Teaching Model for Ventilation and Perfusion Mismatching

Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi
Client: Dr. Christopher Green
Advisor: Dr. Amit Nimunkar

Abstract

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Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.

Design Criteria

- Model ventilation and perfusion mismatching
- Includes an interactive component to display five important V/Q ratios
  - Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage
  - Service life of 5 years

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- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
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Total Cost: $74.24

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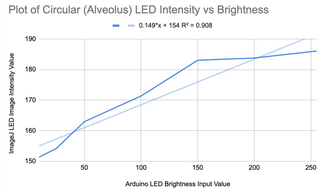

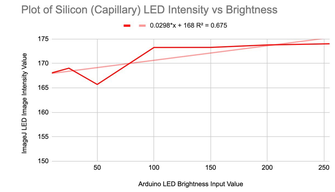

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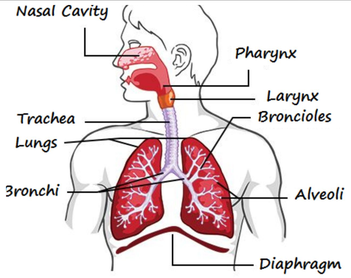

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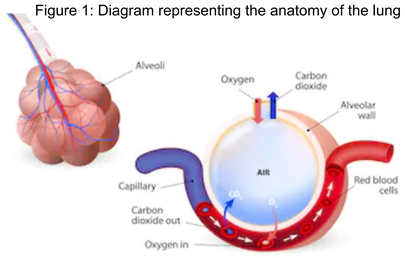

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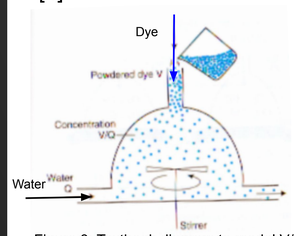

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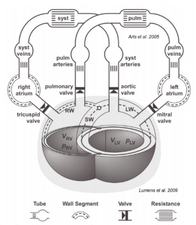

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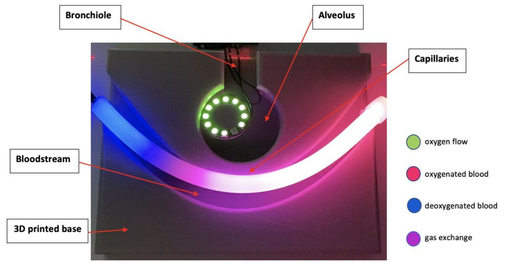

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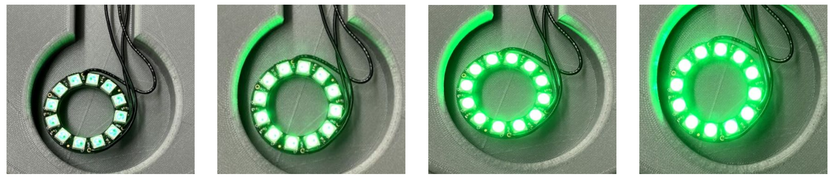

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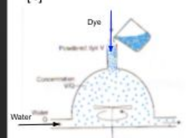

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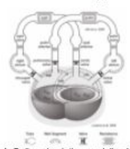

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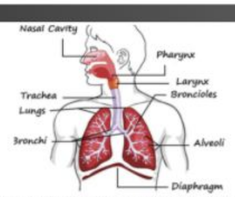

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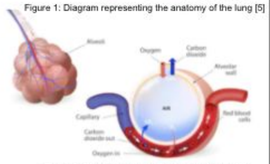

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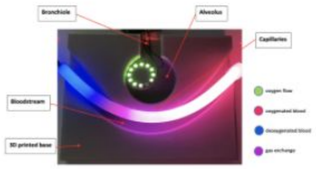

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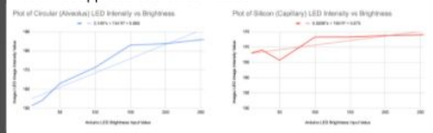

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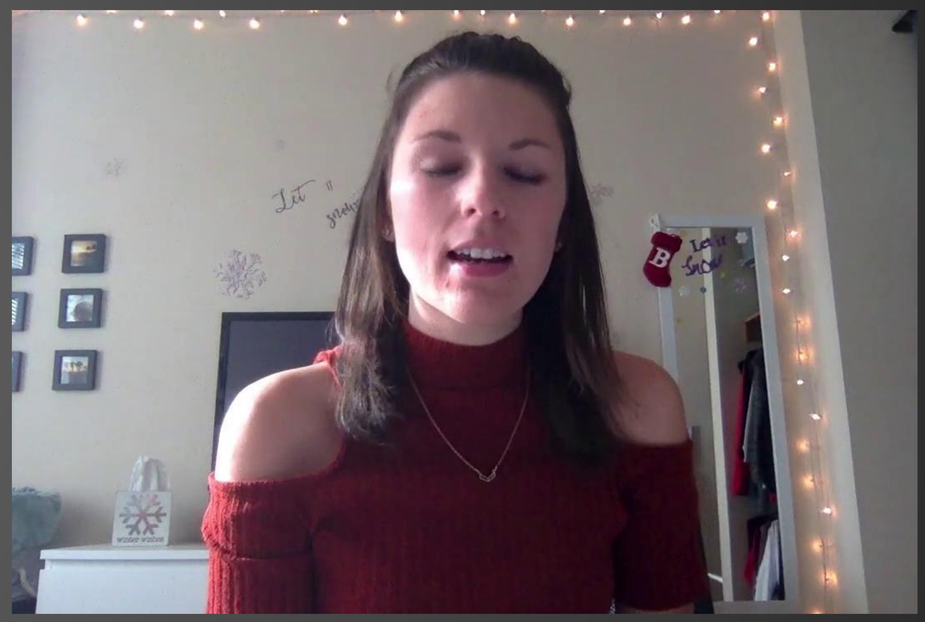

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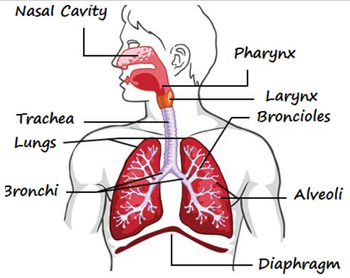

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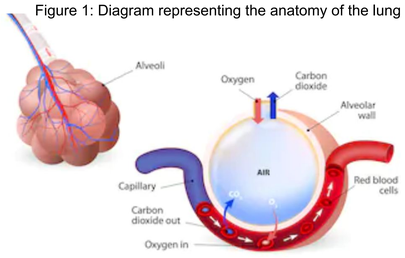

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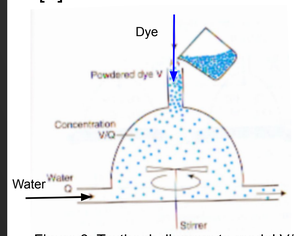

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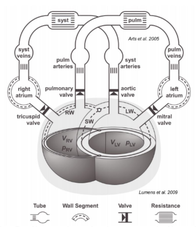

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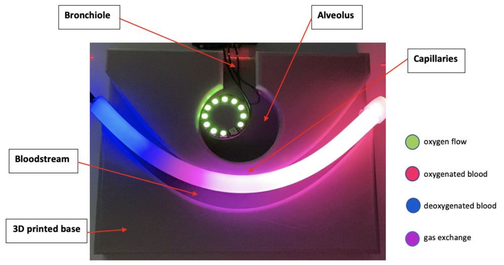

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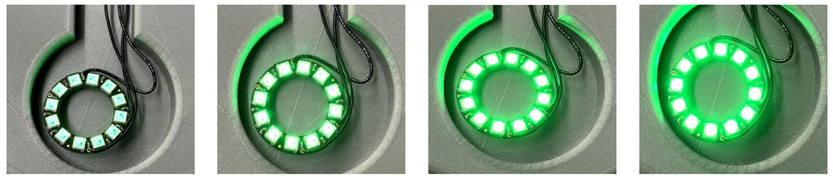

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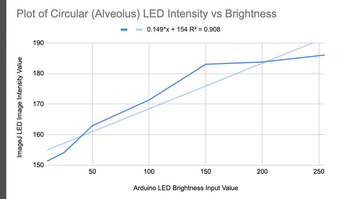

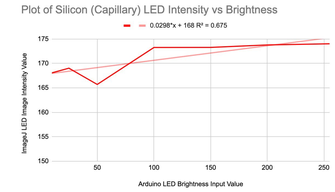

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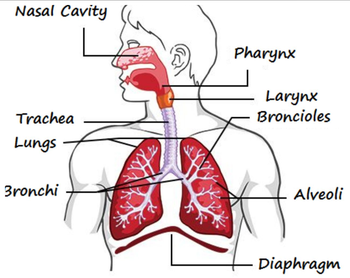

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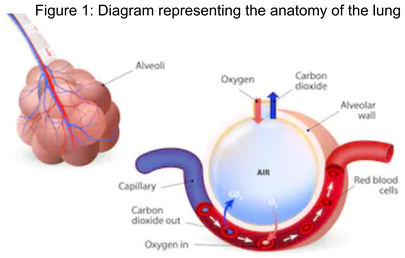

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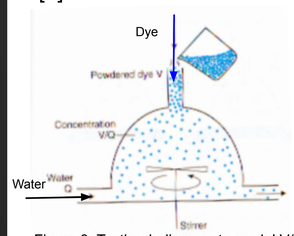

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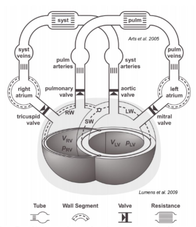

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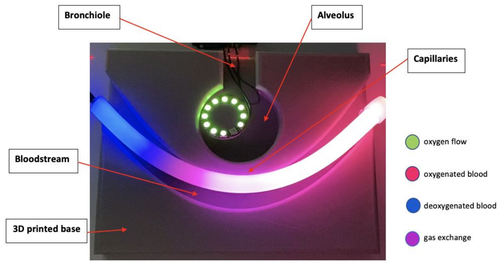

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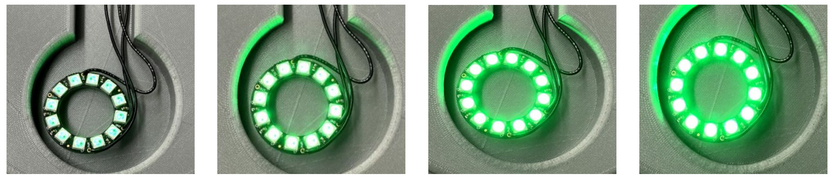

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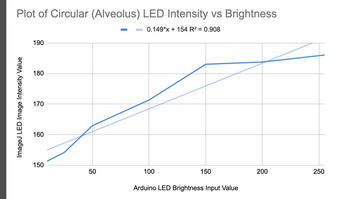

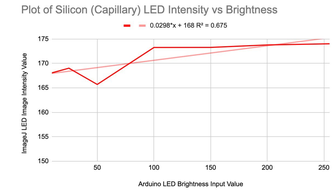

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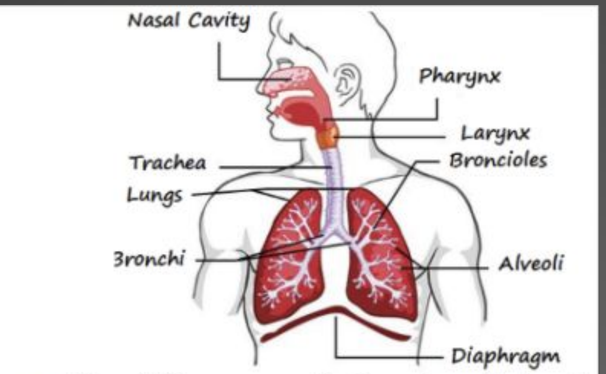

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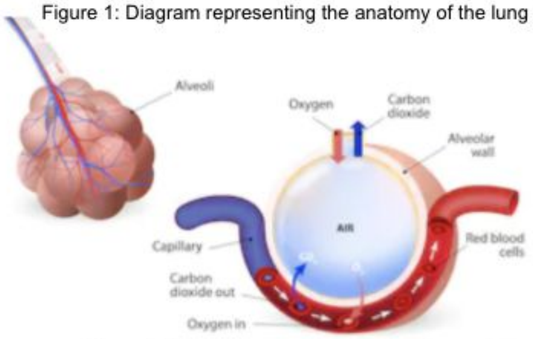

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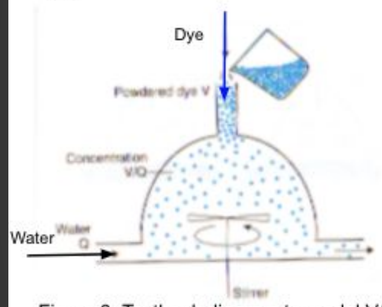

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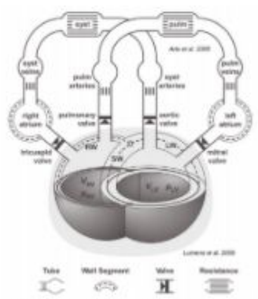

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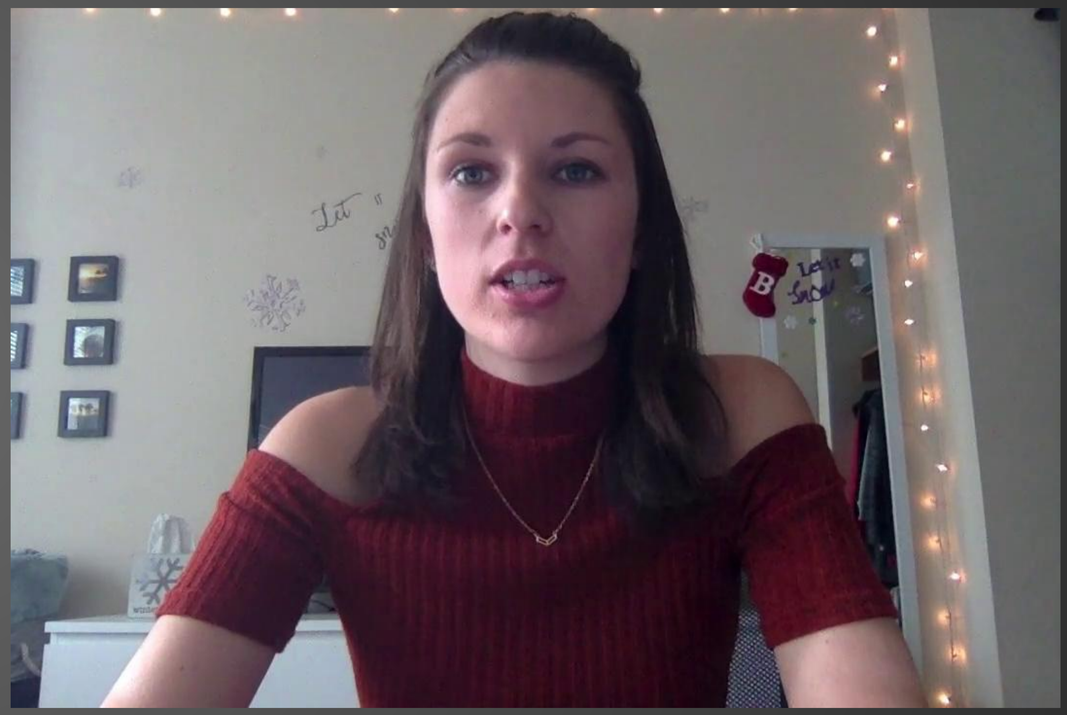

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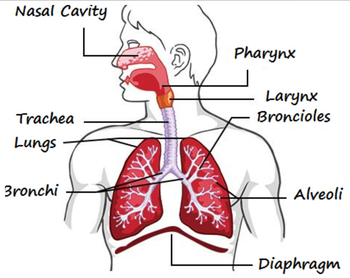

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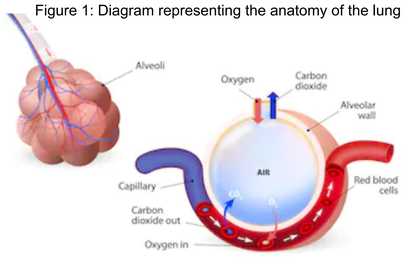

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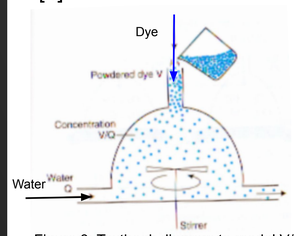

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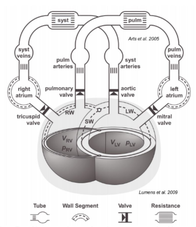

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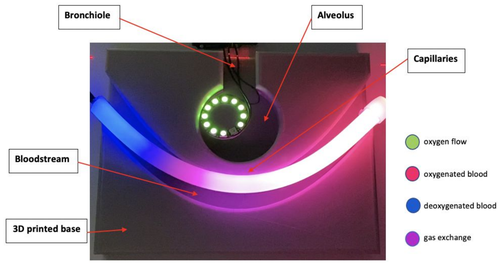

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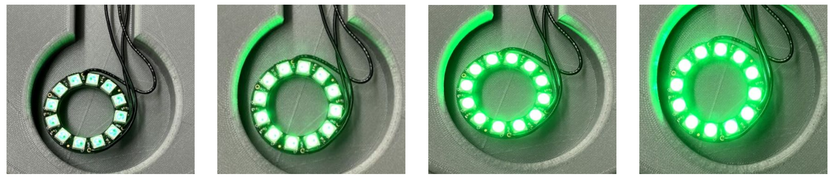

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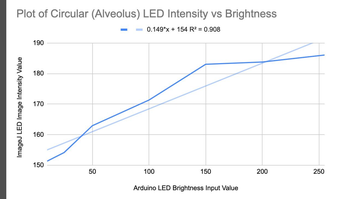

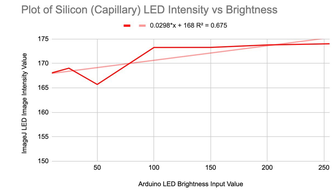

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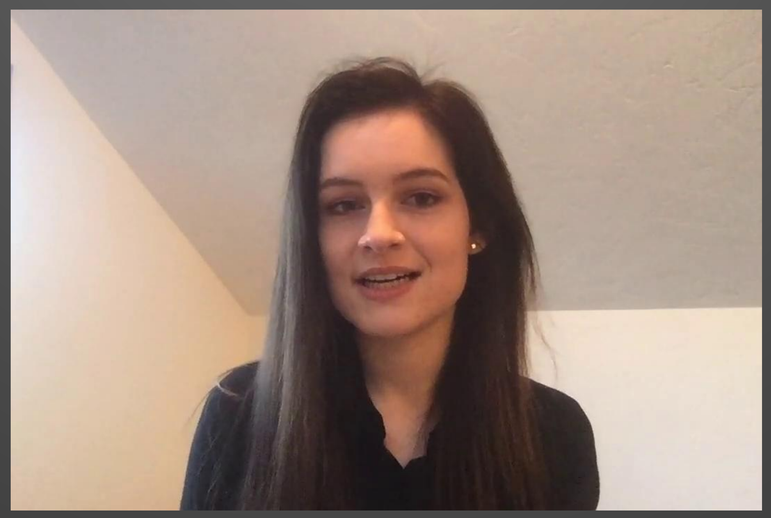

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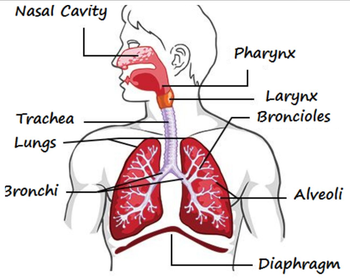

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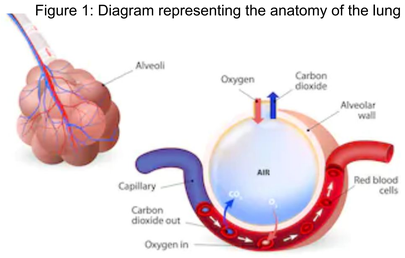

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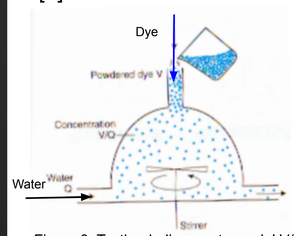

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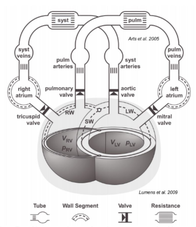

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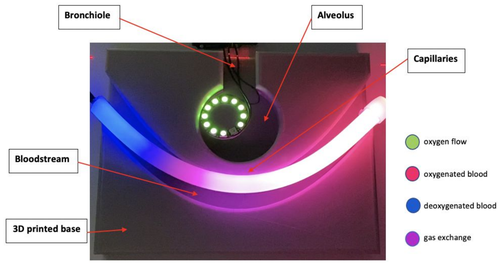

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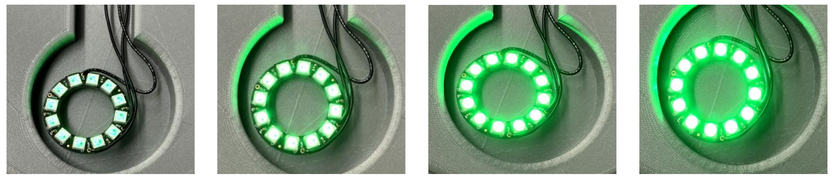

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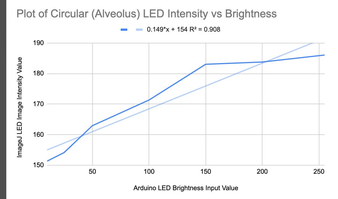

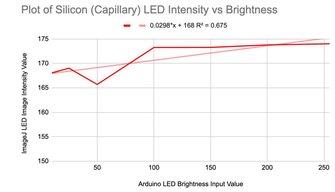

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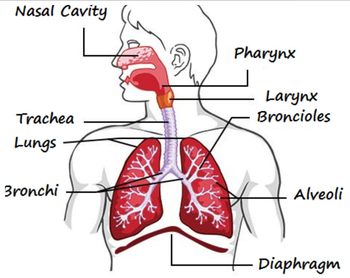

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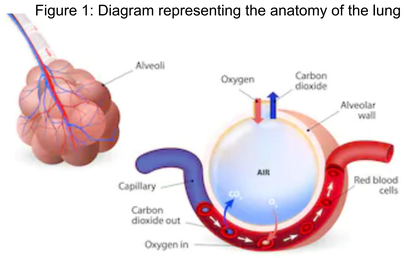

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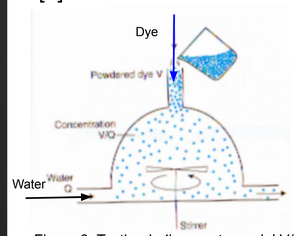

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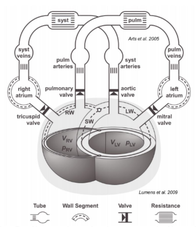

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- Model ventilation and perfusion mismatching
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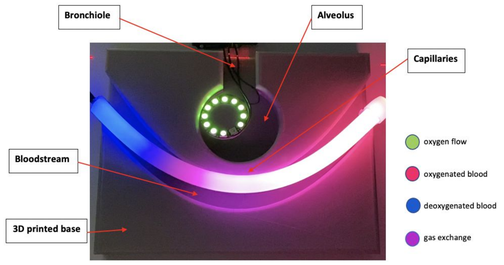

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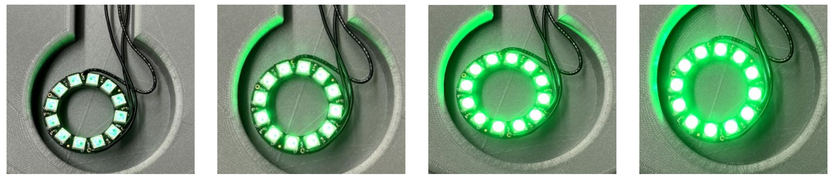

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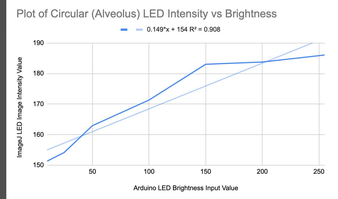

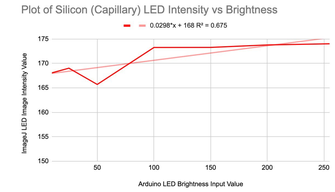

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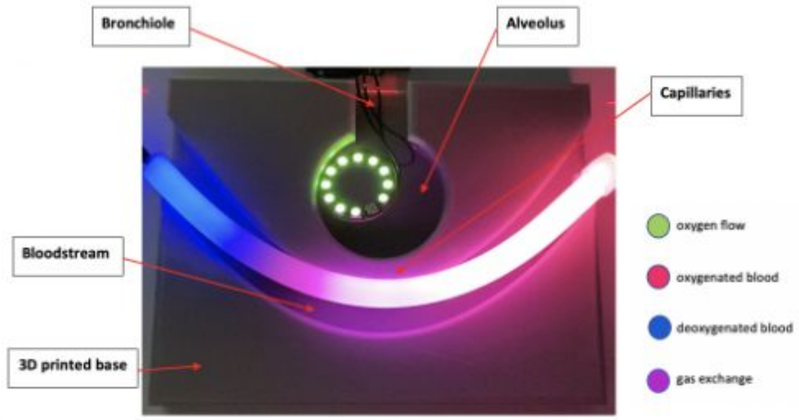

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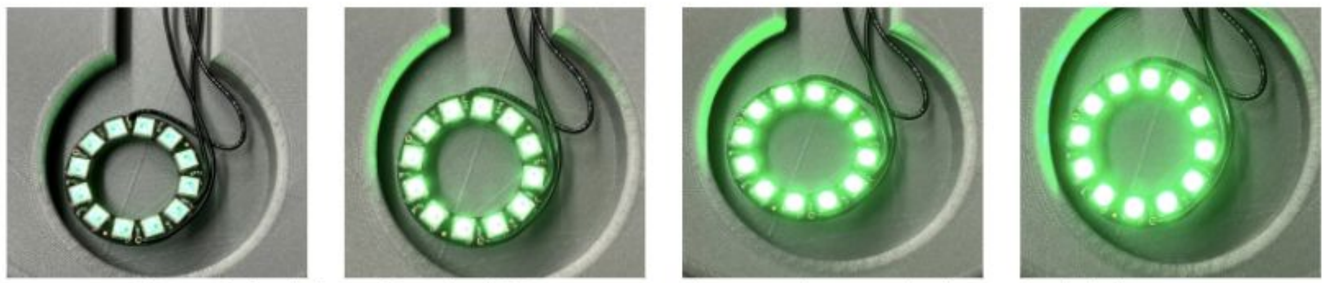

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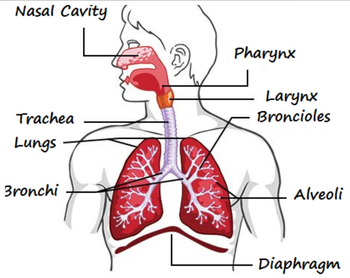

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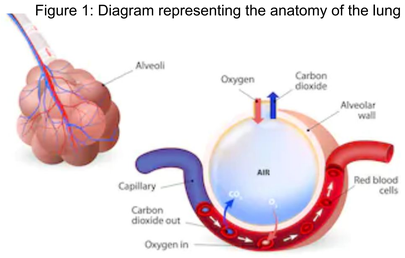

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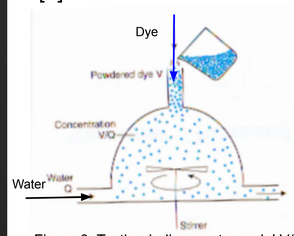

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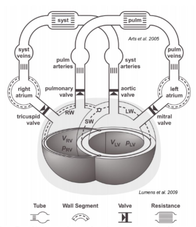

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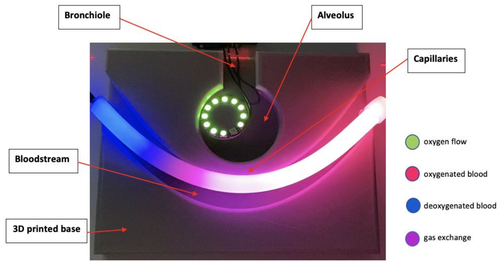

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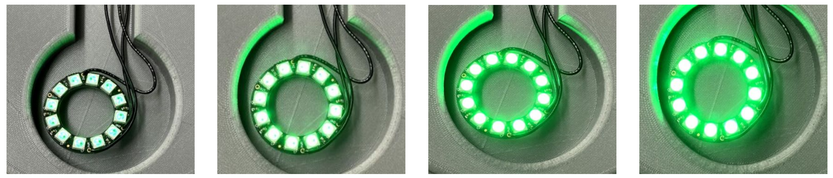

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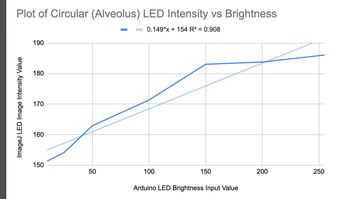

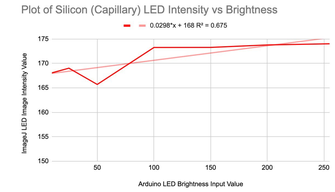

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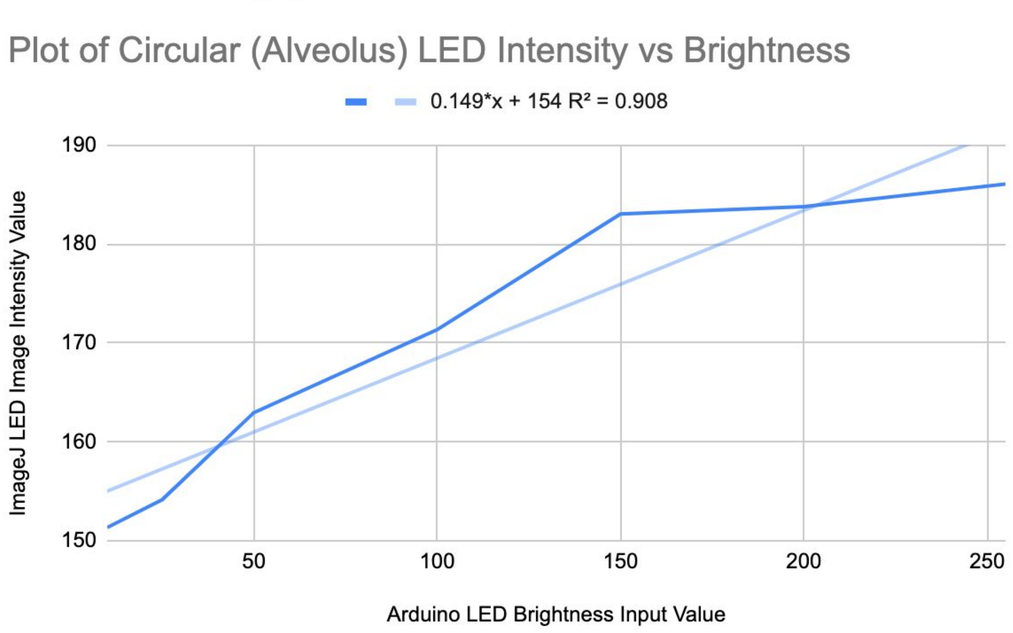

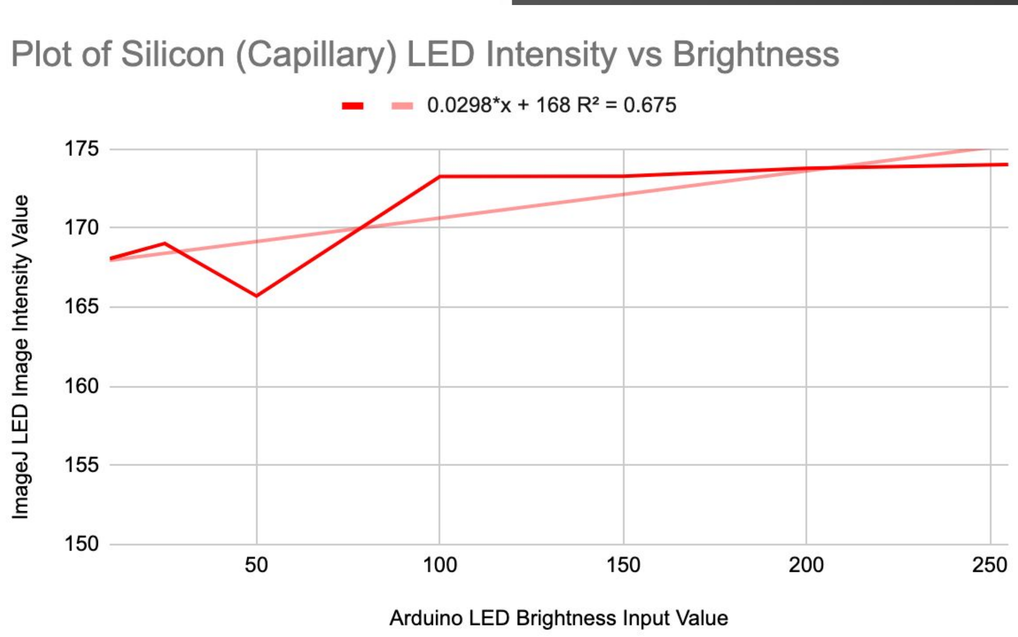

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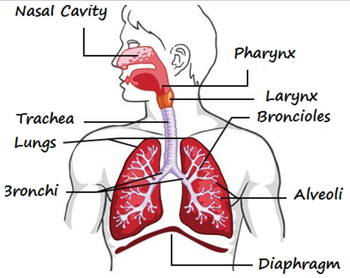

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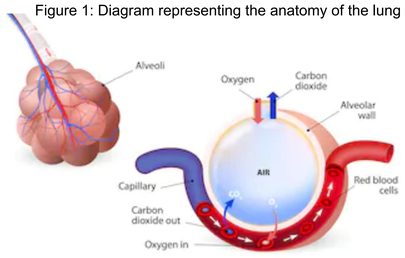

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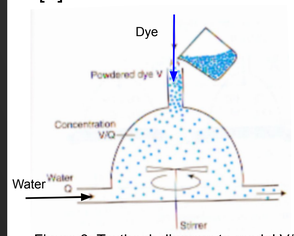

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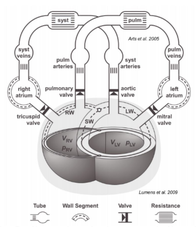

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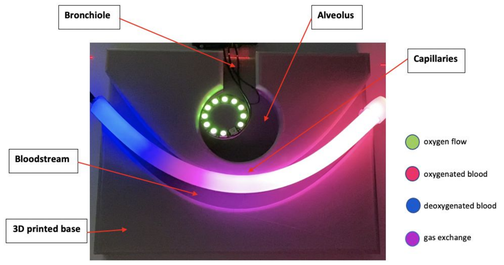

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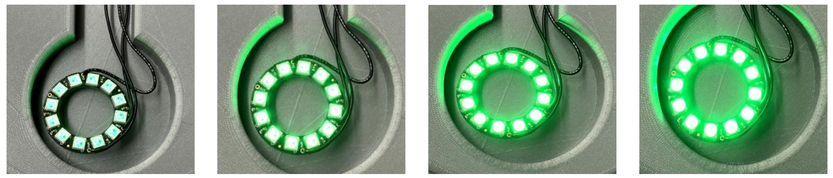

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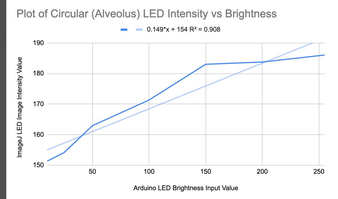

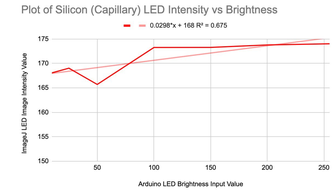

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  - In the form of buttons or dial
- Remodel the circuit
- Edit and reprint the base design with space for integrated microcontroller
- Continue testing the final design
  - Test ability to model V/P mismatching to a population

Teaching Model for Ventilation and Perfusion Mismatching

Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi
Client: Dr. Christopher Green
Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.

Background

- Gas exchange occurs in the alveoli with ventilation (V) into the alveoli and perfusion (Q) into the bloodstream [1]
  - High V/Q: dead space [2]
  - Low V/Q: shunt
- Common diseases can cause mismatching [3]
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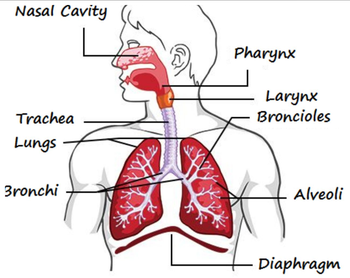

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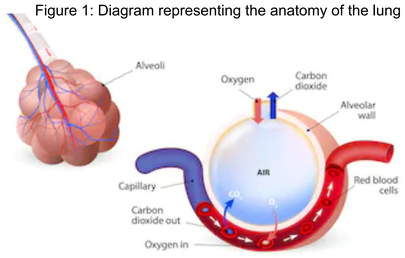

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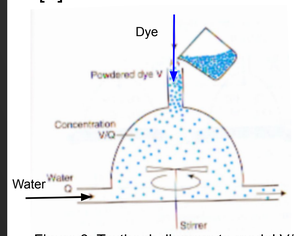

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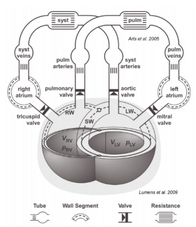

Figure 4: Online simulation modeling V/Q ratios [8]

- Water Model
  - Powered Dye (ventilation)
  - Water (blood flow)
  - Concentration (V/Q)

- Circ-Adapt
  - Computational (online) model of heart and circulation
  - Adjustable parameters
  - Focused on cardiac disease

Design Criteria

- Model ventilation and perfusion mismatching
- Includes an interactive component to display five important V/Q ratios
  - Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage
  - Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Total Cost: $74.24

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.

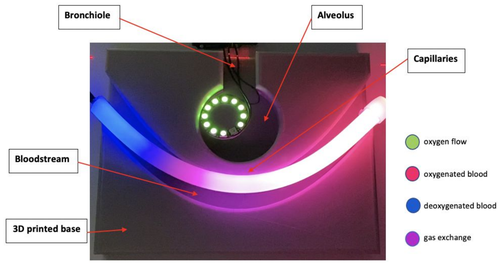

Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- Ring LED: Inserted into the alveolus to represent oxygen present using the color green and different blinking rates
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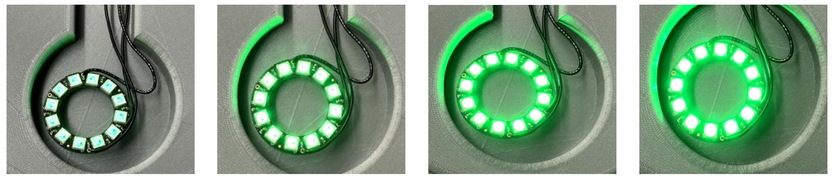

Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

Testing / Results

Testing

- 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255
- Took photos of the LEDs projected onto the screen
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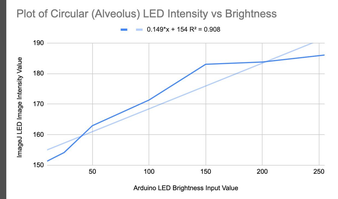

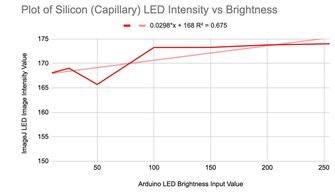

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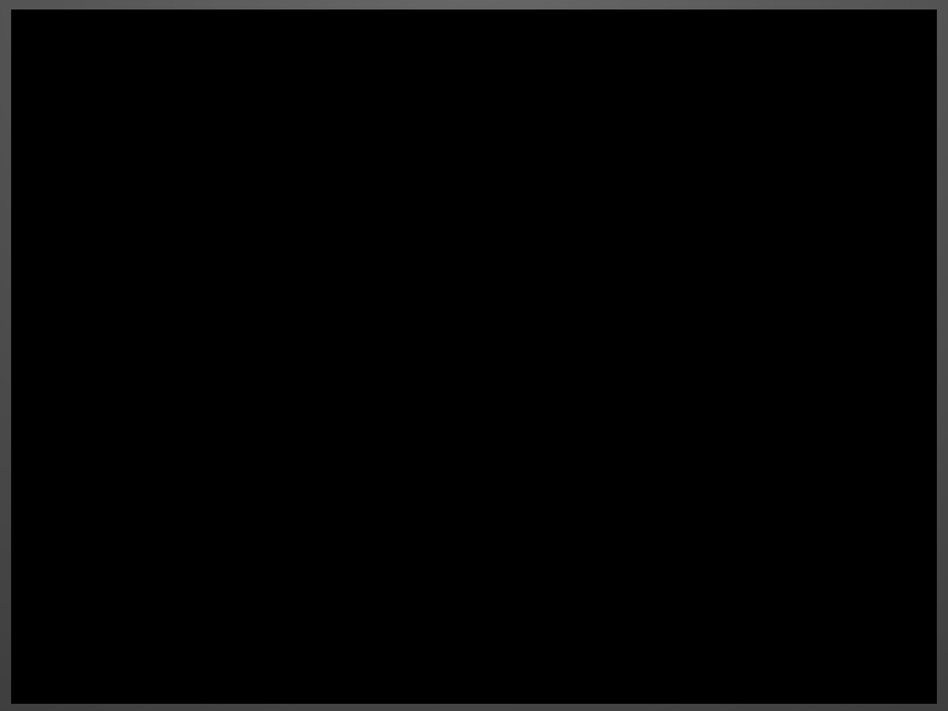

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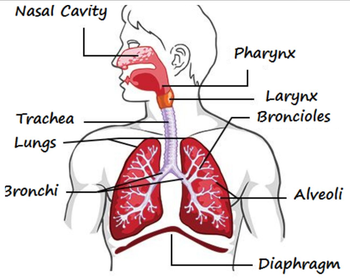

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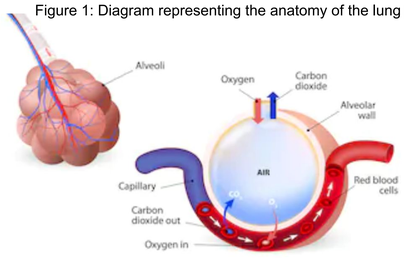

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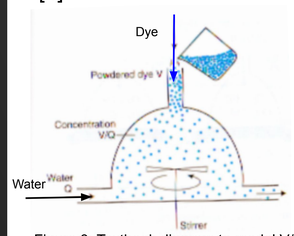

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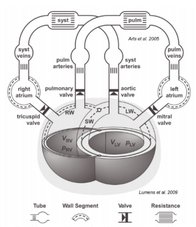

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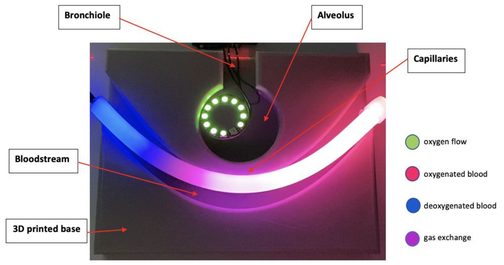

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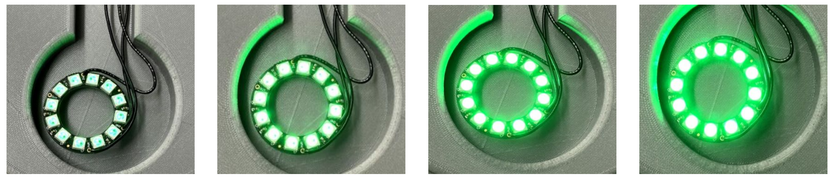

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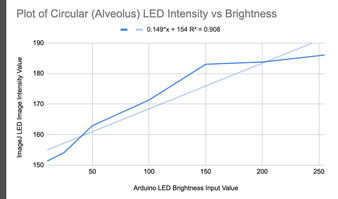

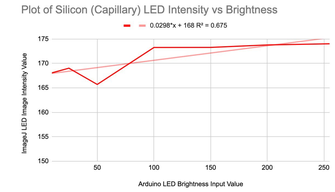

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