Ventilation and Perfusion

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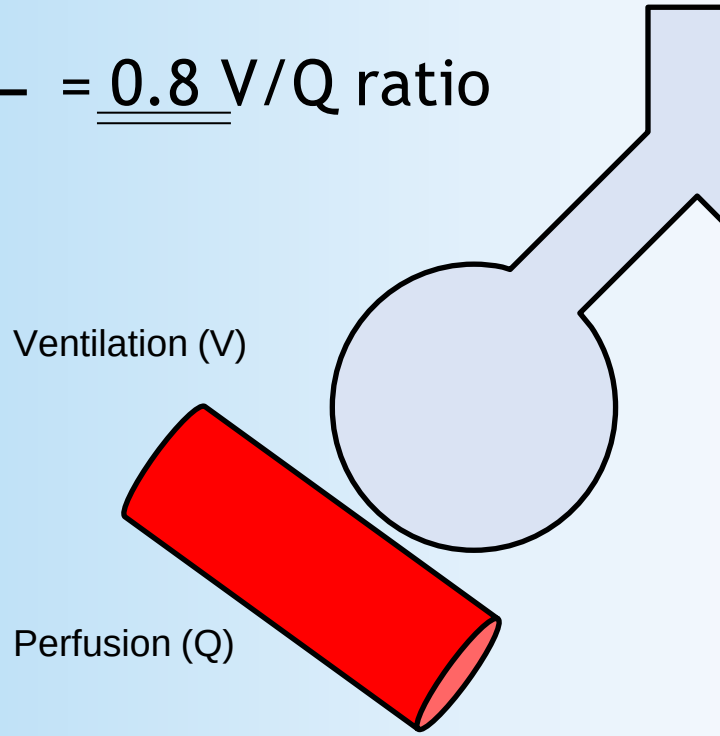
What is ventilation and perfusion?

$$\frac{\text{Ventilation (V) = air flow → lungs}}{\text{Perfusion (Q) = blood flow → lungs}} \quad \frac{V}{Q} \rightarrow \frac{4.2\text{L air}}{5\text{L blood}} = \underline{0.8}\ V/Q \text{ ratio}$$



Minute ventilation
(amount of air in and out every min)

500 ml x RR = **6L/min**

TV

Alveolar ventilation
(amount of air participating in gas exchange every min)

(500 ml – 150 ml) x RR = **4.2L/min**

TV DS

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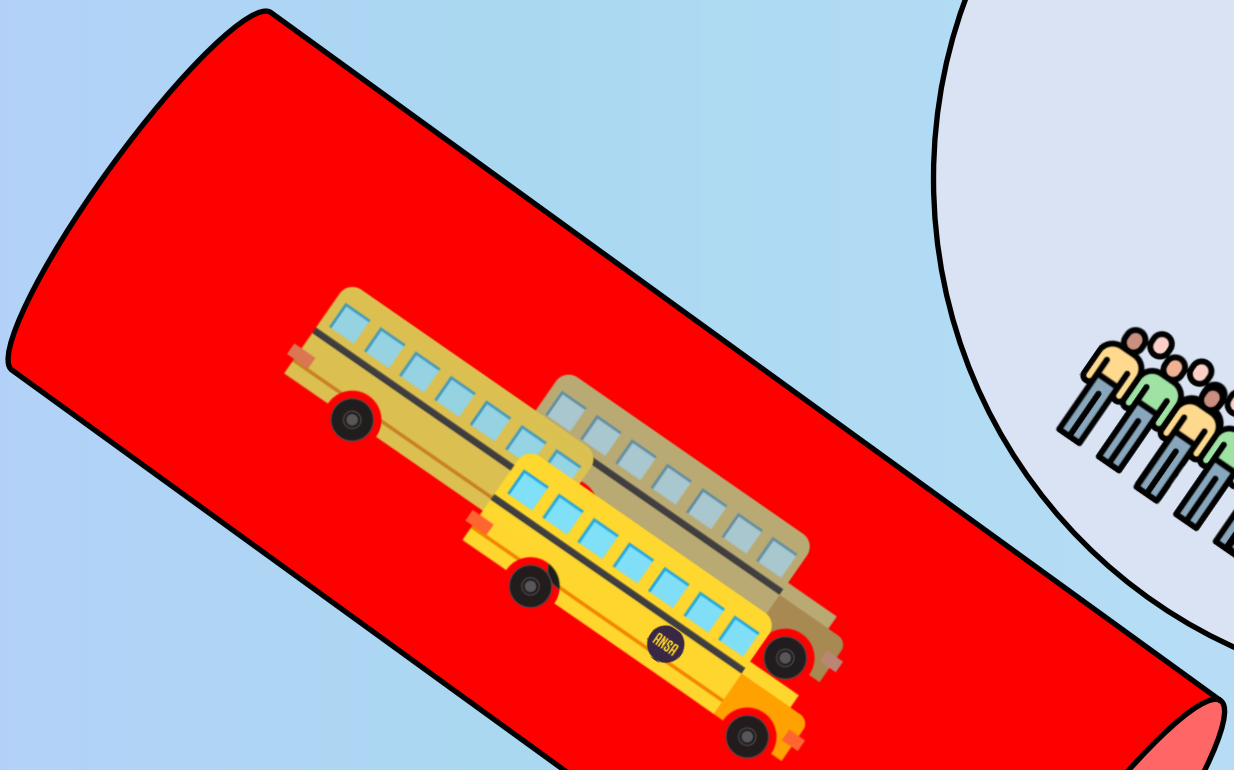

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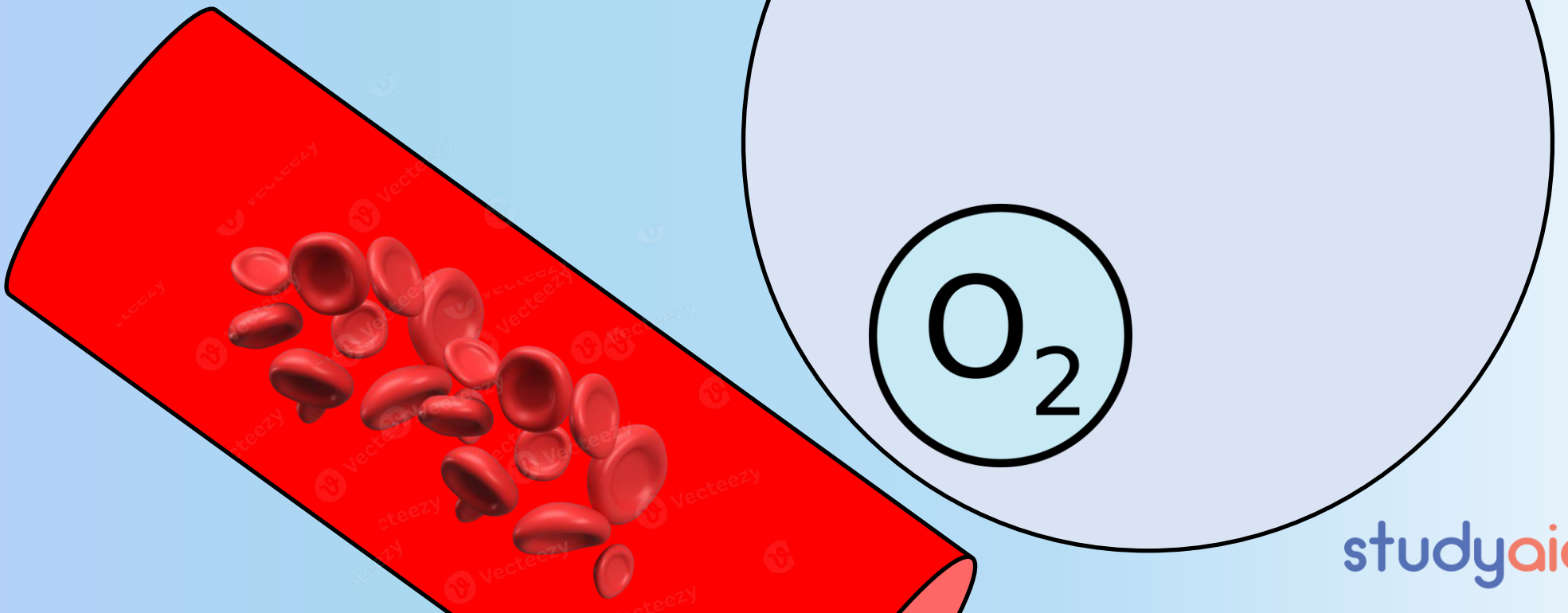
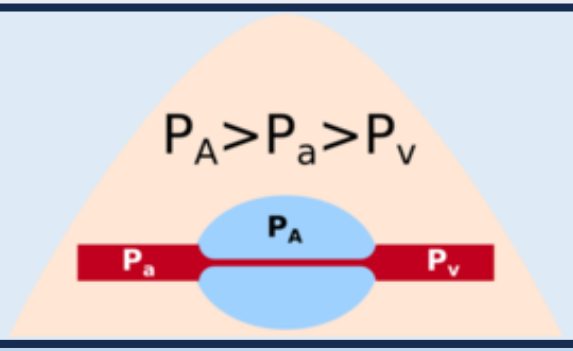

O_2

Zones of the lung

PA = Pressure in alveolus
Pa = Pressure in arteries
Pv= Pressure in veins

Zone 1 Apex (top)

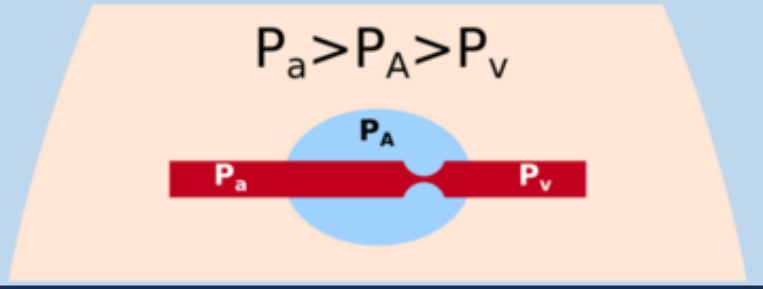
- **Pressure** in alveoli > arteries > veins
- Normally just high enough to prevent closure, but with hemorrhage or PPV this changes



Zone 1
No blood Flow

Zone 2 Middle

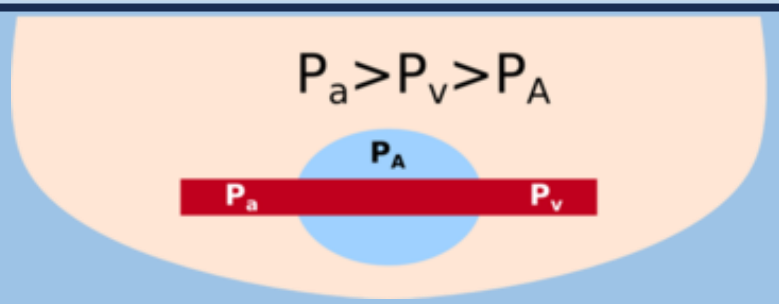
- **Pressure** in arteries > alveoli > veins
- Pulsatile flow during systole → pressure forces them open



Zone 2
Moderate
Blood Flow

Zone 3 Base

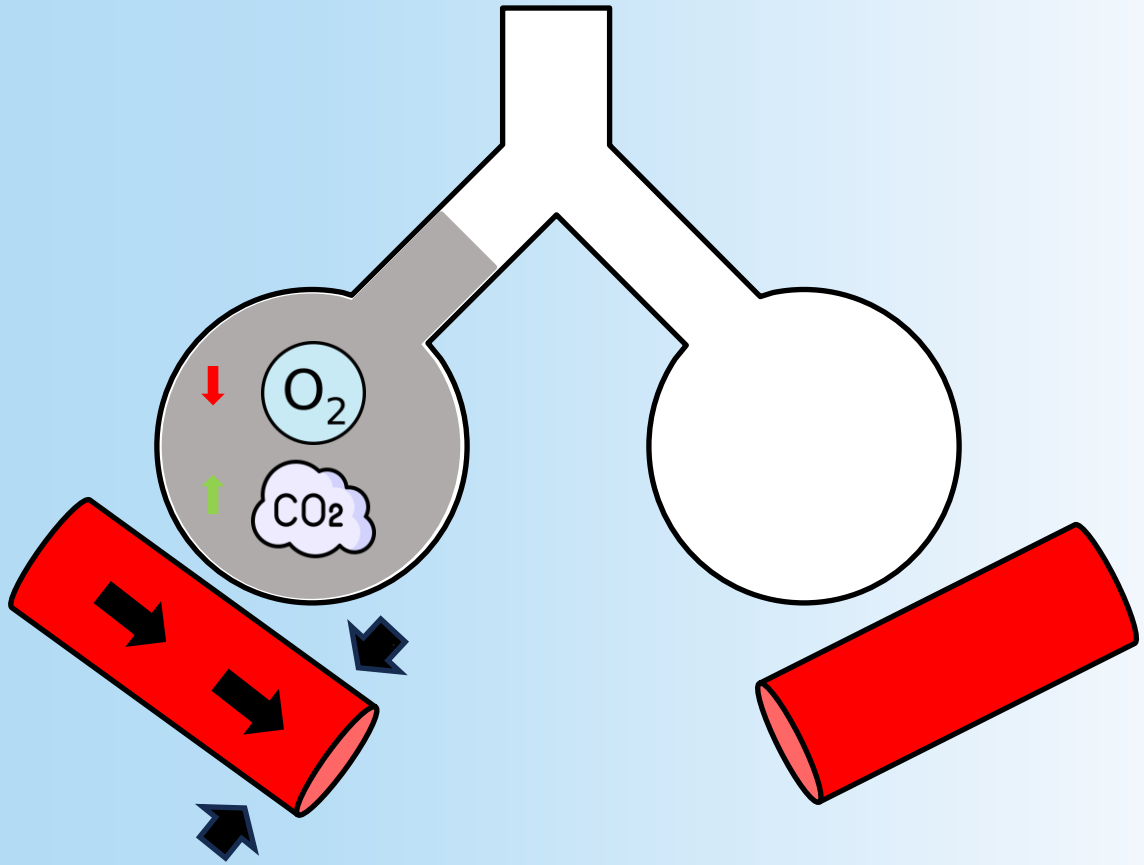
- **Pressure** in arteries > veins > alveoli
- Most of the capillarires are open



Zone 3
Greatest
Blood Flow

V/Q < 1

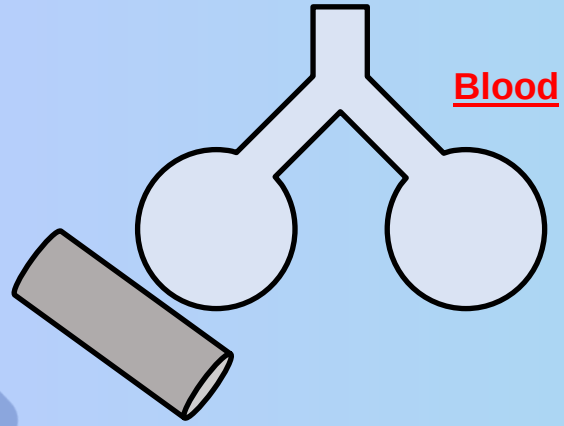
- Reduction in ventilation relative to perfusion
- We have a blockage in alveolus with blood moving past → decreased O2 and increased CO2
- How does the body compensate
  - Pulmonary circulation = decreased O2 → vasoconstriction: body wants to match the perfusion
  - Systemic circulation = decreased O2 → vasodilation: body wants to increase oxygen to the tissue
- What causes the vasoconstriction?
  - O2 highly soluble → diffuse over cell membrane
  - When low amount of O2 is sensed (<70 mmhg) → opening of Ca channels → contraction
- V/Q closer to 0 = shunting



2% of the CO normally bypass the lungs = always a physiological shunt

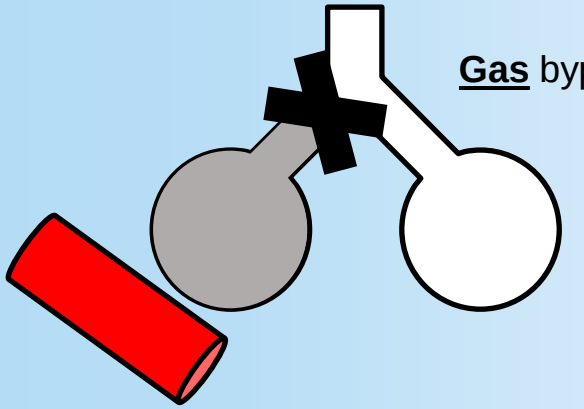
Shunting

Anatomic



Blood bypass the **Gas** completely

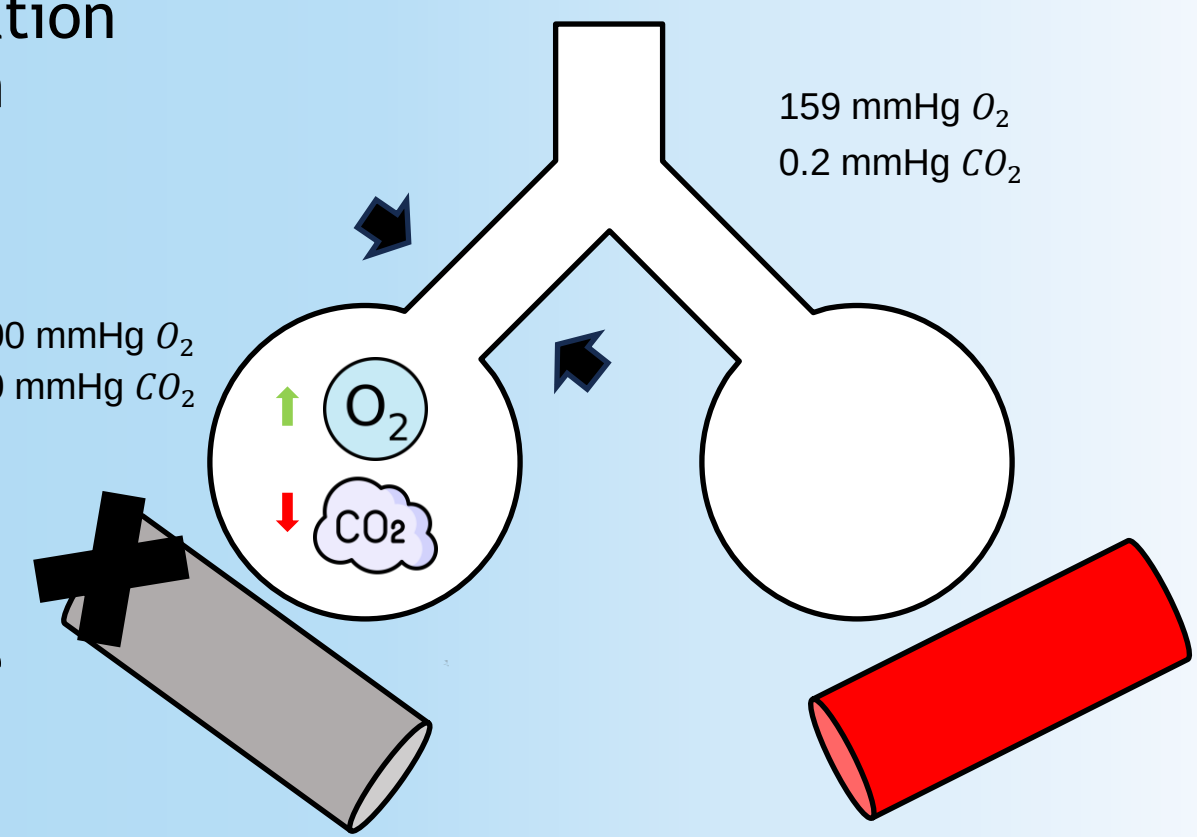
Physiological



Gas bypass the **blood** completely

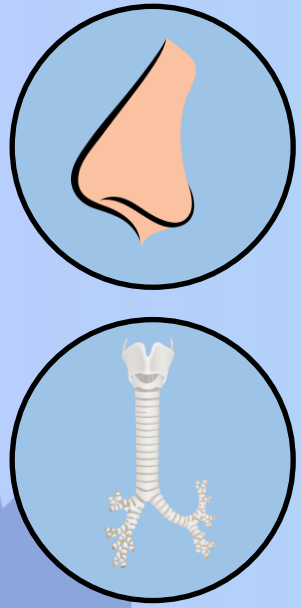
V/Q > 1

- Reduction in perfusion relative to ventilation
- We have a blockage in blood with oxygen moving past
- Atmosphere:
  - O_2 159 mmHg
  - CO_2 0.2 mmHg
- Alveolus:
  - O_2 100 mmHg
  - CO_2 40 mmHg
- Drop in CO_2 = constriction of bronchioles
- V/Q closer to «infinite sign»= dead space



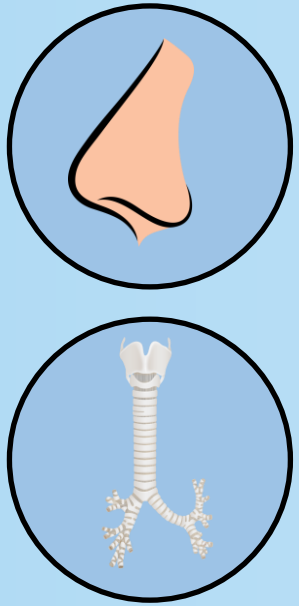
Dead space

Anatomic

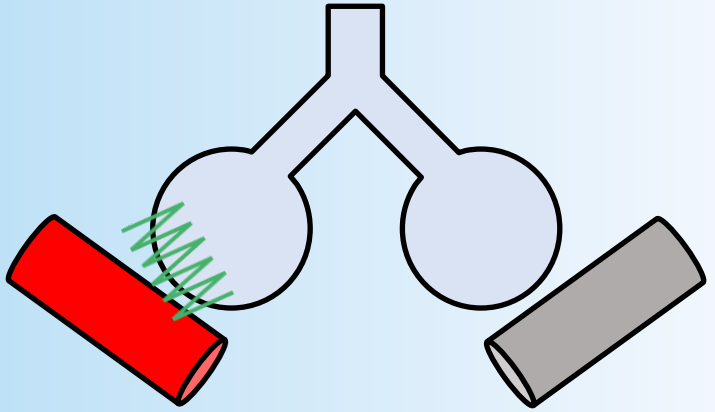


Portion of respiratory tract that does not participate in gas exchange

Physiological

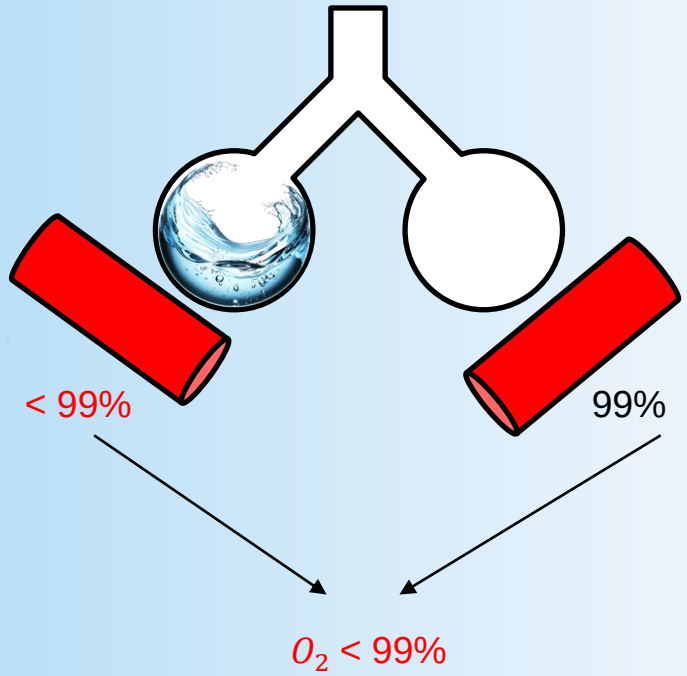


Alveoli that does not participate in gas exchange



V/Q mismatch

- Intermediate state between shunt and dead space
  - Some lung areas low V/Q
  - Others high V/Q
- Inadequate ventilation
- Reduced oxygenation of blood
- ↑ RR → CO_2 normal

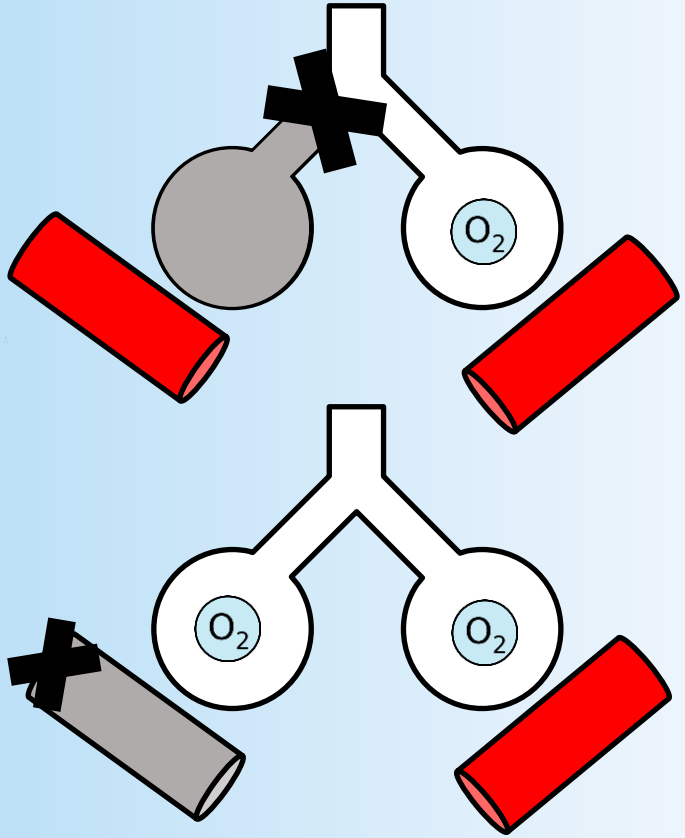


V/Q = 0 V/Q mismatch V/Q = ∞

Shunt Dead space

Inadequate gas exchange

- Caused by shunt, V/Q mismatch, dead space
- Determined by:
  - #1: response to 100% O_2
    - Shunt (V/Q = 0) wont correct with 100% O_2
    - Dead space (V/Q = ∞) will correct with 100% O_2
  - #2: hypercapnia ($\uparrow CO_2$)
    - Causes: Fever, ↓ Ventilation, ↑ **Dead space**
    - Dead space (V/Q = ∞) Hypercapnea
    - Shunt (V/Q = 0) **No** hypercapnea (because of ↑ ventilation)



$$\text{PaCO2} \propto \frac{\text{CO2 production}}{\text{Alveolar Ventilation}} = \frac{\text{CO2 production}}{\text{Tidal Vol} - \text{Dead Space}}$$