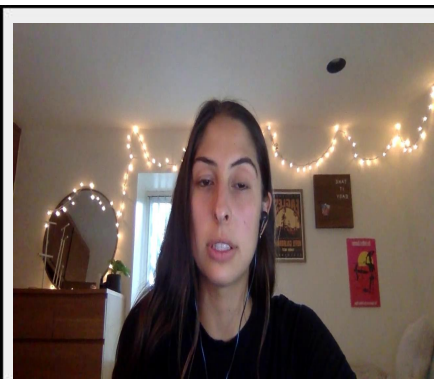
- Pros
 - Easily shows how the air mixes with the blood
 - The original design our client recommended
- Cons
 - Requires a lot of setup/cleanup
 - Can be messy
 - Would require many moving parts
 - Requires a larger system to contain a water reservoir



Closed Water System [9]



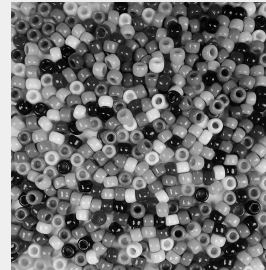
Flow Mechanisms Design Matrix



LEDS



BEADS



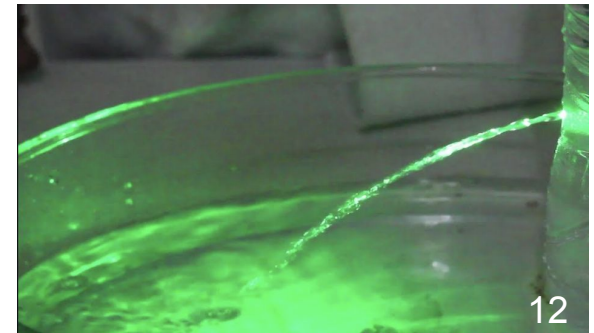
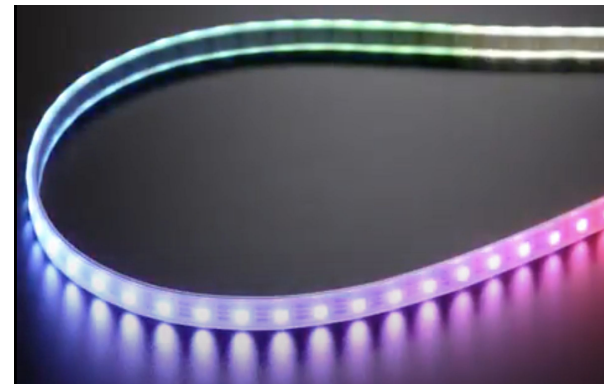
DYE



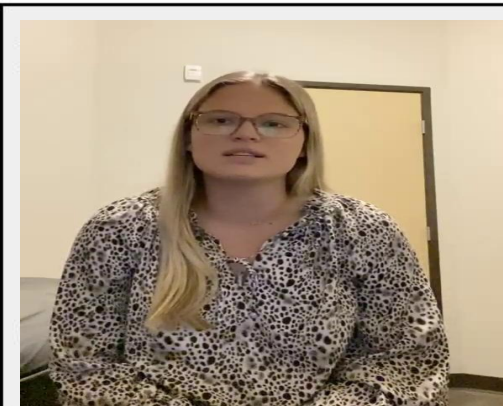
Effectiveness (35) (Competency)	5/5	35	3/5	21	2/5	14
Ease of Use (30)	5/5	30	4/5	24	1/5	6
Ease of Fabrication (15)	4/5	12	3/5	9	2/5	6
Viability (10)	4/5	8	4/5	8	2/5	4
Safety (5)	3/5	3	4/5	4	4/5	4
Cost (5)	4/5	4	3/5	3	2/5	2
Total (100)		92		69		36

LED Flow Models

1. Original - individual LED-lined model
 - Lack of flow representation
2. Implanted string of LEDs inside tubing
 - Synchronous activity
 - Refraction of light for flow representation
3. LEDs submerged in water
 - Flow representation



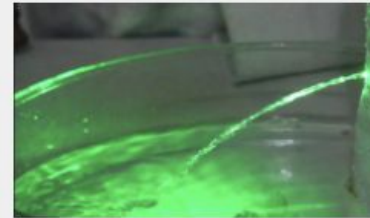
LED Mechanism Design Matrix



Diffused LEDs



LEDs + Water



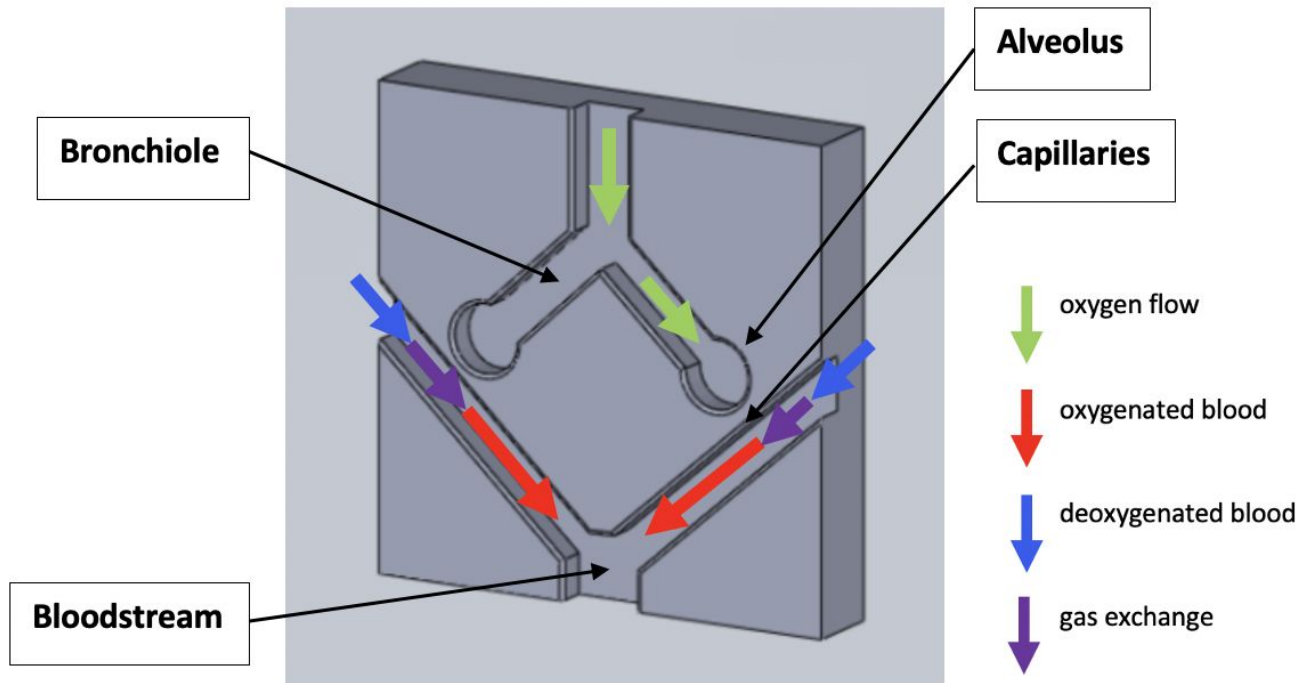
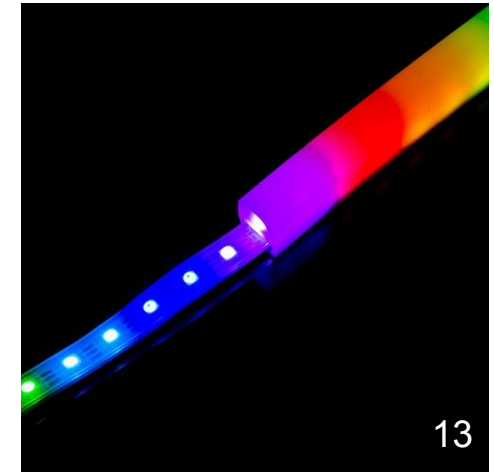
Original LEDs



	Diffused LEDs		LEDs + Water		Original LEDs	
Effectiveness (35) (Competency)	5/5	35	5/5	35	3/5	21
Ease of Use (30)	5/5	30	4/5	25	5/5	30
Ease of Fabrication (15)	4/5	12	3/5	9	3/5	9
Viability (10)	4/5	8	4/5	8	4/5	8
Safety (5)	3/5	3	4/5	4	4/5	4
Cost (5)	4/5	4	3/5	3	2/5	2
Total (100)	92		84		74	

Future Work

- Confirm final design with the client
- Determine materials to begin ordering
- Fabrication plan
 - 3D printing
 - Electronics
 - Code



Acknowledgements

We would like to thank...

Our advisor: Dr. Amit Nimunkar

Our client: Dr. Chris Green

The BME faculty and staff!



References

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