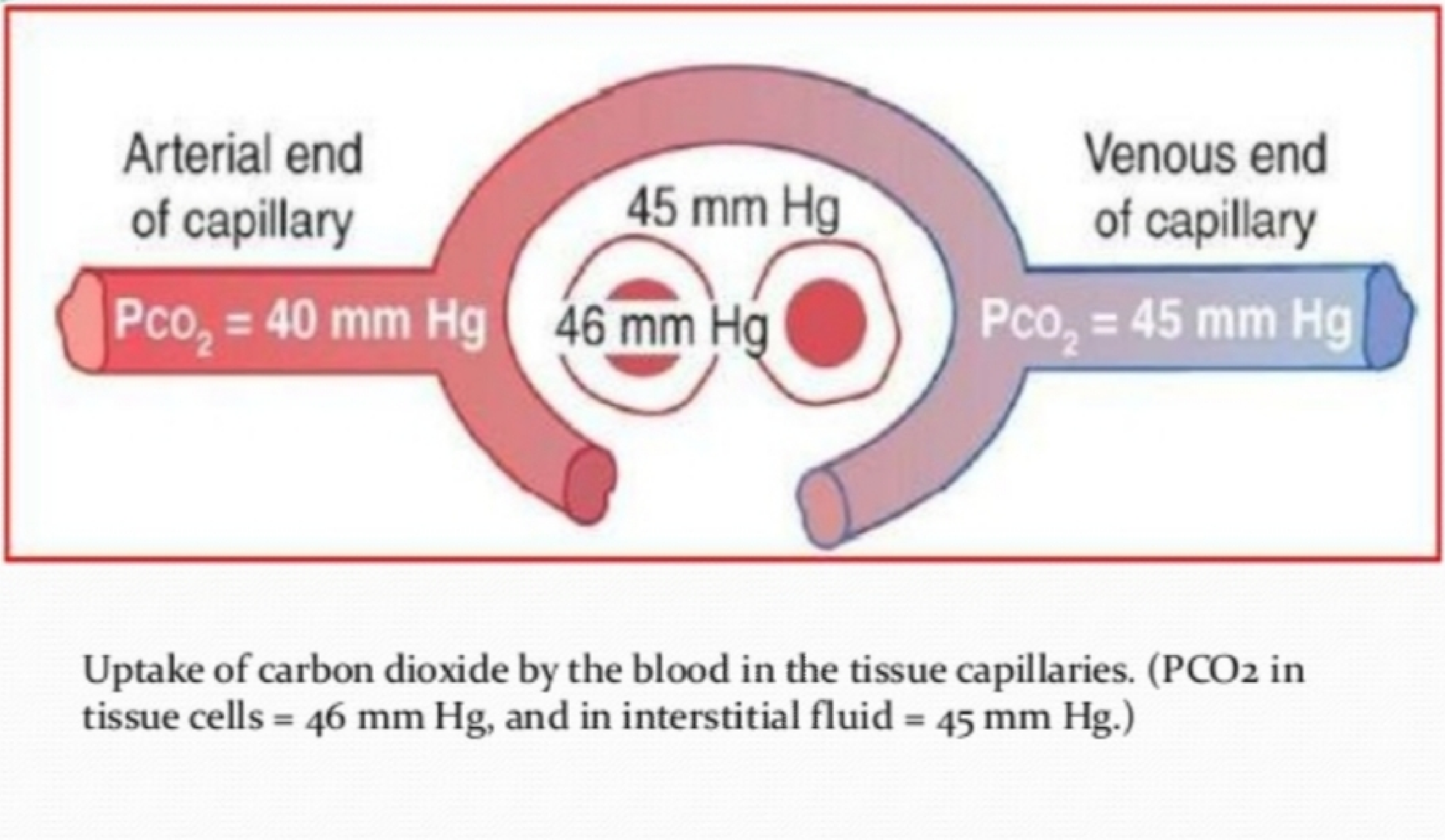
Diffusion of CO_2 from the Peripheral Tissue Cells into the Capillaries and from the Pulmonary Capillaries into the Alveoli

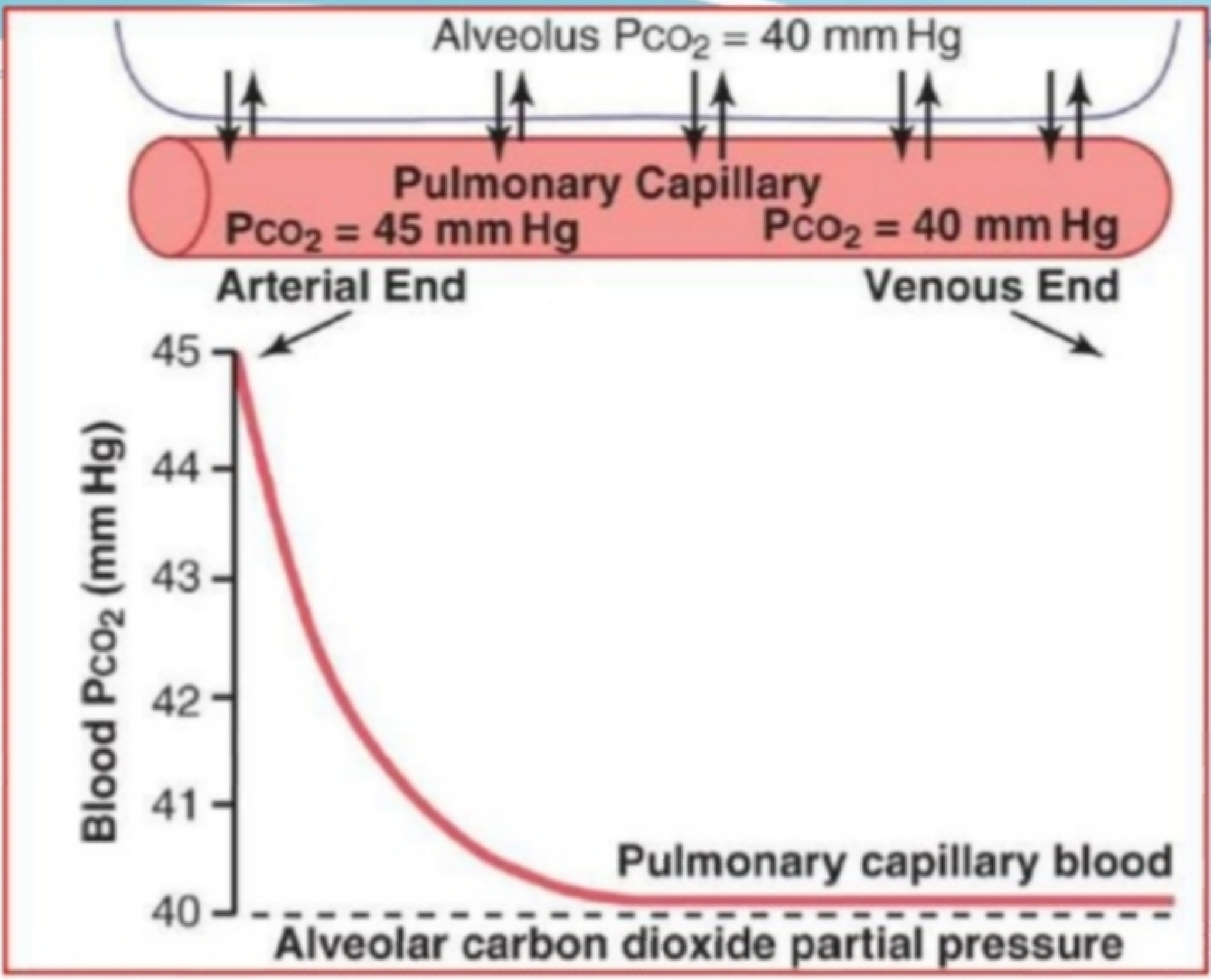
- intracellular PCO_2 is high so CO_2 diffuses from the cells into the tissue capillaries and is then carried by the blood to the lungs.
- In the lungs, it diffuses from the pulmonary capillaries into the alveoli and is expired.



Uptake of carbon dioxide by the blood in the tissue capillaries. (PCO2 in tissue cells = 46 mm Hg, and in interstitial fluid = 45 mm Hg.)

- The CO_2 pressures are approximately the following:
- 1. Intracellular PCO_2, 46 mm Hg; interstitial PCO_2, 45 mm Hg. Thus, there is only a 1 mm Hg pressure differential,
- 2. PCO_2 of the arterial blood entering the tissues, 40 mm Hg; PCO_2 of the venous blood leaving the tissues, 45 mm Hg.

- Thus, the tissue capillary blood comes almost exactly to equilibrium with the interstitial PCO_2 of 45 mm Hg



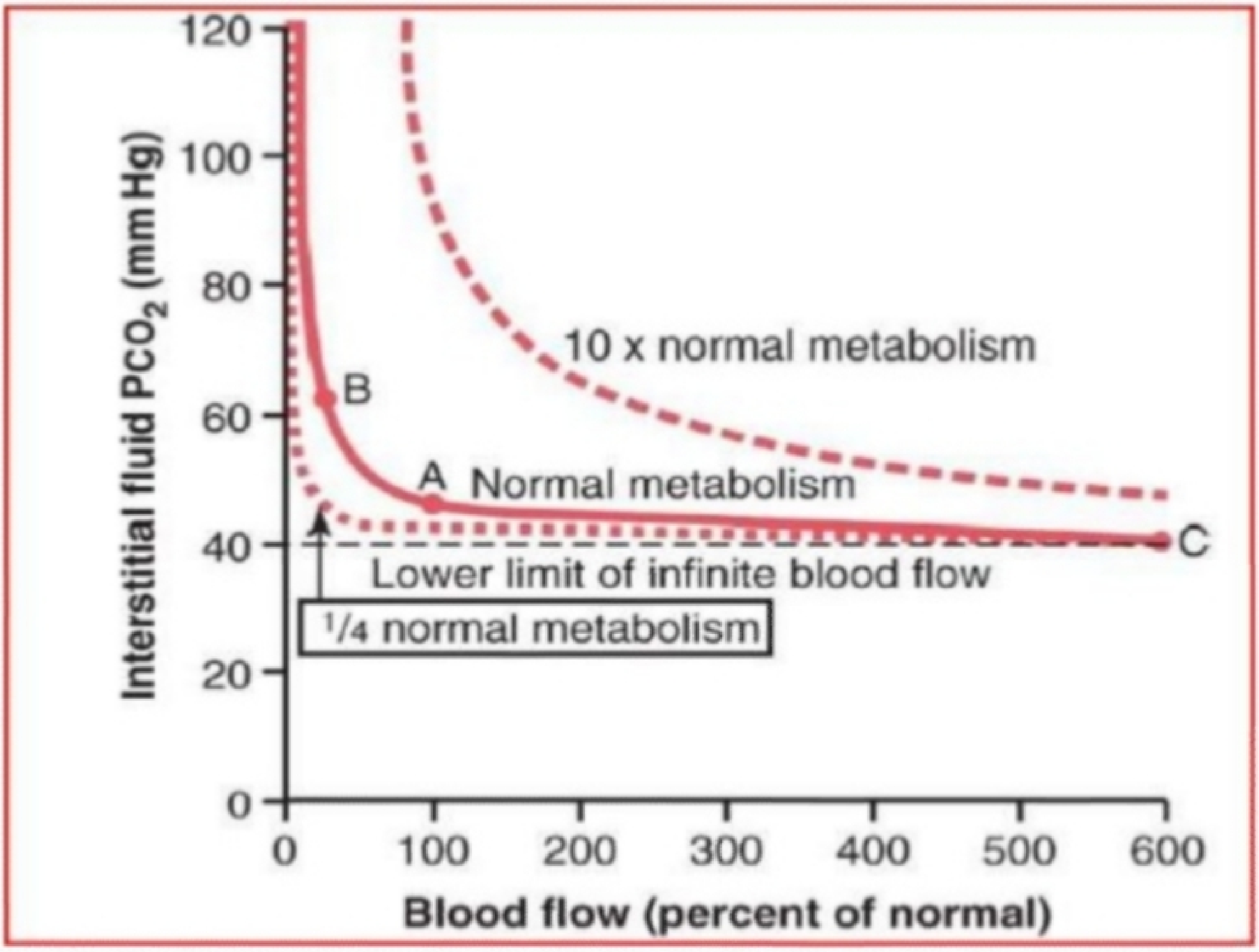
Diffusion of carbon dioxide from the pulmonary blood into the alveolus.

- 3. PCO_2 of the blood entering the pulmonary capillaries at the arterial end, 45 mm Hg; PCO_2 of the alveolar air, 40 mm Hg.

- only a 5 mm Hg pressure difference causes all the required CO_2 diffusion out of the pulmonary capillaries into the alveoli.

- the PCO_2 of the pulmonary capillary blood falls to almost exactly equal the alveolar PCO_2 of 40 mmHg.

Effect of Rate of Tissue Metabolism and Tissue Blood Flow on Interstitial PCO_2



- A decrease in blood flow from normal (point A) to one quarter-normal (point B) increases peripheral tissue PCO_2 from the normal value of 45 mm Hg to an elevated level of 60 mm Hg.

- increasing the blood flow to six times normal (point C) decreases the interstitial PCO_2 from the normal value of 45 mm Hg to 41 mm Hg, down to a level almost equal to the PCO_2 in the arterial blood (40 mm Hg) entering the tissue capillaries.

- a 10-fold increase in tissue metabolic rate greatly elevates the interstitial fluid PCO_2 at all rates of blood flow,
- whereas decreasing the metabolism to one-quarter normal causes the interstitial fluid PCO_2 to fall to about 41 mm Hg, closely approaching that of the arterial blood, 40 mm Hg.

Transport of Carbon Dioxide in the Blood

1) dissolved CO_2 , 7%.
2)bound to Hb (carbamino hemoglobin),23%.
3) as bicarbonate (HCO_3^-), 70%.

1)Transport of Carbon Dioxide in the Dissolved State

- A small portion of the carbon dioxide is transported in the dissolved state to the lungs about 7%.

2)Transport of Carbon Dioxide in the Form of Bicarbonate Ion

1) CO_2 is generated in the tissues and diffuses freely into the venous plasma and then into the RBCs.

2) in the RBCs, CO_2 combines with H_2O to form H_2CO_3, a reaction that is catalyzed by carbonic anhydrase. H_2CO_3 dissociate into H^+ and HCO_3^-.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H + HCO_3^-$$

3) HCO_3^- leaves the RBCs in exchange for CL^- (chloride shift) and is transported to the lungs in the plasma.

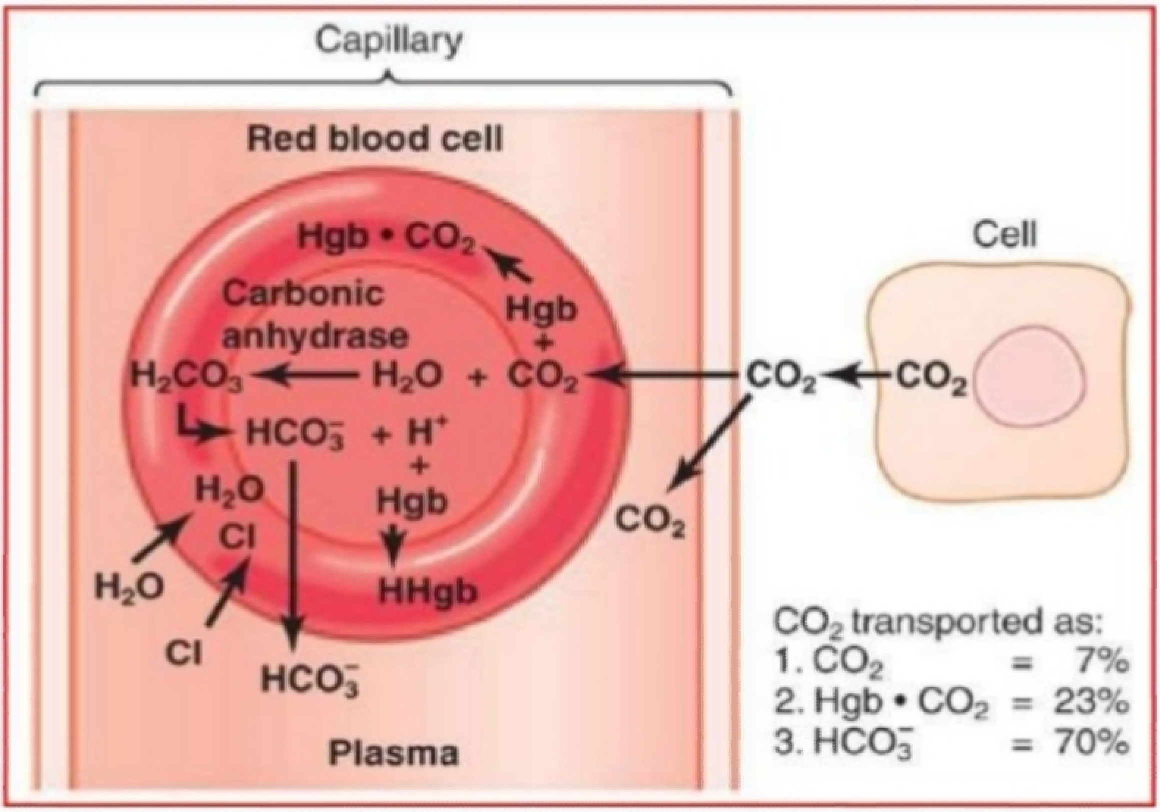
4) H^+ is buffered inside the RBCs by deoxyhemoglobin.

- Because deoxyhemoglobin is a better buffer for H^+ than oxyhemoglobin , it is advantageous that hemoglobin has been deoxygenated by the time blood reaches the venous end of the capillaries.

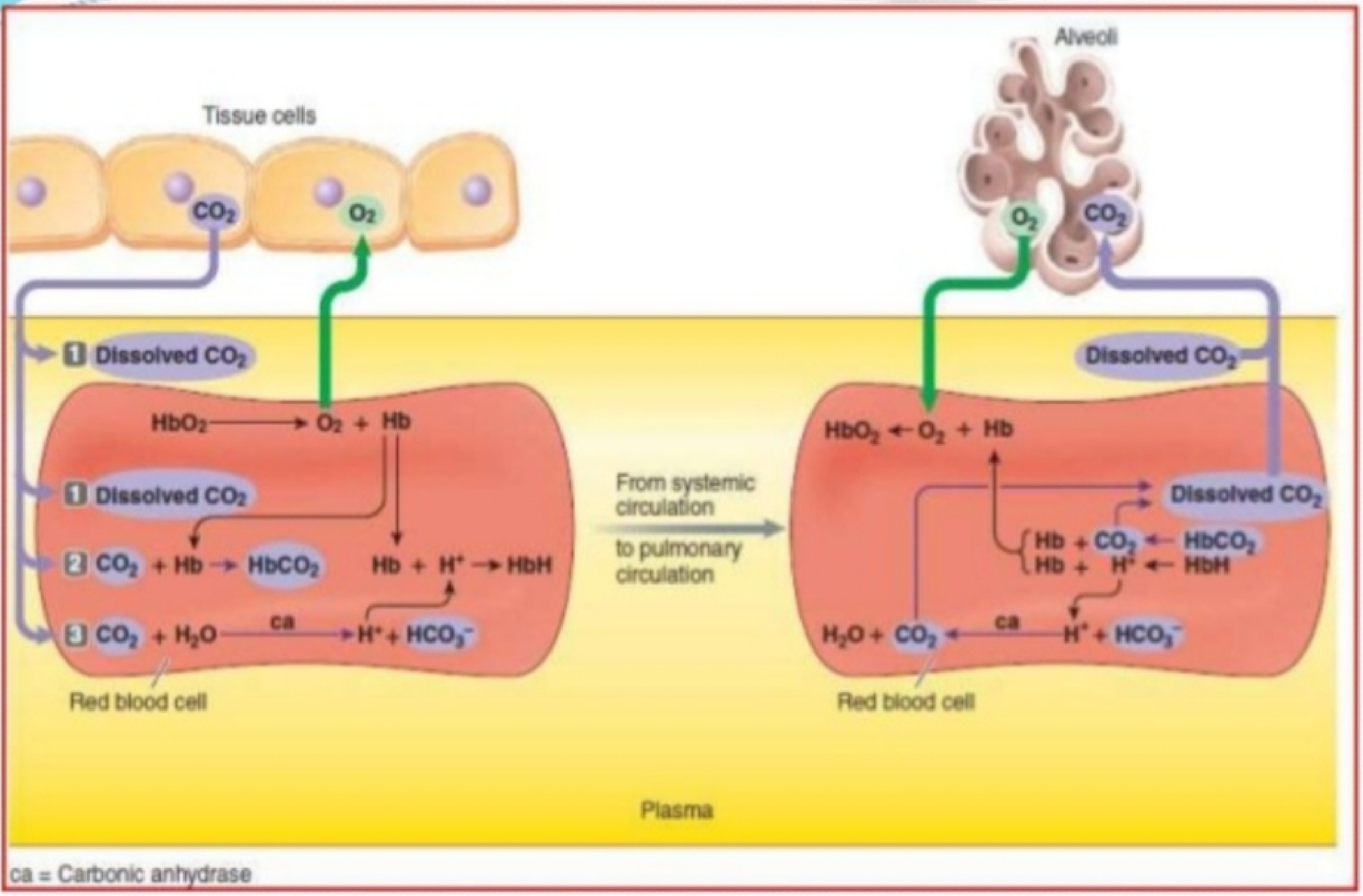
5) in the lungs, all of the previous reactions occur in reverse.

- HCO_3^- enters the RBCs in exchange for CL^-.
- HCO_3^- recombines with H^+ to form H_2CO_3 which decomposes into CO_2 and H_2O.
- Thus, CO_2 originally generated in the tissues, is expired.

Transport of carbon dioxide in the blood



Carbon dioxide transport in the blood



- Carbon dioxide (CO_2) picked up at the tissue level is transported in the blood to the lungs in three ways:

(1) physically dissolved,

(2)bound to hemoglobin (Hb),

(3) as bicarbonate ion (HCO_3^-).

- Hemoglobin is present only in the red blood cells, as is carbonic anhydrase, the enzyme that catalyzes the production of HCO_3^-.

- The H^+ generated during the production of HCO_3^- also binds to Hb.

- The reactions that occur at the tissue level are reversed at the pulmonary level, where CO_2 diffuses out of the blood to enter the alveoli.

CO_2 dissociation curve

- It is a curve represents the relationship between the total CO_2 content and CO_2 tension.
- It is linear, in the physiological range of PCO_2.
- The normal PCO_2 range is:
  - 40 mmHg in arterial blood with CO_2 content of 48 ml/100 ml blood
  - 46 mmHg in venous blood with CO_2 content of 52 ml/100 ml blood.
- This linear relationship means that any change in PCO_2 will produce a great change in CO_2 content of the blood.
- Also, at any given CO_2 tension, reduced Hb carries more CO_2 than oxyHb.

Bohr's Effect

- Represents the effect of PCO_2 and H^+ (acidity) on the O_2-Hb dissociation curve.

- At tissues: Increased PCO_2 & H^+ concentration ⟶ shift of O_2-Hb curve to the right.
- At lungs: Decreased PCO_2 & H^+ concentration ⟶ shift of O_2-Hb curve to the left.

So, Bohr's effect facilitates

i) O_2 release from Hb at tissues.
ii) O_2 uptake by Hb at lungs.

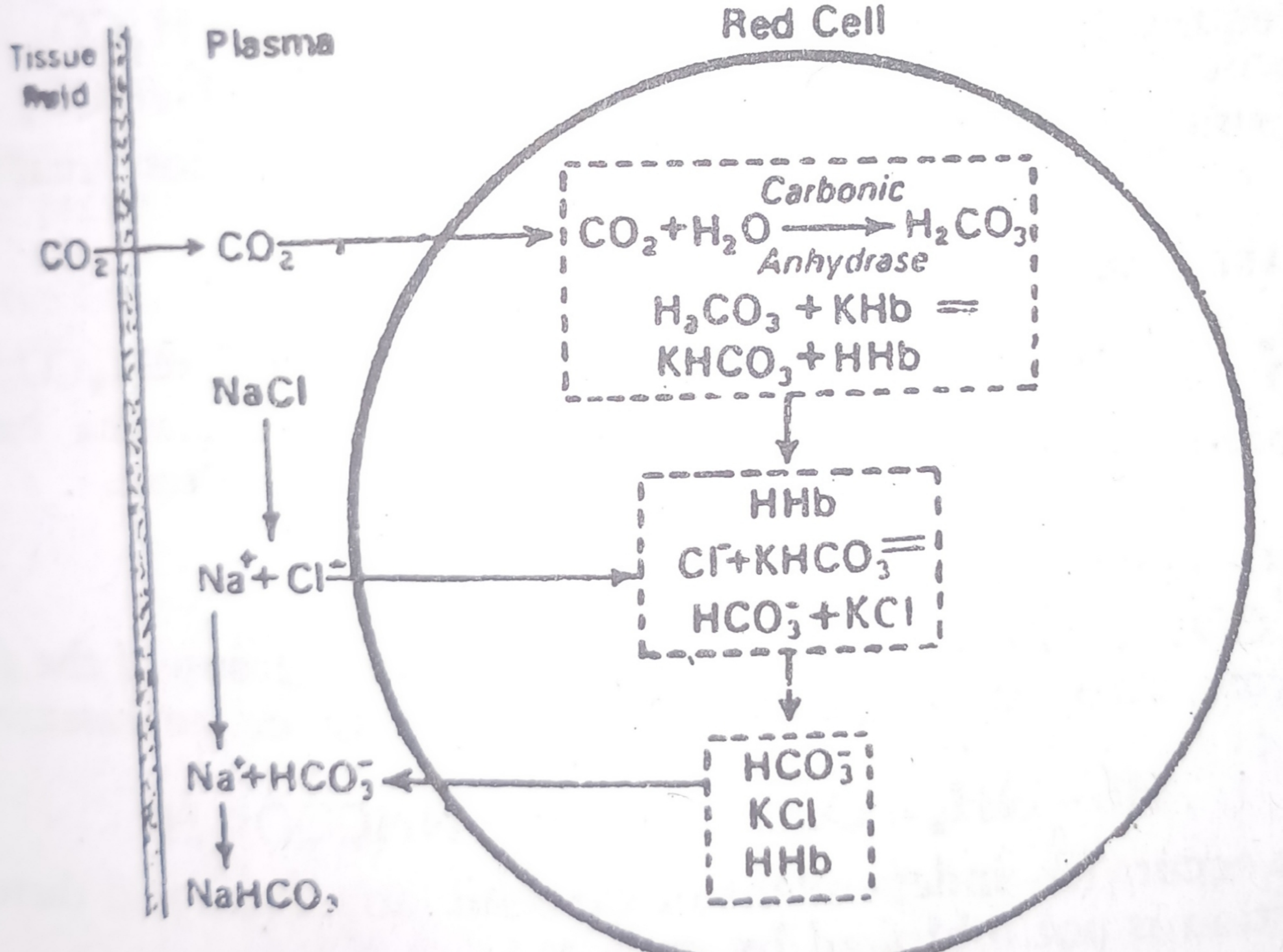


Fig. 267. Schematic representation showing the steps of chloride shift.