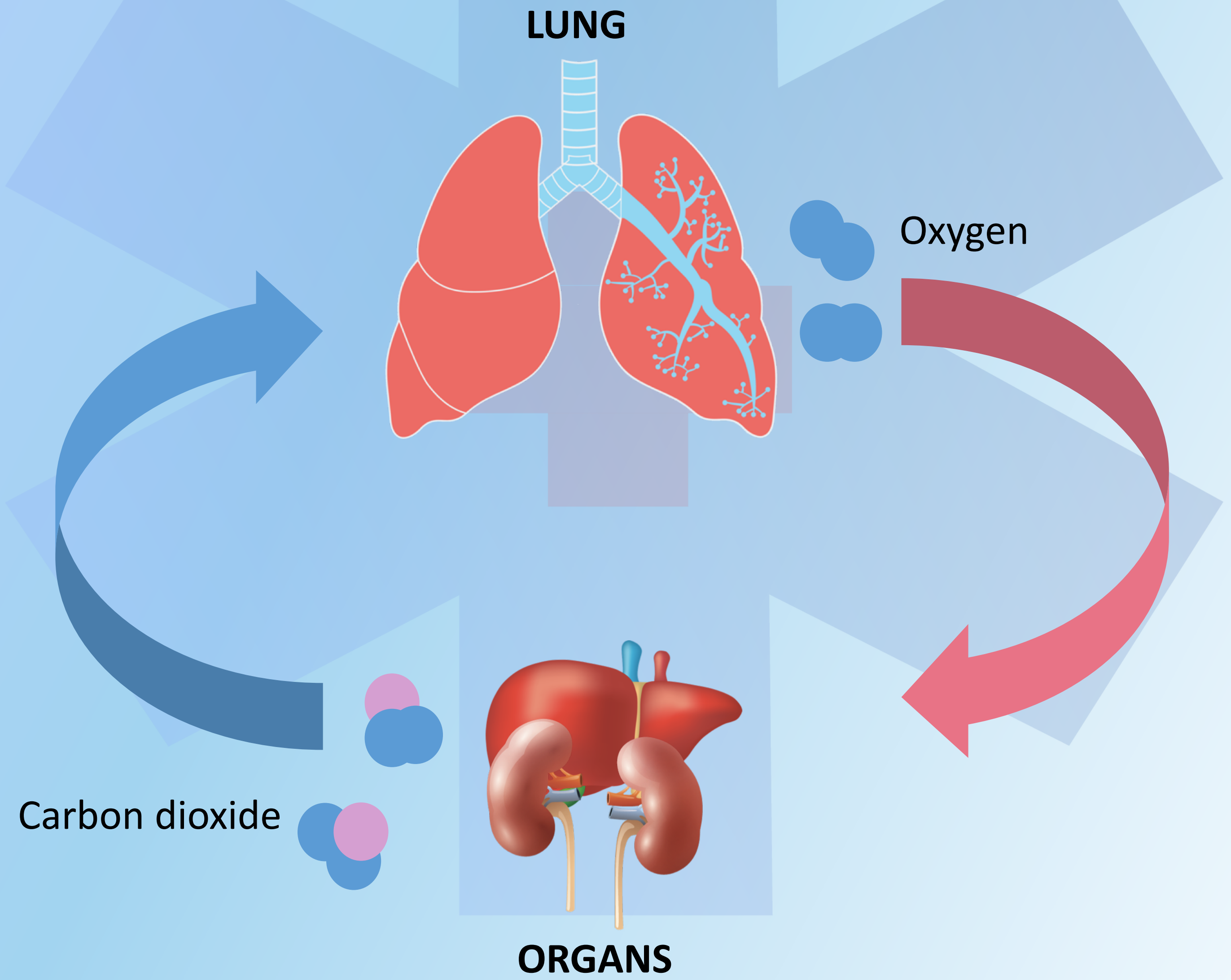
Respiration

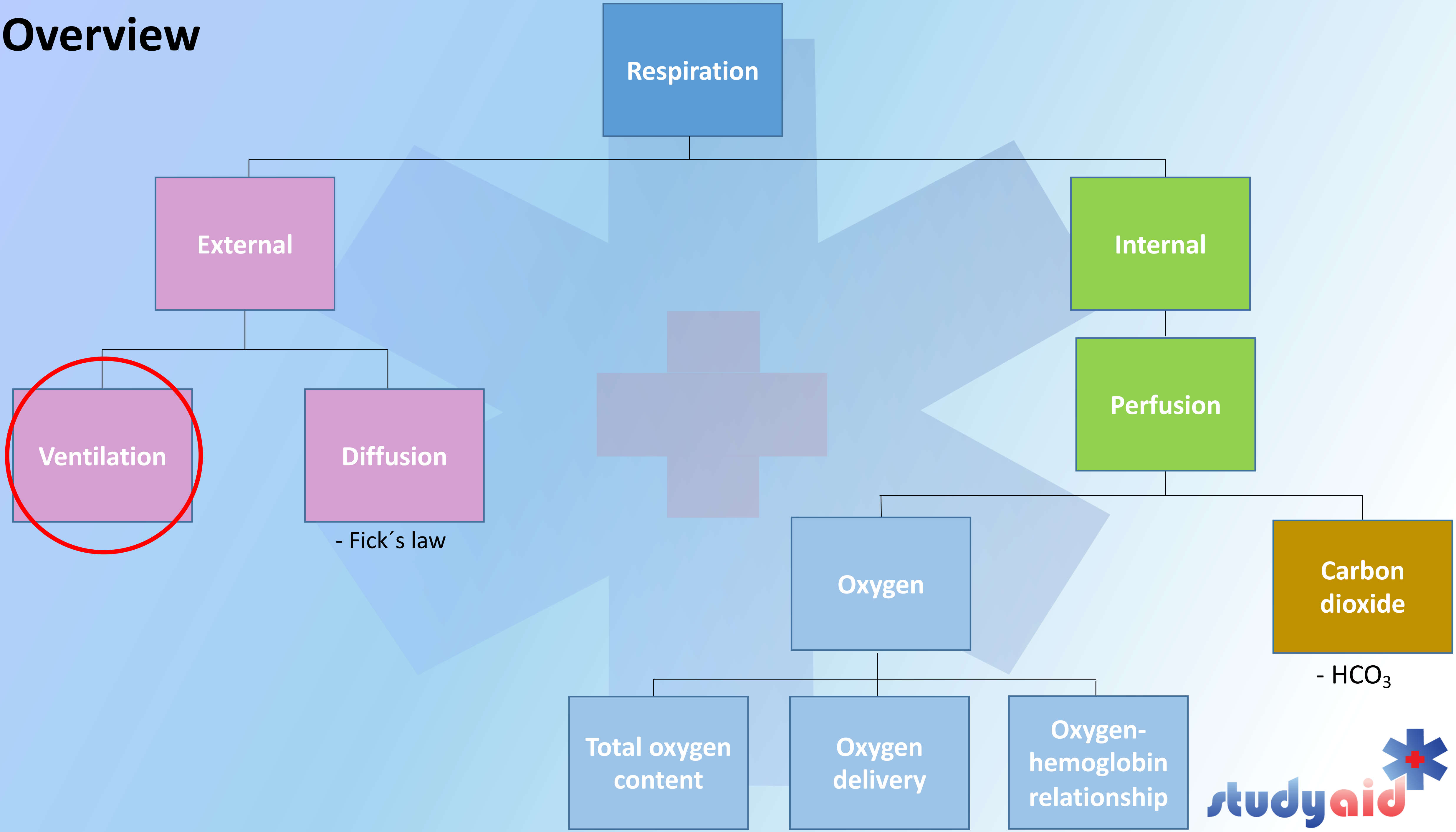


studyaid

How to we express the **amount** of gas present in the alveolus and blood?

Partial pressure

Overview

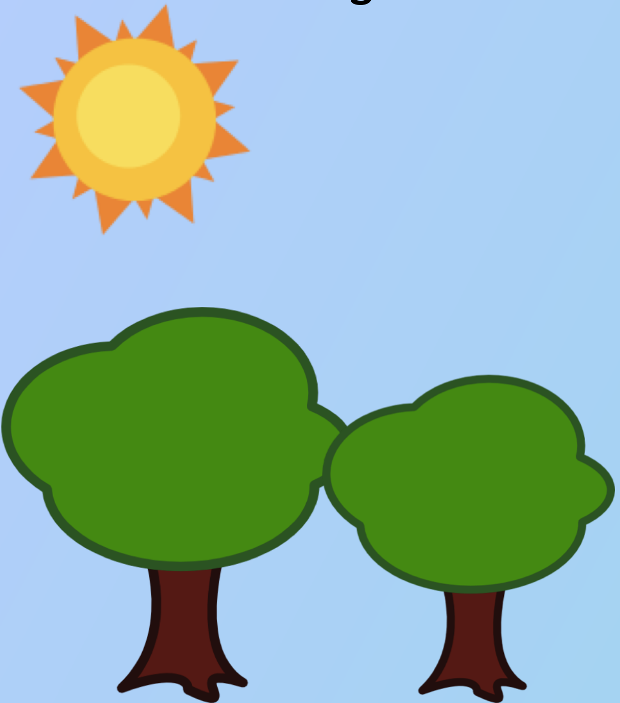

Respiration
External
Internal
Ventilation
Diffusion
- Fick´s law
Perfusion
Oxygen
Carbon dioxide
- HCO3
Total oxygen content
Oxygen delivery
Oxygen-hemoglobin relationship

Outside

$P_{O2} = Fi_{O2} \times P_{atm}$

$= 0.21 \times 760$ mmHg

160mmHg



Conducting zone

$P_{O2} = Fi_{O2} \times (P_{atm} - P_{H2O})$

$Pi = 0.21 \times (760 - 47)$ mmHg

150mmHg

Pi = Partial pressure of inspired oxygen

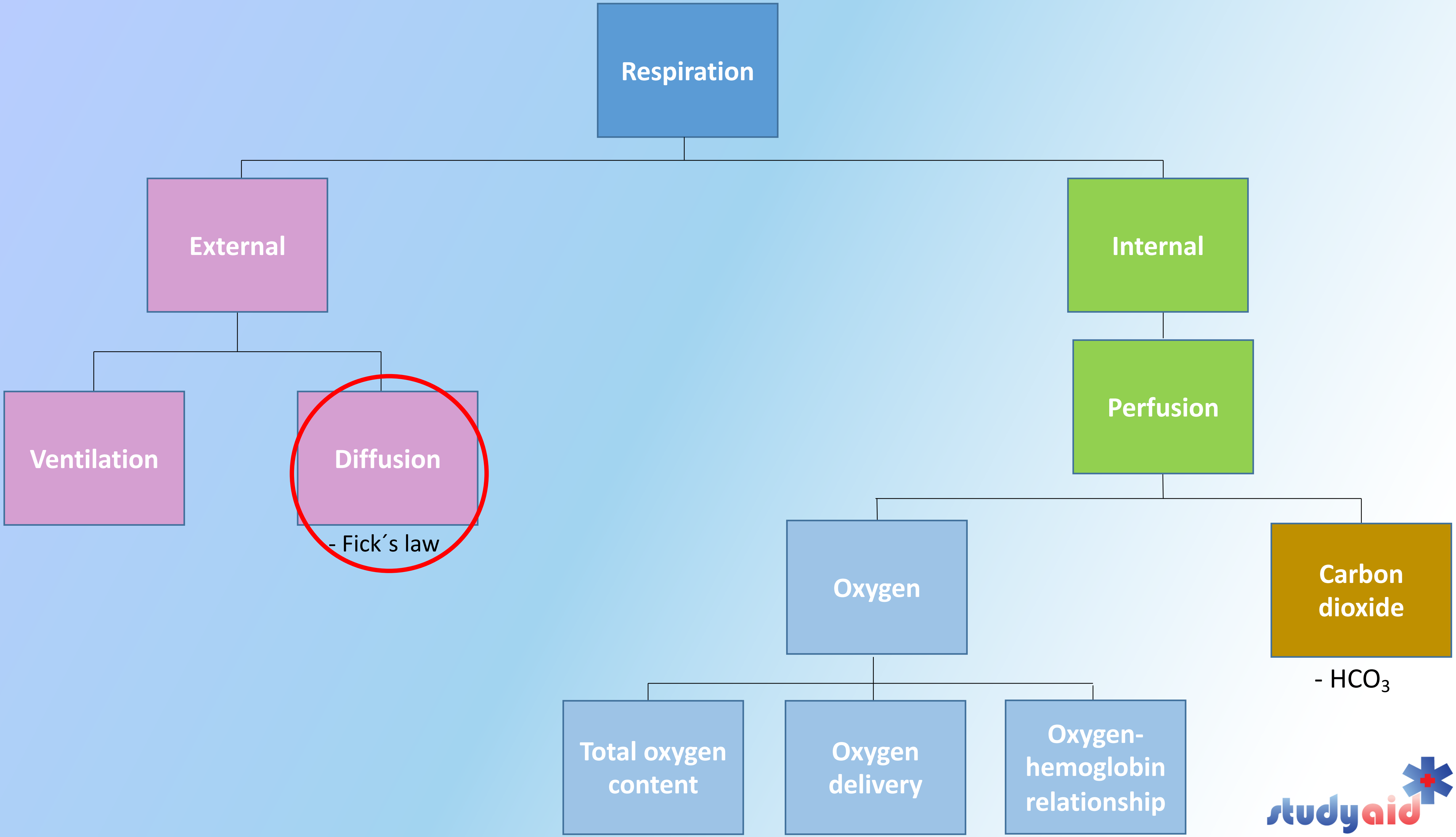
Respiratory zone

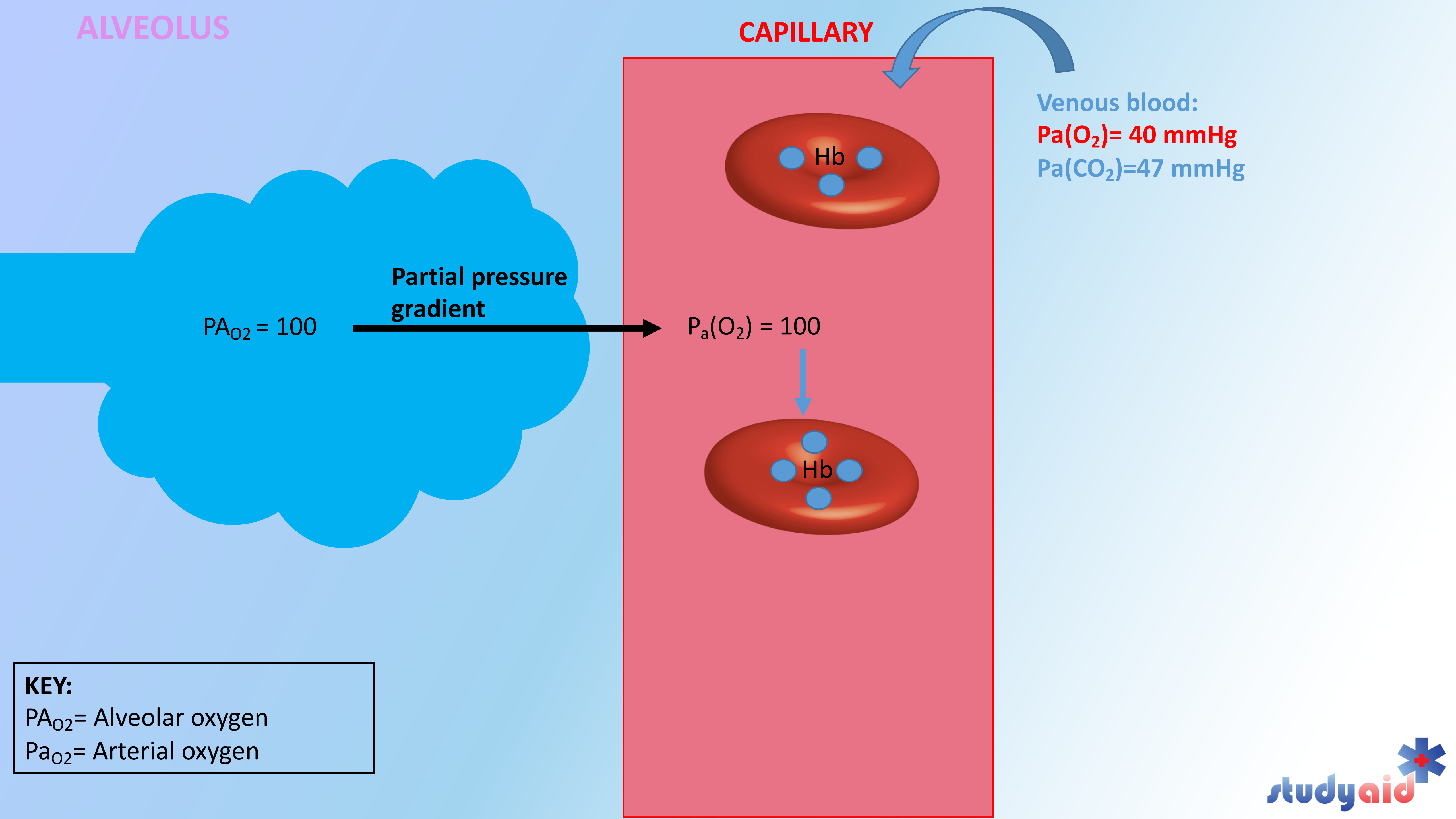
$PA_{O2} = Pi - (P_{CO2}/R)$

$= 150 - (40/1)$

100mmHg

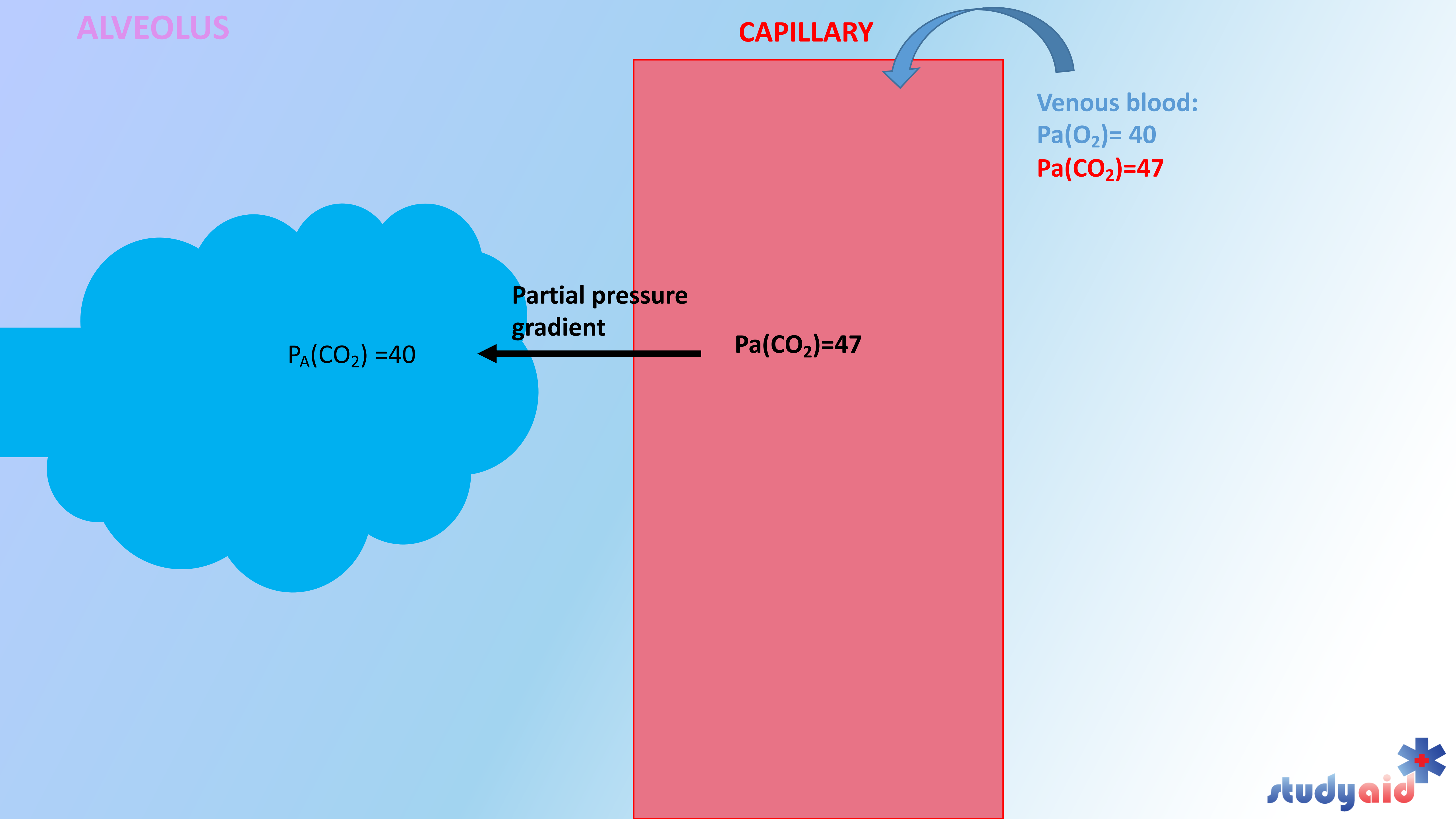
PA_{O2} = Alveolar oxygen


Respiration
External
Internal
Ventilation
Diffusion
- Fick´s law
Perfusion
Oxygen
Carbon dioxide
- HCO_3
Total oxygen content
Oxygen delivery
Oxygen-hemoglobin relationship
studyaid


ALVEOLUS
CAPILLARY
Venous blood:
Pa(O2)= 40 mmHg
Pa(CO2)=47 mmHg
Hb
Partial pressure gradient
PAO2 = 100
Pa(O2) = 100
Hb
KEY:
PAO2= Alveolar oxygen
PaO2= Arterial oxygen
studyaid

„If the partial pressure of carbon dioxide in blood (Pa_{CO2}) is 47 mmHg and the partial pressure of carbon dioxide in the alveolus (PA_{CO2}) is 40 mmHg , in which direction will the gas diffuse?"

A. From the alveolus into the blood
B. From the blood into the alveolus
C. The partial pressure gradient is too small for diffusion to occur
D. CO_2 will continue to diffuse until the partial pressure in the alveolus reaches 47 mmHg
E. A and C
F. B and D


ALVEOLUS
CAPILLARY
Venous blood:
$Pa(O_2)$= 40
$Pa(CO_2)$=47
Partial pressure gradient
$P_A(CO_2)$ =40
$Pa(CO_2)$=47
studyaid

Key points

	PA_{O2}	PA_{CO2}
Directly proportional to	Pa_{O2}	Pa_{CO2}
Main determinants	- P_{atm} - Fi_{O2}	- V_A[1] - Metabolism

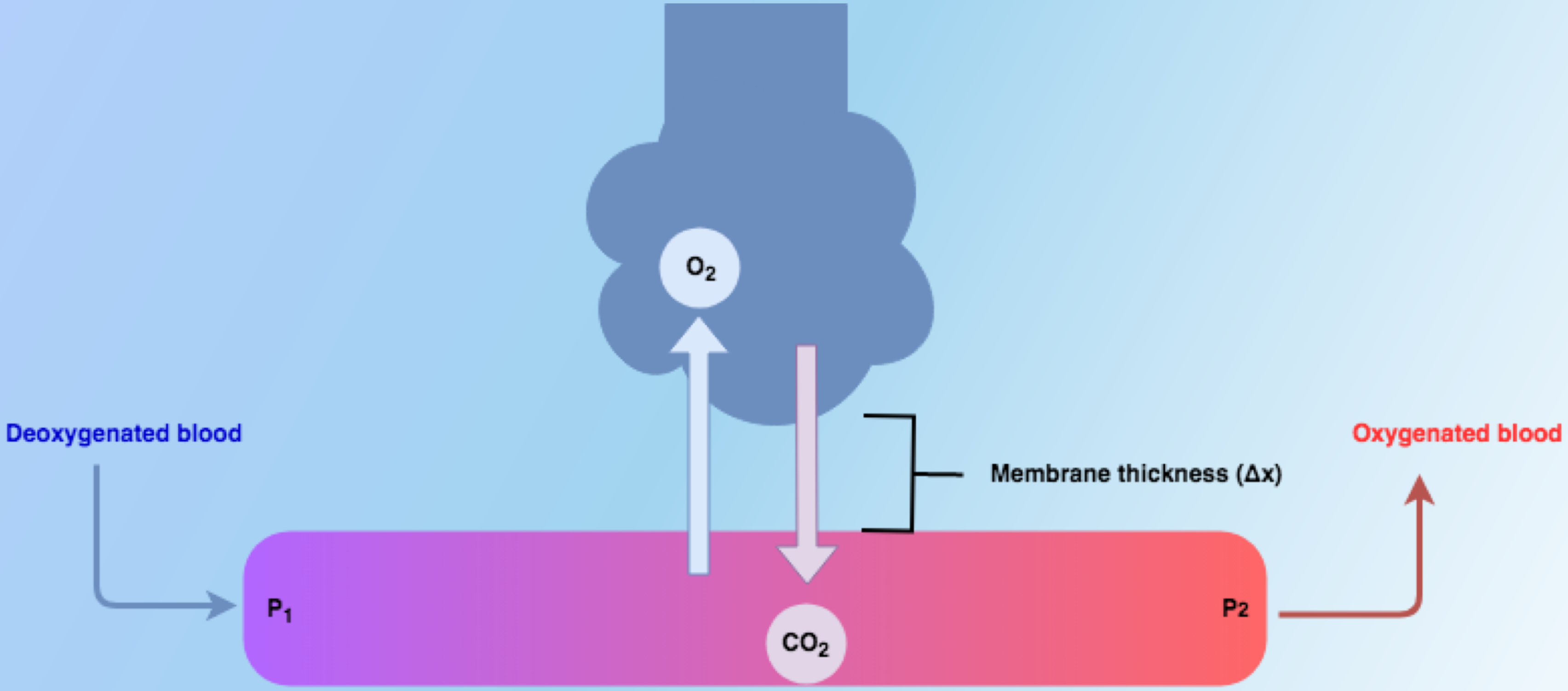
$$PA_{CO2} = \frac{\text{Metabolism}}{V_A}$$

Fick´s law of diffusion

- **Definition**
  - How fast a gas will diffuse across a permeable membrane

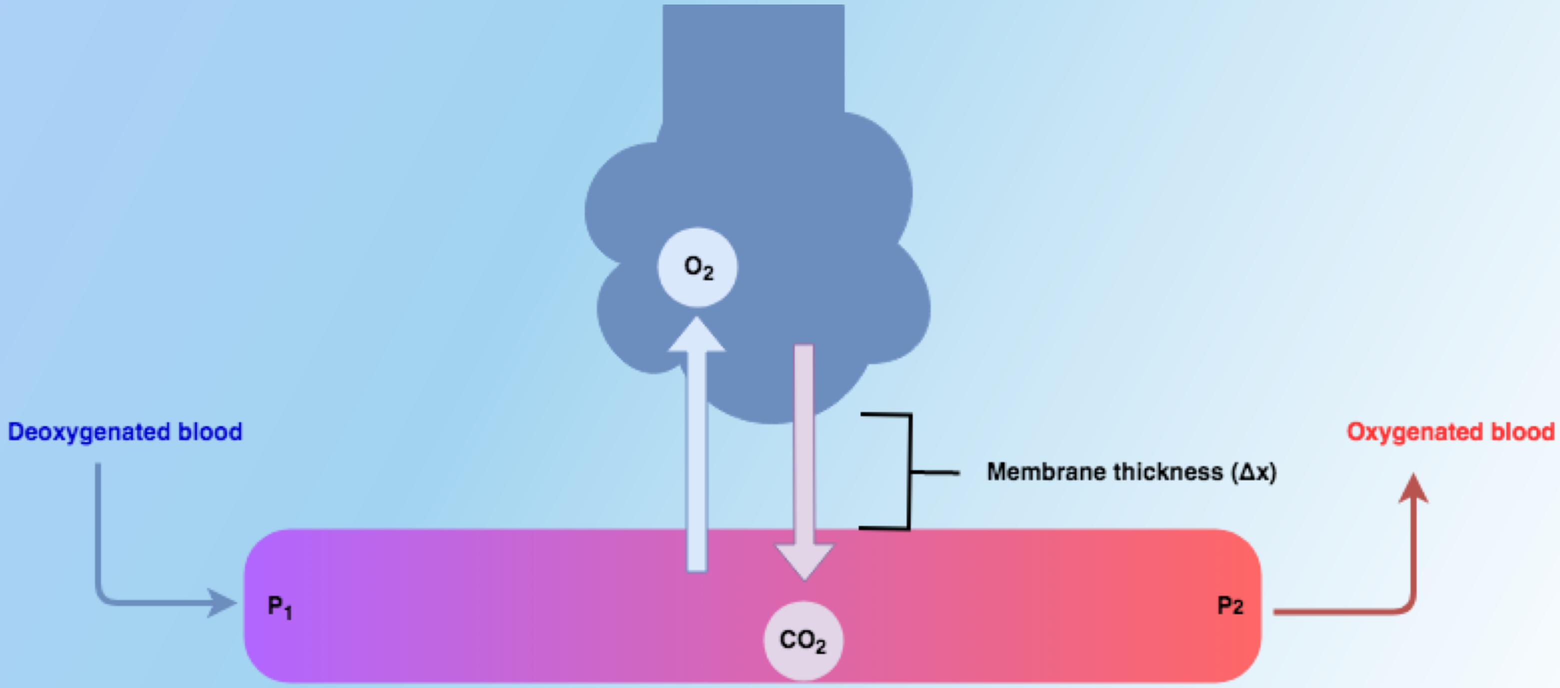
Lung - factors determining diffusion rate

Lung	Abbreviation	Comment
Surface area	A	- Determined by number of alveoli
Membrane thickness	Δx	- Interstitial space



Gas - factors determining diffusion rate

Gas	Abbreviation	Comment
Solubility	S	$CO > CO_2 >> O_2$
Partial pressure gradient	$P_1 – P_2$	



Fick´s law - Equation

$$D = \frac{A \times \Delta P \times S}{\Delta x} \longrightarrow D = \Delta P \times S$$

Which gas will diffuse first? O_2 or CO_2?

O_2

D= ΔP x S

D= (100-40) x 1

D= 60

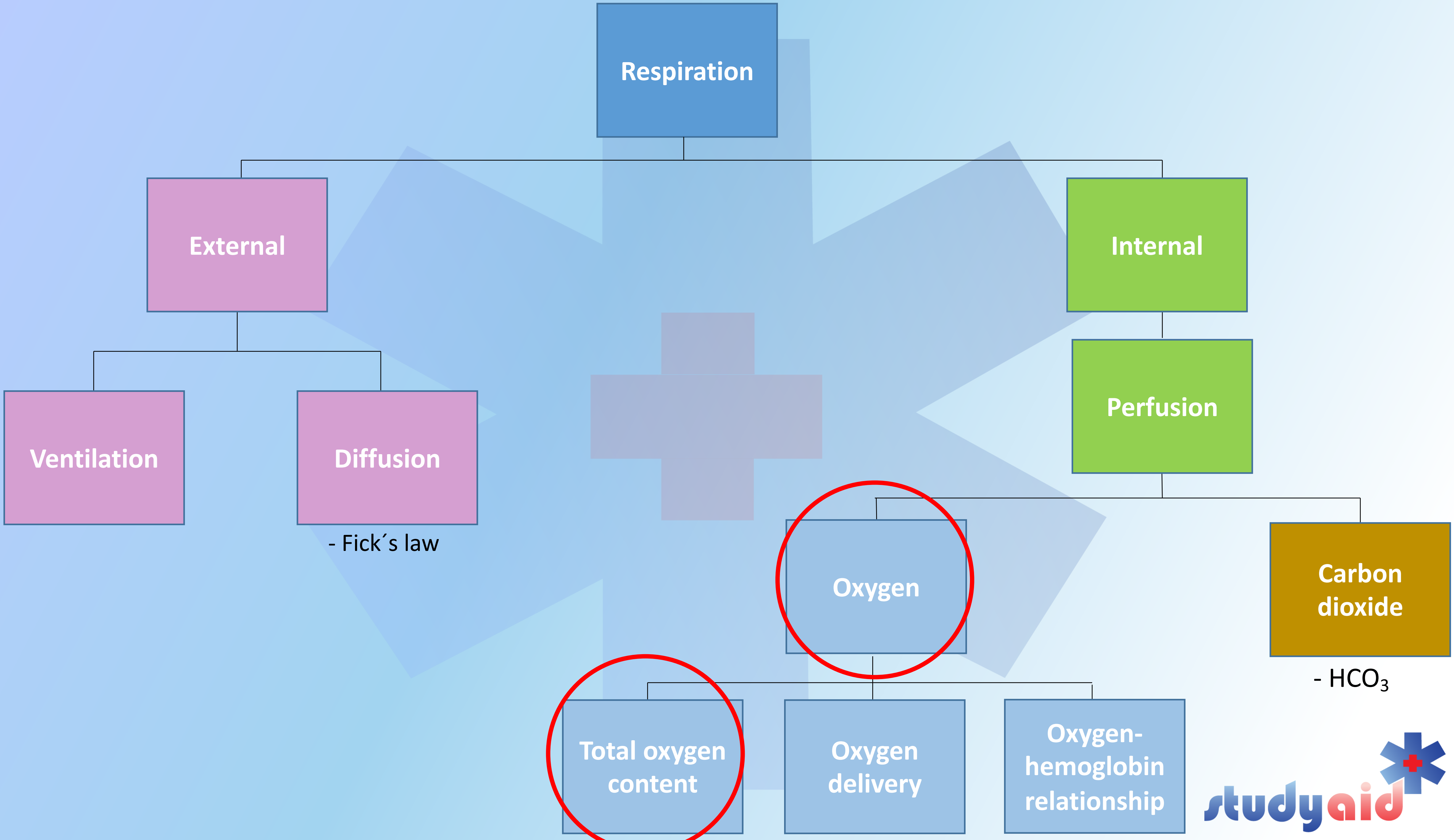
CO_2

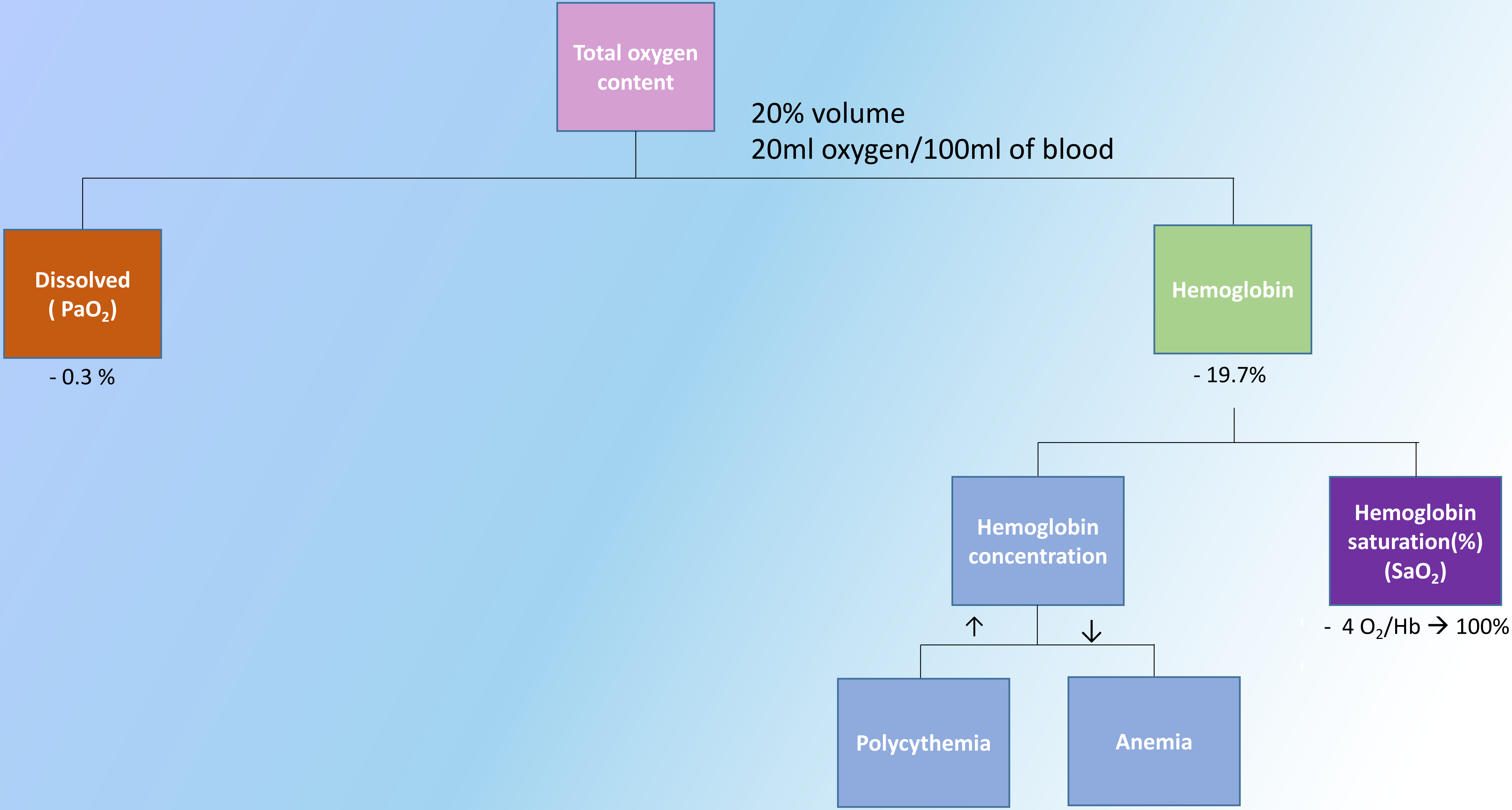
D= ΔP x S

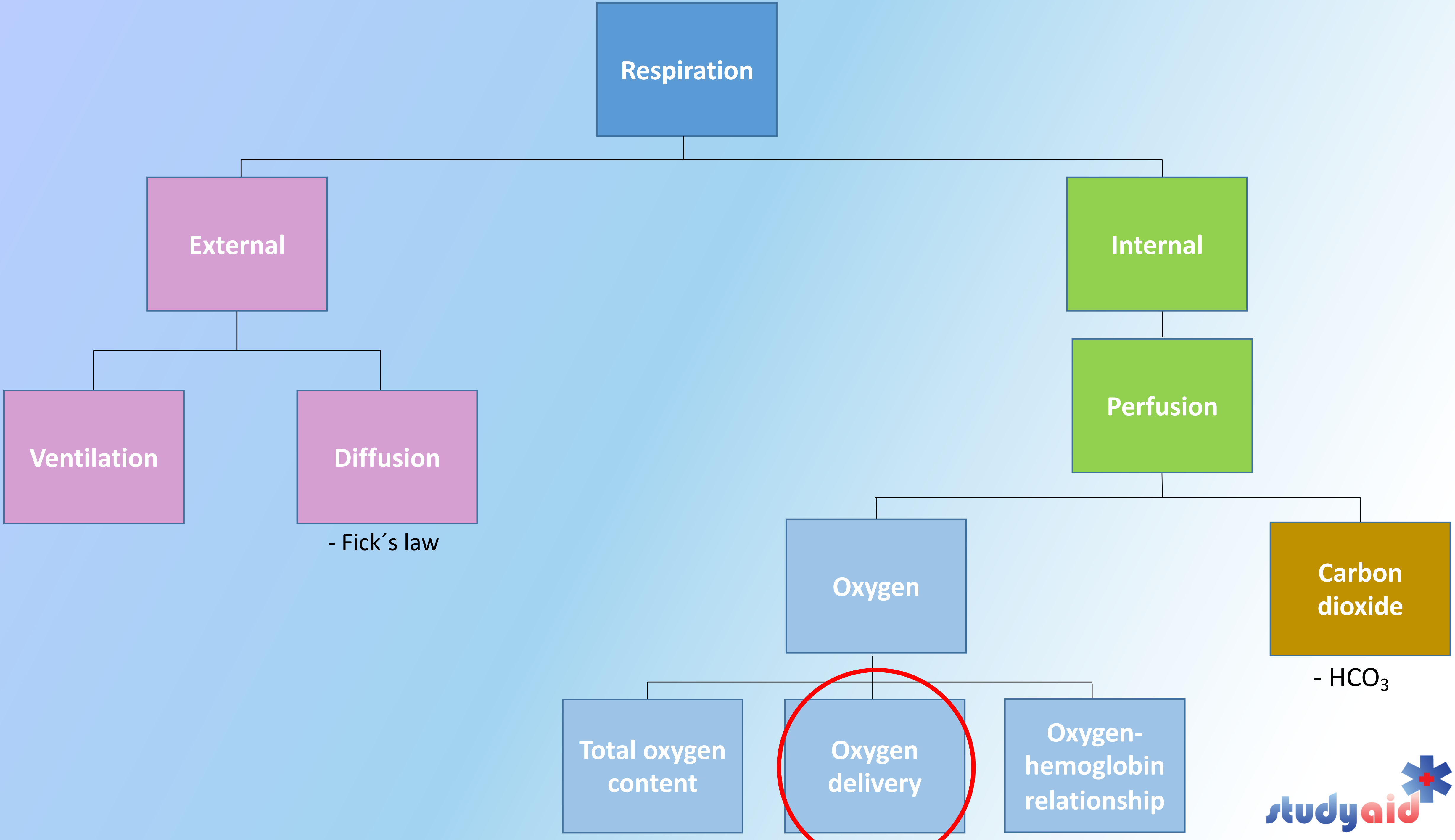
D= (47-40) x 20

D= 140

Even though O_2 has a larger pressure gradient, CO_2 is 20 times more soluble than O_2 → CO_2 will therefore diffuse first!


Respiration
External
Internal
Ventilation
Diffusion
- Fick´s law
Perfusion
Oxygen
Carbon dioxide
- HCO_3
Total oxygen content
Oxygen delivery
Oxygen-hemoglobin relationship
studyaid


Total oxygen content
20% volume
20ml oxygen/100ml of blood
Dissolved (PaO_2)
- 0.3 %
Hemoglobin
- 19.7%
Hemoglobin concentration
↑
↓
Polycythemia
Anemia
Hemoglobin saturation(%) (SaO_2)
- 4 O_2/Hb → 100%



Respiration
External
Internal
Ventilation
Diffusion
- Fick´s law
Perfusion
Oxygen
Carbon dioxide
- HCO_3
Total oxygen content
Oxygen delivery
Oxygen-hemoglobin relationship

Oxygen delivery to the tissues (D_LO_2)

D_LO_2 = **Cardiac output** x **Total oxygen content**

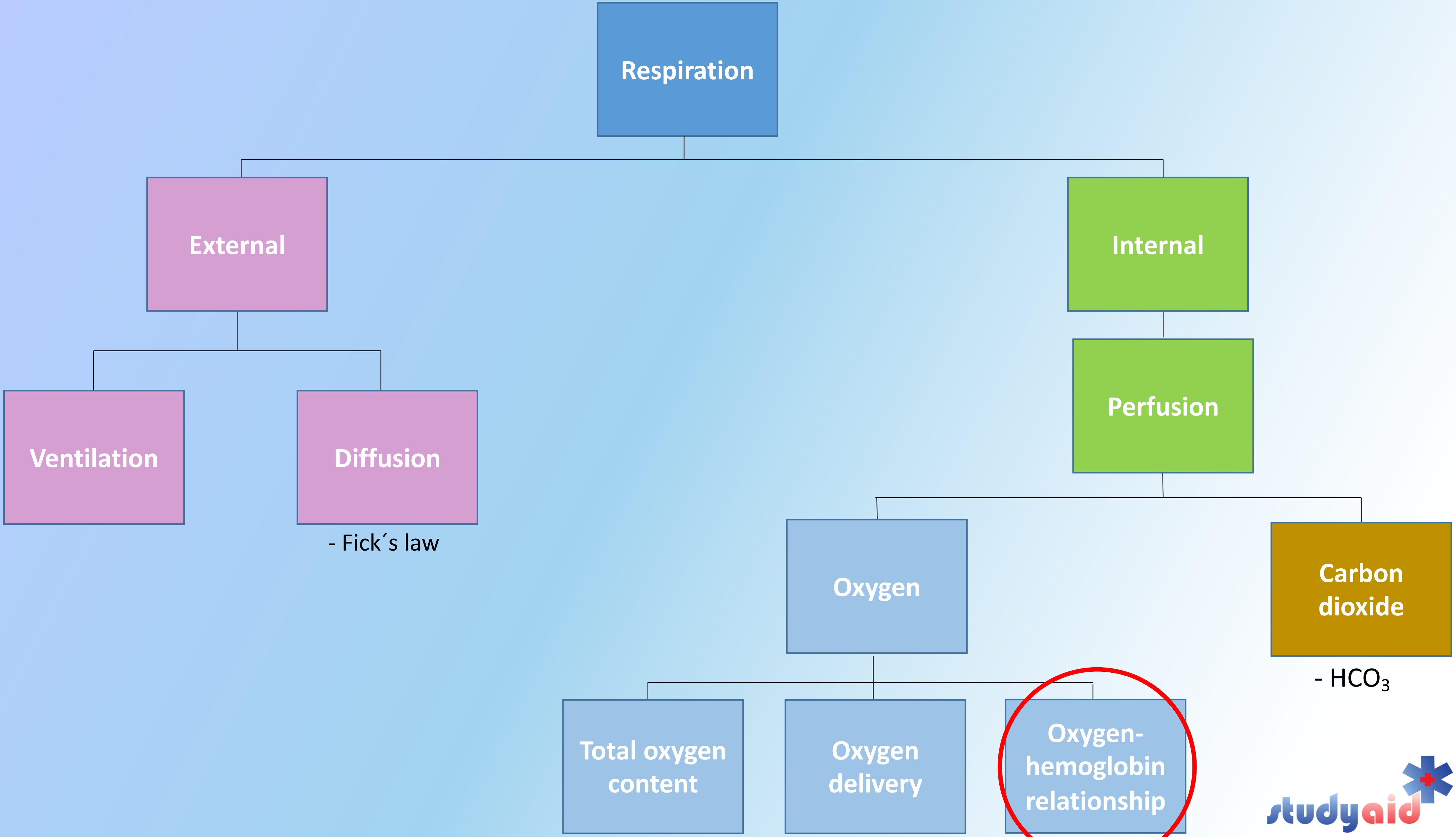
= **Cardiac output** x **Hemoglobin concentration** x **Hemoglobin saturation**

D_LO_2 - Example

- ”How will mild anemia affect the oxygen delivery in a young athlete?”

D_LO_2 = Cardiac outpt x Hemoglobin concentration x Hemoglobin saturation

D_LO_2 = ↑ ↓ ↔


Respiration
External
Internal
Ventilation
Diffusion
- Fick´s law
Perfusion
Oxygen
Carbon dioxide
- HCO_3
Total oxygen content
Oxygen delivery
Oxygen-hemoglobin relationship

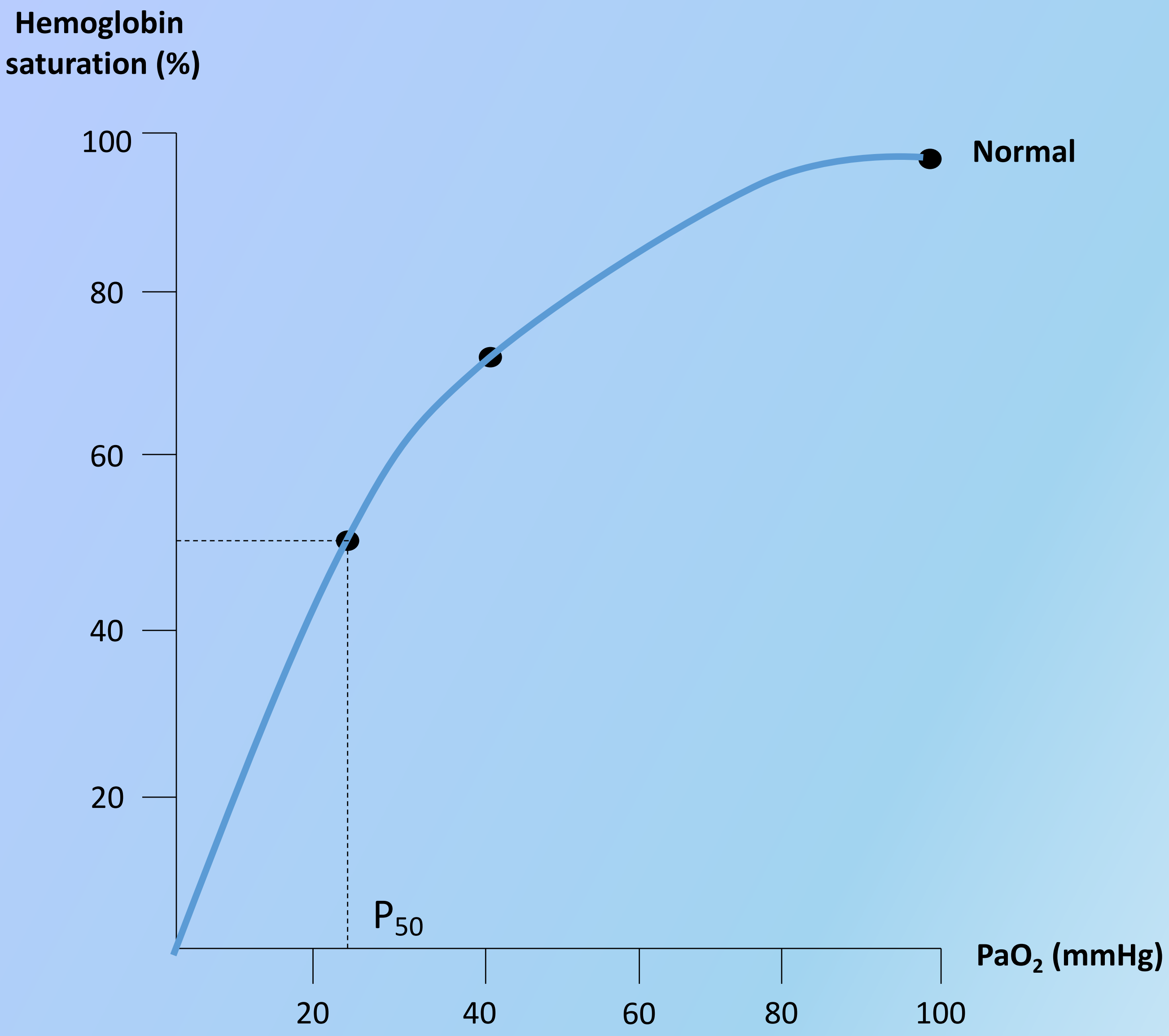
Oxygen-Hemoglobin relationship

PO_2 (mmHg)	Saturation (%)
100	> 97
40	75
25	**50**

→ P_{50}

studyaid

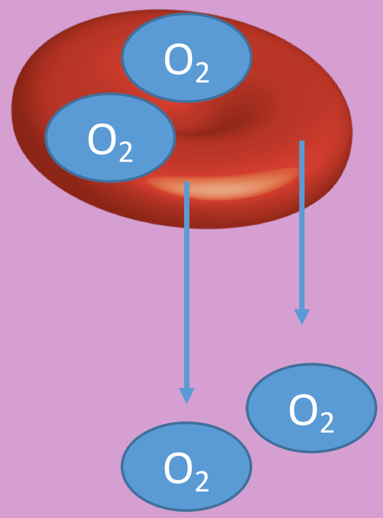
Oxygen – Hemoglobin Dissociation Curve



PO_2 (mmHg)	Saturation (%)
100	> 97
40	75
25	**50**

Decreased affinity of hemoglobin to oxygen

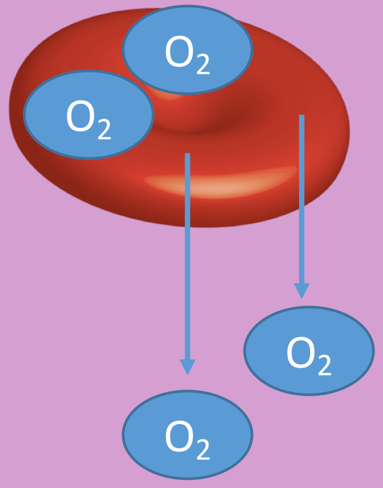
Normal



PaO_2 = 25 mmHg

P_{50} = 25 mmHg

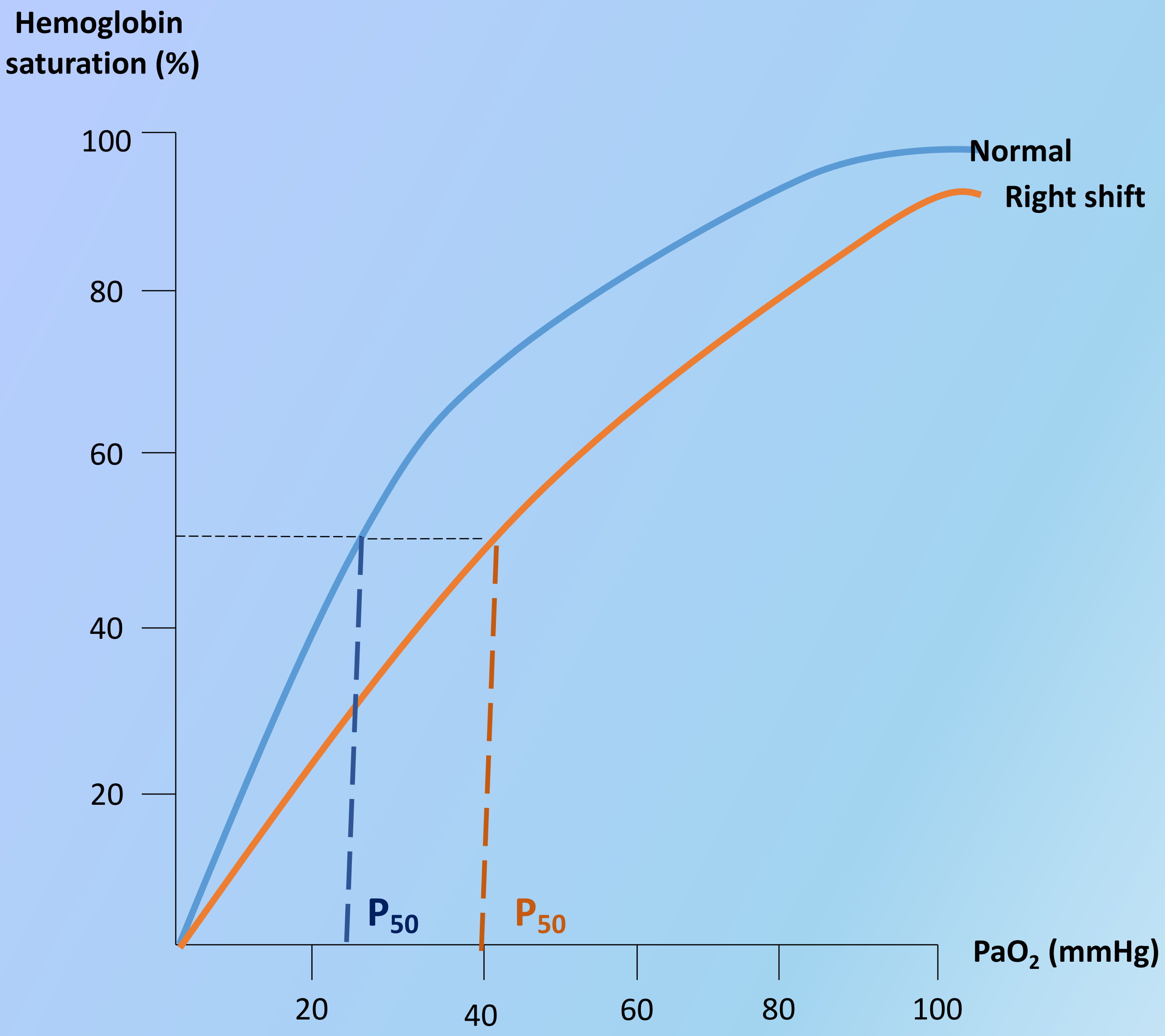
Decreased affinity



PaO_2 = 40 mmHg

P_{50} = 40 mmHg

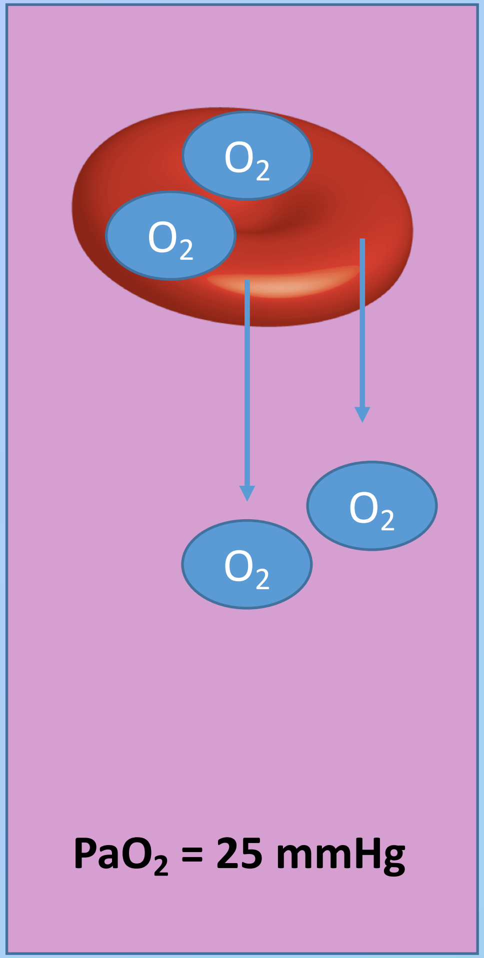
Right shift = Muscle



Right shifts	
Factor	**Comment**
↑PCO_2 and ↑H+ (↓pH) (Bohr effect)	- ↑Metabolic activity - ↑Oxygen demand
↑Temperature	- ↑Metabolic activity - ↑Heat production - ↑Oxygen demand
↑ 2,3-diphosphoglycerate (2,3-DPG)	- Product of RBC glycolysis - Produced during hypoxia

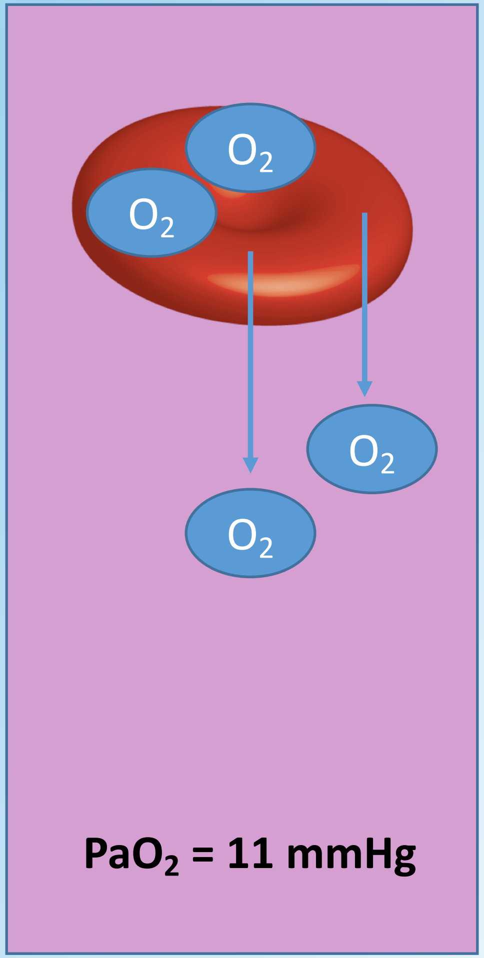
Increased affinity of hemoglobin to oxygen

Normal



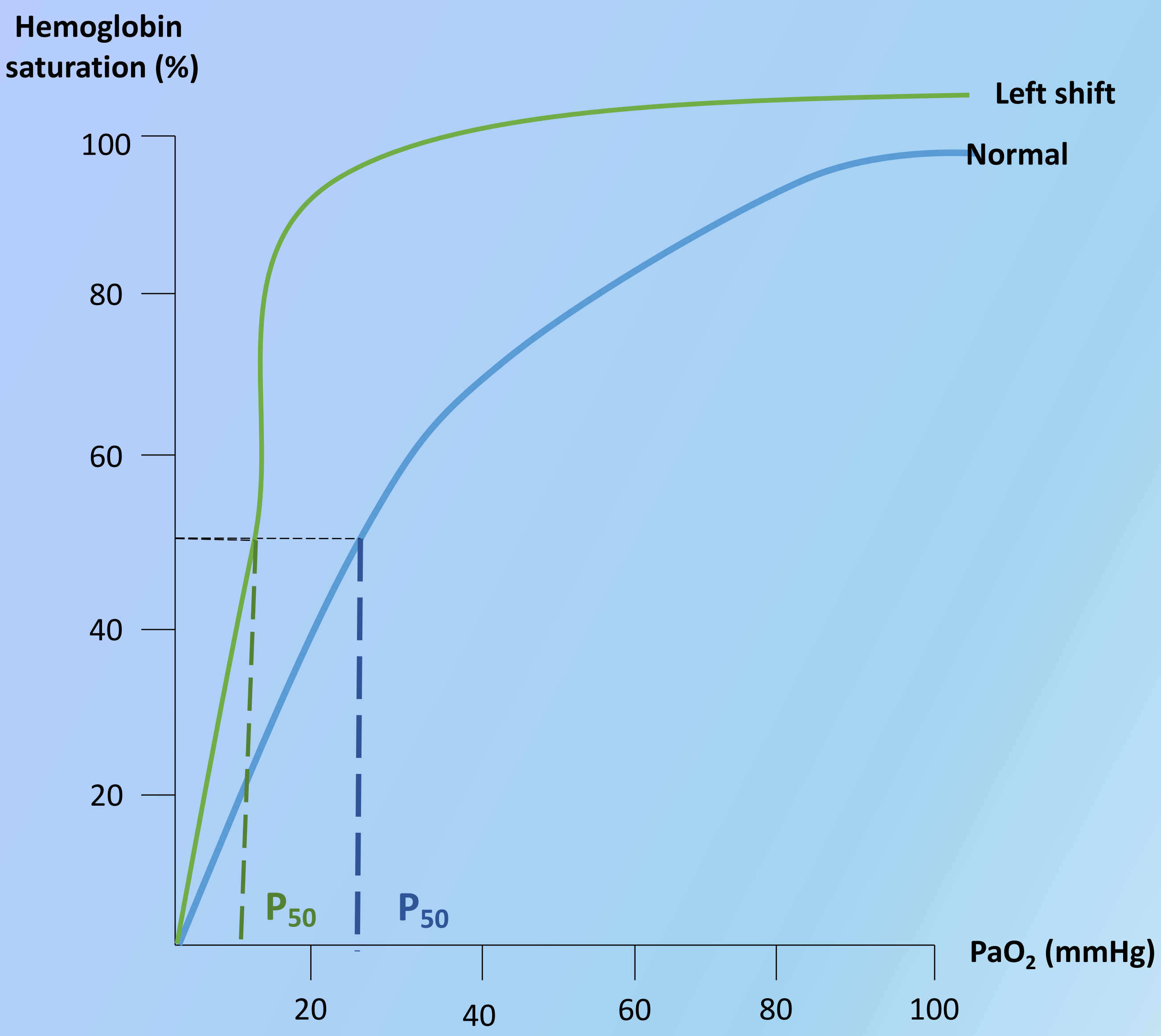
P_{50} = 25 mmHg

Increased affinity



P_{50} = 11 mmHg

Left shift = Pulmonary circulation (after gas exchange)



Left shift	
Variable	**Comment**
↓PCO_2 and ↓H+ (↑pH)	- ↓Metabolic activity - ↓Oxygen demand
↓Temperature	- ↓ Metabolic activity - ↓ Heat production - ↓ Oxygen demand
↓ 2,3-diphosphoglycerate (2,3-DPG)	- ↓ Oxygen demand

Select the correct statement concerning P_{50} when the O_2-hemoglobin dissociation curve is shifted to the right:

- A. It is the same as under normal circumstances
- B. It is increased
- C. It is decreased
- D. P_{50} is a gas transported in blood
- E. Only D is correct

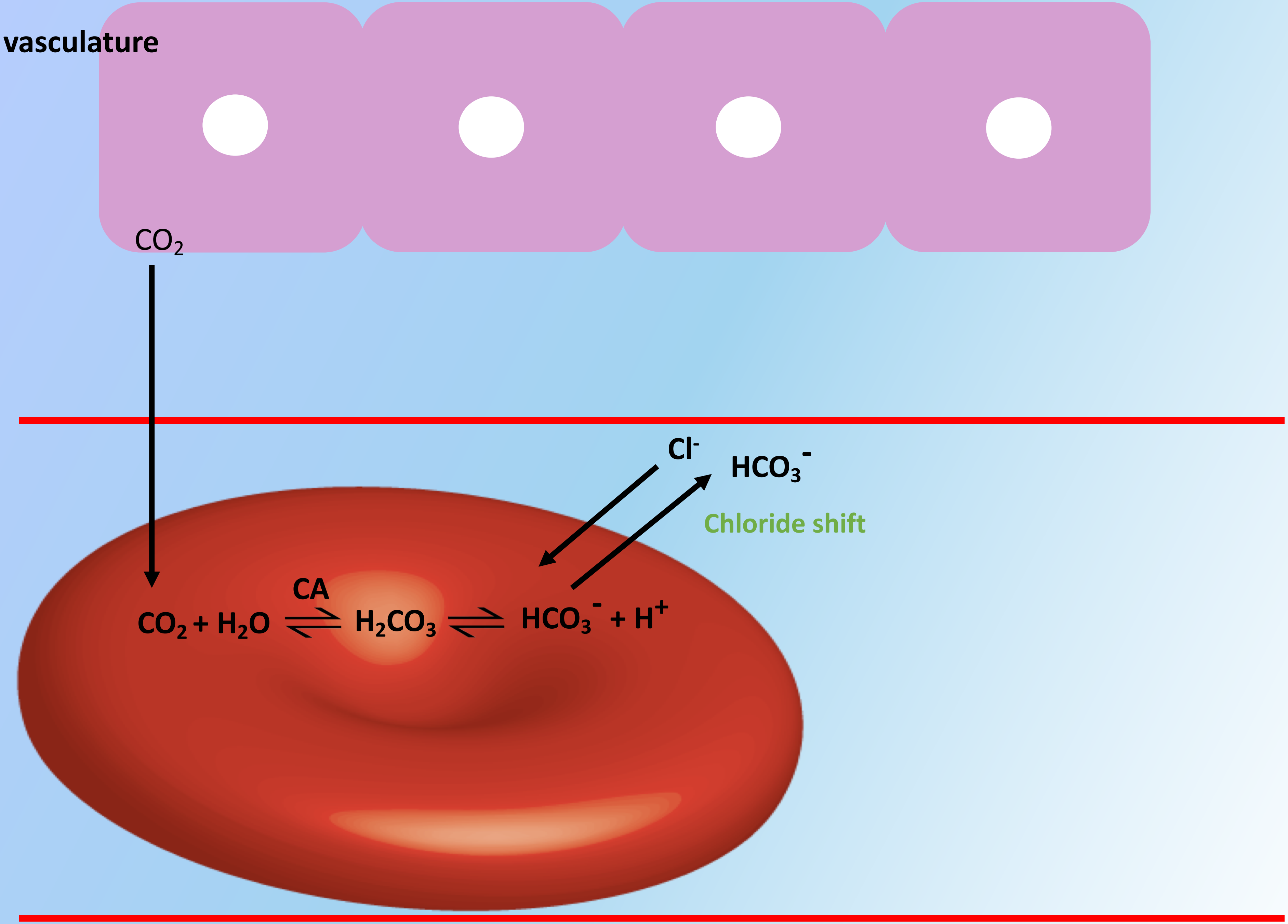
Overview

CO_2 transport

- **Dissolved**
  - Pa_{CO2}
  - 5%
- **Carbamino-hemoglobin**
  - CO_2 - Hb
  - 5 %
- **HCO_3-**
  - 90%

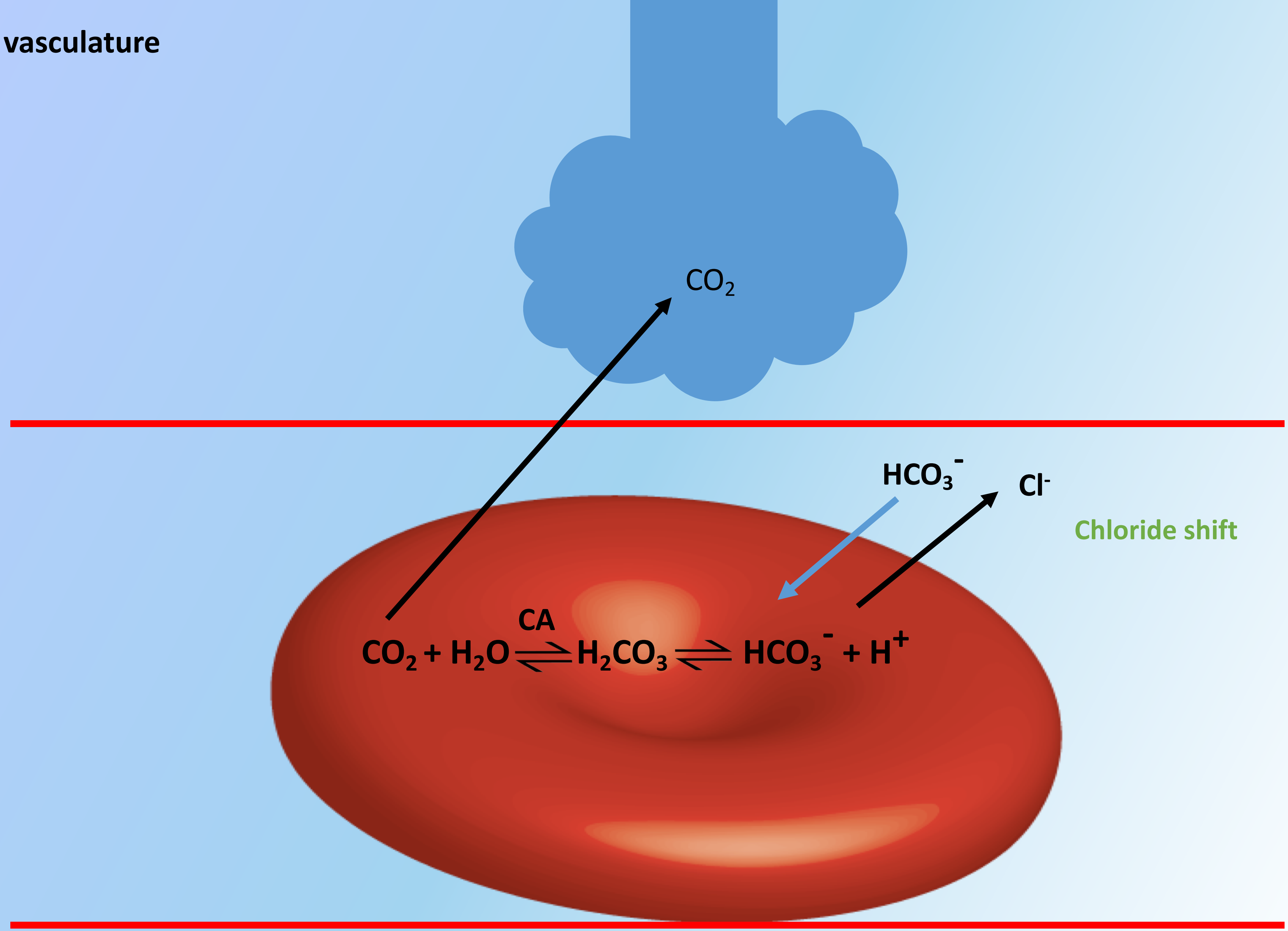
Peripheral vasculature

CA: Carbonic anhydrase



Pulmonary vasculature

CA: Carbonic anhydrase



Most of the CO_2 transported in the blood is:

A. dissolved in plasma
B. in carbamino compounds formed from plasma proteins
C. in carbamino compounds formed from hemoglobin
D. bound to Cl^-
E. Transported as $HCO3^-$