Gas exchange

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Definitions

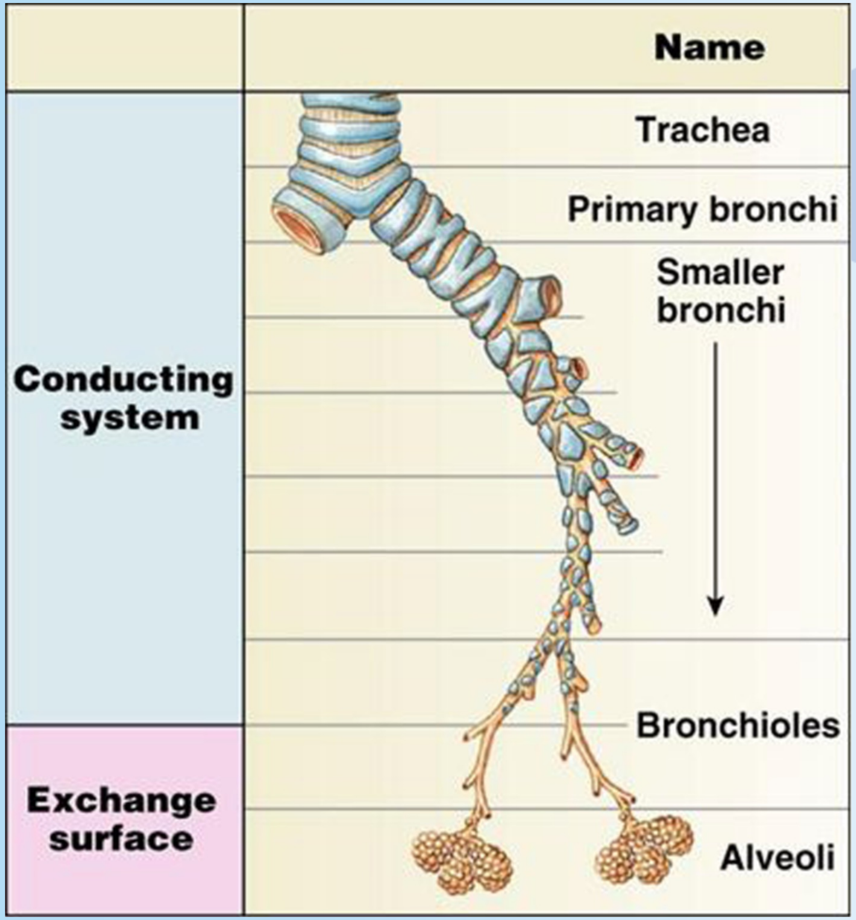
- Partial pressure
  - How to express the amount of O_2 and CO_2 present in our airways and blood?

- External respiration – Environment → Alveoli
- Internal respiration – Blood → Tissues

Conducting airway vs respiratory airway

Moves air in and out of the lungs

Moves CO2 and O2 in and out of the blood



Ficks law

- Rate of diffusion of a gas across a permeable membrane depends on:
  - Gas:
    - Solubility - Molecular weight - Partial pressure gradient
  - Lung:
    - Surface area - Membrane thickness

Respiratory zone
PaO_2 104mm/Hg

↓

Deoxygenated blood
PaO_2 40mm/Hg

→

Oxygenated blood
PaO_2 104mm/Hg

↓

Tissue
PaO_2 40mm/Hg

$$D = \frac{SA \times \Delta P \times S}{T \times \sqrt{mw}}$$

↓

$$D = \Delta P \times S$$

D= Diffusion rate
ΔP= Pressure gradient
S= Solubility of gas
T= Thickness of membrane
mw=molecular weight

MATH!!!

<u>O2</u>

$D = \Delta P \times S$

$D = (100-40) \times 1$

$D = 60 \times 1 = 60$

<u>CO2</u>

$D = \Delta P \times S$

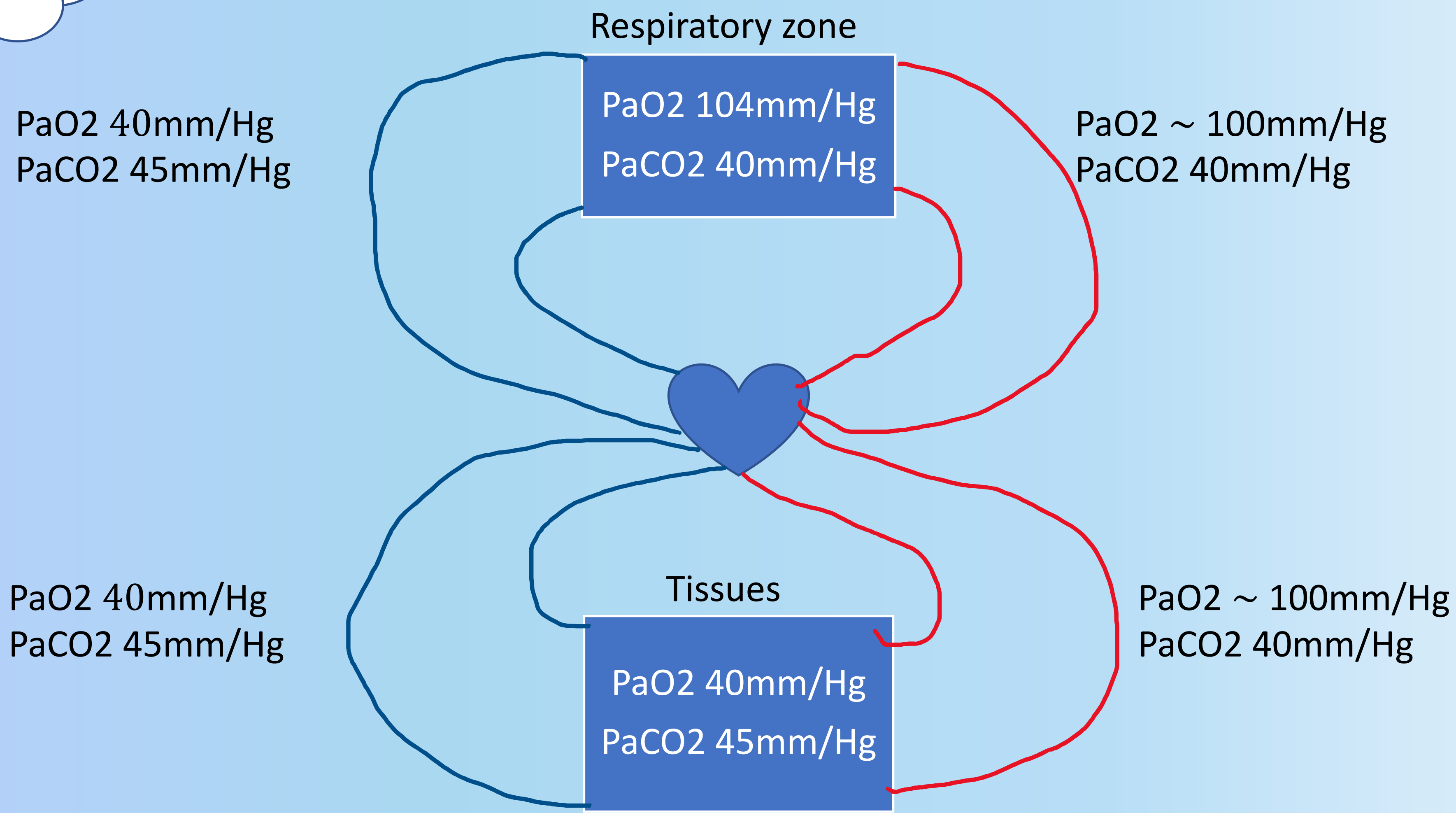
$D = (45-40) \times 20$

$D = 5 \times 20 = 100$

- Despite O_2 having a larger gradient, CO_2 will diffuse at a greater rate. CO_2 will therefore have “priority”.

PaO2 160mm/Hg

Partial pressures to remember



Gas exchange

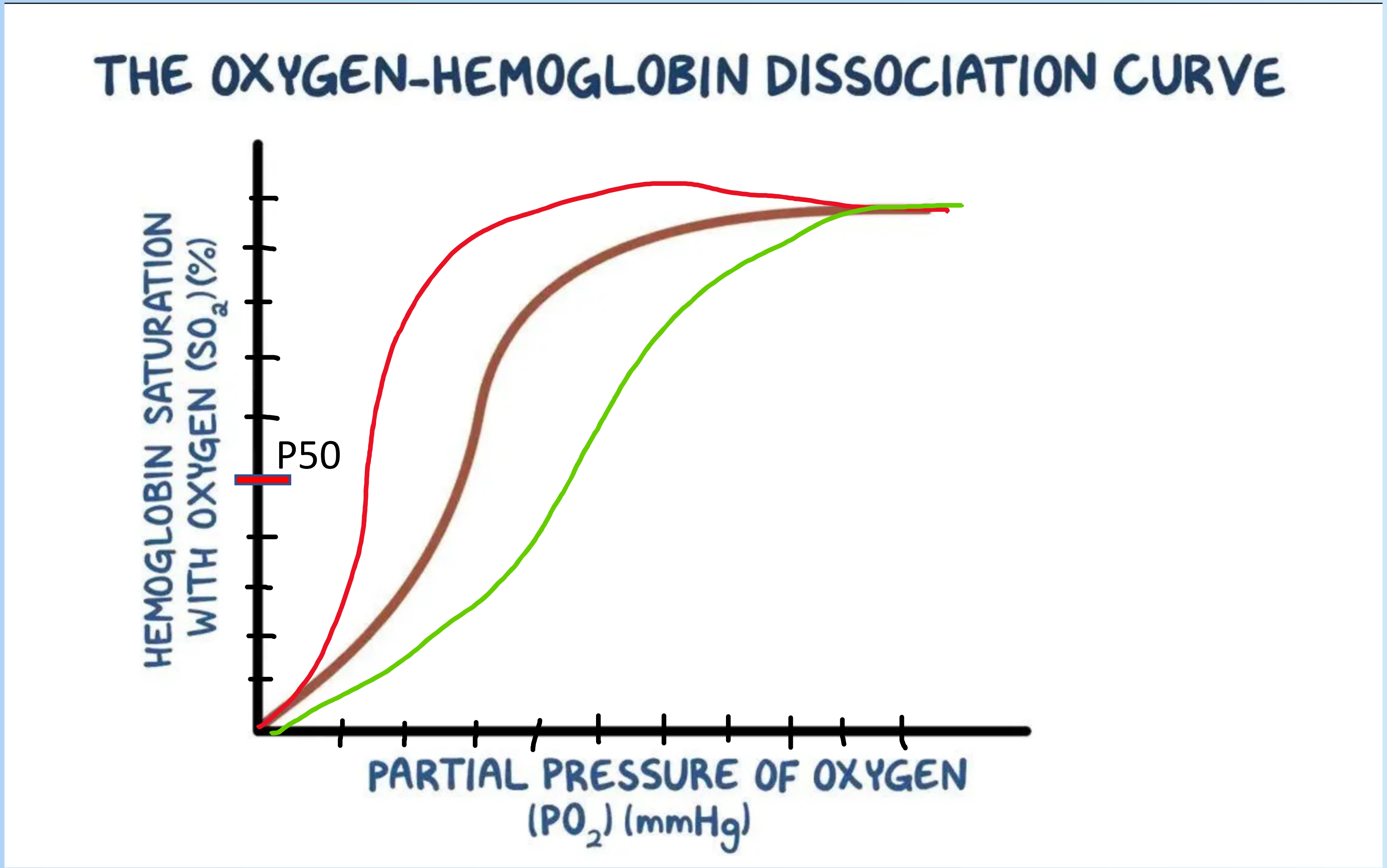
- T-state hemoglobin
  - ↓ O_2 affinity
  - ↑ CO_2 affinity
  - ↑ H^+ affinity
  - 2,3-BPG affinity

- R-state hemoglobin
  - ↑ O_2 affinity
  - ↓ CO_2 affinity
  - ↓ H^+ affinity
  - 2,3-BPG affinity

- Total CO_2
  - 20% bound as carbaminohemoglobin
  - 70% as HCO_3^- buffer
  - 2-10% dissolved as CO_2

Oxygen-Hemoglobin dissociation curve

Left shift
Tissue gets too little O2
The y-axis increases
More O2 remains in hgb



Right shift
Too much O2 is given to tissues
The y-axis decreases
Less O2 remains in hgb

- The curve is sigmoidal due to the concept of positive cooperativity

Shifts of the oxygen-hemoglobin dissociation curve

Left shifts	
Factor	**Comment**
↓PaCO2, ↓H+ (↑pH)	- ↓Tissue metabolism - ↓Oxygen demand
↓Temperature	- ↓Tissue metabolism - ↓Heat production - ↓Oxygen demand
↓2,3-diphosphoglycerate (2,3-DPG)	
Hemoglobin F	- ↑Oxygen affinity
CO	- ↑Oxygen affinity

Right shifts	
Factor	**Comment**
↑PaCO_2 and ↑H+ (↓pH)	- ↑Metabolic activity - ↑Oxygen demand - Bohr effect!
↑Temperature	- ↑Metabolic activity - ↑Heat production - ↑Oxygen demand
↑ 2,3-diphosphoglycerate (2,3-DPG)	- Product of RBC glycolysis - Produced in periods of tissue hypoxia

Right shift—**ACE BAT**s **right** handed:
Acid
CO2
Exercise
2,3-**B**PG
Altitude
Temperature

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