TRANSPORT OF OXYGEN AND CARBON DIOXIDE

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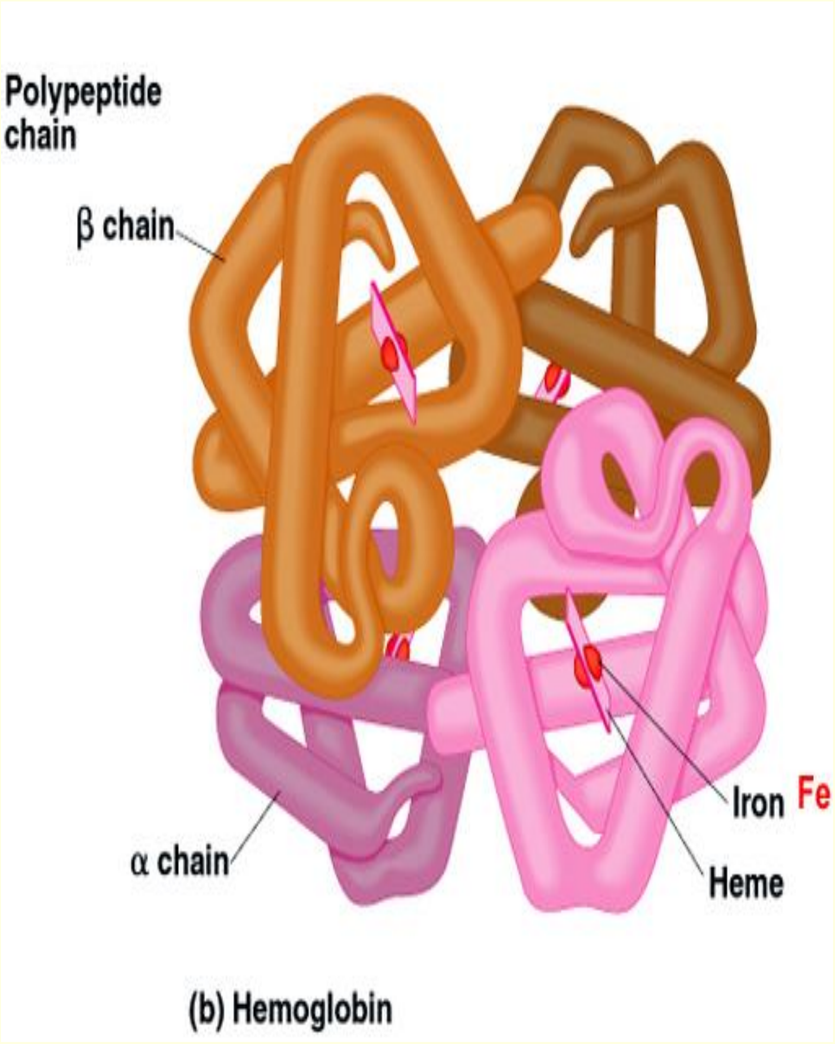
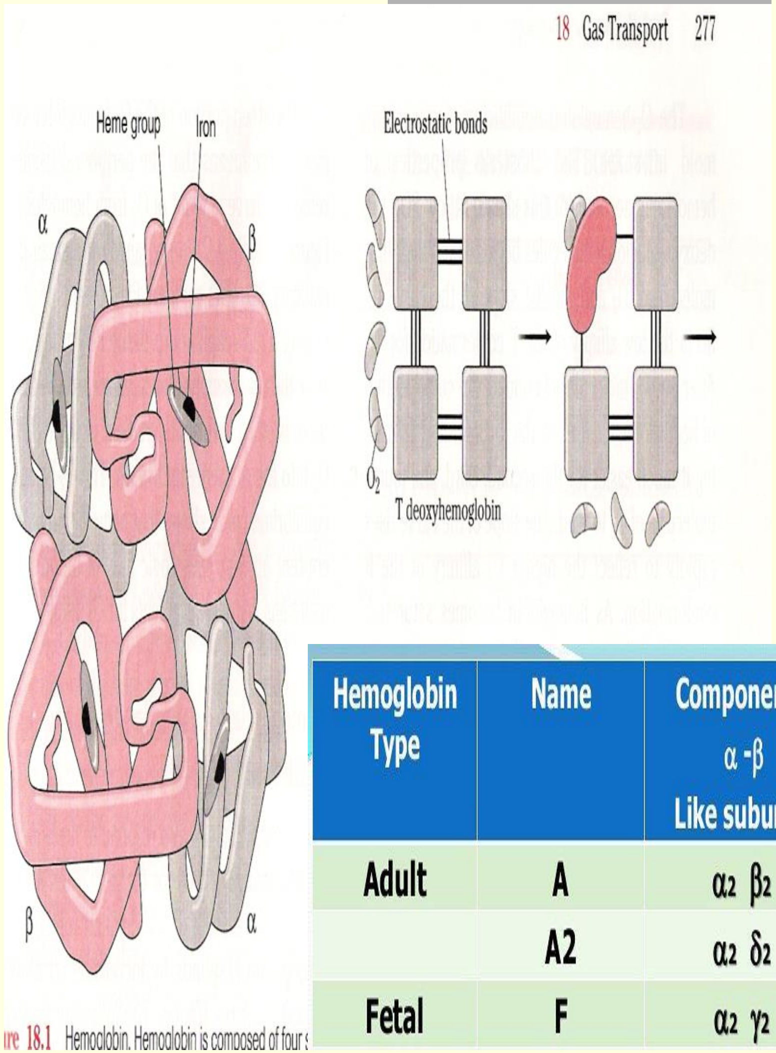
HEMOGLOBIN



(b) Hemoglobin



re 18.1 Hemoglobin. Hemoglobin is composed of four s

Hemoglobin Type	Name	Component α -β Like subunit
Adult	A	α_2 β_2
	A2	α_2 δ_2
Fetal	F	α_2 γ_2

HEMOGLOBIN

Oxygen molecule combines loosely and reversibly with the heme portion of hemoglobin.

When Po_2 is high, as in the pulmonary capillaries, oxygen binds with the hemoglobin.

when Po_2 is low, as in the tissue capillaries, oxygen is released from the hemoglobin.

HEMOGLOBIN

- Oxyhemoglobin:
  - Normal heme contains iron in the reduced form (Fe^{2+}).
  - Fe^{2+} shares electrons and bonds with oxygen.
- Deoxyhemoglobin:
  - When oxyhemoglobin dissociates to release oxygen, the heme iron is still in the reduced form.

HEMOGLOBIN

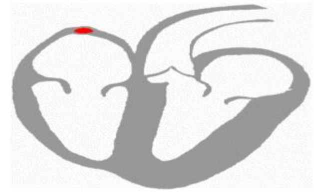
- Methemoglobin:
  - Has iron in the oxidized form (Fe^{3+}).
    - Lacks electrons and cannot bind with 0_2.
    - Blood normally contains a small amount.

- Carboxyhemoglobin:
  - The reduced heme is combined with carbon monoxide.
  - The bond with carbon monoxide is **210** times stronger than the bond with oxygen.
  - Transport of 0_2 to tissues is impaired.

HEMOGLOBIN

- Oxygen-carrying capacity of blood determined by its [hemoglobin].
  - Anemia:
    - [Hemoglobin] below normal.
  - Polycythemia:
    - [Hemoglobin] above normal.
  - Hemoglobin production controlled by erythropoietin.
    - Production stimulated by P_{C0_2} delivery to kidneys.
- Loading/unloading depends:
  - P_{0_2} of environment.
  - Affinity between hemoglobin and 0_2.

TRANSPORT OF O2



Transport of respiratory gases between the lungs and body tissues is the main function of blood.

- 97 % of the oxygen transported from the lungs to the tissues is carried in chemical combination with hemoglobin
- 3 % is carried by physically being dissolved in plasma.

$$Hb + 4O_2 \rightarrow Hb(O_2)_4$$

TRANSPORT OF O2

Transport of O_2 by haemoglobin: Hb combines with oxygen the compound formed is called oxyhaemoglobin.

The amount of O_2 carried in the blood in oxyhaemoglobin depends on the amount of Hb present in the blood.

The normal amount of Hb in young adults is about 16 gm/dl of the blood. Each gram of Hb can bind with 1.34 ml of O_2. Thus, if a person has a Hb is 16 gm/dl of blood his blood can carry

16 x 1.34 = 21.44 ml of O_2/dl.

TRANSPORT OF O2

The haem part of the hemoglobin contains 4 atoms of iron, each capable of combining with a molecule of oxygen. Oxygen can combine loosely and reversibly with hemoglobin.

- $Hb + O_2 \qquad HbO_2$

The important factor which determines how much oxygen combines with Hb when the haemoglobin (deoxygenated Hb) is converted to HbO_2, is the PO_2. When the PO_2 is high, it binds with Hb, but when the PO_2 is low O_2 is released from Hb.

TRANSPORT OF O2

Partial Pressure Difference

1. High Partial Pressure of O_2 (Po_2)in Alveoli
2. Low Po_2 in Capillary

- Concentration Gradient

1. High Concentration of O_2 in Alveoli
2. Low Concentration of O_2 in Capillary O_2

TRANSPORT OF O2

- Diffusion Difference-Very Short
- O_2 Diffusion-Very Rapid
- O_2 Diffuses from Alveoli Into RBC
- Attaches to Heme Molecule→HbO
- Carried To Tissues

TRANSPORT OF CO2

- Large amount of CO_2 is continuously produced in the body. Under normal resting conditions each 100 ml of deoxygenated blood contains 4 ml of CO_2 which is carried in the blood in three forms:
- 70% of CO_2 is transported in bicarbonate form.
- 23% combines with the globin part of haemoglobin to form carbamino haemoglobin
- 7% is dissolved in plasma

TRANSPORT OF CO2

Transport of CO_2 dissolved in plasma: Little carbon dioxide is transported in the dissolved state to the lungs. PCO_2 of venous blood is 45 mm Hg and the PCO_2 of arterial blood is 40 mmHg. The amount of CO_2 dissolved in the blood at 45 mmHg is 2.7 ml/dl (2.7%). The amount of CO_2 dissolved at 40 mmHg is about 2.4 ml. The difference between 2.7 and 2.4 is only 0.3 ml.

About 0.3 ml CO_2 is transported in the form of dissolved CO_2 by each 100 ml of blood. It is about 7 % of all CO_2 is transported in this form.

TRANSPORT OF CO2

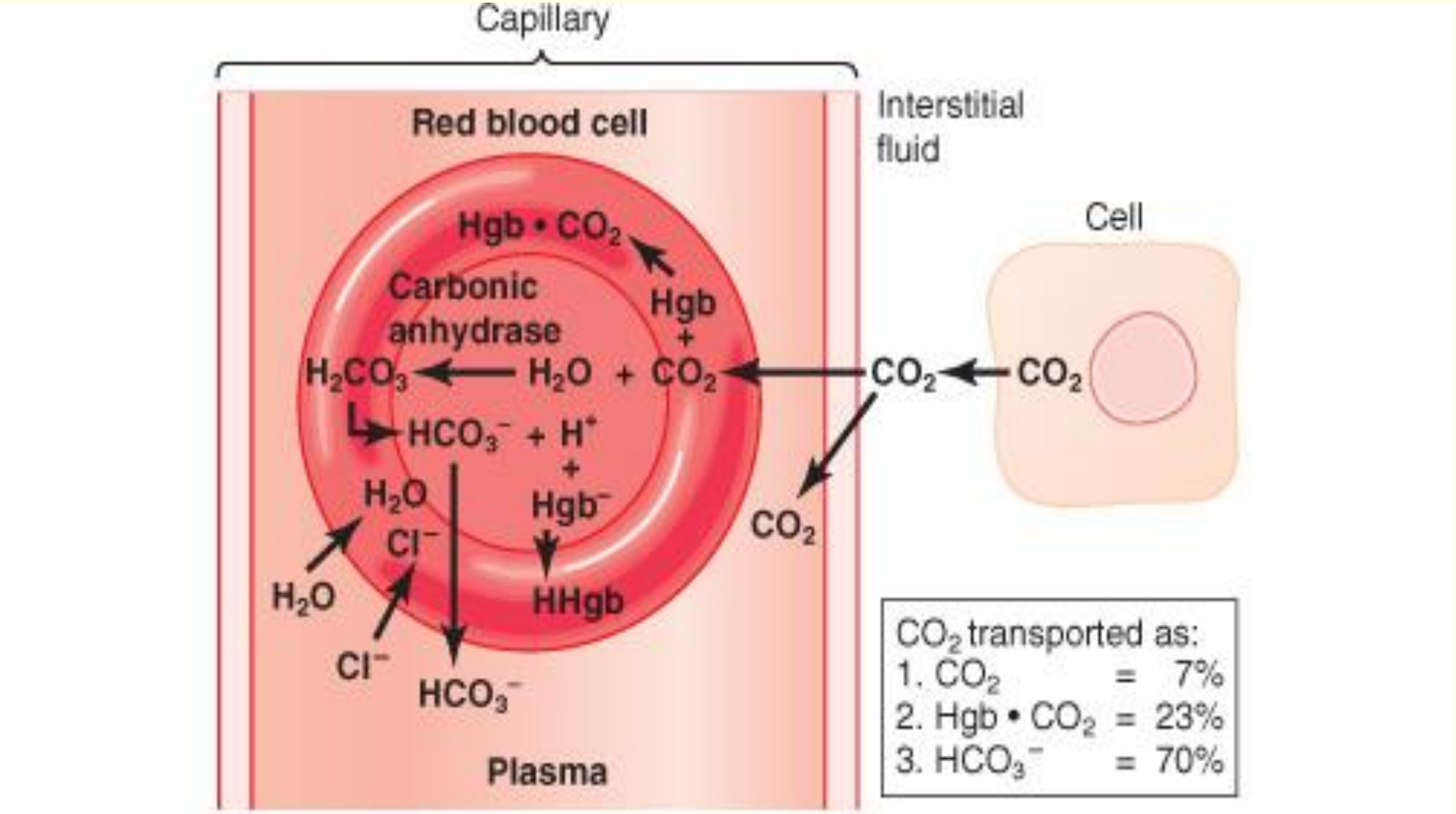
- Transport of CO_2 in Bicarbonate form: As CO_2 diffuses into the tissue capillaries it then enters the red blood cells. CO_2 reacts with water to form carbonic acid in the presence of carbonic anhydrase enzyme. This enzyme accelerates the reaction 4800 times more, so it occurs within a fractions of second. The carbonic acid is then dissociated into hydrogen ions (H^+) and bicarbonate ions. Hydrogen ions combine with haemoglobin to form H,Hb, and the bicarbonate ions (HCO_3^-) leave RBCs and enter the plasma. To maintain the negativity of RBCs, chloride ions (Cl^-) enter from the plasma into the RBCs. The exchange of bicarbonate ions from RBCs to plasma and Cl^- ions from plasma to RBCs is called the bicarbonate chloride shift phenomenon.

TRANSPORT OF CO2

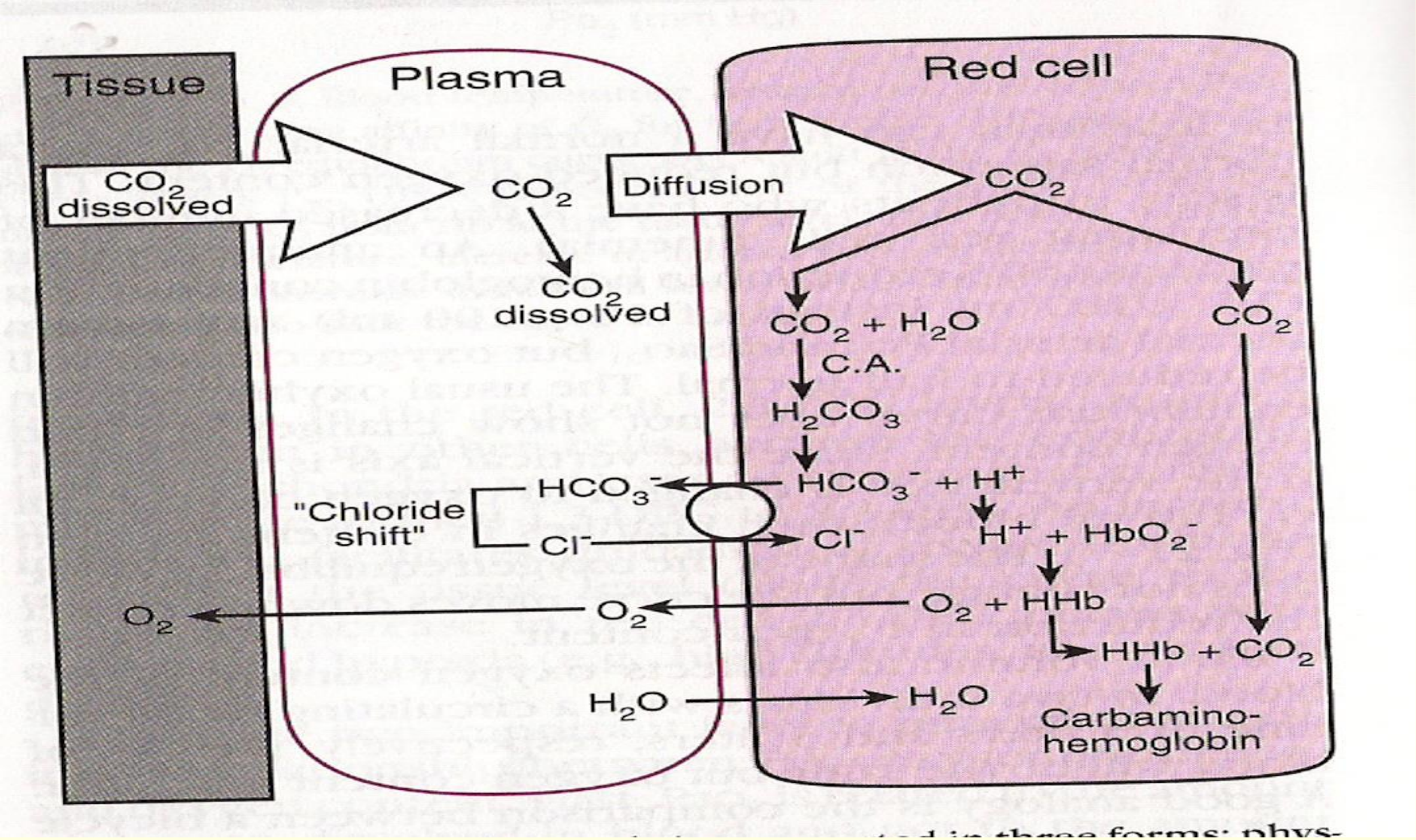
Diffusion Effected By

- Partial Pressure of CO_2 (Pco_2)-Higher In Tissues Than In Capillary
- Concentration Gradient-CO_2 Higher In Tissues Than In Capillary
- Distance-Very Short

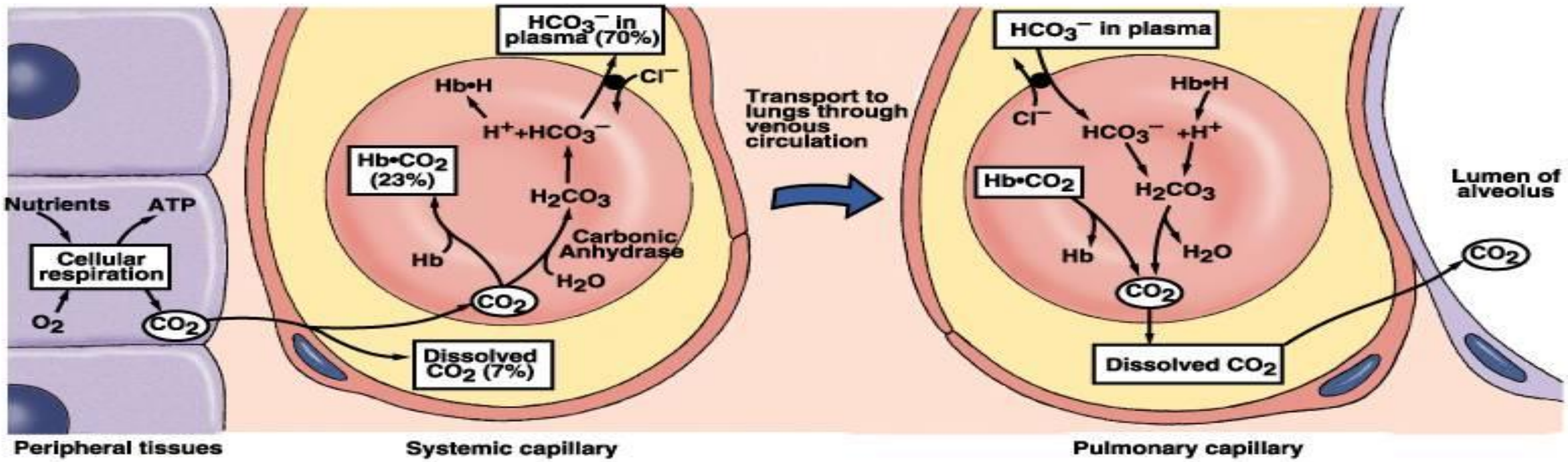
TRANSPORT OF CO2



TRANSPORT OF CO2



TRANSPORT OF CO2



TRANSPORT OF CO2

- **$H_20 + C0_2$ H_2C0_3 $H^+ + HC0_3^-$**
- At the tissues, $C0_2$ diffuses into the RBC; shifts the reaction to the right.
  - Increased [$HC0_3^-$] produced in RBC:
    - $HC0_3^-$ diffuses into the blood.
  - RBC becomes more +.
    - Cl^- attracted in (Cl^- shift).
  - H^+ released buffered by combining with deoxyhemoglobin.
- $HbC0_2$ formed.
  - Unloading of 0_2.

AT PULMONARY CAPILLARIES

- **$H_20 + C0_2$ $\quad$ H_2C0_3 $\quad$ $H^+ + HC0_3^-$**
- At the alveoli, $C0_2$ diffuses into the alveoli; reaction shifts to the left.
- Decreased [$HC0_3^-$] in RBC, $HC0_3^-$ diffuses into the RBC.
  - RBC becomes more -.
    - Cl^- diffuses out (reverse Cl^- shift).
- Deoxyhemoglobin converted to oxyhemoglobin.
  - Has weak affinity for H^+.
- Gives off $HbC0_2$.

OXYHEMOGLOBIN DISSOCIATION CURVE

This is a curve which denotes the relationship between the percent O_2 saturation of Hb and the partial pressure of O_2.

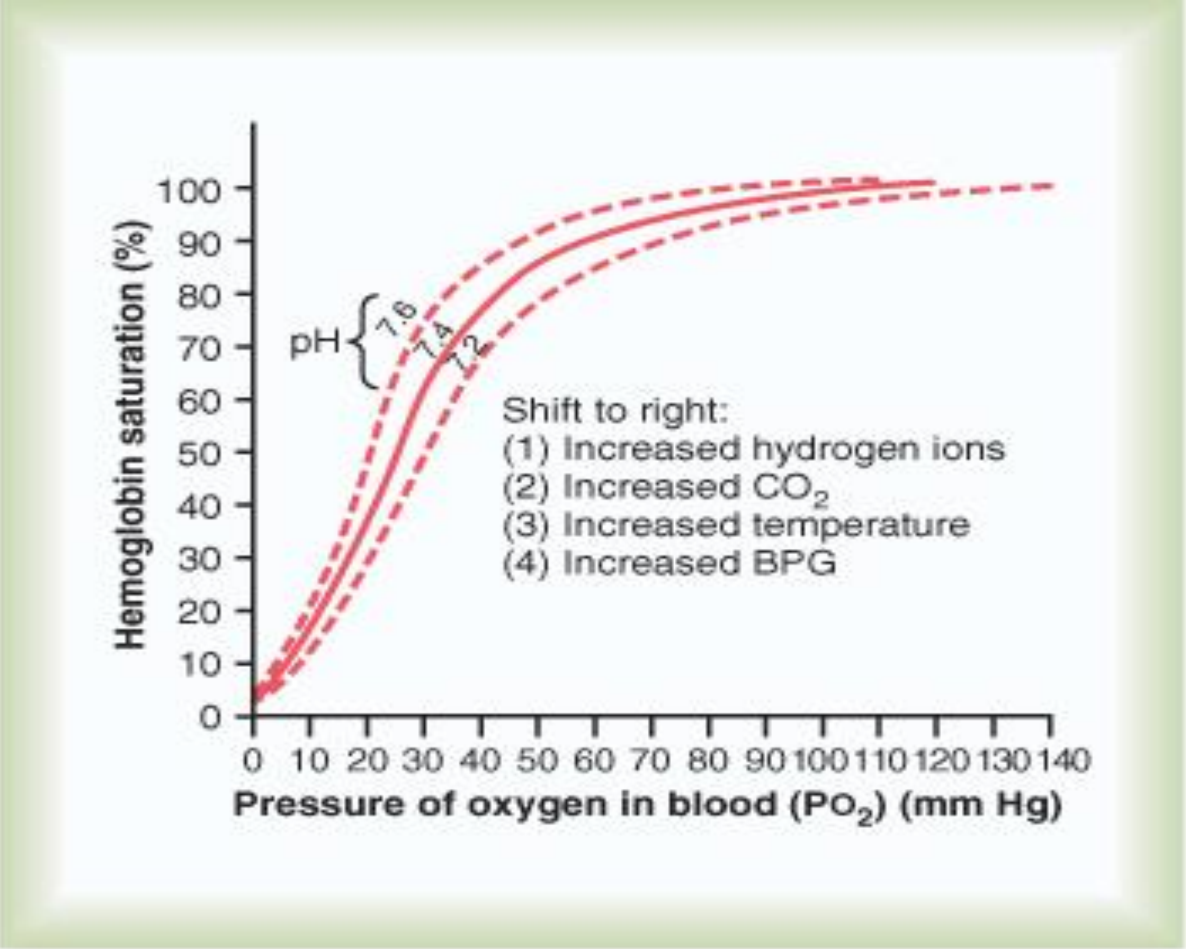
Right shift of oxy-Hb-dissociation curve: When the oxy-haemoglobin dissociation curve is shifted to the right, it means oxygen is dissociated or released from haemoglobin.

Factors shifting the curve to the right: Increase H^+ concentration or decrease pH, Increase CO_2, Increase temperature, Increase 2, 3 DPG

OXYHEMOGLOBIN DISSOCIATION CURVE

- **Left shift of oxy-haemoglobin dissociation curve:** When the oxy-hemoglobin dissociation curve is shifted to the left. It shows that hemoglobin affinity for oxygen is increased.
- **Factors shifting the curve to the left:**
- Decrease H^+ concentration or increase pH
- Decrease CO_2
- Decrease temperature
- Decrease 2, 3 DPG
- Fetal haemoglobin

FACTORS EFFECTING OXYHEMOGLOBIN DISSOCIATION CURVE



THANK YOU