

Bangladesh University of Engineering and Technology

Department of Biomedical Engineering

Course No- BME 205

MECHANICAL VENTILATOR

Presented By:

Group – 4

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MECHANICAL VENTILATOR

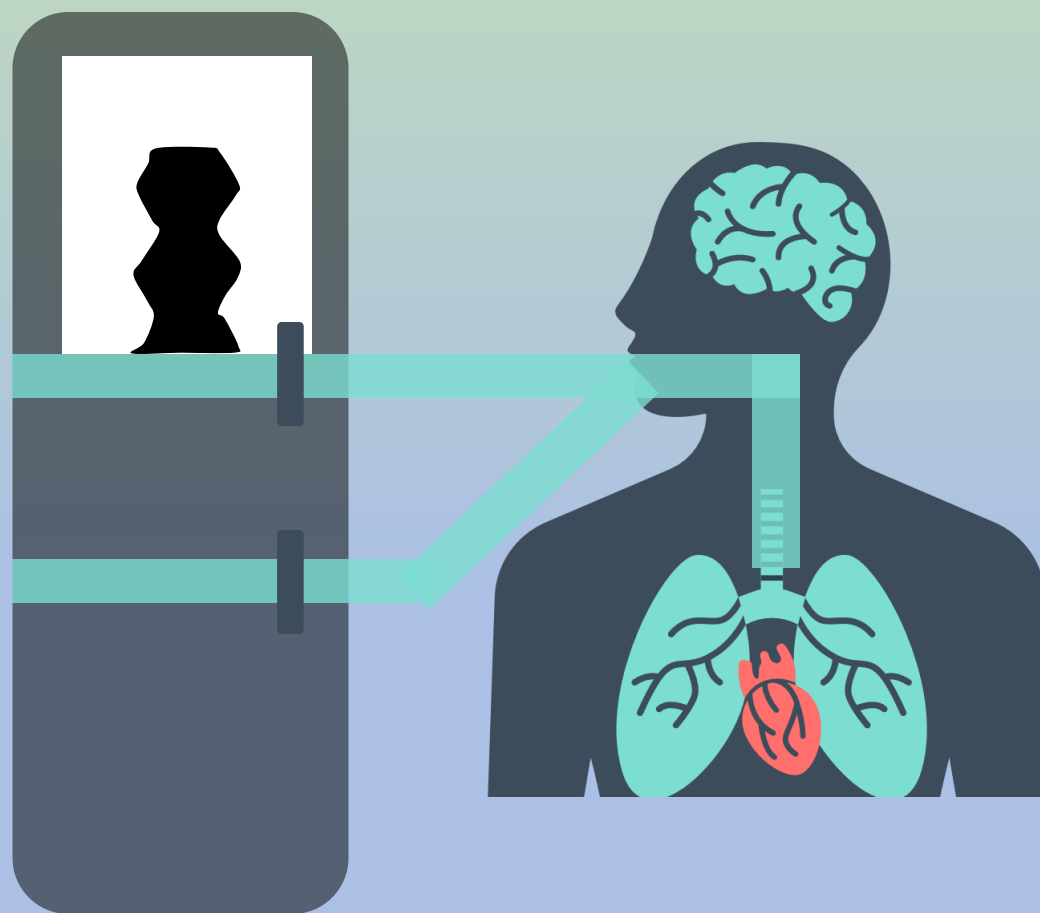
Overview:

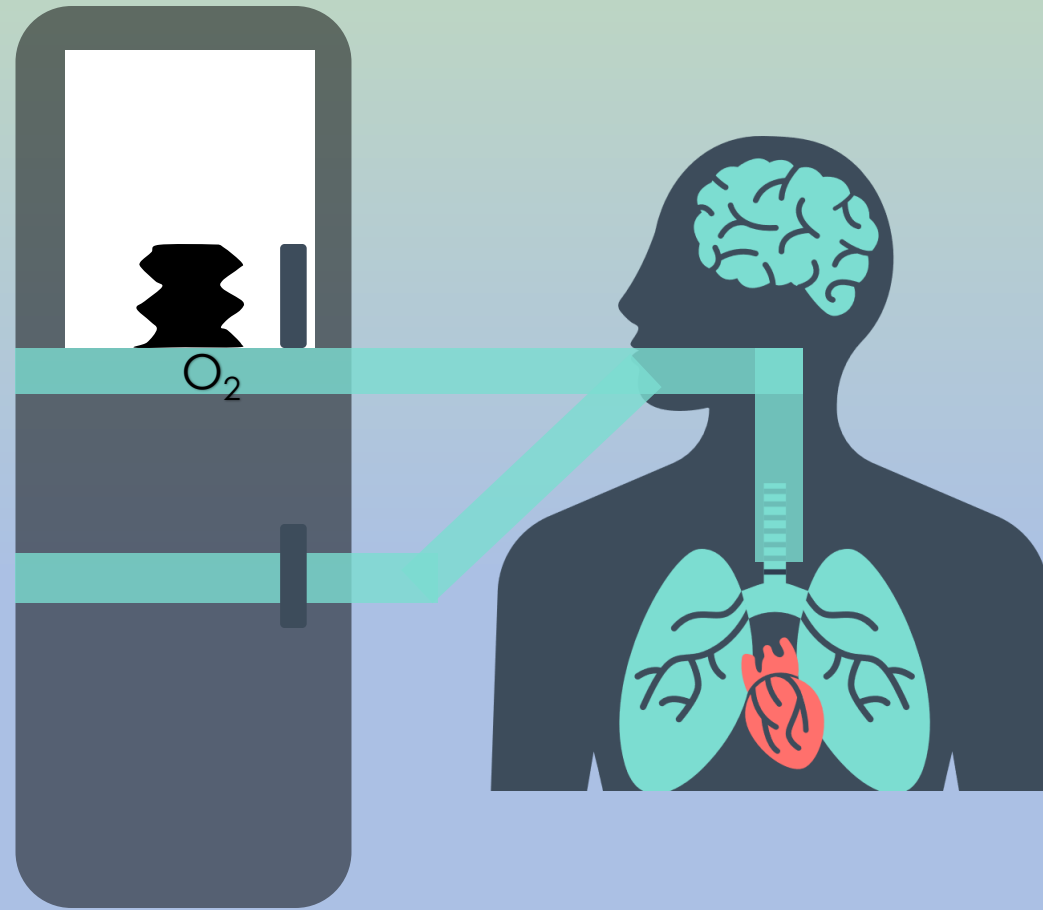
1. Definition
2. Physiology
3. Usage
4. Components
5. Mechanism
6. Applications of fluid mechanics
6. Problems and Solution
7. Q&A

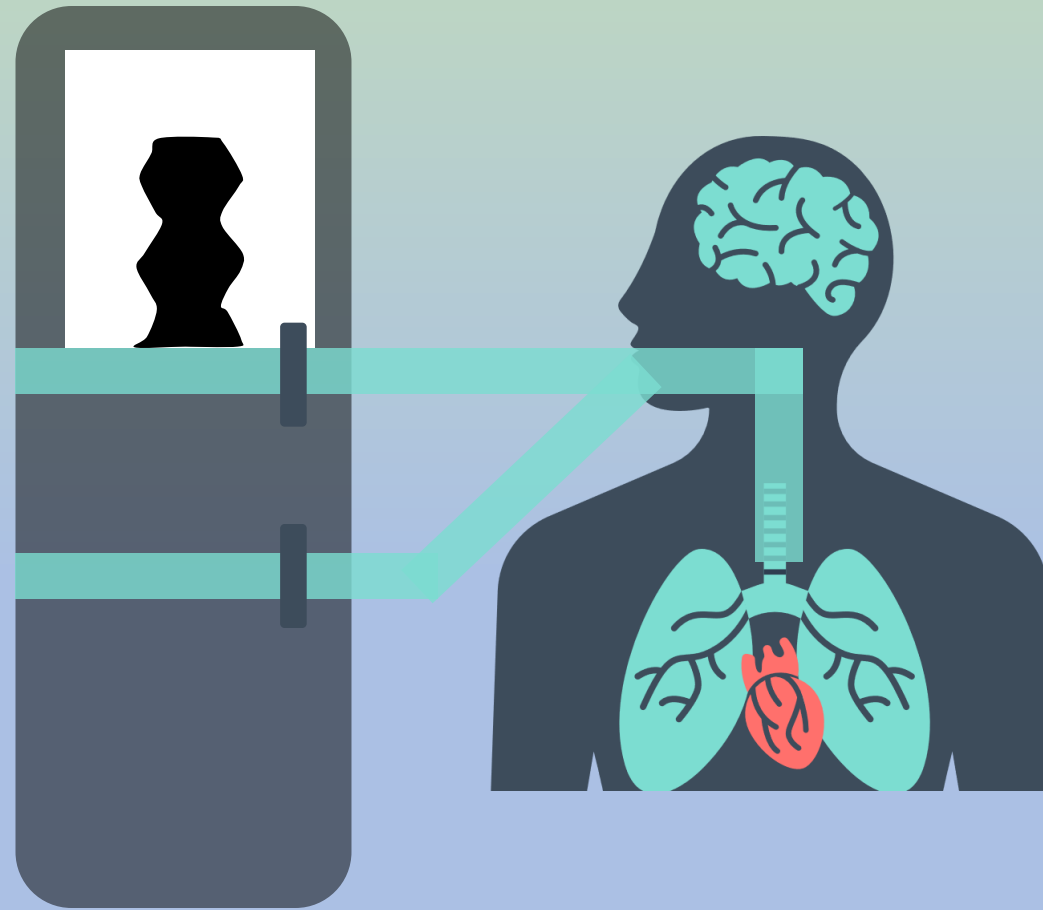
What is a ventilator

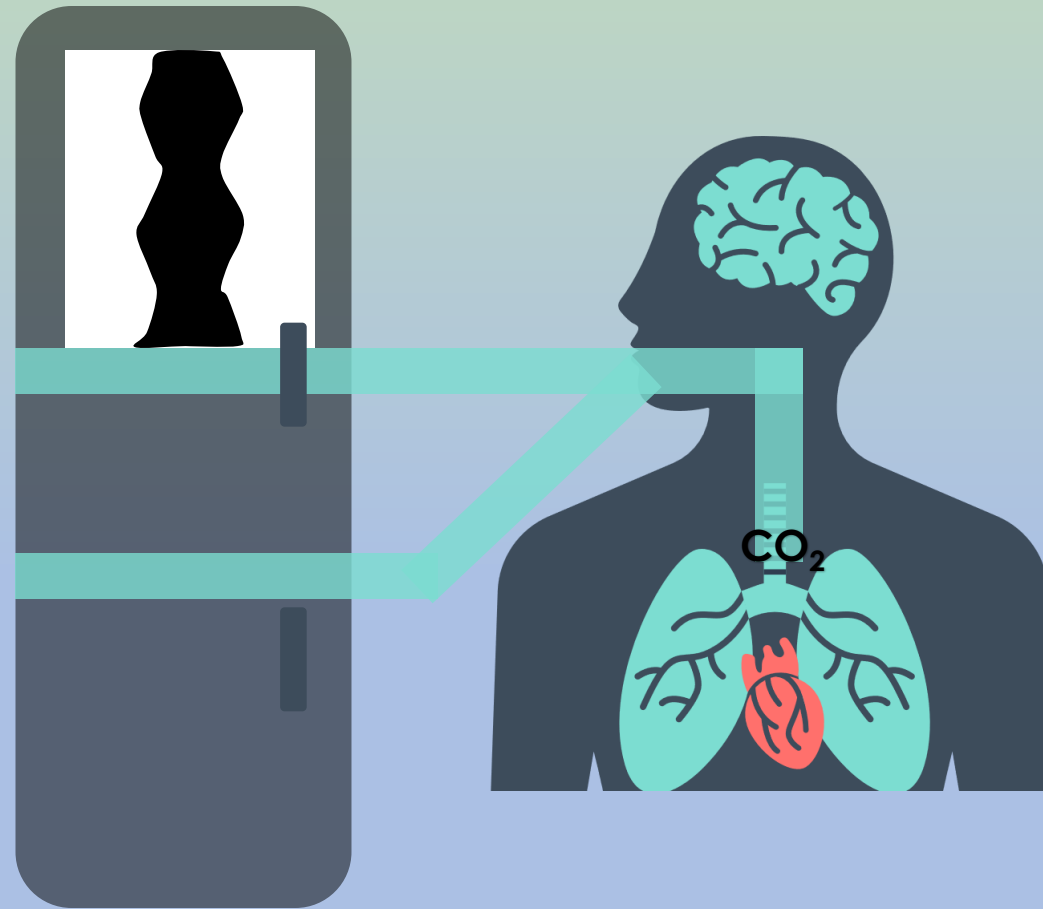


- ❑ Machine that helps people breathe when they can't breathe on their own
- ❑ Helps to move oxygen into the lung and CO₂ out of the lung by using a pressure.



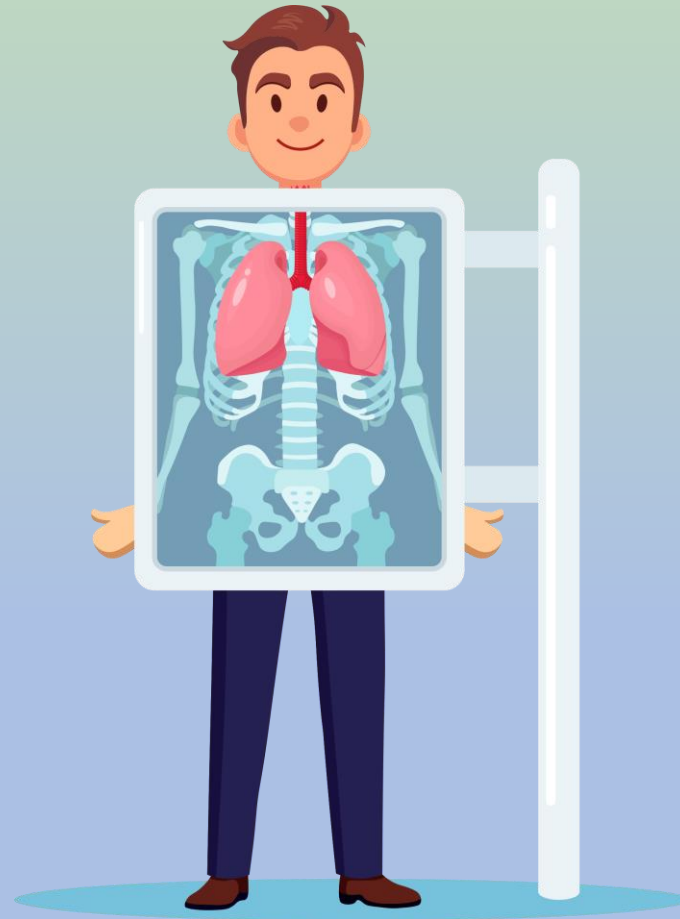


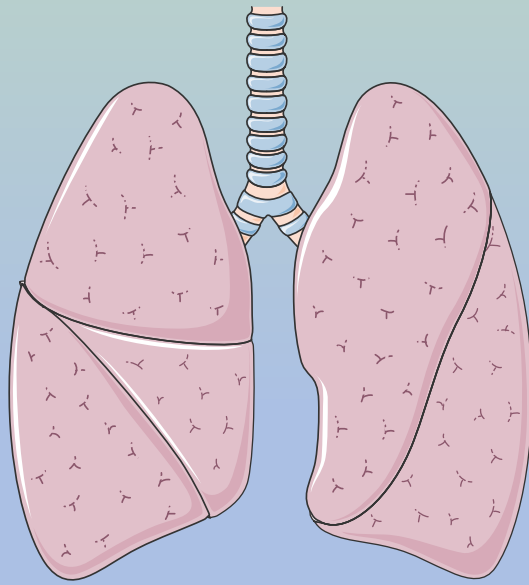




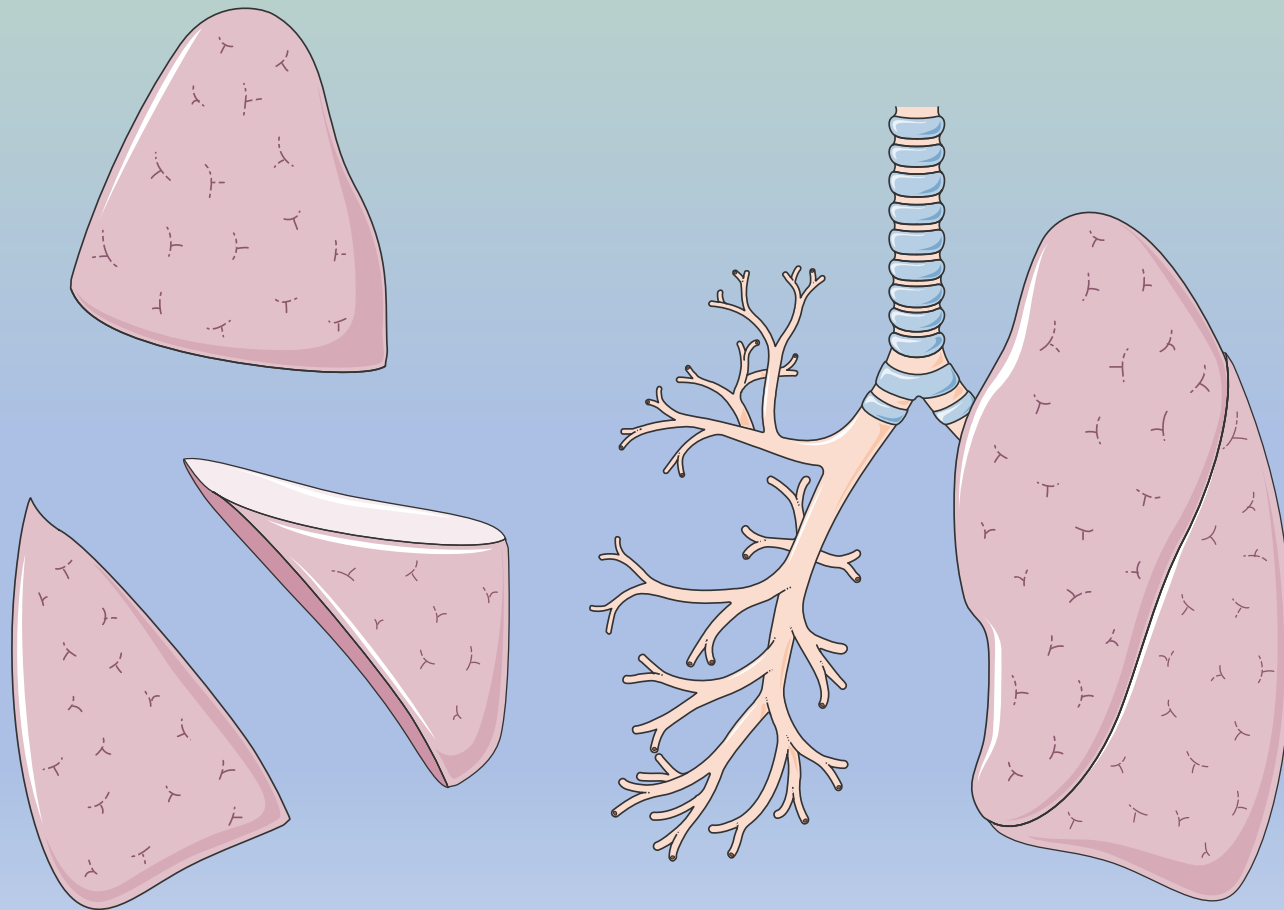
LUNG PHYSIOLOGY

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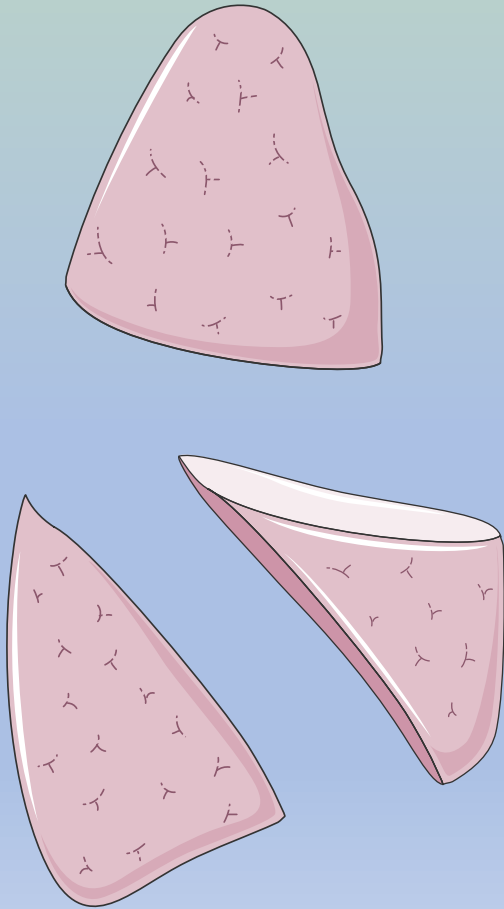




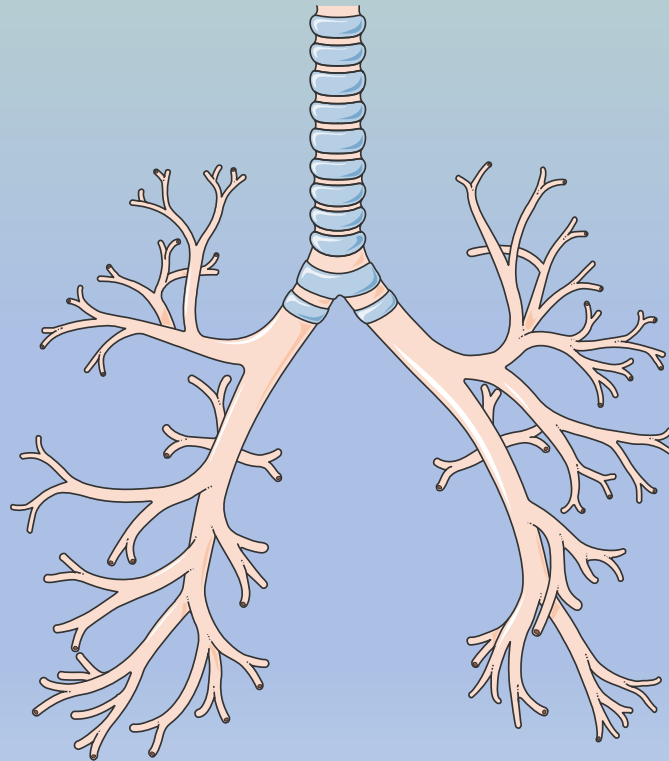
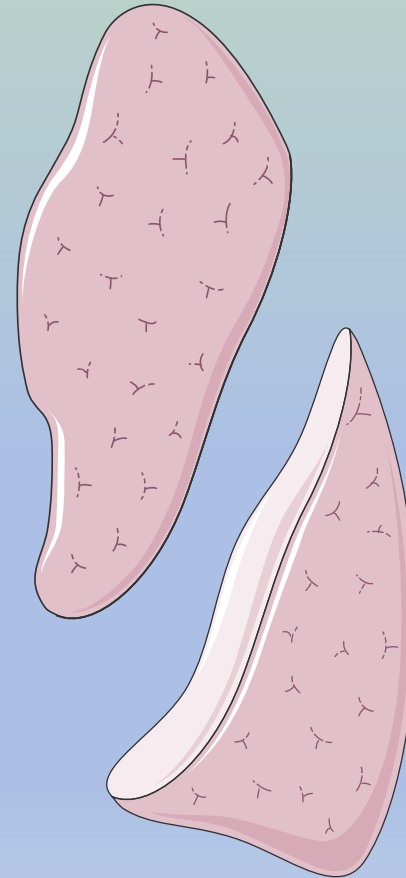
Lung



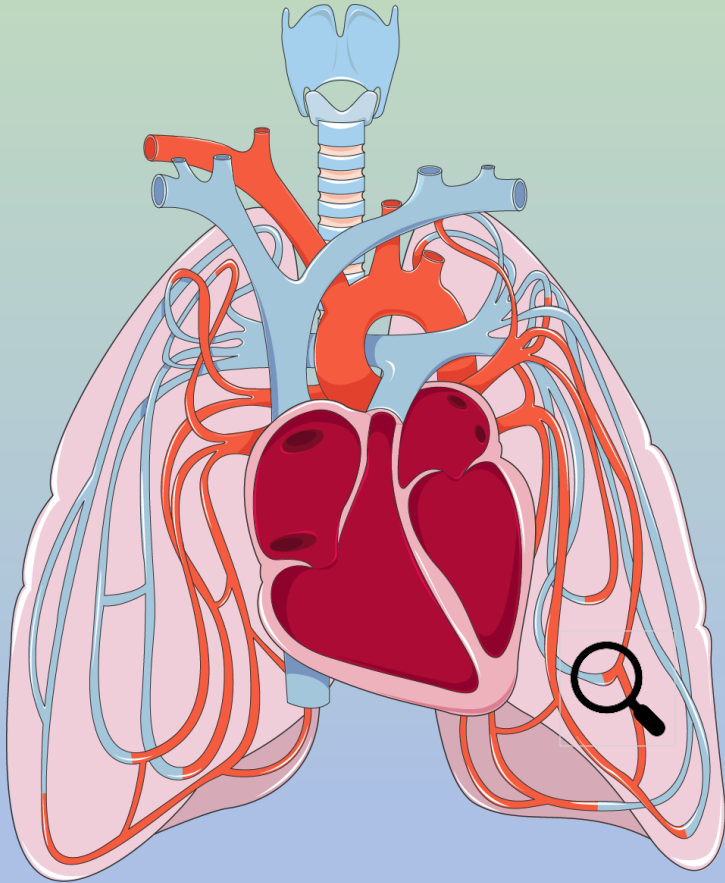
Right Lung (3 lobes)



Left Lung (2 lobes)



Pulmonary Blood Flow

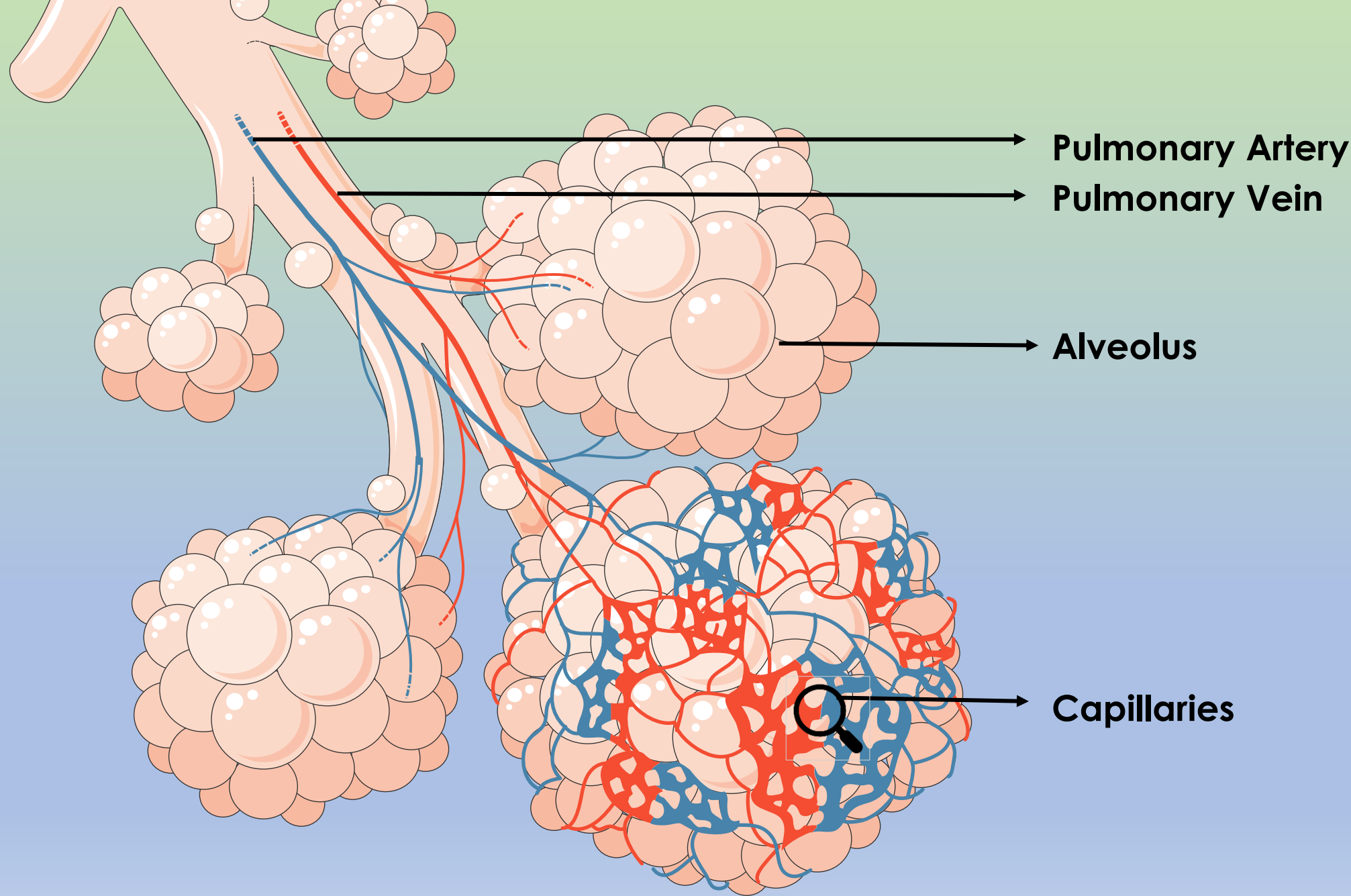


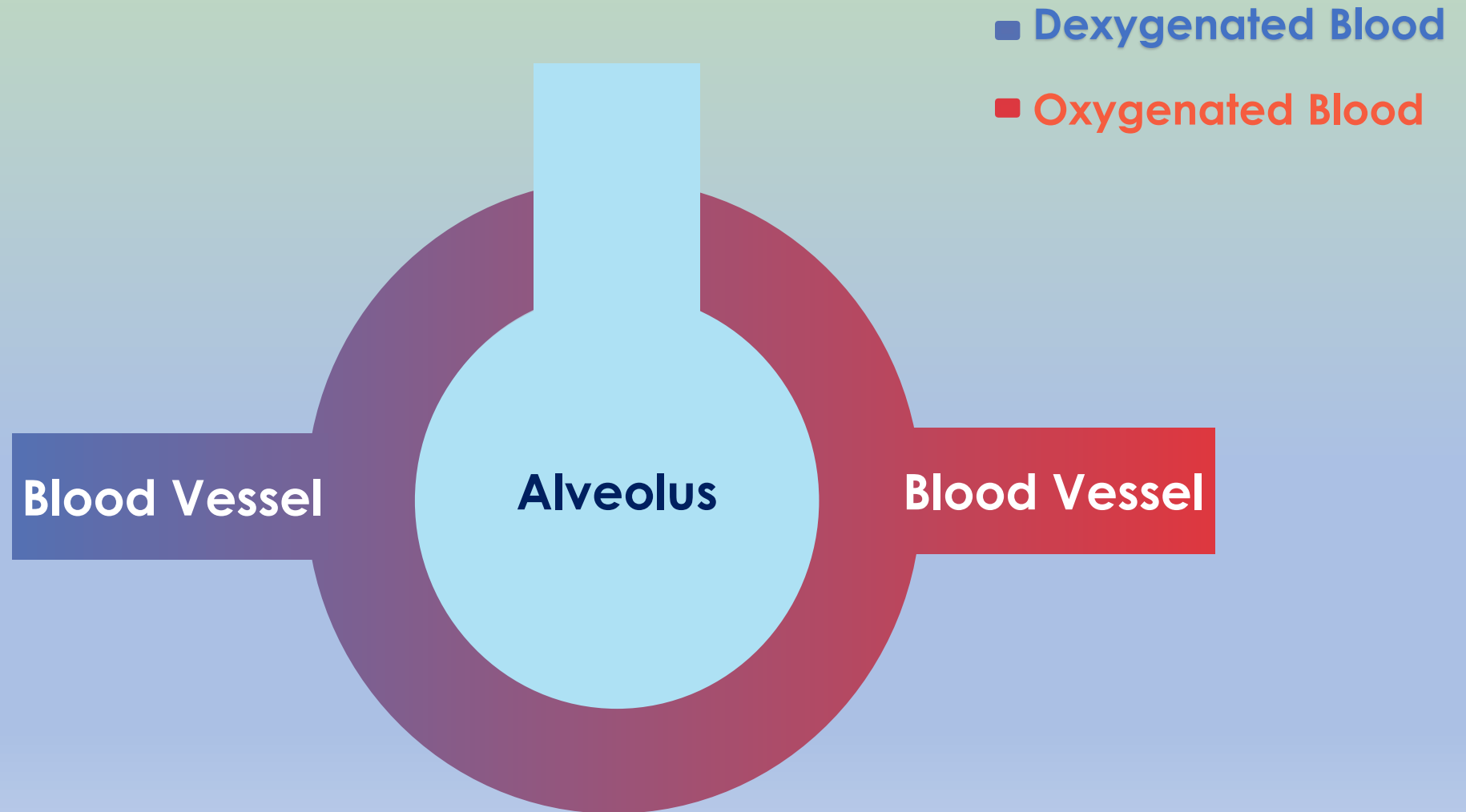
Deoxygenated Blood

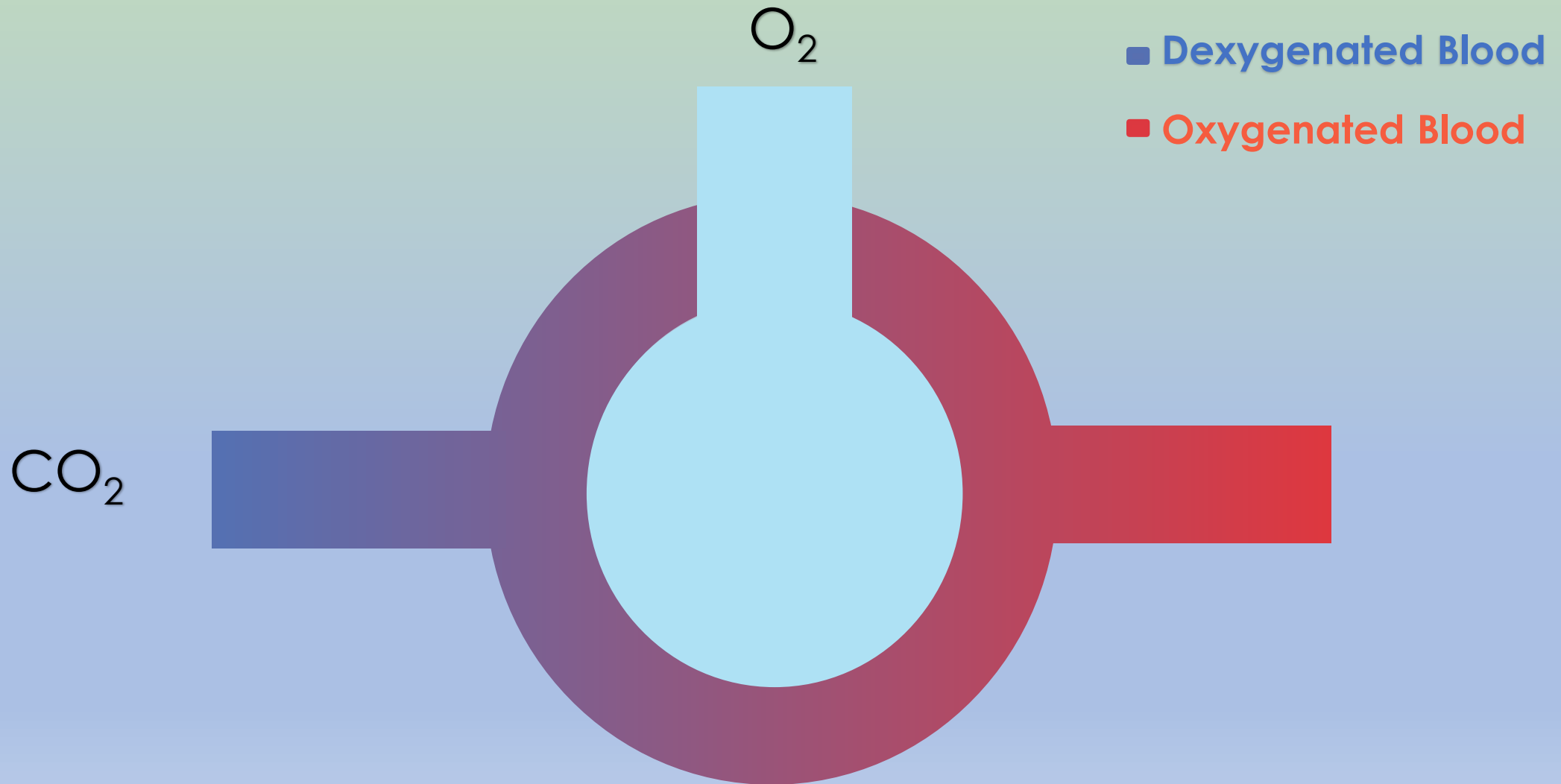
Oxygenated Blood

The respiratory system is fed by two separate blood circulation:

1. The Pulmonary Circulation (Lower P) which supply blood flow to the alveoli for gas exchange.
2. The bronchial Circulation (Higher P) which supply blood flow to the bronchial system

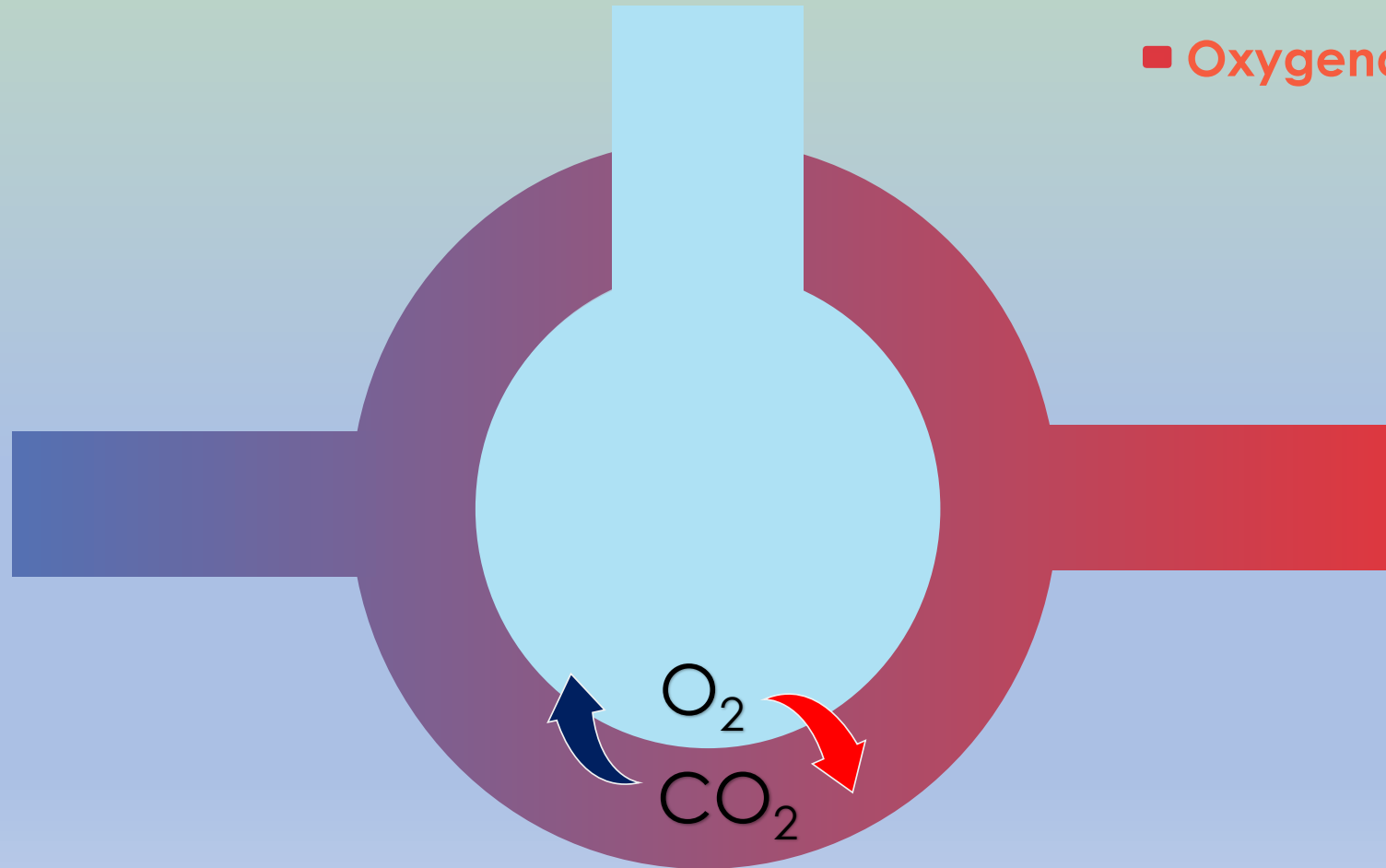






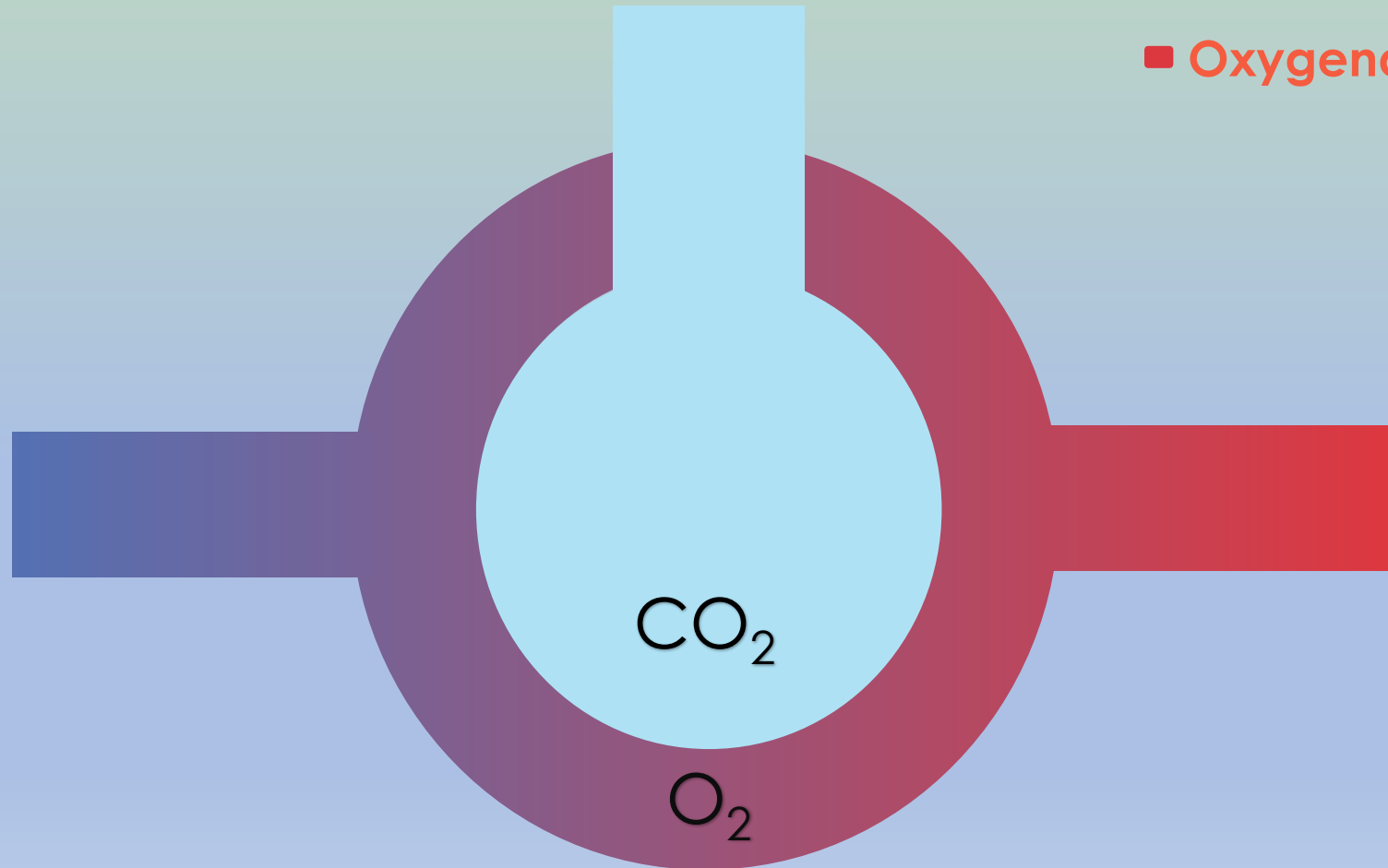
■ Deoxygenated Blood

■ Oxygenated Blood

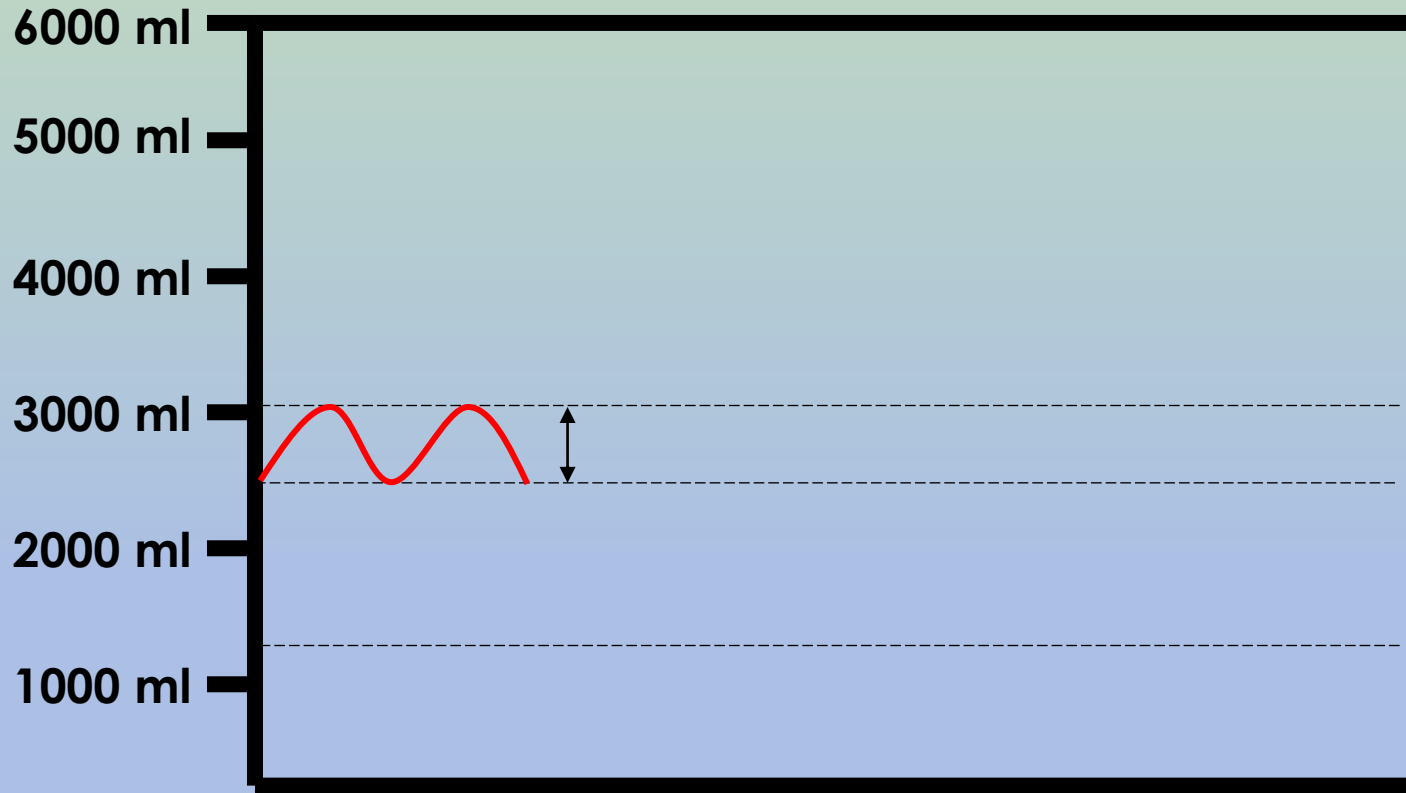


■ Deoxygenated Blood

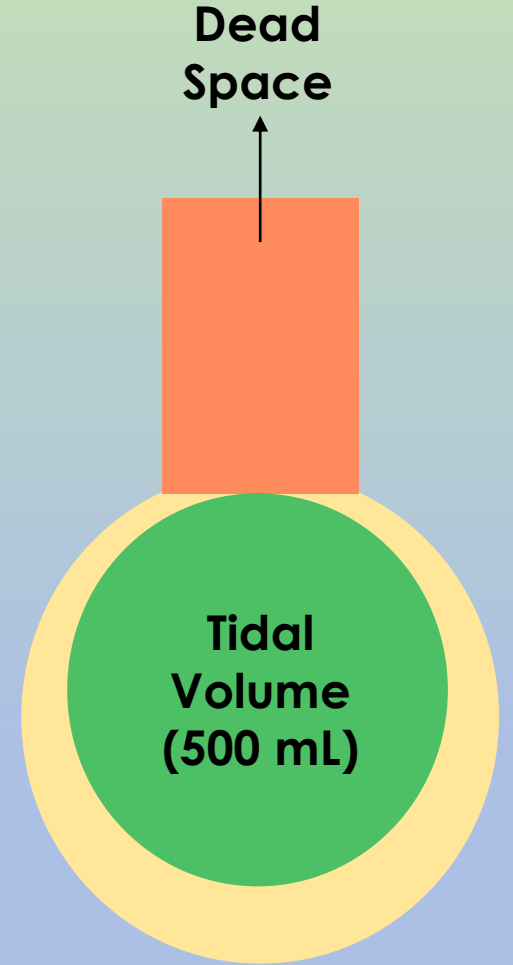
■ Oxygenated Blood



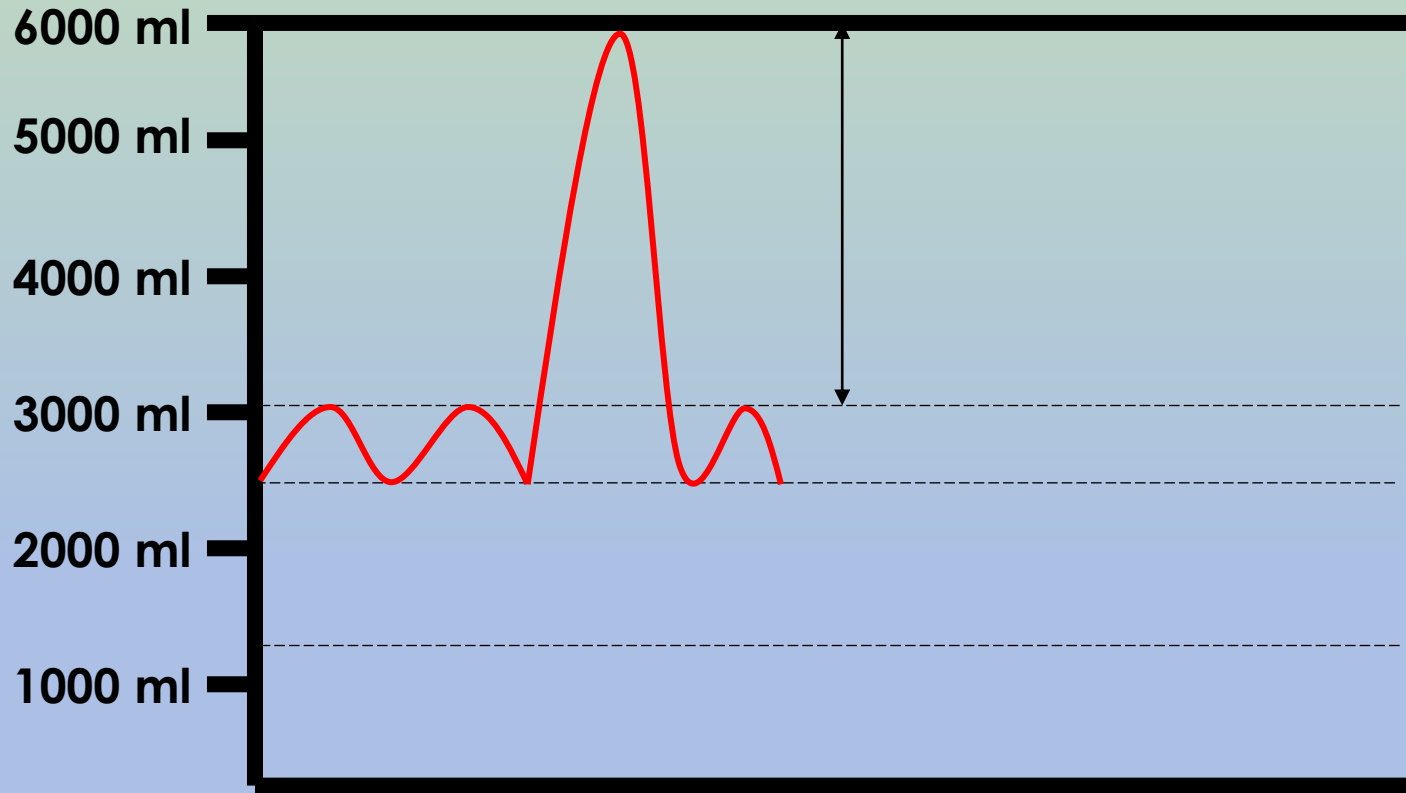
EXPIRATION - LUNG VOLUME - INSPIRATION



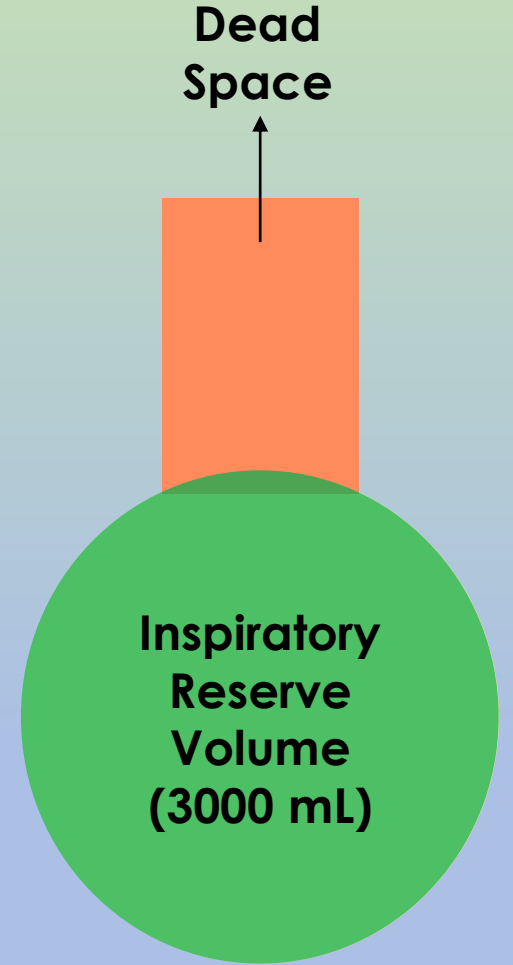
Tidal Volume – The amount of air entering and leaving the lungs during normal breathing



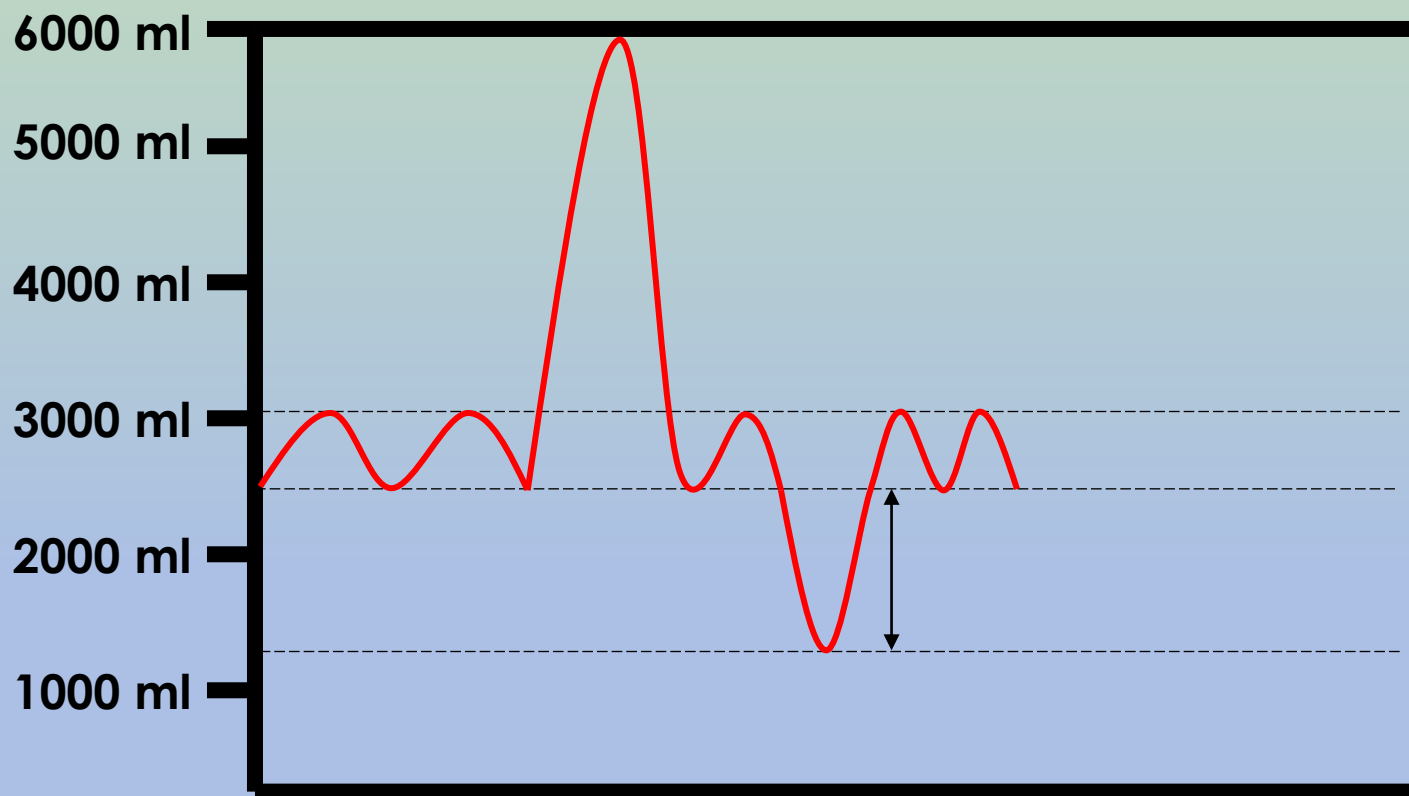
EXPIRATION - LUNG VOLUME - INSPIRATION



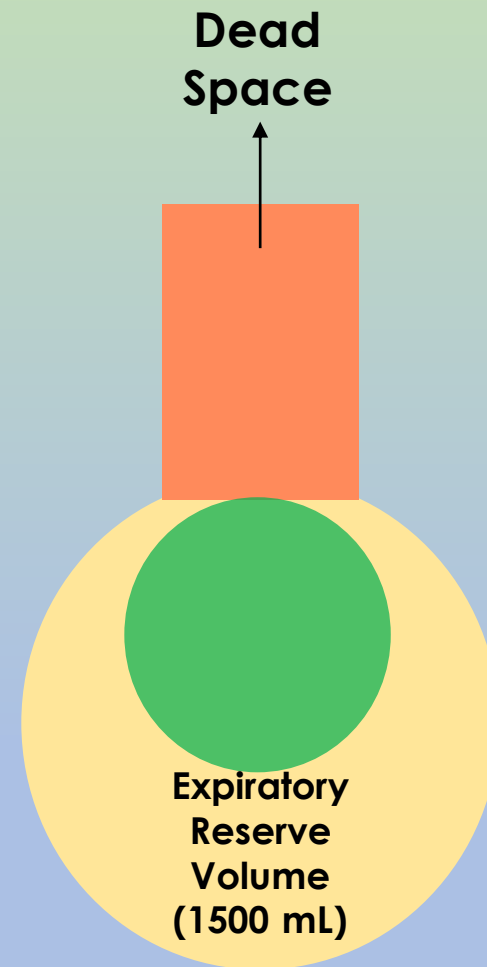
Inspiratory Reserve Volume –Extra volume of air that the patient Can inhale with maximum effort.



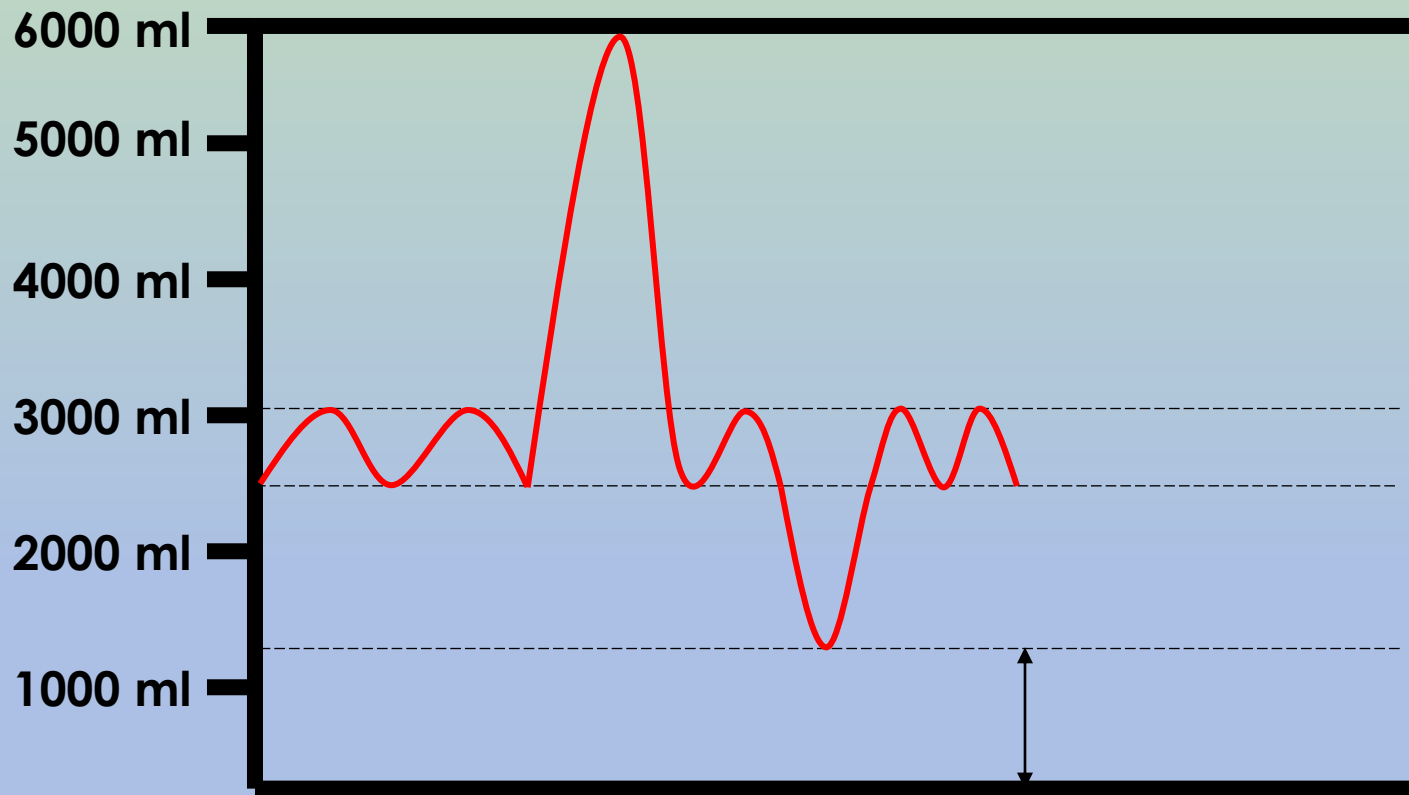
EXPIRATION - LUNG VOLUME - INSPIRATION



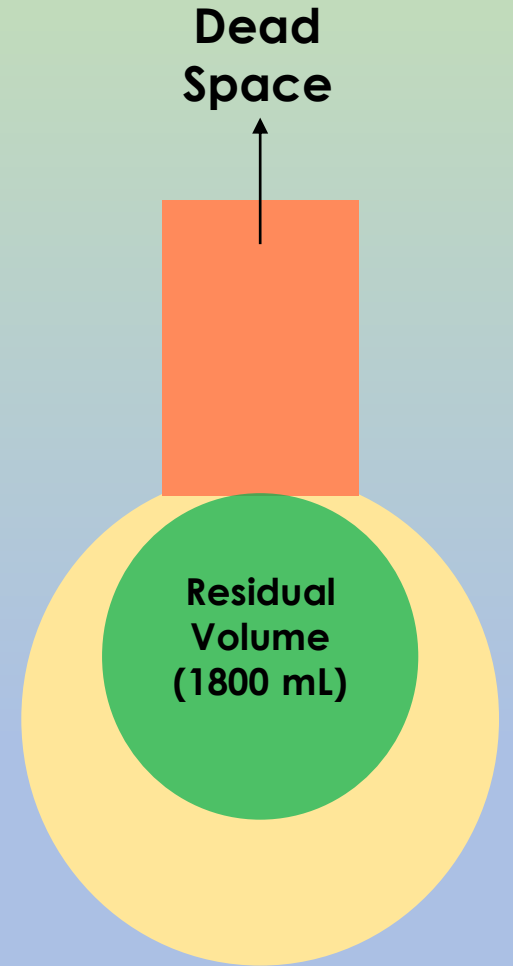
Expiratory Reserve Volume –Extra volume of air that the patient Can exhale with maximum effort.



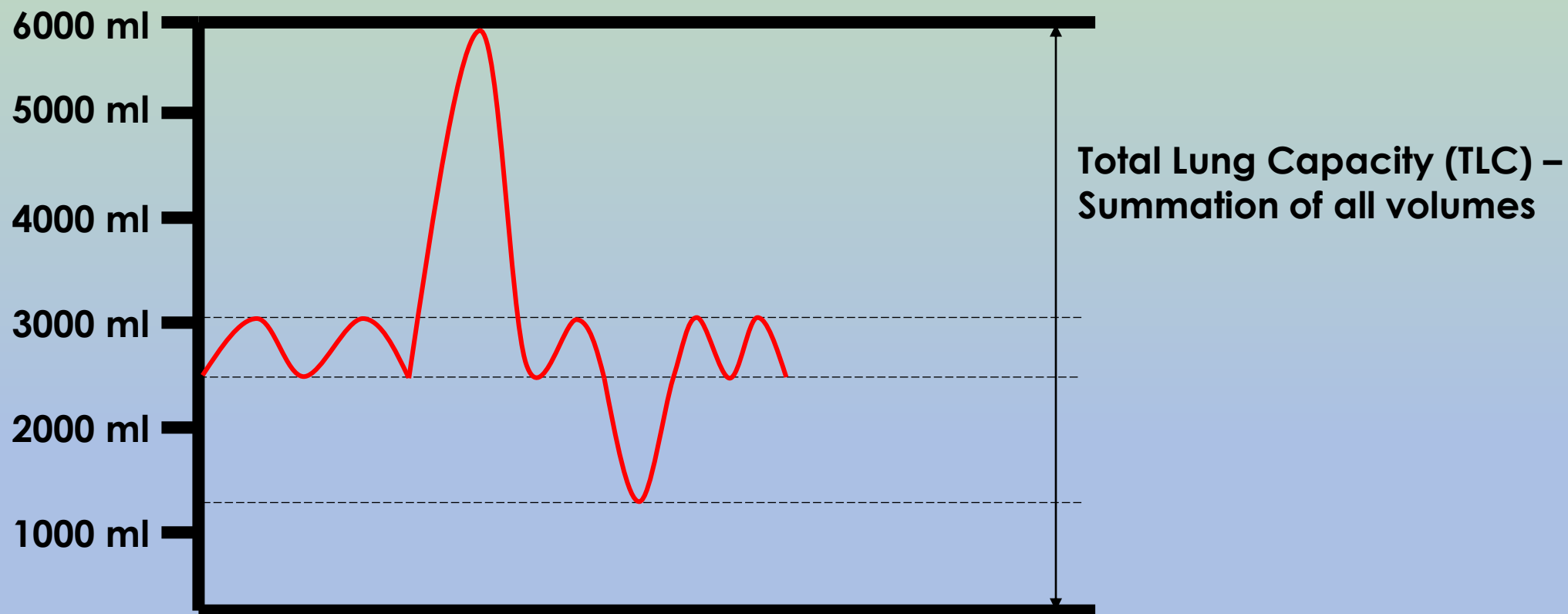
EXPIRATION - LUNG VOLUME - INSPIRATION



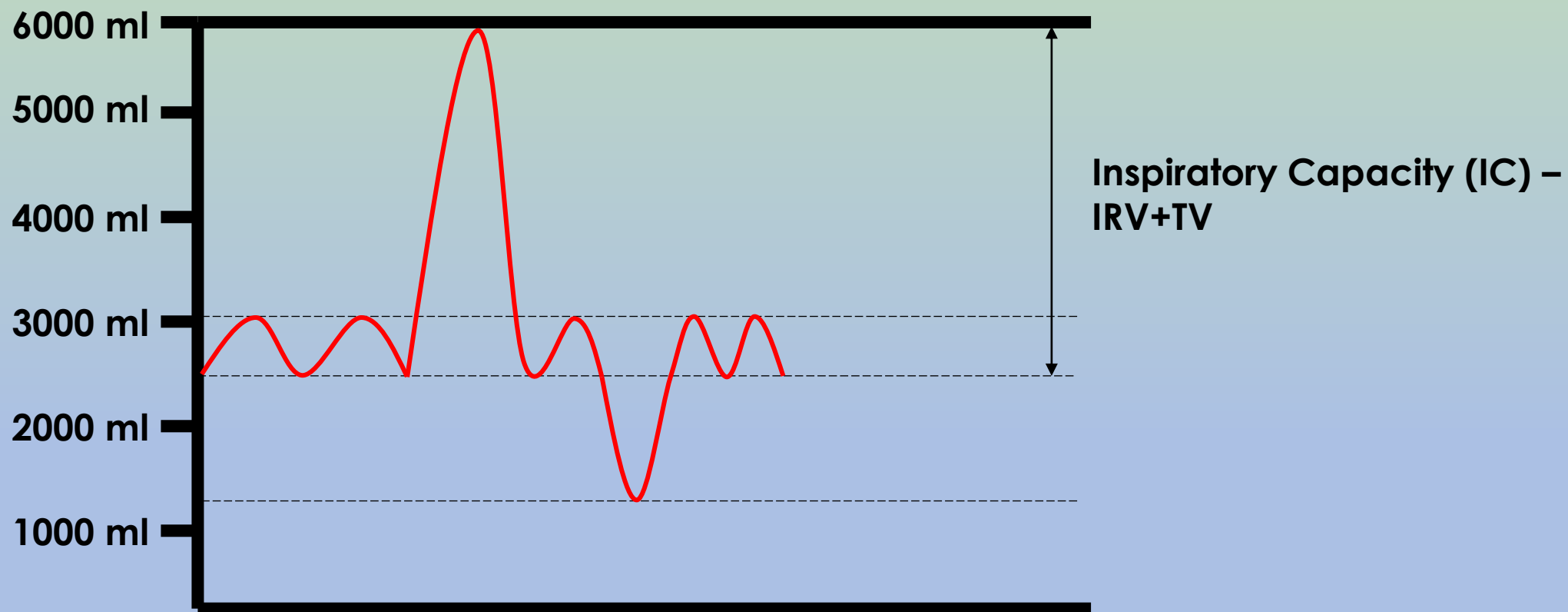
Residual Volume – Remained air volume in the lings after expiraion



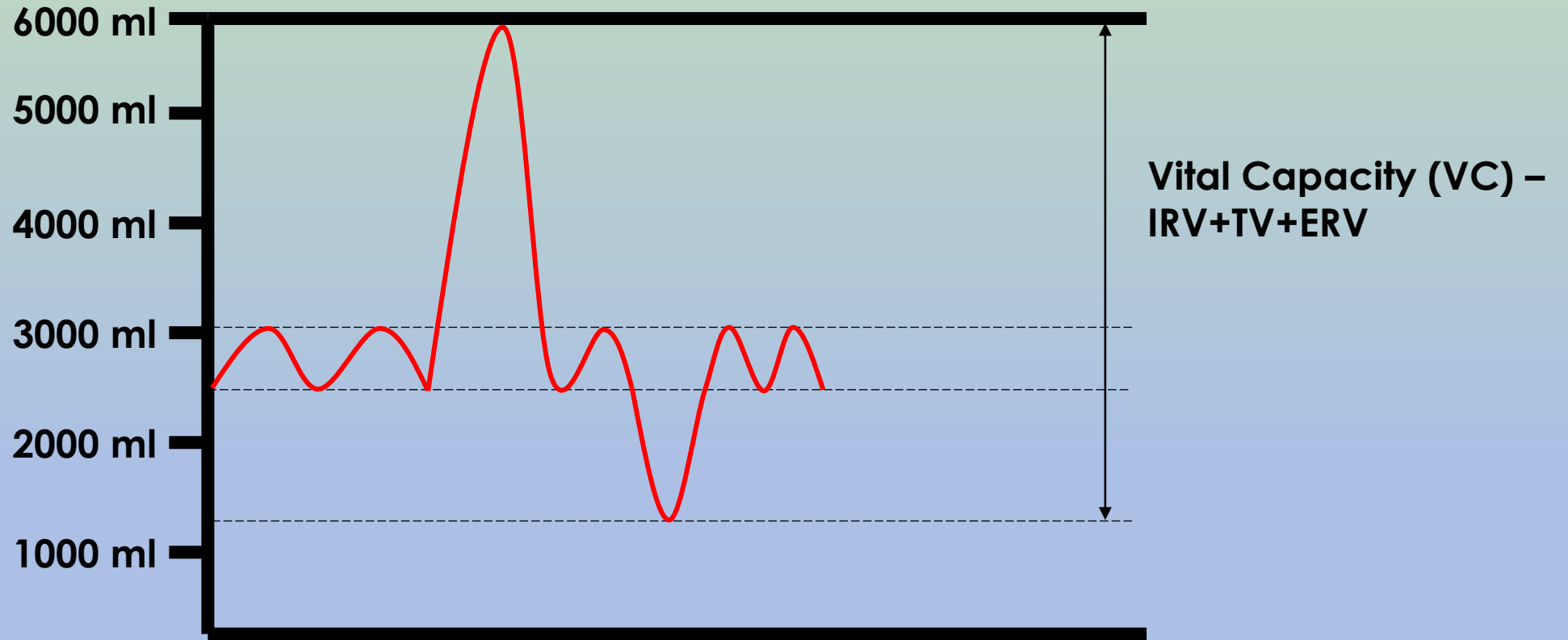
EXPIRATION - LUNG VOLUME - INSPIRATION



EXPIRATION - LUNG VOLUME - INSPIRATION



EXPIRATION - LUNG VOLUME - INSPIRATION



Diseases

- Brain injury
- Lung infection
- Pneumonia
- Asthma
- Stroke
- Coma or loss of consciousness
- Collapsed lung

During Surgery

- **surgery** with general anesthesia
- The medicines **used** for anesthesia can affect normal breathing
- **ventilator** helps control for breathing.

Usage of ventilator

Recovering from surgery

- Helps to breathe for hours or even days after surgery

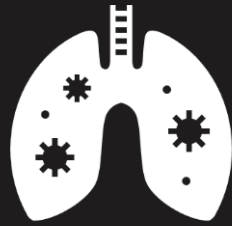
In babies

- Premature lung development

Covid19 and ventilators



When a virus enters and the body's immune system does not fight off the infection



Travel to the lungs and cause a potentially fatal condition called acute respiratory distress syndrome (ARDS)



- ☐ Alveolar collapse
- ☐ Less oxygen
- ☐ enters into blood
- ☐ Fluid enters
- ☐ into alveolar sac



Ventilator helps to maintain this imbalance

Components of Ventilator

1. Gas supply(O₂ and air)

2. Humidifier

3. Inspiratory Valve

4. Expiratory Valve

5. Breathing Circuit

6. Airway

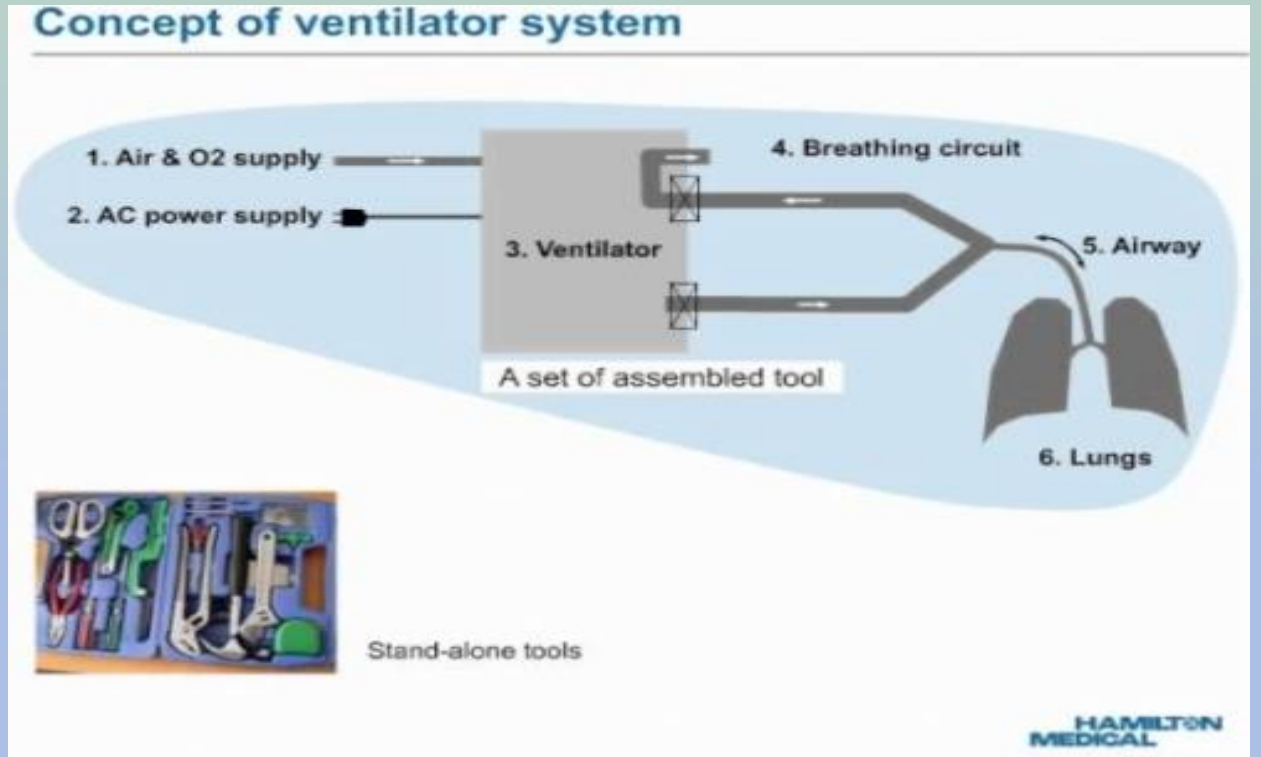


Fig: Basic diagram of ventilator

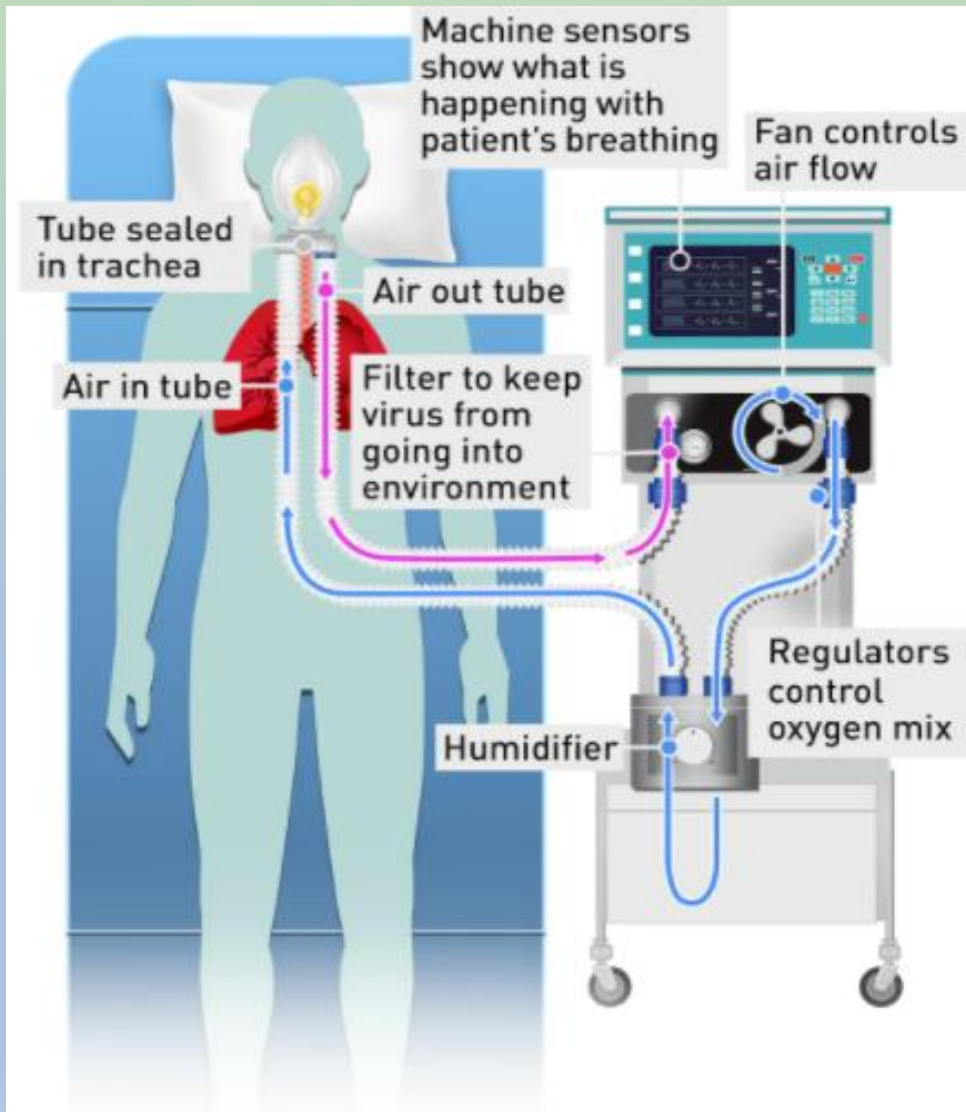


Fig: Ideal(for hospital) ventilator

Ventilation Process

- 1 Inspiratory valve opens and expiratory valve closes
- 2 Circuit creates a positive pressure (pressure gradient)
- 3 Air and O₂ move to humidifier
- 4 Then go to Lung by trachea (windpipe)
- 5 Lung expand and amount of O₂ controlled by monitor
- 6 Inspiratory valve closes and expiratory valve opens
- 7 Circuit pressure drops than lung pressure
- 8 Lung shrinks and exhale occurs

Knowledge of fluid mechanics in understanding this device

Poiseuille's Law:

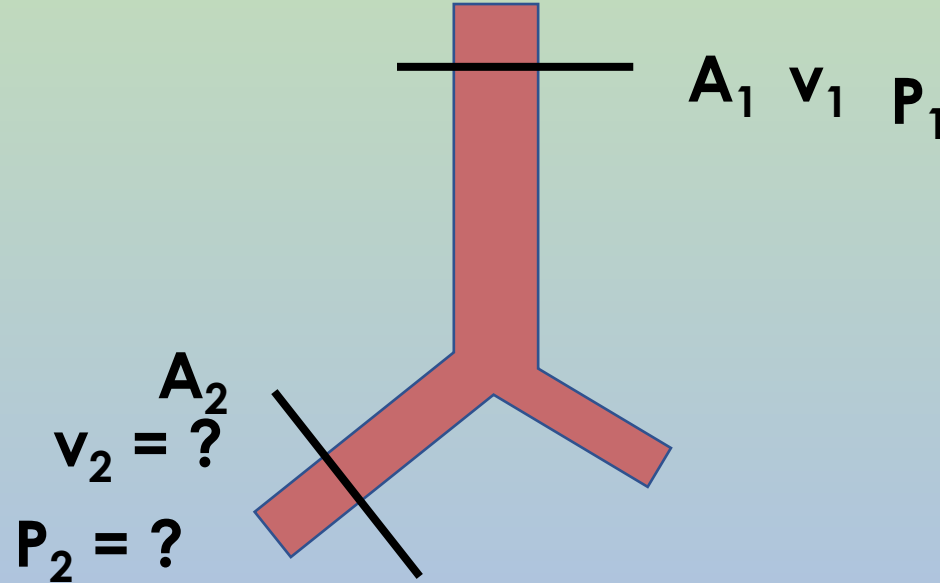
The flow of a fluid depends on pressure gradient and resistance.

$$Q = \frac{\Delta P}{R}$$

$$Q (\text{Flow rate}) = \frac{\text{Ventilator pressure} - \text{Alveolar pressure}}{\text{Resistance}}$$

Lung diseases → Fluid enters into alveoli → Resistance increase → Flow rate decrease

Knowledge of Fluid Mechanics Used in Mechanical Ventilator



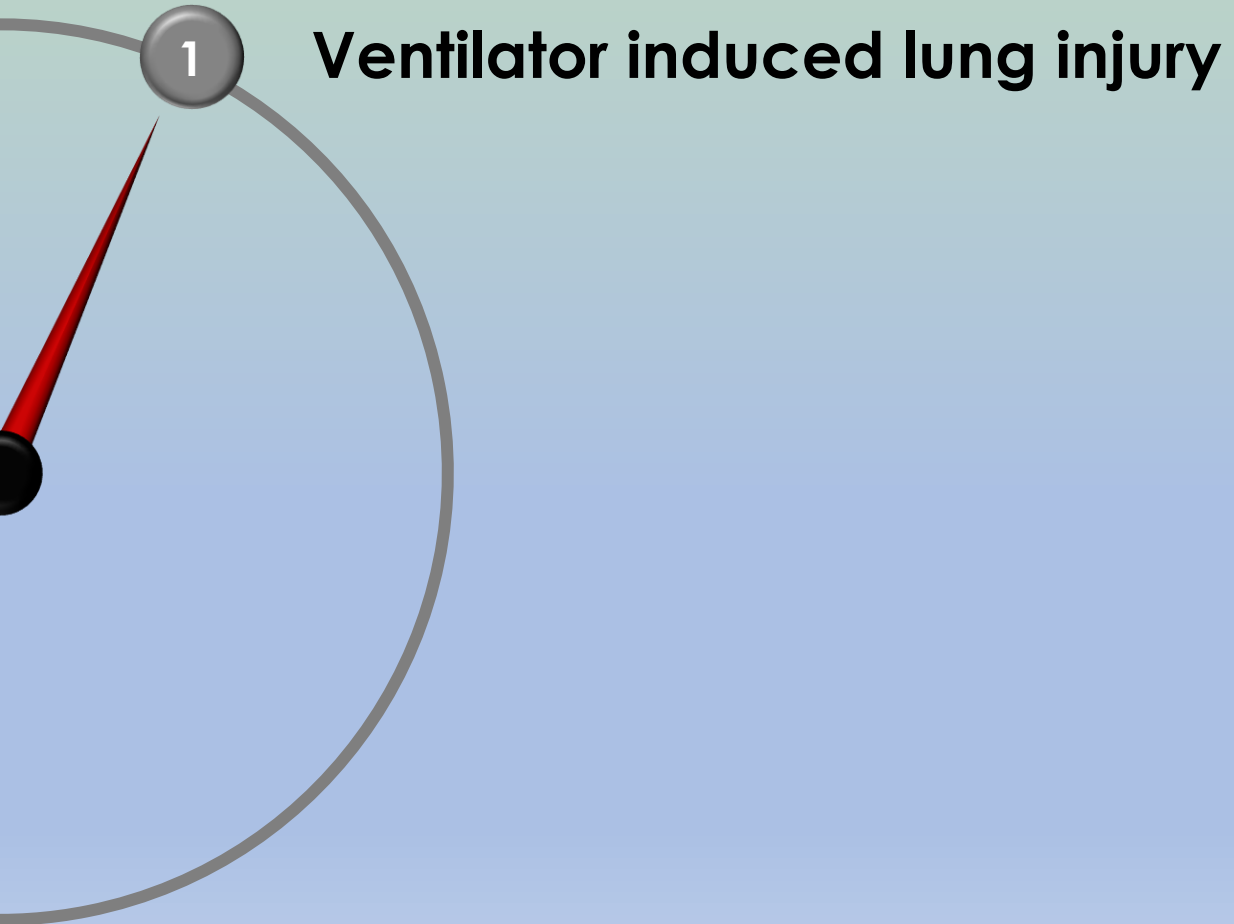
Equation of continuity

$$A_1 v_1 = A_2 v_2$$

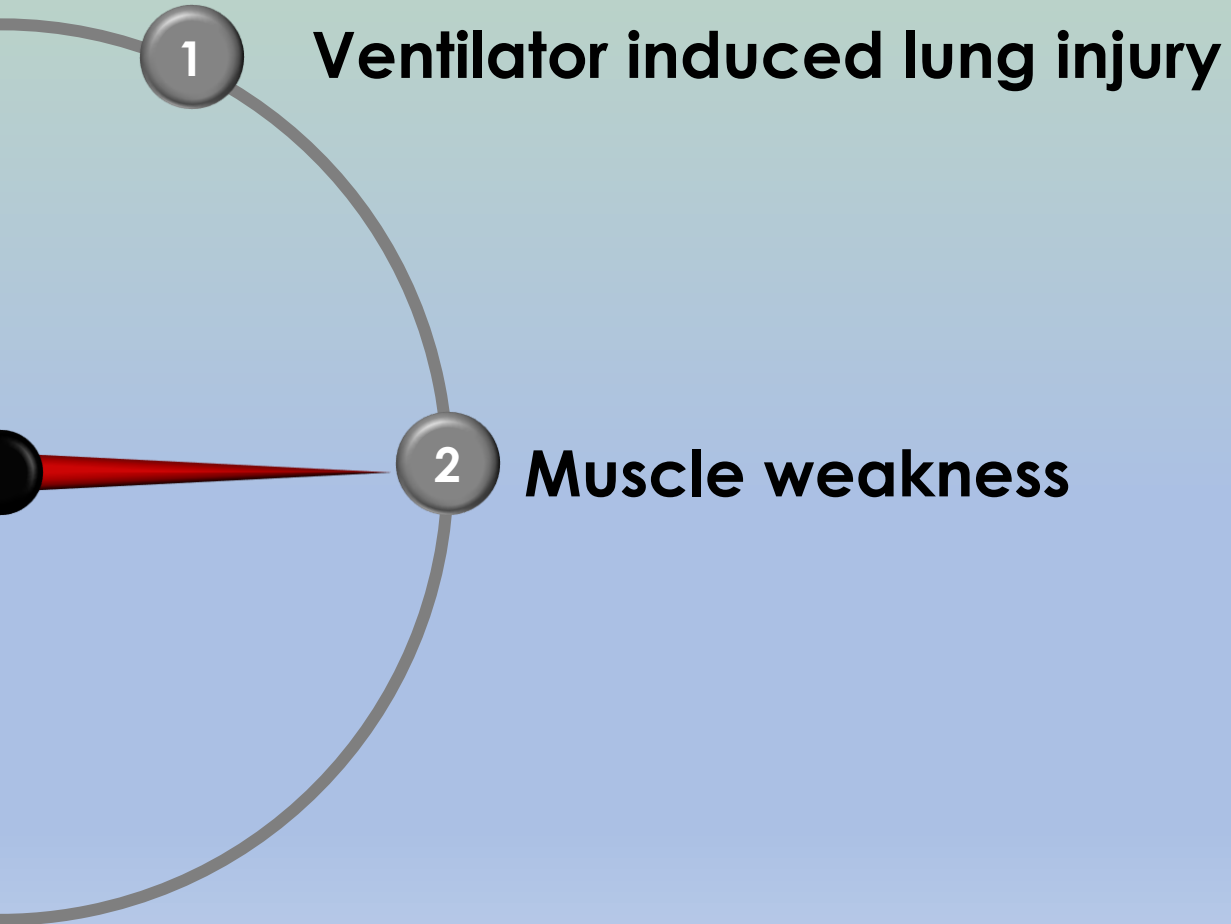
Bernoulli's Equation

$$\begin{array}{ccccccc} P & + & \rho gh & + & \frac{1}{2} \rho v^2 & = & \text{CONSTANT} \\ \downarrow & & \downarrow & & \downarrow & & \\ \text{Pressure} & & \text{Potential} & & \text{Kinetic} & & \\ \text{Energy} & & \text{Energy /} & & \text{Energy /} & & \\ & & \text{Unit} & & \text{Unit} & & \\ & & \text{Volume} & & \text{Volume} & & \end{array}$$

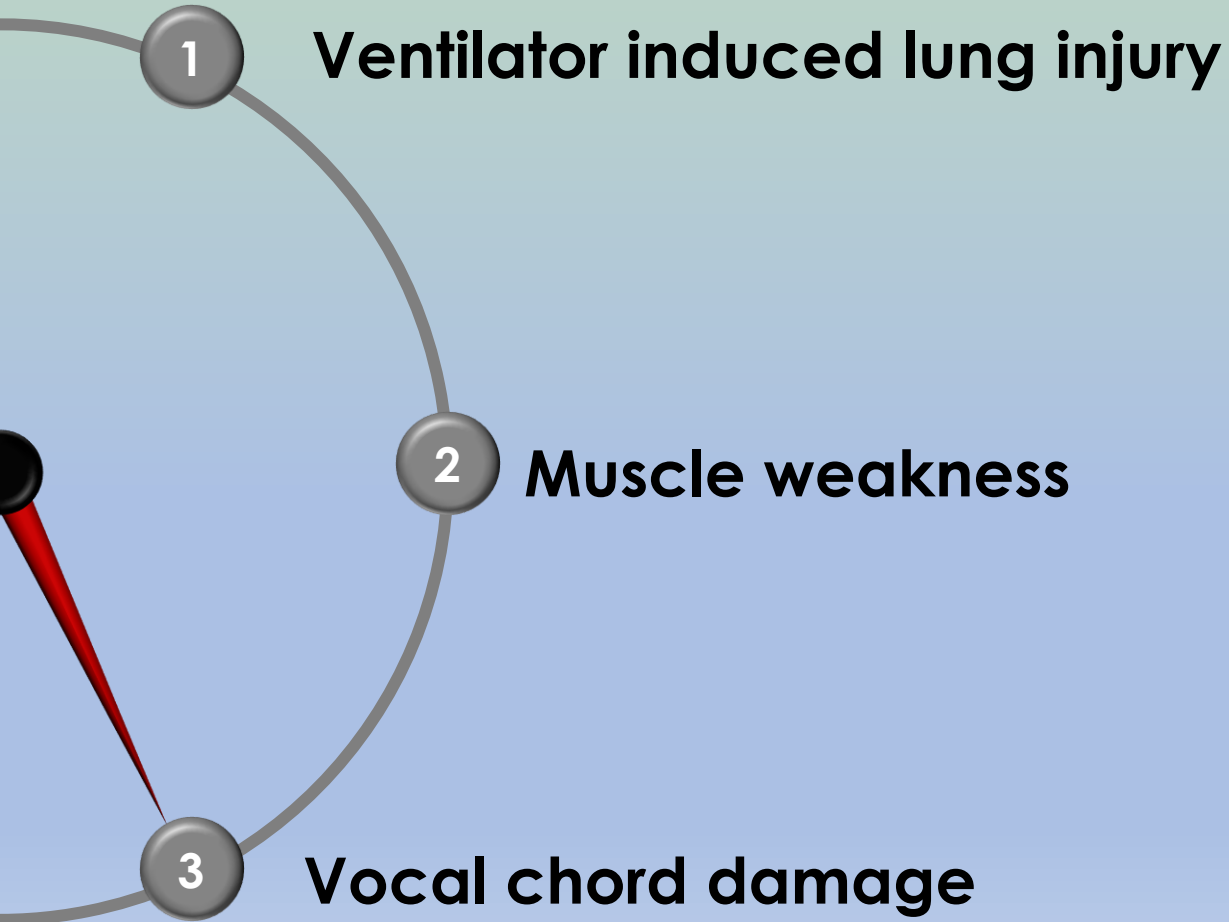
Risks of being on ventilation for too long



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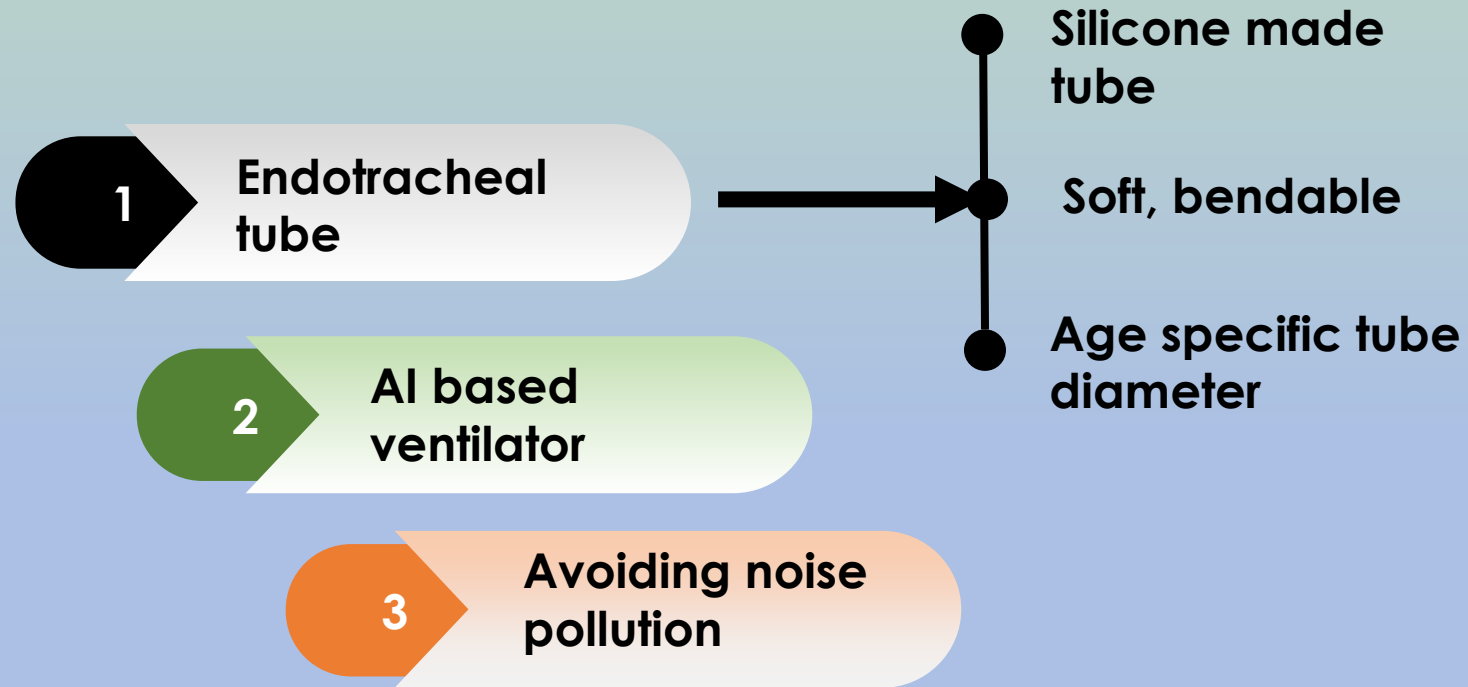


Risks of being on ventilation for too long





Future Features



Any Question?





**THANK
YOU**