Respiration

Based on GROUP-IV Examination syllabus -prepared by G.SRIRAM

NOTE: Dear kalam achievers kindly read at lest 4 to 5 times you can easily understand..

Respiration – Breathing and Exchange of Gases

- Oxygen (O2) is utilized by the organisms to indirectly break down nutrient molecules like glucose and to derive energy for performing various activities. Carbon dioxide (CO2) which is harmful is also released during the above **catabolic reactions**. It is, therefore, evident that O2 has to be continuously provided to the cells and CO2 produced by the cells have to be released out. This process of exchange of O2 from the atmosphere with CO2 produced by the cells is called breathing, commonly known as respiration.

Metabolic Pathways

- Metabolic pathways that lead to a more complex structure from a simpler structure are called **biosynthetic pathways** or **anabolic pathways**. Example:**acetic acid becomes cholesterol.**
- Metabolic pathways that lead to a simpler structure from a complex structure are called **catabolic pathways**. Example: **glucose becomes lactic acid in our skeletal muscle**.
- Anabolic pathways **consume energy**. Assembly of a protein from amino acids requires energy input.
- On the other hand, catabolic pathways lead to the release of energy. For example, when glucose is degraded to lactic acid in our skeletal muscle, energy is liberated. This metabolic pathway from glucose to lactic acid which occurs in 10 metabolic steps is called **glycolysis**.
- Living organisms have learnt to trap this energy liberated during degradation and store it in the form of chemical bonds.
- As and when needed, this **bond energy** is utilized for biosynthetic, osmotic and mechanical work that we perform.
- The most important form of energy currency in living systems is the bond energy in a chemical called **adenosine triphosphate (ATP)**.

- Mechanisms of breathing vary among different groups of animals depending mainly on their habitats and levels of organization.

- Lower invertebrates like sponges, coelenterates, flatworms, etc., exchange O2 with CO2 by **simple diffusion** over their entire body surface.
- Earthworms use their moist **cuticle** and insects have a network of tubes (**tracheal tubes**) to transport atmospheric air within the body.
- Special vascularized structures called **gills** are used by most of the aquatic arthropods and molluscs whereas vascularised bags called lungs are used by the terrestrial forms for the exchange of gases.
- Among vertebrates, fishes use gills whereas reptiles, birds and mammals respire through lungs. Amphibians like frogs can respire through their moist **skin**Mammals usually have a well-developed respiratory system.

Human Respiratory System

- We have a pair of external nostrils opening out above the upper lips. It leads to a nasal chamber through the nasal passage. The nasal chamber opens into the**pharynx**, a portion of which is the **common passage** for food and air.
- The pharynx opens through the larynx region into the trachea. **Larynx** is a cartilaginous box which helps in sound production and hence called the **sound box**.
- During swallowing glottis can be covered by a thin elastic cartilaginous flap called**epiglottis** to prevent the entry of food into the larynx.
- Trachea is a straight tube which divides into a right and left primary **bronchi**. Each bronchi undergoes repeated divisions to form the secondary and tertiary bronchi and **bronchioles** ending up in very thin terminal bronchioles. The tracheae, primary, secondary and tertiary bronchi are supported by **incomplete cartilaginous rings**.
- Each terminal bronchiole gives rise to a number of very thin, irregular-walled and vascularised bag-like structures called **alveoli**. The branching network of bronchi, bronchioles and alveoli comprise the lungs.
- We have two lungs which are covered by a double layered **pleura**, with pleural fluid between them. It **reduces friction** on the lung-surface. The

outer pleural membrane is in close contact with the thoracic lining whereas the inner pleural membrane is in contact with the lung surface.

- The part starting with the external nostrils up to the terminal bronchioles constitute the conducting part whereas the alveoli and their ducts form the respiratory or exchange part of the respiratory system.
- The conducting part transports the atmospheric air to the alveoli, **clears it from foreign particles, humidifies** and also brings the **air to body temperature**. Exchange part is the site of **actual diffusion** of O2 and CO2 between blood and atmospheric air.
- The lungs are situated in the thoracic chamber which is anatomically an air-tight chamber. The thoracic chamber is formed dorsally by the **vertebral column**, ventrally by the **sternum** [breastbone], laterally by the ribs and on the lower side by the dome-shaped **diaphragm**.
- The anatomical setup of lungs in thorax is such that *any change in the volume of the thoracic cavity will be reflected in the lung (pulmonary) cavity*. Such an arrangement is essential for breathing, as we cannot directly alter the pulmonary volume.

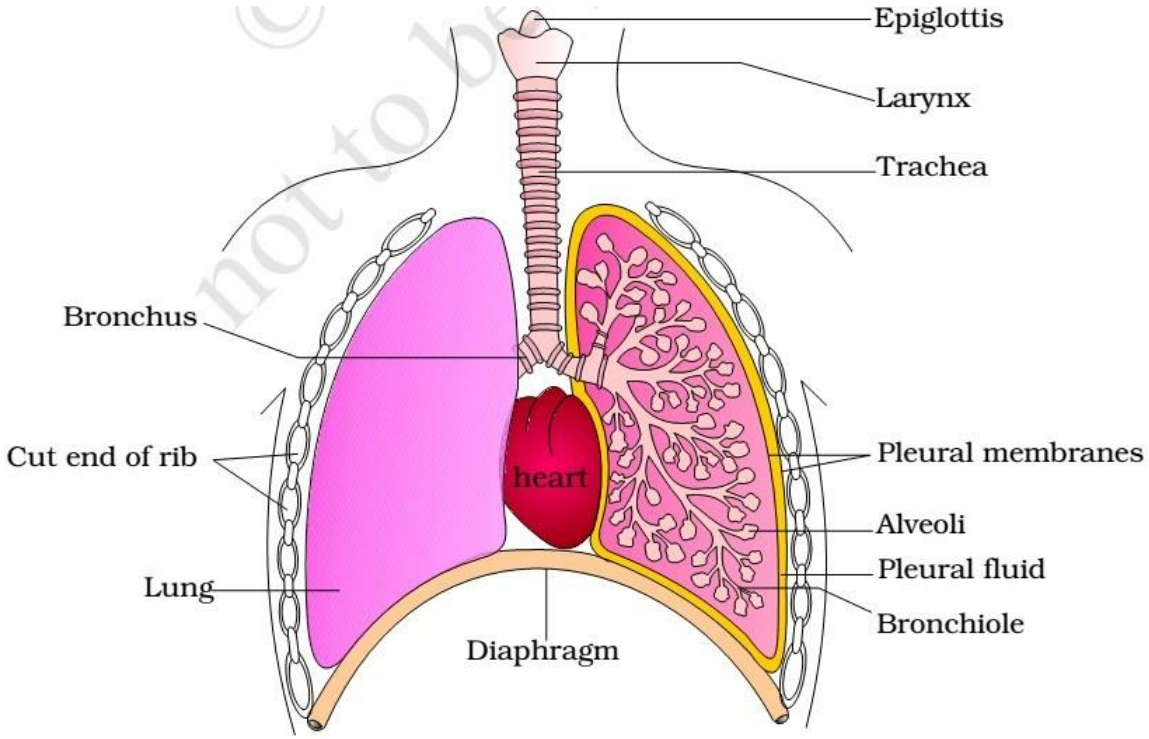

Figure 17.1 Diagrammatic view of human respiratory system (Sectional view of the left lung is also shown)

-

Respiration involves the following steps:

1. Breathing or pulmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out.
2. Diffusion of gases (O_2 and CO_2) across alveolar membrane.
3. Transport of gases by the blood.
4. Diffusion of O_2 and CO_2 between blood and tissues.
5. Utilisation of O_2 by the cells for catabolic reactions and resultant release of CO_2.

Mechanism of Breathing

- Breathing involves two stages: **inspiration** during which atmospheric air is drawn in and **expiration** by which the alveolar air is released out.

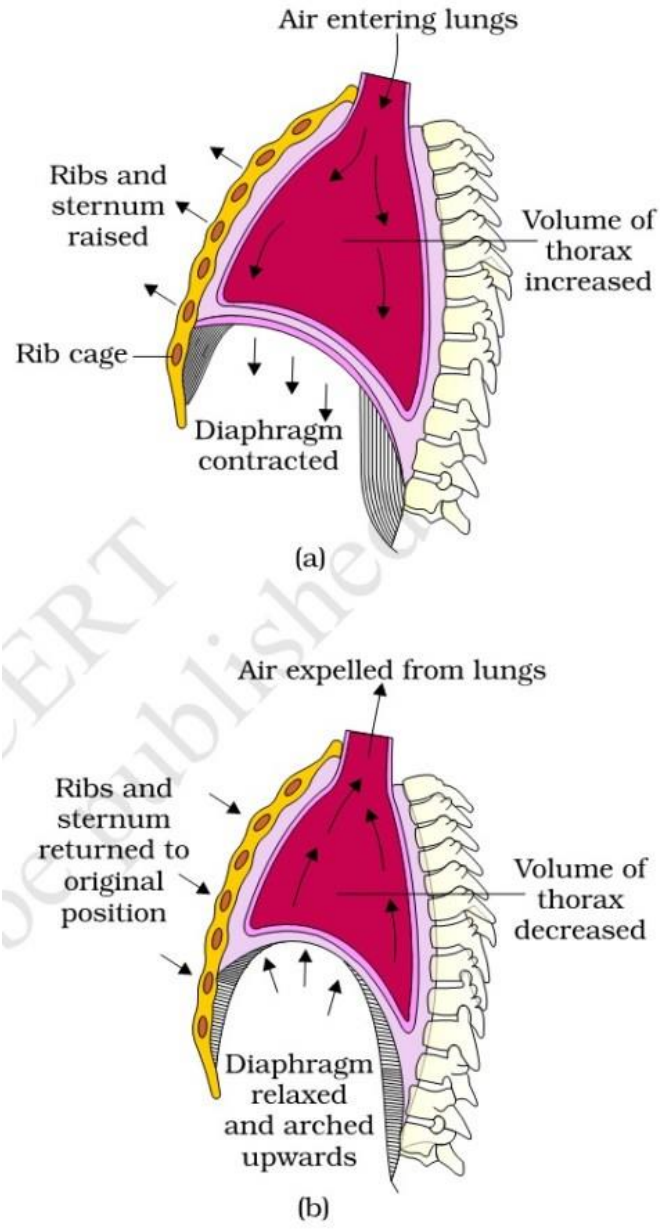

Figure 17.2 Mechanism of breathing showing : (a) inspiration (b) expiration

-
- The movement of air into and out of the lungs is carried out by creating a pressure gradient between the lungs and the atmosphere.
- Inspiration can occur if the pressure within the lungs (intra-pulmonary pressure) is less than the atmospheric pressure, i.e., there is a negative pressure in the lungs with respect to atmospheric pressure. Similarly, expiration takes place when the intra-pulmonary pressure is higher than the atmospheric pressure.

- The **diaphragm** and a specialized set of muscles – external and internal**intercostals** between the ribs, help in generation of such gradients.
- Inspiration is initiated by the **contraction** of diaphragm which increases the volume of thoracic chamber in the antero-posterior axis. The **contraction** of external inter-costal muscles lifts up the ribs and the sternum causing an increase in the volume of the thoracic chamber in the dorso-ventral axis. The overall**increase in the thoracic volume** causes a **similar increase in pulmonary volume**.
- An increase in pulmonary volume decreases the intra-pulmonary pressure to less than the atmospheric pressure which forces the air from outside to move into the lungs, i.e., inspiration.
- Relaxation of the diaphragm and the inter-costal muscles returns the diaphragm and sternum to their normal positions and reduce the thoracic volume and thereby the pulmonary volume. This leads to an increase in intra-pulmonary pressure to slightly above the atmospheric pressure causing the expulsion of air from the lungs, i.e., expiration. We have the ability to increase the strength of inspiration and expiration with the help of additional muscles in the abdomen.
- On an average, a healthy human breathes **12-16 times/minute**. The volume of air involved in breathing movements can be estimated by using a **spirometer** which helps in clinical assessment of pulmonary functions.

Exchange of Gases

- **Alveoli** are the primary sites of exchange of gases. Exchange of gases also occur between **blood and tissues**. O2 and CO2 are exchanged in these sites by simple**diffusion** mainly based on pressure/concentration gradient.
- **Partial pressure** of gasses, **Solubility** of the gases as well as the **thickness** of the membranes involved in diffusion are some important factors that can affect the rate of diffusion.
- Pressure contributed by an individual gas in a mixture of gases is called partial pressure.

TABLE 17.1 Partial Pressures (in mm Hg) of Oxygen and Carbon dioxide at Different Parts Involved in Diffusion in Comparison to those in Atmosphere

Respiratory Gas	Atmospheric Air	Alveoli	Blood (Deoxygenated)	Blood (Oxygenated)	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

Transport of Gases

- **Blood** is the medium of transport for O2 and CO2.
- About **97 per cent** of O2 is transported by **RBCs** in the blood. The remaining 3 per cent of O2 is carried in a **dissolved state** through the plasma.
- Nearly 20-25 per cent of CO2 is transported by **RBCs** whereas 70 per cent of it is carried as **bicarbonate**. About 7 per cent of CO2 is carried in a **dissolved state**through plasma.

Transport of Oxygen

- **Haemoglobin** is a red coloured **iron** containing pigment present in the RBCs. O2 can bind with haemoglobin in a reversible manner to form **oxyhaemoglobin**.
- Each haemoglobin molecule can carry a maximum of **four** molecules of O2. Binding of oxygen with haemoglobin is primarily related to **partial pressure** of O2.
- Partial pressure of CO2, hydrogen ion concentration and temperature are the other factors which can interfere with this binding.

Transport of Carbon dioxide

- CO2 is carried by haemoglobin as **carbamino-haemoglobin** (about 20-25 per cent). This binding is related to the partial pressure of CO2. Partial pressure of O2 is a major factor which could affect this binding. RBCs contain a very high concentration of the enzyme, **carbonic anhydrase** and minute quantities of the same is present in the plasma too.

Nearly 70 per cent of carbon dioxide is transported as bicarbonate (HCO_3) with the help of the enzyme carbonic anhydrase.

- At the tissue site where partial pressure of CO_2 is high due to catabolism [the breakdown of complex molecules in living organisms to form simpler ones, together with the release of energy], CO_2 diffuses into blood (RBCs and plasma) and forms HCO_3 and H+-.
- At the alveolar site where pCO_2 is low, the reaction proceeds in the opposite direction leading to the formation of CO_2 and H_2O.
- Thus, CO_2 trapped as bicarbonate at the tissue level and transported to the alveoli is released out as CO_2. Every 100 ml of deoxygenated blood delivers approximately 4 ml of CO_2 to the alveoli.

Regulation of Respiration

- Human beings have a significant ability to maintain and moderate the respiratory rhythm to suit the demands of the body tissues. This is done by the neural system.
- A specialised centre present in the **medulla region** of the brain called **respiratory rhythm centre** is primarily responsible for this regulation.
- Another centre present in the **pons** region of the brain called **pneumotaxic centre**can moderate the functions of the respiratory rhythm centre. Neural signal from this centre can reduce the duration of inspiration and thereby alter the respiratory rate.
- A chemosensitive area is situated adjacent to the rhythm centre which is highly sensitive to CO_2 and hydrogen ions. Increase in these substances can activate this centre, which in turn can signal the rhythm centre to make necessary adjustments in the respiratory process by which these substances can be eliminated.

Disorders of Respiratory System

- ***Asthma:*** Asthma is a difficulty in breathing causing wheezing due to**inflammation of bronchi** and bronchioles.

- ***Emphysema:*** Emphysema is a chronic disorder in which alveolar walls are damaged due to which respiratory surface is decreased. One of the major causes of this is **cigarette smoking**.
- Occupational Respiratory Disorders: In certain industries, especially those involving grinding or stone-breaking, so much dust is produced that the defense mechanism of the body cannot fully cope with the situation. Long exposure can give rise to inflammation leading to **fibrosis** (proliferation of fibrous tissues) and thus causing serious lung damage. Workers in such industries should wear protective masks.