Breathing & Exchange of Gases

14 Chapter

1. Define vital capacity. What is its significance?

Ans: The vital capacity (Vc) is the maximum amount of air that a person can expel from the lungs after a maximum inspiration. The quantity of cubic inches or cubic centimeters of air that can be forcefully expelled following a full inhalation is the lungs' breathing capacity. In the human body, it is around 3.5 to 4.5 liters.

Promotes the supply of fresh air and the removal of stale air, thus increasing the gas exchange between tissue and the environment.

2. State the volume of air remaining in the lungs after normal breathing.

Ans: The volume of air remaining within the lungs after a traditional expiration is understood as functional residual capacity (FRC). It comprises expiratory reserve volume (ERV) and residual volume (RV). ERV is the maximum volume of air that will be exhaled after a traditional expiration. It's about 1000 ml to 1500 ml. RV is the volume of air remaining within the lungs after maximum expiration. It's about 1100 mL to 1500 ml.

$\therefore = +$ FRC ERV RV

$\cong 1500 + 1500$

$\cong 3000$ mL

The functional residual capacity of the human lungs is about 2500 – 3000 ml.

3. Diffusion of gases occurs in the alveolar region only and not in the other parts of the respiratory system. Why?

Ans: Each alveolus is composed of a thin, highly permeable layer of squamous cells. Blood capillaries are also composed of layers of squamous cells. The oxygen-rich air enters the human body through the nose and reaches the alveoli. The deoxygenated blood from the body is transported to the heart through a vein. The heart pumps it into the lungs to supply oxygen. The exchange of O2 and CO2 occurs between the capillaries surrounding the alveoli and the gas present in the alveoli. Therefore, the alveoli are the place for gas exchange. Due to pressure or concentration differences, gas exchange is carried out by simple diffusion.

The barrier between the alveoli and, by extension, the capillaries is extremely thin, allowing gases to diffuse from higher partial pressures to lower partial pressures. The blood that reaches the alveoli has the lower partial pressure of O2 and better partial pressure of CO2 as compared to alveolar air. Hence, oxygen gas diffuses into the blood. Simultaneously, CO2 diffuses out of the blood and into the alveoli.

4. What are the major transport mechanisms for CO_2? Explain.

Ans: Plasma and red blood cells carry carbon dioxide because they are easily soluble in water.

- **Through plasma:**
  Approximately 7% of the CO2 is transported through the plasma in a dissolved state. Carbon dioxide will combine with the water to form carbonic acid.
  $CO_2 + H_2O \rightarrow H_2CO_3$
  (Carbonic acid)
  As the process of forming carbonic acid is slow, only a small amount of carbon dioxide is carried this way.
- **Through RBCs:**
  Approx 25% of CO_2 is transported with the help of red blood cells as carbaminohemoglobin. Carbon dioxide will bind to the amino groups on the polypeptide chains of hemoglobin and form a compound which is known as carbaminohemoglobin.
- **Through sodium bicarbonate:**
  Approximately 70% of CO2 is transported within the sort of sodium bicarbonate. As CO2 diffuses into the plasma, an outsized amount of it combines with water to make acid within the presence of the enzyme carbonic anhydrase. Carbonic anhydrase is an enzyme that contains zinc that accelerates the formation of acid. This carbonic acid formed will dissociate into bicarbonate (HCO_3^-) and hydrogen ions (H^+).
  $CO_2 + H_2O \xrightarrow{\text{Carbonic anhydrase}} H_2CO_3$
  $H_2CO_3 \xrightarrow{\text{Carbonic anhydrase}} HCO_3^- + H^+$

5. What will be the pO_2 and pCO_2 in the atmospheric air compared to those in the alveolar air?

(i) pO_2 lesser, pCO_2 higher
(ii) pO_2 higher, pCO_2 lesser
(iii) pO_2 higher, pCO_2 higher
(iv) pO_2 lesser, pCO_2 lesser

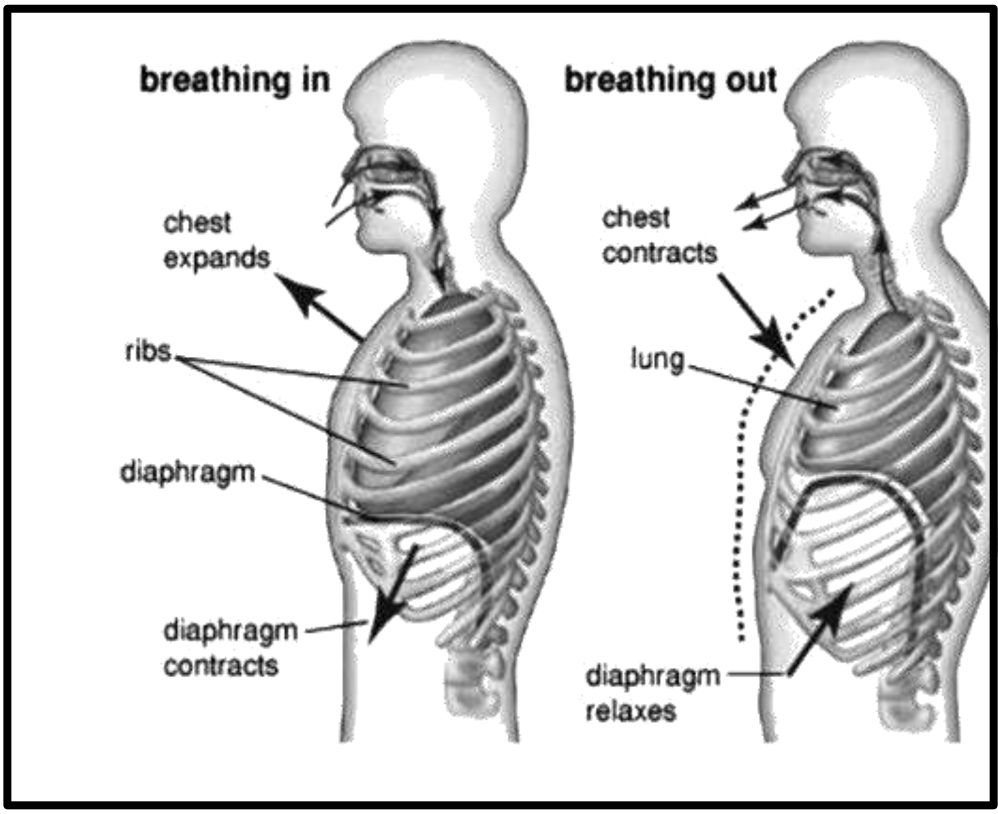
Ans: (ii) pO_2 higher, pCO_2 lesser

The partial pressure of oxygen in atmospheric air tends to be more than the partial pressure of oxygen in alveolar air. In atmospheric air, the pO2 is approximately 159 mm Hg. In alveolar air, it's approximately 104 mm Hg. The partial pressure of CO_2 in atmospheric air is lower. as CO2 within the alveolar air. In atmospheric air, the pCO_2 is around 0.3 mmHg. In alveolar air, it's about 40 mm Hg.

6. Explain the process of inspiration under normal conditions.

Ans: Inspiration, or inhalation, is the process by which air is brought into the lungs from outside the body. It's performed by creating a pressure gradient between the lungs and therefore the atmosphere. When air enters the lungs, the diaphragm expands into the abdomen, increasing the space within the thoracic cavity to accommodate the air that's inhaled.

The volume of the chest chamber within the anteroposterior axis increases because the external intercostal muscles contract, causing the ribs and sternum to maneuver outward, increasing the quantity of the chest chamber within the dorsoventral axis. Chest volume results in an identical increase in lung volume. As a result of this increase, the intrapulmonary pressure becomes less than air pressure, causing air from outside the body to flow into the lungs.



7. **How is respiration regulated?**

Ans: The center of the breathing rhythm, located in the area of the medulla of the brain, is primarily responsible for regulating breathing. The pneumatic center can change the function of the respiratory rhythm center by sending signals to reduce the inspiratory rate. The chemosensitive region is near the respiratory center. It is sensitive to carbon dioxide and hydrogen ions. This area sends signals to change the expiratory rate to remove connections.

Receptors in the carotid artery and aorta record the concentrations of carbon dioxide and hydrogen ions in the blood. As the carbon dioxide level rises, the respiratory center sends nerve impulses for the necessary changes.

8. **What is the effect of pCO_2 on oxygen transport?**

Ans: pCO2 plays a really important role in oxygen transport. within the alveolus, low pCO2 and high pO2 promote the formation of hemoglobin. In tissues, high pCO2 and low pO2 favor the dissociation of an oxygen atom from the oxyhemoglobin. Hence the affinity of hemoglobin for oxygen is aggravated by the decrease in pCO2 within the blood. Therefore, oxygen is carried within the blood as oxyhemoglobin, and oxygen is dissociated from it within the tissues.

9. **What happens to the respiratory process in a man going up a hill?**

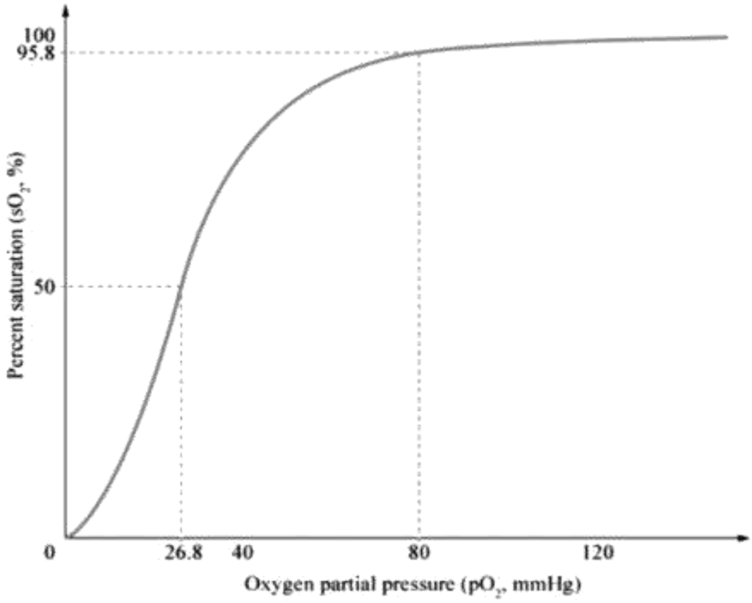
Ans: The oxygen content of the atmosphere decreases with an increase in altitude. As a result, each breath a man takes upward provides him with less oxygen. The amount of oxygen in the blood reduces as a result. The respiratory rate increases in response to a lack of oxygen. the oxygen content of the blood. At the same time, the frequency of the heartbeat increases in order to increase the oxygen supply to the blood.

10. **What is the site of gaseous exchange in an insect?**

Ans: In the case of insects, the exchange of gas takes place through a huge network of tubes known collectively because of the tracheal system. The tiny openings which are present on the edges of an insect's body are called stigmas. Oxygen-rich air enters through the spiracles. The spiracles are connected to the network of the tubes. Oxygen enters into the windpipe from the spiracles. From here, oxygen diffuses into the body cells. The movement of CO2 follows the other path. CO2 from the body's cells first enters the windpipe then leaves the body through the spiracles.

11. Define the oxygen dissociation curve. Can you suggest any reason for its sigmoidal pattern?

Ans: The oxygen dissociation curve is a graph showing the percentage saturation of oxyhemoglobin at various partial pressures of oxygen.



The curve shows us the equilibrium of oxyhemoglobin and hemoglobin at different partial pressures.

The partial pressure of oxygen in the lungs is high, so hemoglobin binds to oxygen and forms oxyhemoglobin.

Tissues have low levels of oxygen, so oxyhemoglobin releases oxygen in tissues to form hemoglobin.

The sigmoid form of the dissociation curve is due to the binding of oxygen to hemoglobin. As the first oxygen molecule binds to hemoglobin, the binding affinity of the second oxygen molecule increases. The hemoglobin then attracts more oxygen.

12. Have you heard about hypoxia? Try to gather information about it, and discuss it with your friends.

Ans: Hypoxia is a condition characterized by insufficient or decreased oxygen supply to the lungs and caused by various extrinsic factors such as decreased pO2, insufficient oxygen, etc. The different types of hypoxia are;-.

- **Hypoxemic hypoxia**

  In this hypoxia, there is a decrease in the oxygen content of the blood due to the low oxygen partial pressure in the arterial blood.

- **Anaemic hypoxia**

  This hypoxia results in a decrease in haemoglobin concentration.

• **Stagnant or ischemic hypoxia**

This type of hypoxia results in a lack of oxygen in the blood due to poor circulation. It occurs when a person is exposed to a cold temperature for a long period of time.

• **Histotoxic hypoxia**

In this type of hypoxia, the tissues cannot use oxygen, which occurs with carbon monoxide or cyanide poisoning.

13. Distinguish between

(a) IRV and ERV

Ans:

Inspiratory reserve volume (IRV)	**Expiratory reserve volume(ERV)**
This is defined as the maximum volume of the air that can be breathed in after a normal inspiration.	It is the maximum volume of air that can be exhaled i.e released out after a normal expiration.
It is approx 2500-3500 ml in human lungs.	It is approx 1000-1100 ml in human lungs.

(b) Inspiratory capacity and Expiratory capacity

Ans:

Inspiratory capacity (IC)	**Expiratory capacity (EC)**
It is defined as the volume of the air that can be inhaled easily after a normal expiration.	It is defined as the volume of air that can be exhaled easily after a normal inspiration.
It comprises inspiratory reserve volume and tidal volume. IC = TV + IRV	It comprises expiratory reverse volume and tidal volume. EC = TV + ERV

(c) Vital capacity and Total lung capacity

Ans:

Vital capacity (VC)	Total lung capacity (TLC)
It is defined as the maximum volume of air that can be exhaled easily after a maximum inspiration. It includes IC and ERV.	It is defined as the volume of air in the lungs after maximum inspiration. It includes IC, ERV, and residual volume.
It is approximately 4000 mL in the human lungs.	It is approximately 5000 – 6000 mL in the human lungs.

14. What is Tidal volume? Find out the Tidal volume (approximate value) for a healthy human in an hour.

Ans: Tidal volume is defined as the volume of air that is inspired or expired during normal respiration. It is approximately 6000 to 8000 mL of air per minute.

The hourly tidal volume for a human with a good health is calculated as shown below:

Tidal volume = 6000 to 8000 mL/minute

Tidal volume in an hour = 6000 to 8000 mL ×(60 min)

= 3.6×10^{5} ml to 4.8×10^{5} ml

Therefore, the hourly tidal volume for a human with good health is around 3.6×10^{5} ml to 4.8×10^{5} ml.