

## 13. Human Respiration

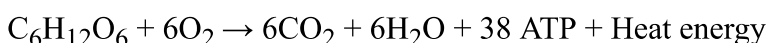
### Respiration

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:

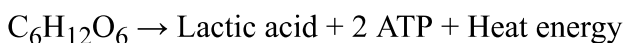


### Types of Respiration

- **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  $\text{CO}_2$  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  $\text{CO}_2$  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 respires 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

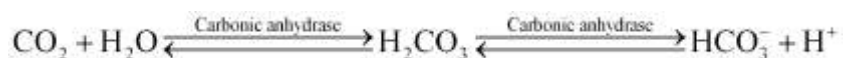
- **Transport of oxygen**



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

- **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.



## 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  $\text{CO}_2$  and  $\text{H}^+$  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

