

13. Human Respiration

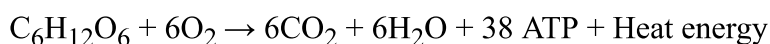
Respiration

Respiration is a chemical process in which glucose is breakdown to release energy for carrying out other life processes. The basic respiration process can be represented as:

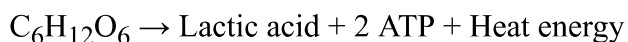


Types of Respiration

- **Aerobic respiration:** Respiration occurring in presence of oxygen. Most common type of respiration process in animals.



- **Anaerobic Respiration:** Respiration occurring in absence of oxygen. Very few animals can respire anaerobically, example tapeworms



Parts of Respiration

- **Breathing:** It is a physical process in which oxygen-rich air is taken in and CO₂ rich air (from our body's internal organs) is expelled out.
- **Gaseous transport:** Firstly, the exchange of gases occurs in the lungs. The oxygen absorbed by the blood in lungs is then carried to other body parts as oxyhaemoglobin. The CO₂ from the tissues is transported to the lungs through blood either as bicarbonates dissolved in plasms, or as carbamino-haemoglobin (by combining with haemoglobin).
- **Tissue respiration:** The capillaries deliver the oxygen to the body cells and pick up the carbon dioxide released by them. This exchange of gases occurs by diffusion through thin walls of capillaries.
- **Cellular respiration:** It involves complex chemical reactions inside the cell in which oxygen is utilised to breakdown the glucose to release energy.

Human respiratory organs

- Human respiratory system extends from nose to lungs.
- It includes nose, nasopharynx, trachea, bronchi, bronchioles, and lungs.
- **Nasopharynx** acts as a common passage for food and air. It opens through glottis into the trachea.
- **Epiglottis** is the covering of glottis which prevents the entry of food into the larynx.
- **Larynx** (sound box) is a cartilaginous structure located at the top of trachea. It helps in sound production
- **Trachea** is a straight tube which is divided into right and left primary bronchi. Bronchi are then further divided into secondary and tertiary bronchi.
- **Bronchi** are then divided into bronchioles, which end into terminal bronchioles.
- **Terminal Bronchioles** give rise to several tiny air sacs called alveoli.
- **Nostrils, trachea, bronchi, and bronchioles** form the conducting part of respiratory system. They transport atmospheric air to alveoli (the exchange part), which clears off any foreign particles from inhaled air.
- **Alveoli** are the site of exchange of gases. They do not play any role in conduction of air. They hold air in the lungs.
- The exchange of gases takes place between the blood capillaries and gases present in alveoli.

Mechanism of Breathing

- The process of breathing involves taking in of atmospheric air (**inspiration**) and giving out of alveolar air (**expiration**).
- **Inspiration**
 - It occurs when intra-pulmonary pressure is lower than atmospheric pressure, which means there is negative pressure in lungs.
 - Diaphragm moves down and ribs move upwards and outwards, thereby leading the movement of air into the lungs.
 - The volume of air in the thoracic chamber increases.
- **Expiration**
 - It occurs when intra-pulmonary pressure is higher than atmospheric pressure, which means that there is positive pressure in lungs.
 - Diaphragm moves to its former position and the ribs move downward and inward. This reduces the size of chest cavity and leads to the movement of air out of lungs.
 - The volume of air in the thoracic chamber decreases.
- An adult human respire at the rate of 12-16 times/minute. Spirometre helps in clinical assessment of pulmonary function.
- **Respiratory volume and capacities**
 - **Tidal volume (TV):** It is the volume of air that is inspired or expired in a single breath during regular breathing. Its value is about 500 mL. Hence, it is about 6000 to 8000 mL of air/minute.
 - **Inspiratory reserve volume (IRV)** – It is the additional volume of air that can be inspired by a person in a forcible inspiration. It is about 2500 – 3000 mL.
 - **Expiratory reserve volume (ERV)** – It is the additional volume of air that can be expired by a person in a forcible expiration. It is about 1000 – 1100 mL.
 - **Residual volume (RV)** – It is the amount of air remaining in the lungs after maximum expiratory effort. It is about 1100 – 1200 mL.
 - **Inspiratory capacity (IC)** – It is the total amount of air that can be inhaled by a person after normal exhalation. It includes TV + IRV.
 - **Expiratory capacity (EC)** – It is the amount of air that a person can exhale after a normal inhalation. It includes TV + ERV.
 - **Functional residual volume (FRV)** – It is the amount of air that remains in lungs after normal exhalation. It includes ERV + RV.

- **Vital capacity (VC)** – It is the maximum volume of air that a person can breathe in after maximum exhalation. It is equal to $ERV + TV + IRV$.
- **Total lung capacity (TLC)** – It is the total amount of air accommodated in lungs after forced inhalation. It includes $VC + RV$.
- **Gaseous exchange**
 - Exchange of gases (O_2 and CO_2) at alveolar and tissue region occurs by **diffusion**.
 - The partial pressure of O_2 in atmospheric air is higher than that of oxygen in alveolar air. In atmospheric air, pO_2 is about 159 mm Hg; while in alveolar air, it is about 104 mm Hg.
 - The partial pressure of CO_2 in atmospheric air is lower than that of CO_2 in alveolar air. In atmospheric air, pCO_2 is about 0.3 mm Hg; while in alveolar air, it is about 40 mm Hg.
- **Hypoxia:** Condition of deficiency of oxygen reaching the tissues. It may occur due to poor ventilation or at higher altitudes.
- **Asphyxiation:** Condition in which blood becomes venous due to accumulation of carbon dioxide and diminished oxygen supply.

Factors Affecting Gaseous Exchange in Tissues

Gaseous exchange

- Exchange of gases (O_2 and CO_2) at alveolar and tissue region occurs by **diffusion**.
- **Factors affecting diffusion of gases are:-**
 - Thickness of membrane involved
 - **Solubility of gases**
 - Solubility of CO_2 is 20 - 25 times higher than that of oxygen.
 - **Partial pressure**
 - The partial pressure of O_2 in atmospheric air is higher than that of oxygen in alveolar air. In atmospheric air, pO_2 is about 159 mm Hg; while in alveolar air, it is about 104 mm Hg. The pO_2 in oxygenated blood is 95 mm Hg while it is 40 mm Hg in tissues.
 - The partial pressure of CO_2 in atmospheric air is lower than that of CO_2 in alveolar air. In atmospheric air, pCO_2 is about 0.3 mm Hg; while in alveolar air, it is about 40 mm Hg. The pCO_2 in oxygenated blood is 40 mm Hg and 45 mm Hg in tissues.

Transport of Gases

- **Transport of oxygen**

1. Oxygen is mainly transported as oxy-haemoglobin.
2. **In lungs**, the pO_2 is high while low pCO_2 , low H^+ and temperature. Therefore, haemoglobin binds to oxygen and forms oxy-haemoglobin.
3. **Tissues** have low pO_2 , high pCO_2 , high H^+ , and higher temperature. Therefore, oxy-haemoglobin releases oxygen to form haemoglobin.
4. Under physiological conditions, every 100 mL of oxygenated blood delivers around 5 mL of O_2 to tissues.
5. An oxygen dissociation curve is formed when percentage saturation of haemoglobin with O_2 is plotted against the pO_2 . This curve is called the Oxygen dissociation curve.

• Transport of carbon dioxide

1. About 7% of CO_2 is carried in dissolved state through **plasma**.
2. About 20 – 25 % of CO_2 is transported by RBCs as **carbamino haemoglobin**.
3. About 70% of CO_2 is transported as **bicarbonate**.



1. When pCO_2 is high, HCO_3^- forms in tissues
2. When pCO_2 is low, $CO_2 + H_2O$ forms in Alveoli.
3. CO_2 is trapped in tissue as HCO_3^- and released from alveoli as $CO_2 + H_2O$.

1. Every 100 mL of deoxygenated blood delivers 4 mL of CO_2 to alveoli.

Respiratory Volume and Capacities

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Regulation of Respiration and Respiratory Disorders

1. Regulation of Respiration

The respiratory rhythm centre in the medulla region of brain regulates respiration. This system is associated with

- **Pneumotaxic centre** that moderates the function of respiratory rhythm centre
- **Chemo sensitive area** which gets activated when the conc. of CO_2 and H^+ increases and provide signals to eliminate them.

1. Respiratory disorders

- **Asthma** – It is caused due to inflammation of bronchi and bronchioles.
- **Emphysema** – It is characterized by loss of elasticity of alveolar wall.
- **Occupational respiratory disorders** – Long exposure to dust leads to inflammation. Example: Fibrosis