Biology Grade 9

CHAPTER 2: RESPIRATION

Activity 4: Transport of Respiratory Gases

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Activity 4: Transport of Respiratory Gases

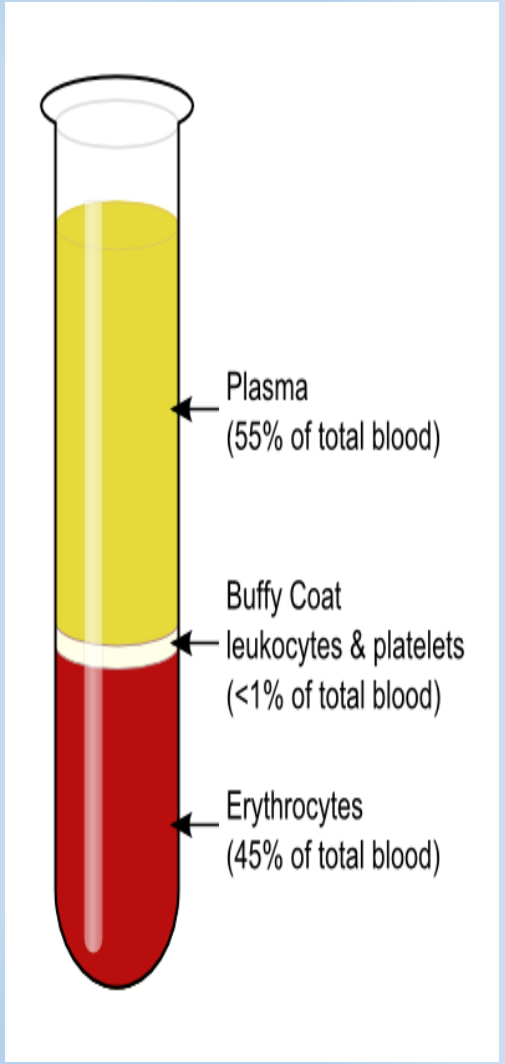
Interpretation of centrifuged blood:

Centrifugation is a technique applied to separate different constituents of a heterogeneous liquid mixture. After whole blood centrifugation, three separate layers are observed.

1. Blood is a heterogeneous liquid mixture. List the blood components.

The blood components are:

- Plasma
- Platelets
- White blood cells (Leukocytes)
- Red blood cells (Erythrocytes)



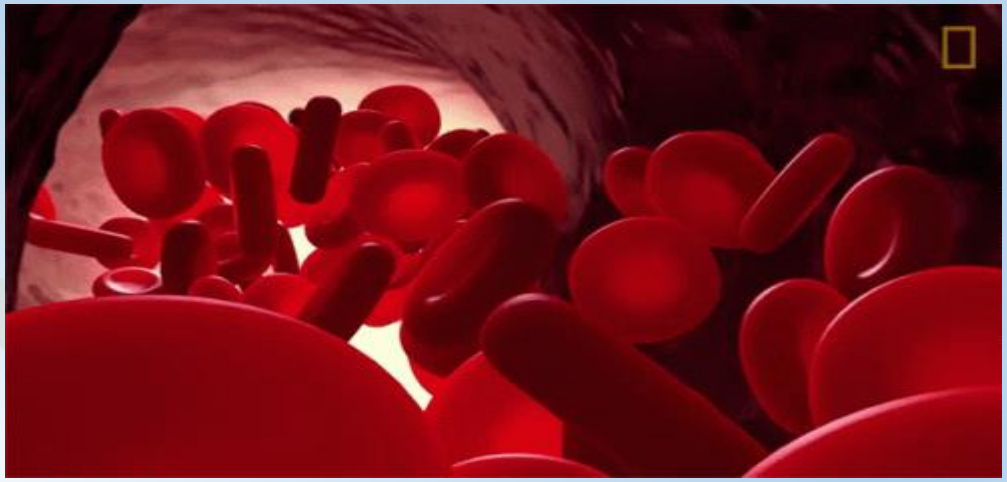
2. Describe the three observed layers.

The colorless upper layer represents the plasma and constitutes 55% of the total blood. The dark red lower layer represents the red blood cells or erythrocytes and constitutes 45% of total blood. In between is a light red layer that represents leukocytes and platelets and constitute of less than 1% of total blood.

❖ Red Blood Cells:

Erythrocytes or red blood cells constitute 45% of total blood.

1. Pick out the characteristics of these cells.



Red blood cells characteristics:

- Disk shaped cell.
- Possesses a red color protein, hemoglobin.
- Anucleated cell (cell without a nucleus).
- Large in number.

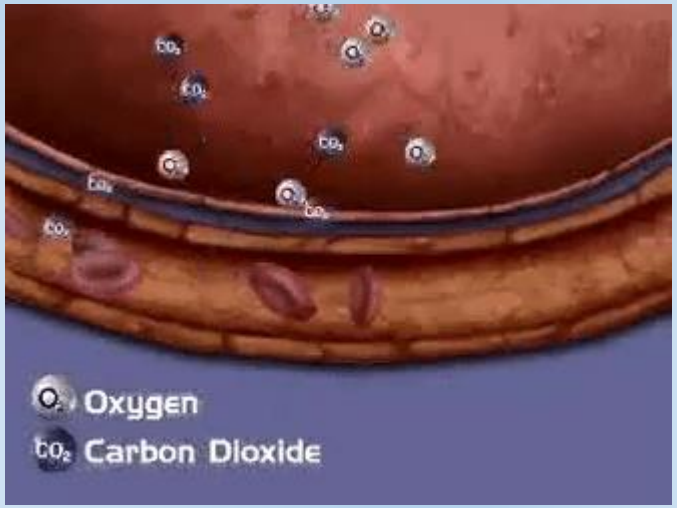
Red blood cells or erythrocytes contain proteins rich in iron. Those proteins are called hemoglobin.

2. Pick out the characteristics of these proteins.

- Hemoglobin characteristics:

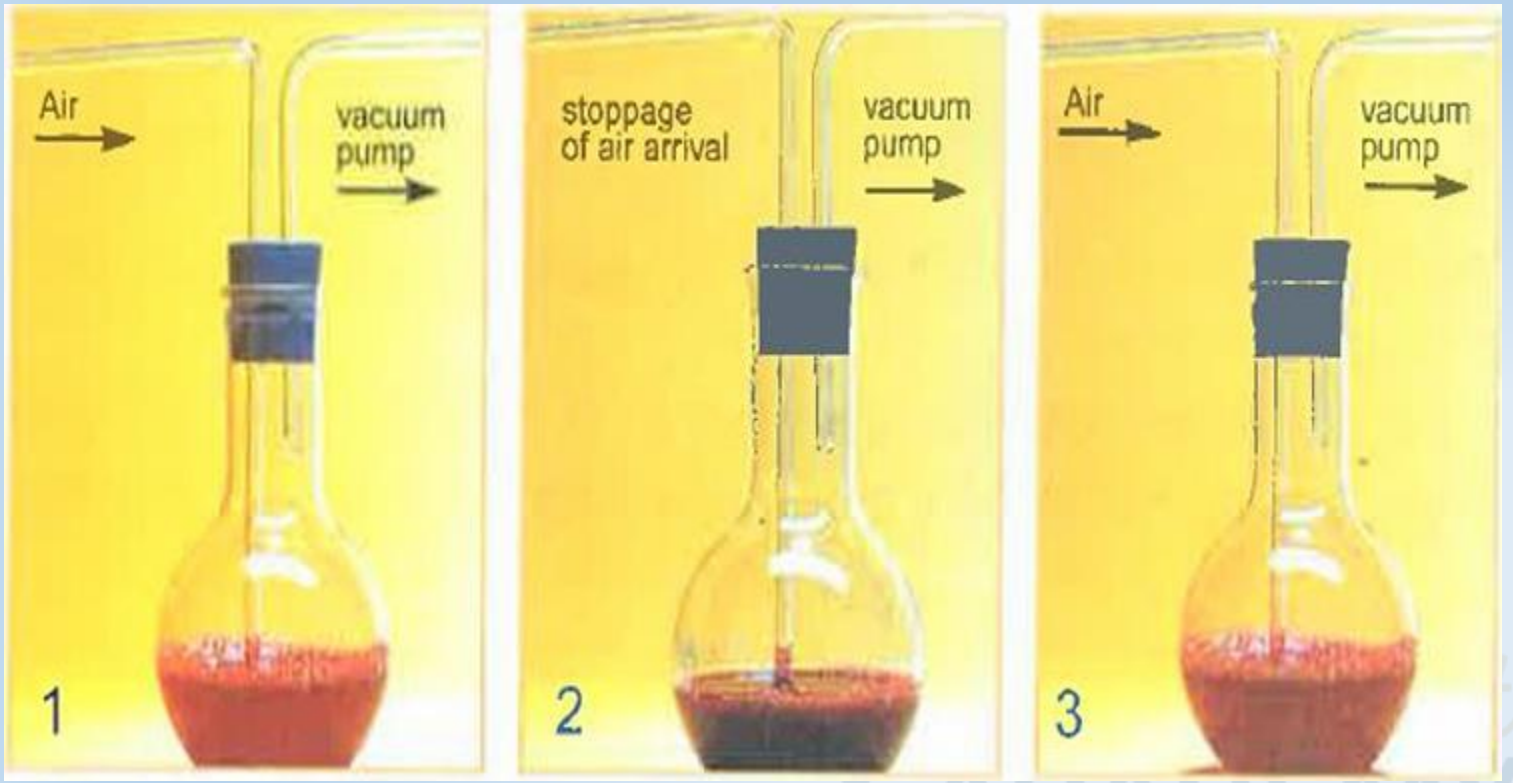
- A red colored protein.
- Rich in iron.
- **Binds to oxygen gas or carbon dioxide gas rapidly in a reverse manner.**

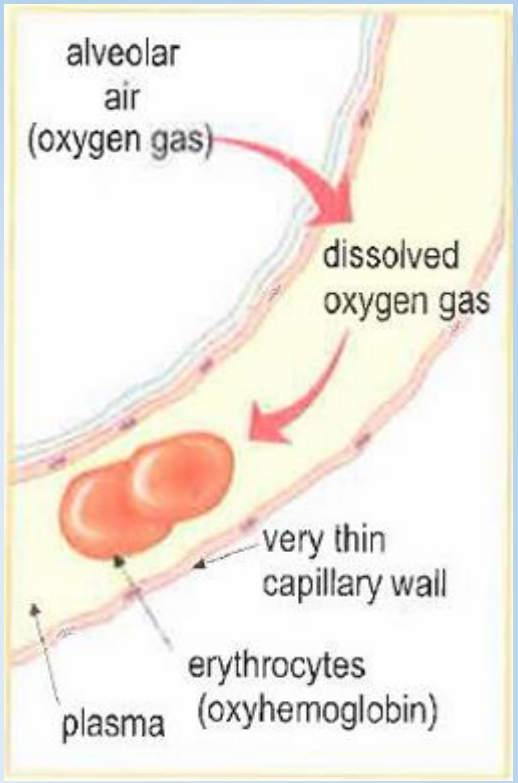
- Oxygen is carried from the lungs towards the cells by the blood.
- Inversely, carbon dioxide is transported from the cells toward the lungs.
- Blood is made up of a liquid called plasma, suspension of cells which are erythrocytes(RBCs), WBCs and platelets.
- Red blood cells or erythrocytes are disk shaped and have no nucleus.
- They possess a red colored protein rich in iron called hemoglobin.
- Hemoglobin has a property of binding rapidly and in a reversible manner (unstable weak bond) to oxygen and carbon dioxide.



- **Role of hemoglobin: transport respiratory gases (O2 and CO2) in the blood.**

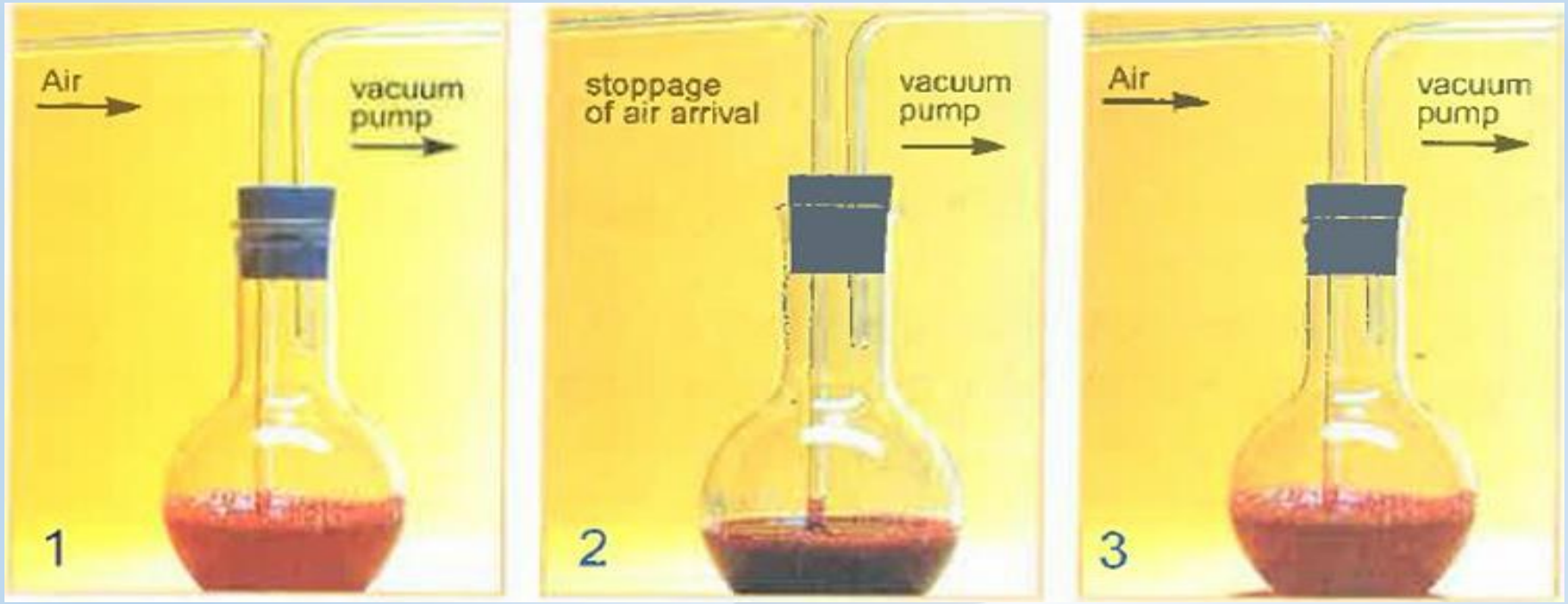
❖ Role of Erythrocytes:





1. Describe the change of color of blood in the above experiment.

The blood color turns bright red when air is in contact with it. When arrival of air to the glass jar is stopped, the blood becomes dark red in color. When blood is placed again in contact with air, the blood color turns back to bright color.

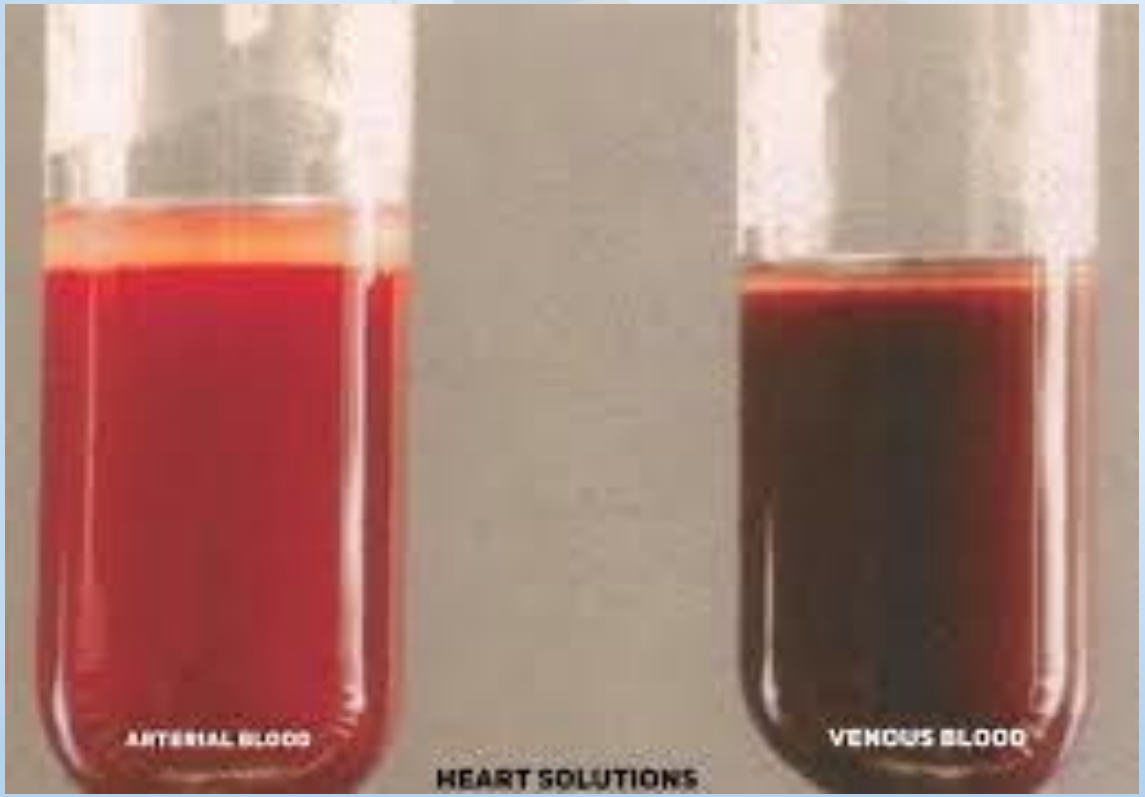


2. Explain the change of color of blood in the above experiment.

In a medium rich in oxygen gas (when air is in contact with blood), hemoglobin combines with oxygen gas and forms oxyhemoglobin of bright red color. In a medium poor in oxygen gas (when air arrival is stopped), oxyhemoglobin decomposes thus releasing oxygen gas and becomes dark red in color.

❑ Color of blood:

- Blood **rich in oxygen (oxygenated)** or poor in carbon dioxide has **bright red color.**
- Blood rich in carbon dioxide or **poor in oxygen (deoxygenated)** has **dark red color.**



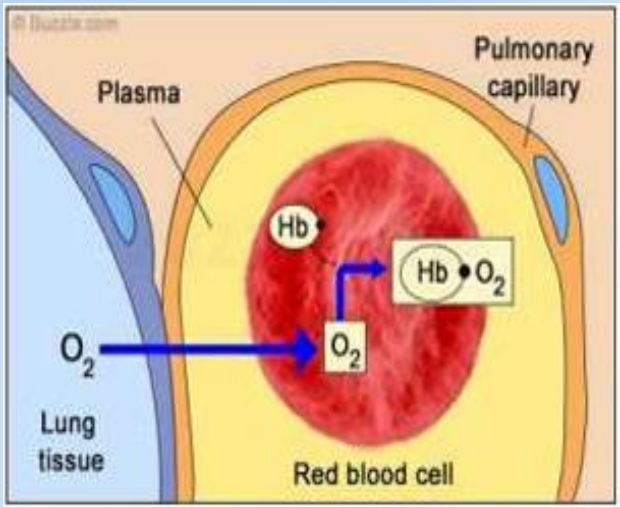
- **Hemoglobin (Hb) combines with dissolved oxygen gas diffused in the blood capillary and forms a complex called oxyhemoglobin (HbO_2).**

3. Write in a word reaction equation the above statement.

The reaction equation of this **combination (formation) reaction** is:

Hemoglobin + Oxygen → Oxyhemoglobin (in blood leaving the lung)

$Hb + O_2 \rightarrow HbO_2$



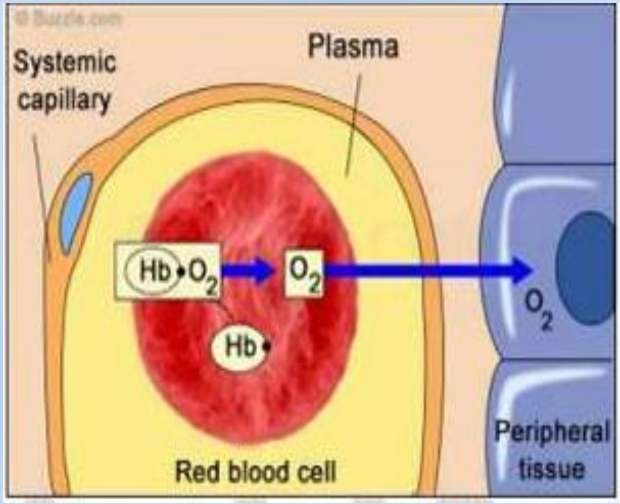
- **In a medium where gas exchange take place between red blood cells that carry oxygen and tissue cells, oxyhemoglobin (HbO2) decomposes thus releasing oxygen gas.**

4. Write in a word reaction equation the above statement.

The **dissociation reaction** equation is:

Oxyhemoglobin → Hemoglobin + Oxygen (in blood entering the cell)

$HbO_2 \rightarrow Hb + O_2$



5. Show that this reaction is an unstable reaction.

- The reaction between hemoglobin and oxygen gas is a **reversible** reaction.
- **Hemoglobin (Hb) + Oxygen (O_2) ⇌ Oxyhemoglobin (HbO_2)**
- Therefore it is unstable reaction.

❑ **The bonding between hemoglobin and oxygen gas is reversible.**

6. Explain the benefit of this reversibility.

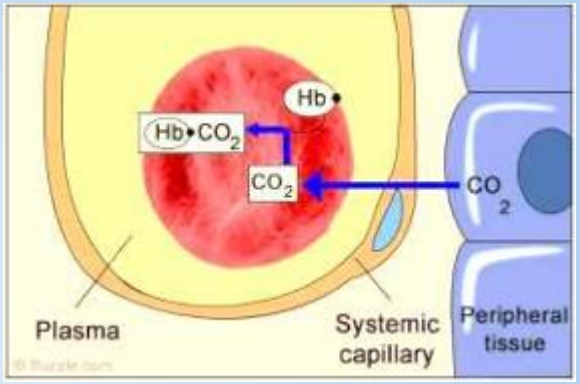
Hemoglobin functions as an **oxygen carrier** which delivers oxygen to the cells. However if this binding is irreversible, oxygen is neither released nor exchanged with cells. Therefore the cells become deprived of oxygen which is a vital source for the production of energy which is needed in the chemical reactions (enzyme production, growth, cell division and all other metabolic reactions) consequently the cells die.

Hemoglobin binds oxygen gas as well as carbon dioxide gas rapidly and in a reversible manner.

Formation equation: (in the blood leaving the cell)

Hemoglobin + carbon dioxide gas → Carbohemoglobin

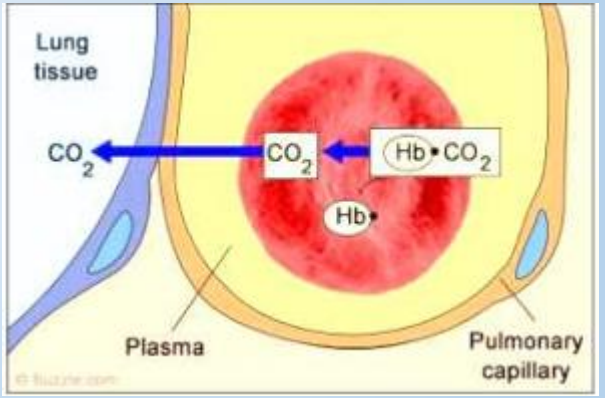
$Hb + CO_2 \rightarrow HbCO_2$



Dissociation equation: (in the blood entering the lung)

Carbohemoglobin → Hemoglobin + carbon dioxide gas

$HbCO_2 \rightarrow Hb + CO_2$



Reversible equation

Hemoglobin + carbon dioxide gas ⇌ Carbohemoglobin

$Hb + CO_2 \rightleftharpoons HbCO2$

- **Oxygen gas is transported in the blood in two forms.**

8. List these two forms.

➢ Oxygen is transported in the blood:

- In the form of **oxyhemoglobin**: by hemoglobin (98.5%)
- In a dissolved form: by **plasma** (1.5%)

- **Carbon dioxide released by the cells is transported in the blood in three main forms.**

9. List the three main forms.

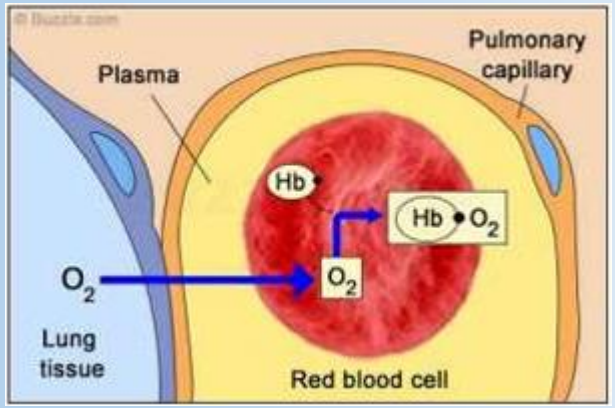
➢ Carbon dioxide is transported in the blood:

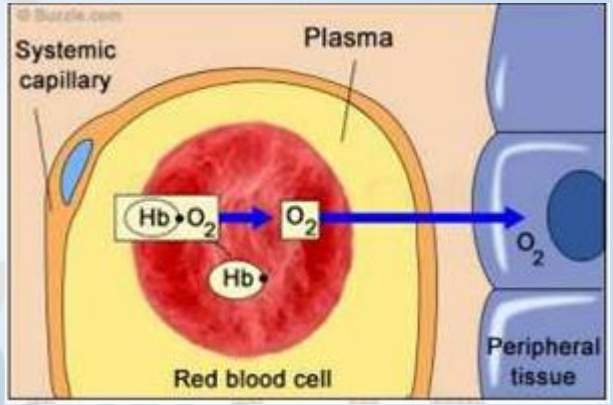
- In the form of **carbohemoglobin**: by hemoglobin (20-30%)
- In the form of **bicarbonate (H_2CO_3)**: by plasma (60-70%)
- In a dissolved form: **by plasma** (7-10%)

Summary

❖ Transport of oxygen in the blood:

1. Most of oxygen (98%) is transported by hemoglobin. Oxygen **combines** with hemoglobin in a medium **rich in oxygen** to form **oxyhemoglobin**. Then in a medium **poor in oxygen**, oxyhemoglobin **decomposes** to give oxygen and hemoglobin.



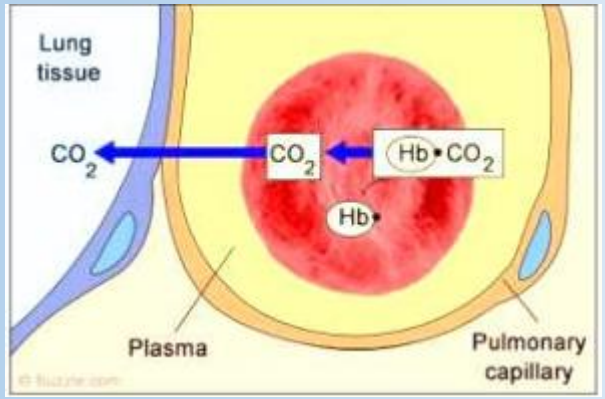


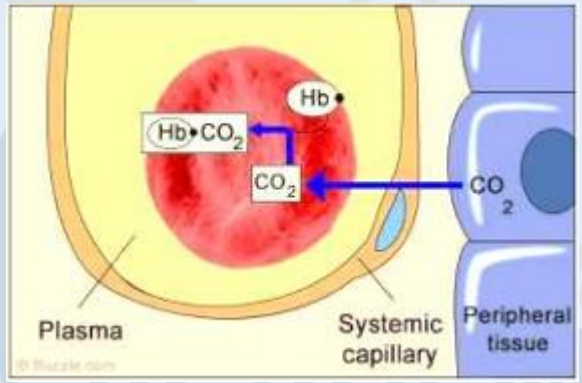
2. A small quantity of oxygen (2%) is dissolved and transported in plasma.

Summary :

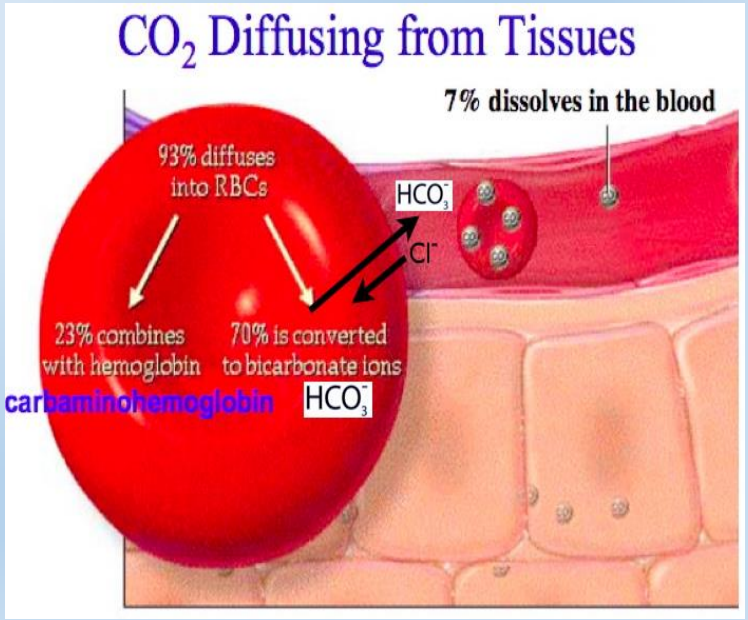
❖ Transportation of carbon dioxide in the blood:

1. (20-30%) of Carbon dioxide **combines** with hemoglobin in a medium rich in carbon dioxide to form **carbohemoglobin**. Then in a medium **poor in carbon dioxide**, carbohemoglobin **decomposes** to give carbon dioxide and hemoglobin.





2. Dissolved form by **plasma** (7-10%)
3. In the form of **bicarbonate** by the plasma (60-70%)

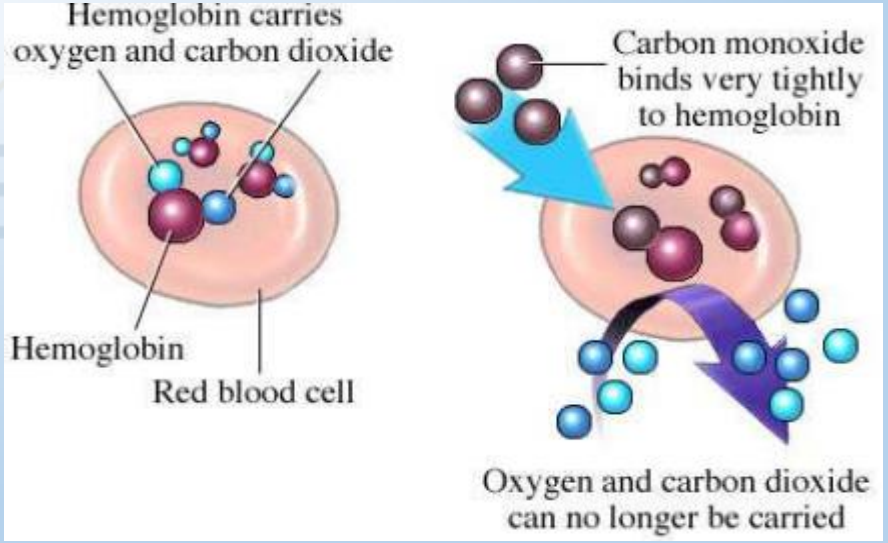


❖ Air Pollution and Respiratory Disturbances:

Air pollution and smoking lead to entry of many harmful substances as sulfur dioxide, nitrogen dioxides, and nicotine that create problems in the respiratory system.

❑ Harmful substances found in tobacco:

1. Nicotine speeds up the heart beats and strains the heart.
2. **Carbon monoxide (CO)** disturbs the process of transporting O2 gas by the blood by making a **strong bond** with hemoglobin (combines with hemoglobin in an **irreversible way**); it decreases the capacity of hemoglobin to fix O2 causing respiratory problems.



3. Irritating substances, including tar, increase mucus secretion. They decrease the activity of cilia which cover the internal wall of the respiratory tract.

Air pollution and nicotine addiction lead to the entry of many harmful substances such as sulfur dioxides, nitrogen dioxide into the respiratory system. This can lead to deadly diseases such as Emphysema, asthma and lung cancer.