Gas exchange

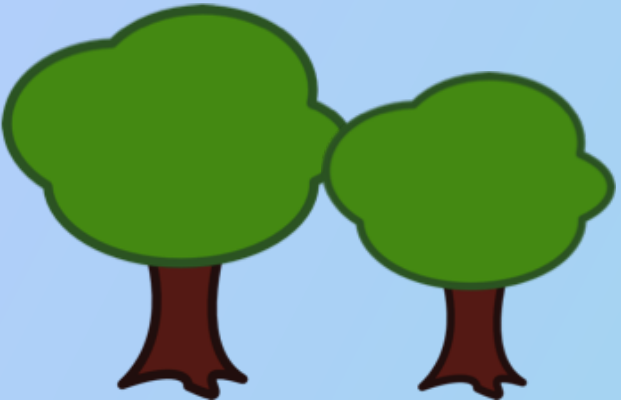
How to express the amount of O_2 and CO_2 present in our airways and blood?

- Partial pressure

Outside

P_{O2}= fO_2x Patm
= 0.21x760

160mmHg



Conducting zone

P_{O2}= fO_2x (Patm-P_{H2O})
Pi =0.21x(760-47)

150mmHg

Respiratory zone

PA_{O2}=Pi- (P_{CO2}/R)
=0.21(760-47)-(40/1)

100mmHg

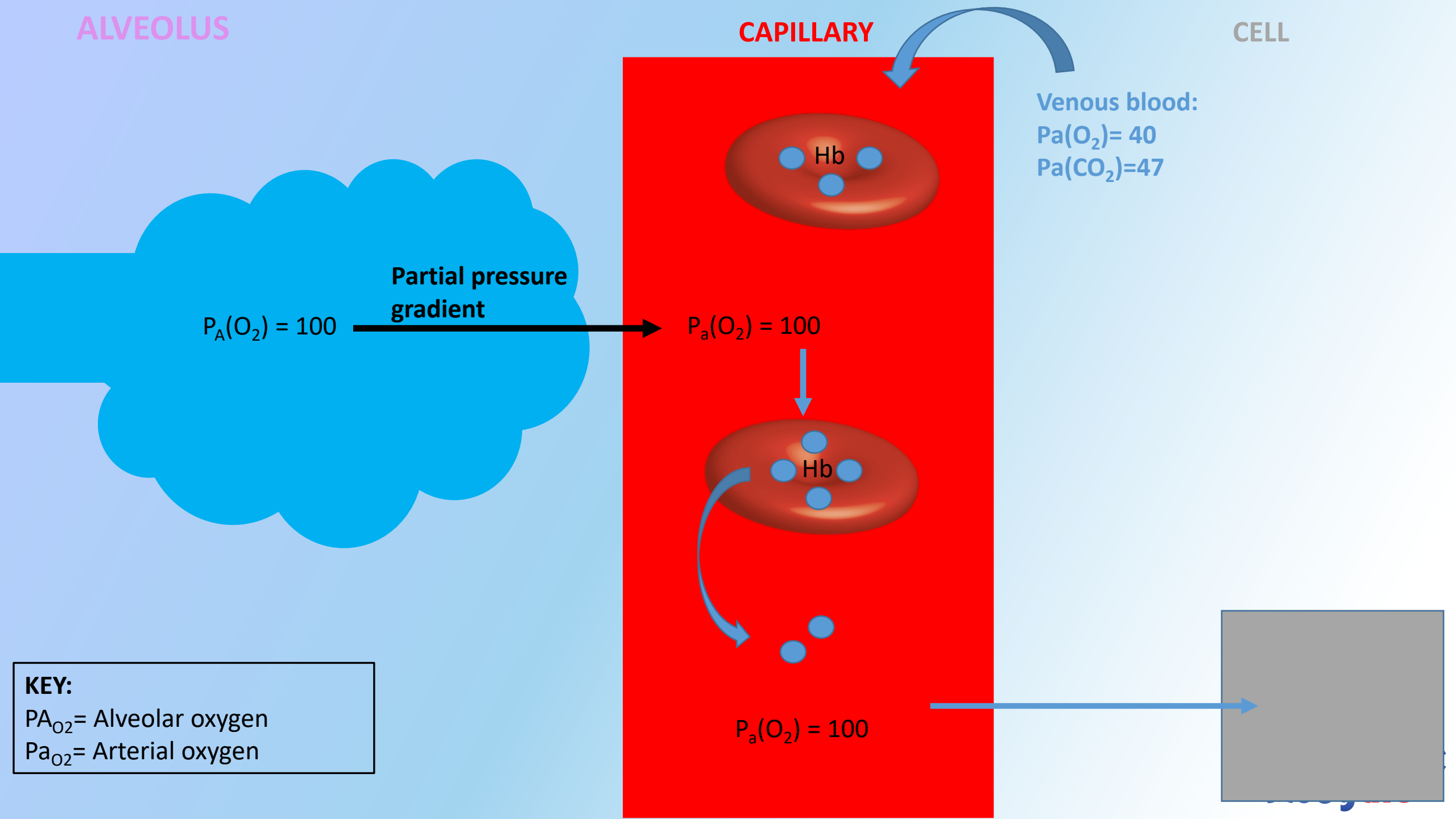
Alveolar oxygen

- Dependent on how much oxygen consumed
- ↑Oxygen consumption → ↓Alveolar oxygen
- Measurement of O_2 consumption → CO_2
- ↑CO_2 → ↑O_2 consumption → ↓Alveolar oxygen

PAO2= Pi – Oxygen consumption

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

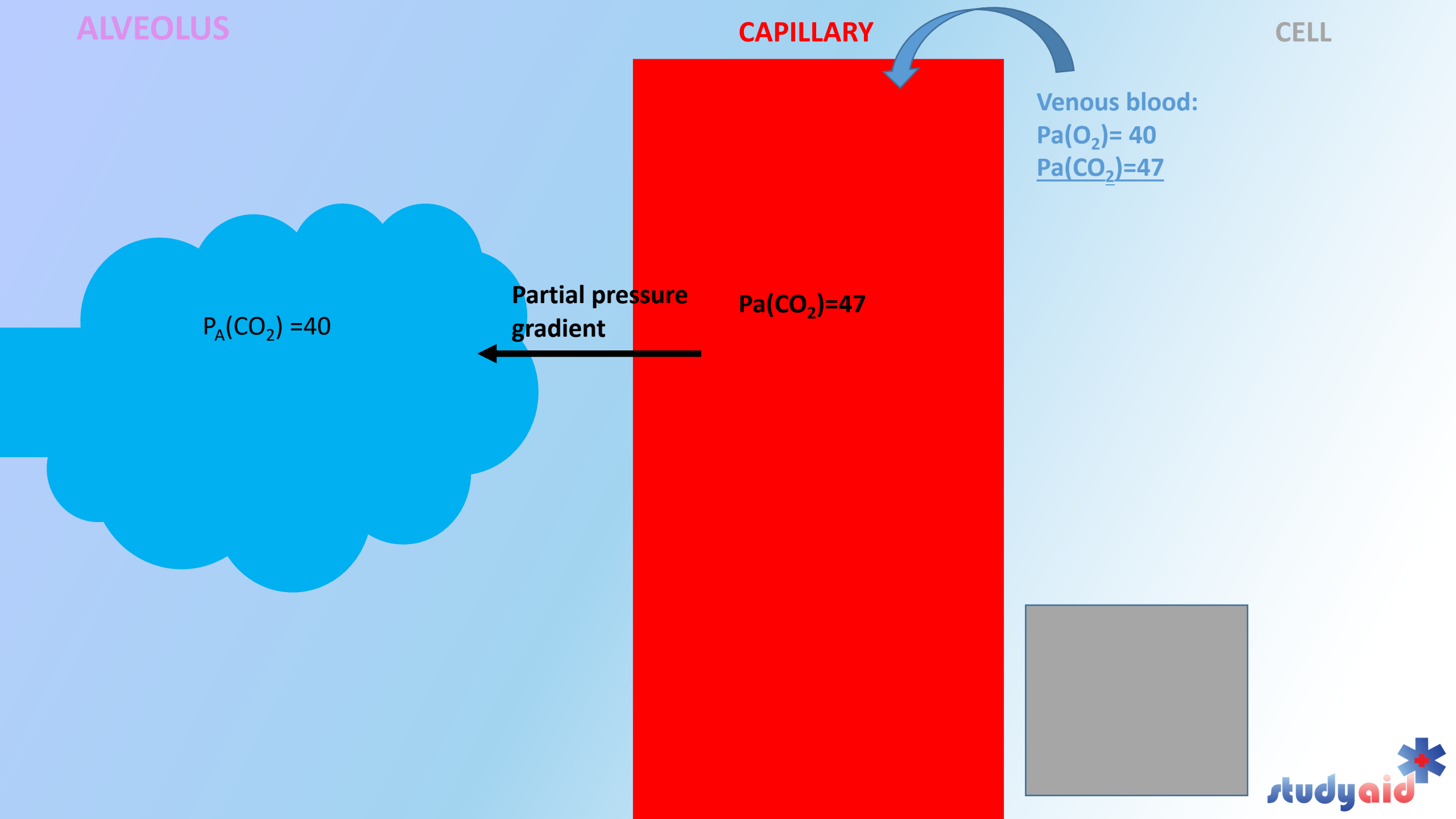
PAO2= Pi-PCO2


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

- Diffusion of gases follow a **pressure gradient**
  - High → Low
- Only gases **dissolved** in **blood** (PaO_2) can participate in the pressure gradient
- Gases bound to hemoglobin does not participate in the pressure gradient

The partial pressure of CO_2 in venous blood entering the lung is 47 mmHg. The partial pressure of CO_2 in the alveoli is 40mmHg. In which direction will CO_2 move?

- A. Into the lung capillaries
- B. It will be transported by active transport into the alveoli
- C. Into the alveoli by passive diffusion 
- D. It will not diffuse at all since the partial pressure of CO_2 in the venous blood and alveoli is at equilibrium


ALVEOLUS
CAPILLARY
CELL
Venous blood:
Pa(O2)= 40
Pa(CO2)=47
PA(CO2) =40
Partial pressure gradient
Pa(CO2)=47

Fick´s 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

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

$$\downarrow$$

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

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

Which gas will diffuse first? O_2 or CO_2?

O_2

D= ΔP x S

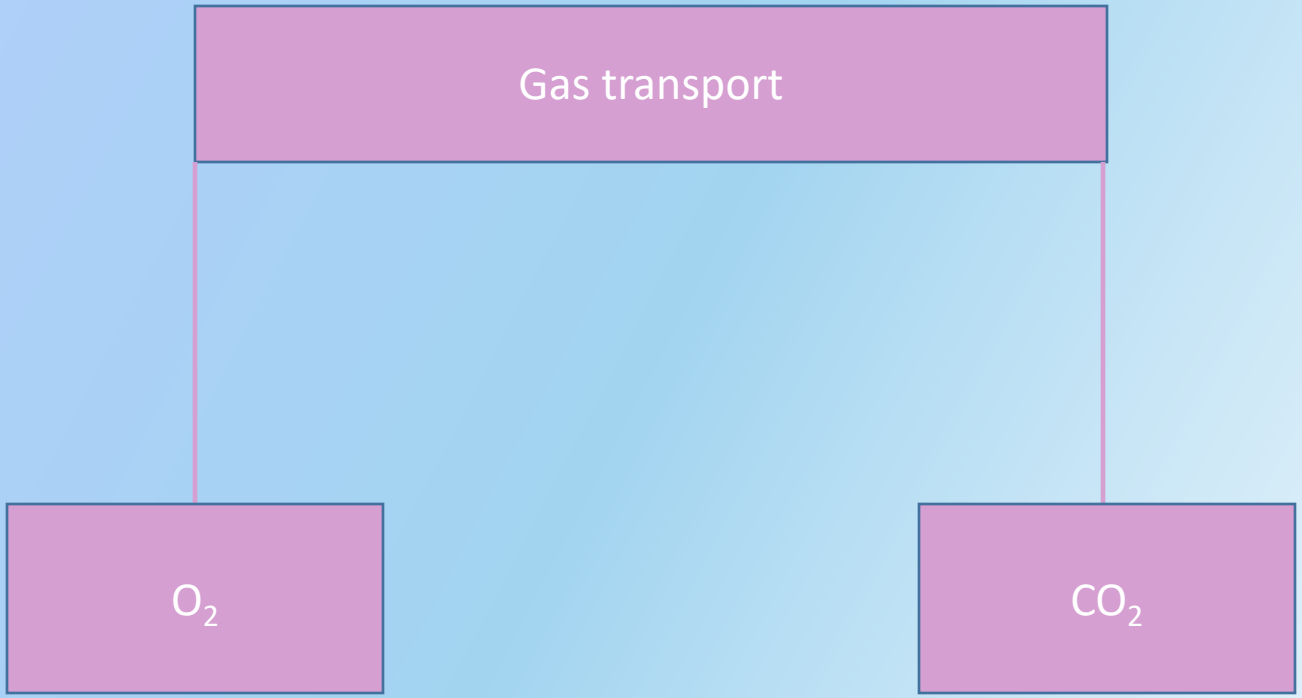
D= (100-40) x 1
D= 60

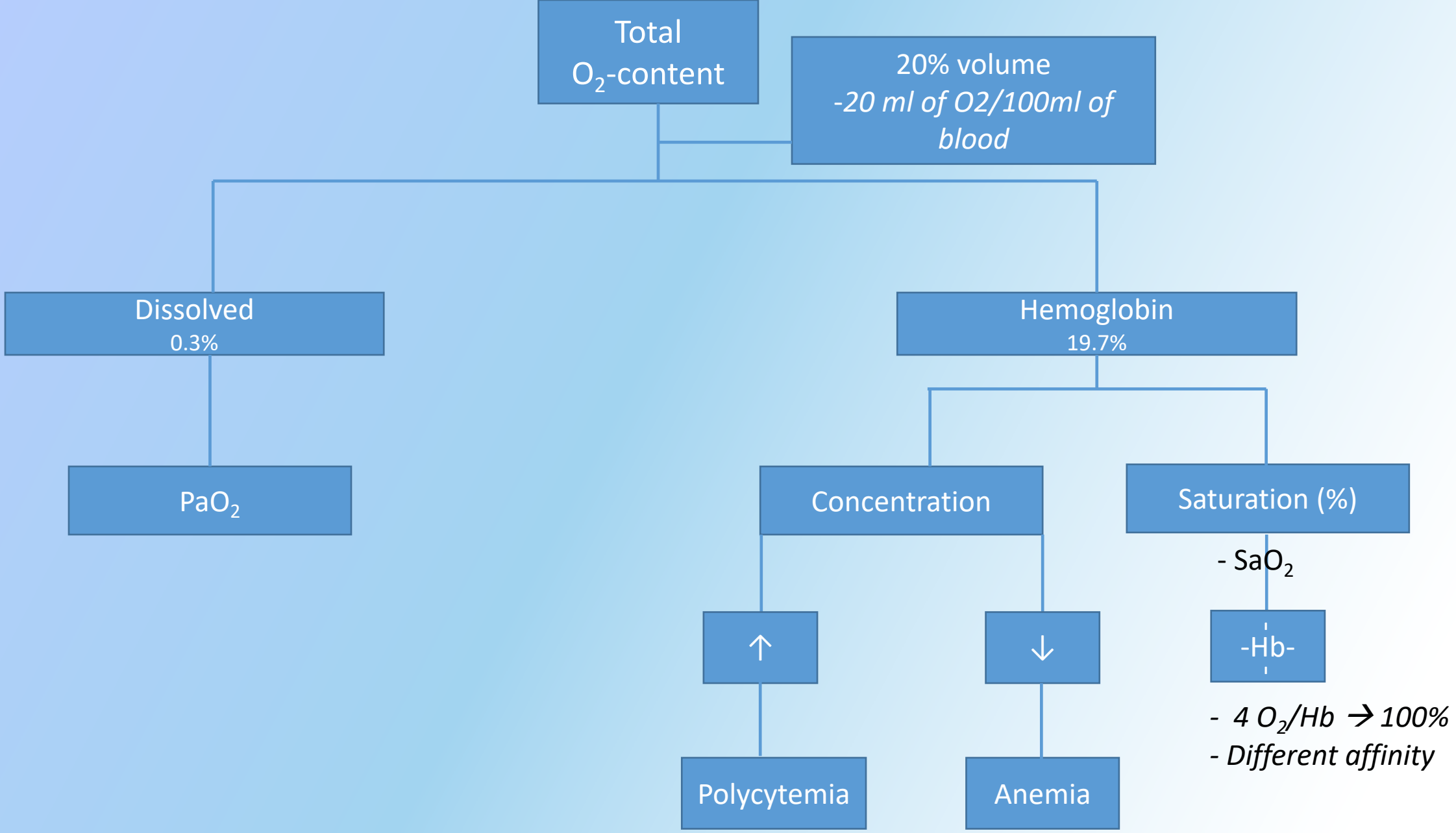
CO_2

D= ΔP x S

D= (47-40) x 20
D= 140

«Even though O2 has a larger pressure gradient, CO2 is 20 times more soluble than O2 → CO2 will therefore diffuse first!»


Gas transport
O_2
CO_2

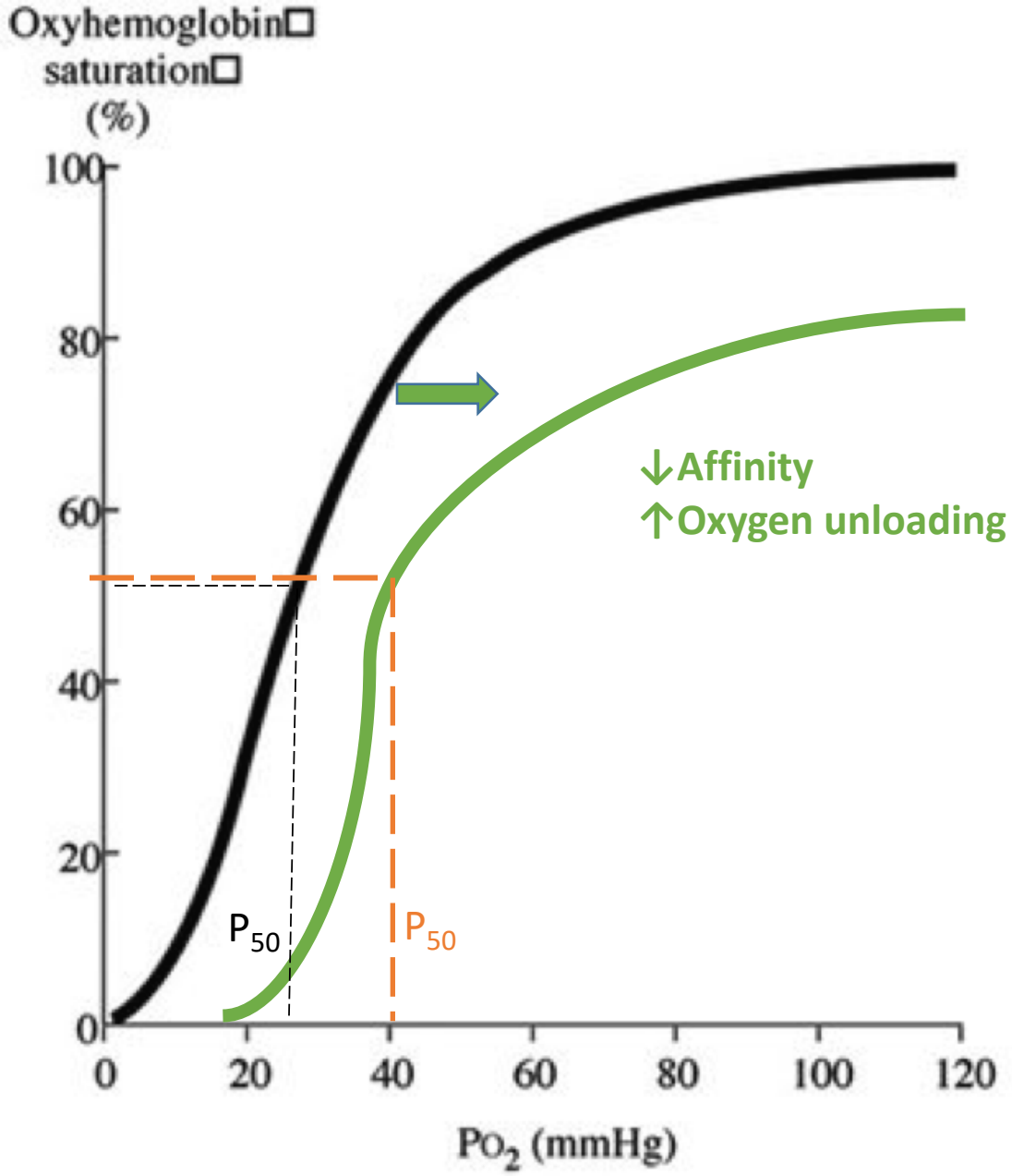

Total O_2-content
20% volume
-20 ml of O2/100ml of blood
Dissolved
0.3%
PaO_2
Hemoglobin
19.7%
Concentration
Saturation (%)
↑
↓
- SaO_2
-Hb-
- 4 O_2/Hb → 100%
- Different affinity
Polycytemia
Anemia

O_2-binding capacity

PO_2 (mmHg)	Saturation (%)
100	>97
80	96
60	90
50	85
40	75
25	**50**
20	35

→ P_{50}

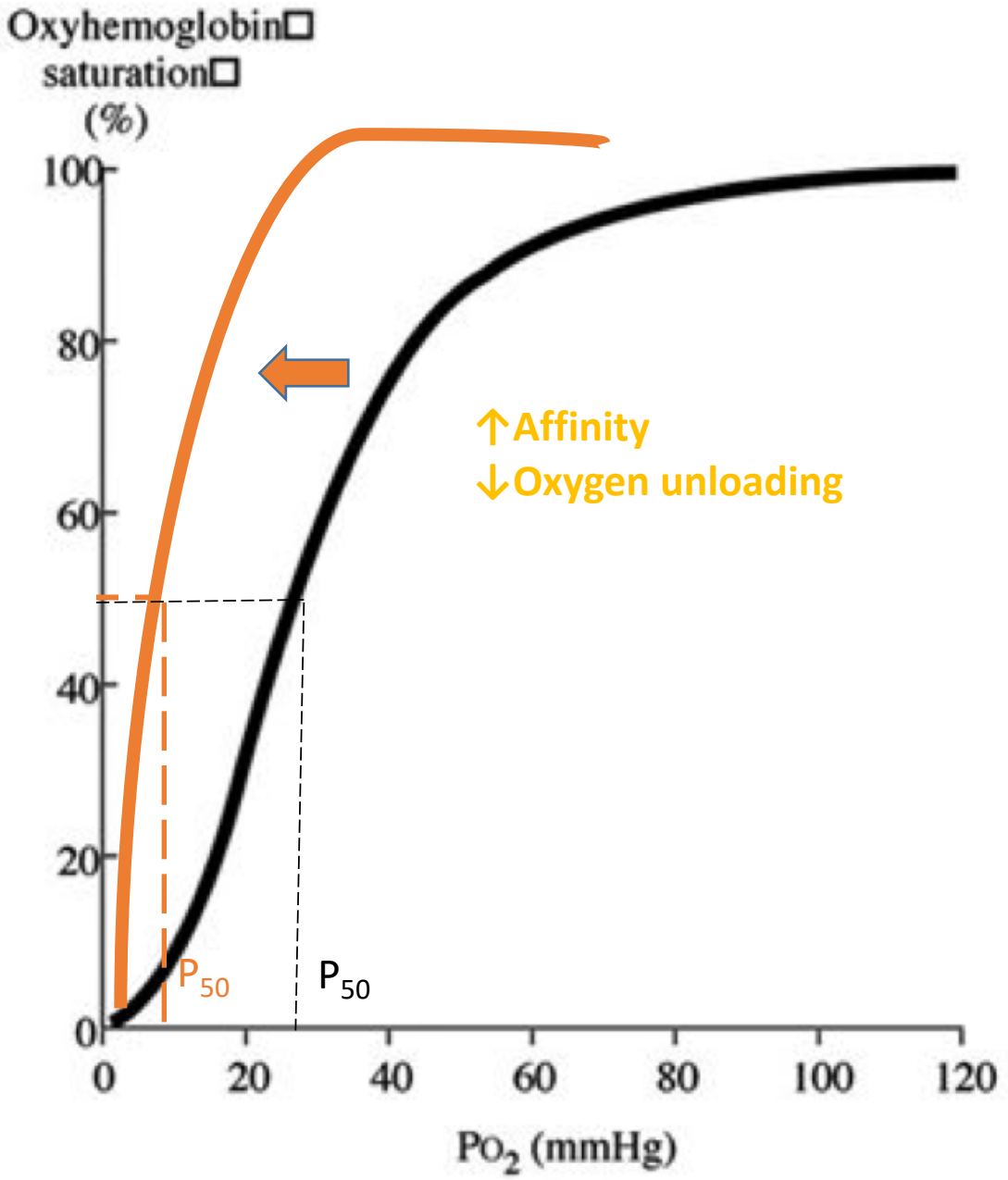
O2-Hemoglobin Dissociation Curve



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

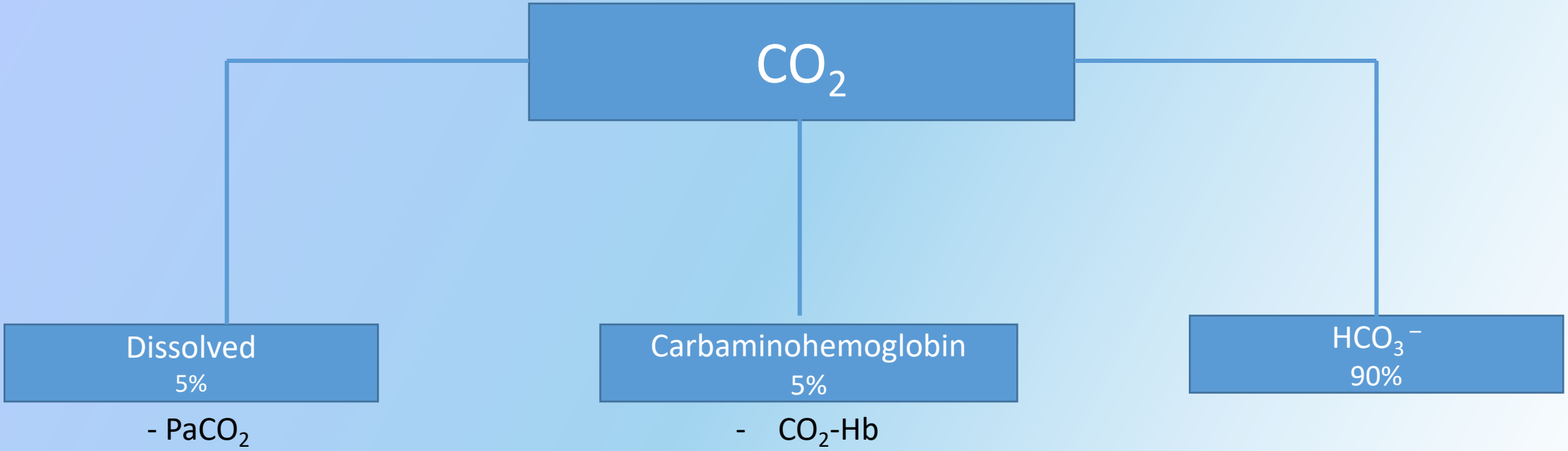
O2-Hemoglobin Dissociation Curve



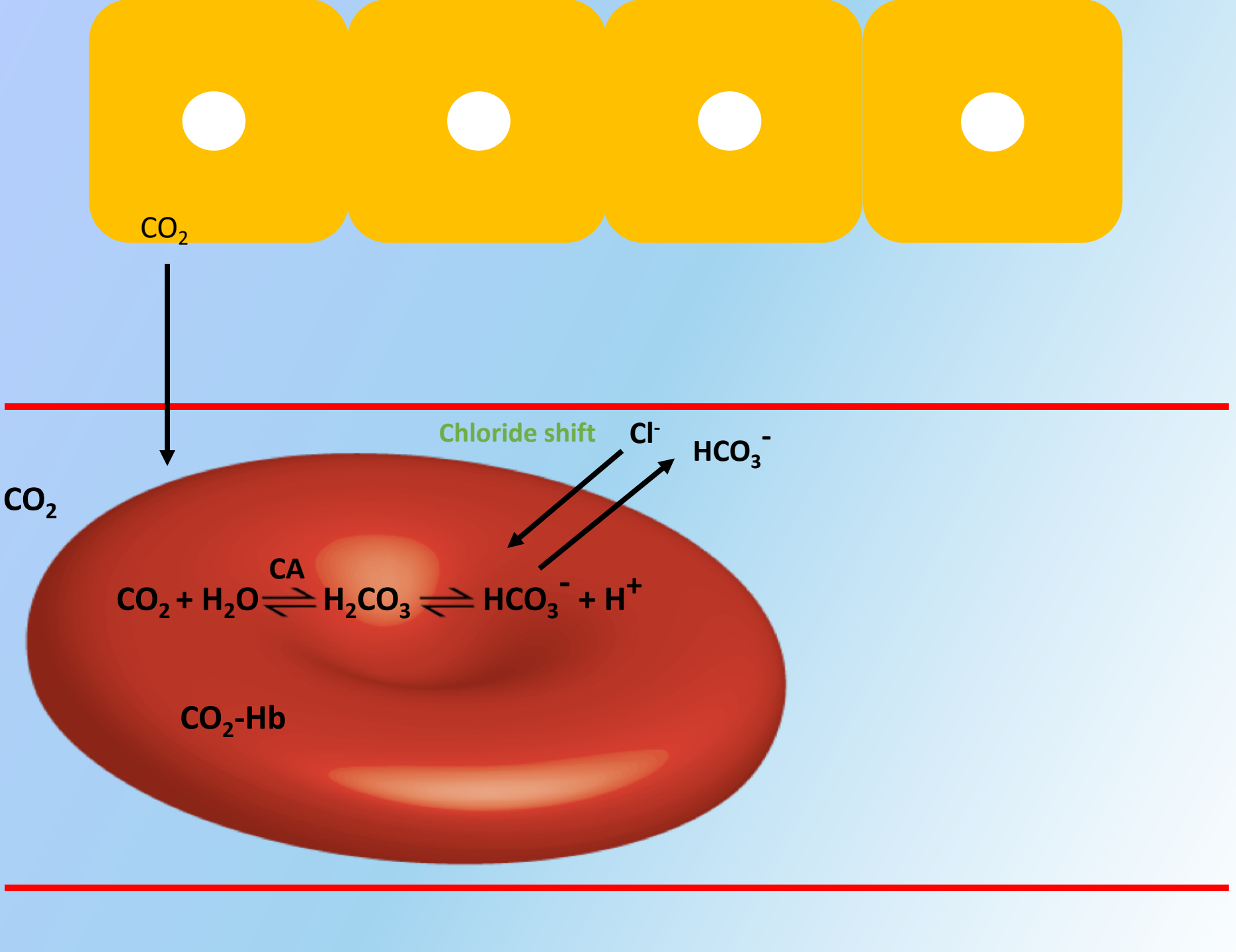
Left shifts	
Factor	**Comment**
↓PaCO2, ↓H+ (↑pH)	- ↓Tissue metabolism - ↓Oxygen demand
↓Temperature	- ↓Tissue metabolism - ↓Heat production - ↓Oxygen demand
↓2,3-diphosphoglycerate (2,3-DPG)	
Hemoglobin F	- ↑Oxygen affinity
CO	- ↑Oxygen affinity

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


CO_2
Dissolved
5%
- $PaCO_2$
Carbaminohemoglobin
5%
- CO_2-Hb
HCO_3^-
90%

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. in HCO_3^-