

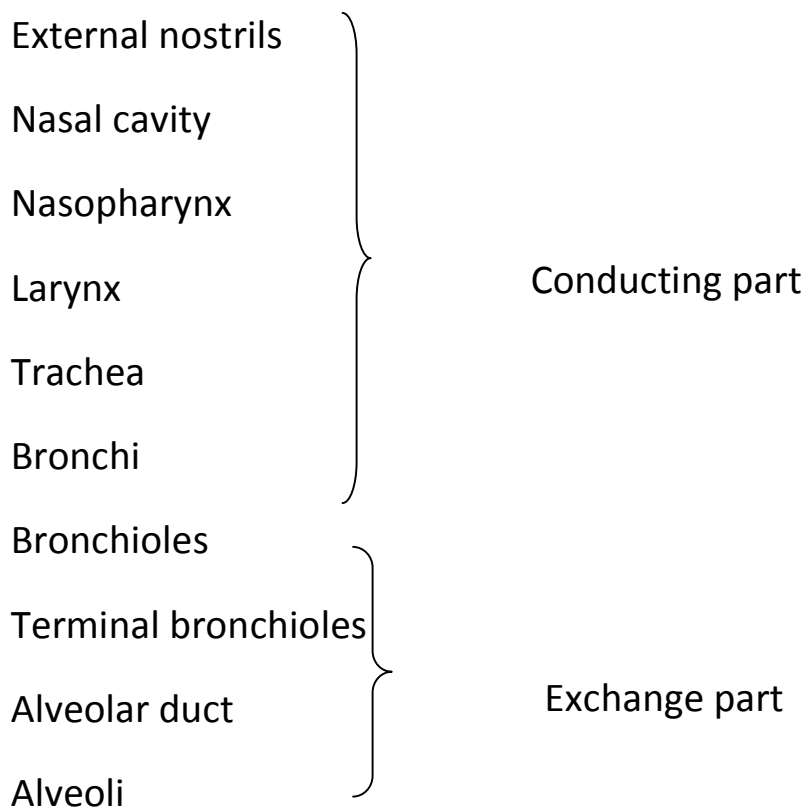
## BREATHING AND EXCHANGE OF GASES

The process of exchange of  $O_2$  from the atmosphere with  $CO_2$  produced by the cells is called **breathing**, commonly known as **respiration**.

### Respiratory organs in different animals

- Invertebrates like **sponges, coelenterates**, earthworms by simple diffusion through body surface. (Cutaneous respiration)
- Insects-Tracheal tubes
- Aquatic mollusks and fishes- Gills
- Aquatic mollusks and arthropods-book Lungs
- Amphibia-Skin , Lungs
- Reptiles, Birds, and mammals-lungs

### HUMAN RESPIRATORY SYSTEM



- **Nasopharynx**, a portion of pharynx.

**Larynx**- (**sound box**) - a cartilaginous box which helps in sound production

**Glottis** -Opening of the larynx

- **Epiglottis** -the lid which guards the opening of larynx (glottis).It **prevent the entry of food into the larynx.**
- Trachea – a straight tube
- Bronchus-divides into **right and left primary bronchi and then branches out into bronchioles.**
- The tracheae, primary, secondary and tertiary bronchi, are supported by C shaped **cartilaginous rings**
- **Alveoli**- thin bag like structures into which terminal bronchiole ends.
- **bronchi, bronchioles** and **alveoli** comprise the **lungs.**
- **Conducting part**-transports the atmospheric air to the alveoli,
- **Exchange part**- alveoli and their ducts-Here diffusion of O<sub>2</sub> and CO<sub>2</sub> takes place.
- **The lungs**
- **Pleura**- A double layered covering of lungs- a fluid in between -called **pleural fluid**. It **reduces friction on the lung surface.**
- Situated in the **thoracic chamber** an air-tight chamber.
- The thoracic chamber is formed dorsally by the vertebral column, ventrally by the sternum, laterally by the ribs and on the lower side by the dome-shaped diaphragm.
- **Any change in the volume of the thoracic cavity will be reflected in the lung (pulmonary) cavity.**

## **Steps of respiration**

- 1. Breathing by which atmospheric air is drawn in and CO<sub>2</sub> rich alveolar air is released out.
- 2. Diffusion of gases (O<sub>2</sub> and CO<sub>2</sub>) across alveolar membrane.
- 3. Transport of gases by the blood.
- 4. Diffusion of O<sub>2</sub> and CO<sub>2</sub> between blood and tissues
- 5. Utilisation of O<sub>2</sub> by the cells and resultant release of CO<sub>2</sub> (cellular respiration).

## **• MECHANISM OF BREATHING**

**Inspiration-** Atmospheric air is drawn in

Occurs passively when intra pulmonary pressure is less than atmospheric pressure.

- Step1. Intercostals muscles contract.
- 2. Lift up the ribs and sternum.
- 3. Diaphragm contracts and flattens.
- 4. Volume of thoracic cavity increases.
- 5. As the volume increases, air pressure decreases.

## **• EXPIRATION (Breathing out)**

- Occurs when intra pulmonary pressure is higher than atmospheric pressure.
- 1. Intercostals muscles relax.
- 2. Ribs move downwards.
- 3. Diaphragm relaxes and arches upward.
- 4. Volume of thorax decreases.

- 5. Air pressure in thorax increases.
- 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**

## **RESPIRATORY VOLUMES**

### **1. TIDAL VOLUME (TV)**

- **Volume of air inspired or expired during a normal respiration.**
- It is approx. 500 ml., i.e., a healthy man can inspire or expire approximately 6000 to 8000 ml of air per minute.

### **2.INSPIRATORY RESERVE VOLUME (IRV)**

- **Additional volume of air, a person can inspire by a forcible inspiration.**
- This averages 2500 ml to 3000 ml.

### **3. EXPIRATORY RESERVE VOLUME (ERV)**

- **Additional volume of air, a person can expire by a forcible expiration.**
- This averages 1000 ml to 1100 ml.

### **4. RESIDUAL VOLUME (RV)**

- **Volume of air remaining in the lungs even after a forcible expiration.**
- This averages 1100 ml to 1200 ml.

## **PULMONARY CAPACITIES-**

### **5. INSPIRATORY CAPACITY (IC)**

Total volume of air a person can inspire after a normal expiration.

This includes tidal volume & inspiratory reserve volume (TV+IRV).

### **6. EXPIRATORY CAPACITY (EC)**

**Total volume of air a person can expire after a normal inspiration.**

This includes tidal volume and expiratory reserve volume (TV+ERV).

## **7. FUNCTIONAL RESIDUAL CAPACITY (FRC)**

**Volume of air that will remain in the lungs after a normal expiration.**

This includes ERV+RV.

## **8. VITAL CAPACITY (VC)**

**The maximum volume of air a person can breathe in after a forced expiration.**

V C includes ERV, TV and IRV or the maximum volume of air a person can breathe out after a forced inspiration

## **9. TOTAL LUNG CAPACITY**

**Total volume of air accommodated in the lungs at the end of a forced inspiration.**

This includes RV, ERV, TV and IRV or vital capacity + residual volume.

## **EXCHANGE OF GASES**

Occurs in Alveoli and also between **blood and tissues**.

### **Mechanism**

**Simple Diffusion based on pressure gradient**

Factors that can affect the rate of diffusion of gases

**1. Partial pressure of gases**

**2. Solubility of the gases**

**2. Thickness of the membranes involved in diffusion**

Partial pressure- Pressure of an individual gas in a mixture of gases is called **partial pressure**

Partial pressure of oxygen is represented as **pO<sub>2</sub>** and of carbon dioxide as pCO<sub>2</sub>

The diffusion membrane is made up of three major layers

1. **Squamous epithelium of alveoli,**
2. **The endothelium of alveolar capillaries**
3. **The basement substance in between them.**

Its total thickness is much less than a millimetre.

## **TRANSPORT OF GASES**

### **Transport of oxygen**

3 % is carried in a dissolved state through the plasma.

97 % of O<sub>2</sub> is transported by RBC (binding with Hb)

O<sub>2</sub> can bind with haemoglobin to form **oxyhaemoglobin**.

Each Hb molecule can carry a maximum of 4 molecules of O<sub>2</sub>.

### **Factors affecting the binding of oxygen with Hb**

1. Partial pressure of O<sub>2</sub>.
2. Partial pressure of CO<sub>2</sub>,
3. Hydrogen ion concentration
4. Temperature

## **OXYGEN DISSOCIATION CURVE**

A sigmoid curve is obtained when percentage saturation of haemoglobin with O<sub>2</sub> is plotted against the pO<sub>2</sub>. This curve is called the **Oxygen dissociation curve**

It is highly useful in studying the effect of factors like pCO<sub>2</sub>, H<sup>+</sup> concentration, etc., on binding of O<sub>2</sub> with haemoglobin.

**In the alveoli**-High  $pO_2$  low  $pCO_2$  lesser  $H^+$  concentration and lower temperature.

This leads to the formation of oxyhaemoglobin.

**In the tissues** -low  $pO_2$ , high  $pCO_2$  , high  $H^+$  concentration and higher temperature

This leads to the dissociation of oxygen from the oxyhaemoglobin

**ie.  $O_2$  gets bound to haemoglobin in the lung surface and gets dissociated at the tissues.**

Every 100 ml of oxygenated blood can deliver around **5 ml of  $O_2$**  to the tissues under normal physiological conditions.

### **TRANSPORT OF CARBON DIOXIDE**

1. 25 % by RBCs. as carbamino haemoglobin
2. 70 % of it is carried as bicarbonate.
3. 7 % in a dissolved state through plasma.(As carbonic acid)

#### **1.As carbamino haemoglobin(25%)**

Depends on the partial pressure of  $CO_2$ .

$pCO_2$  is high and  $pO_2$  is low as in the tissues --binding of carbon dioxide occurs

$pCO_2$  is low and  $pO_2$  is high as in the alveoli--dissociation of  $CO_2$  from carbamino-haemoglobin, i.e.,  $CO_2$  bound to haemoglobin from the tissues is delivered at the alveoli.

#### **2.As bicarbonate**

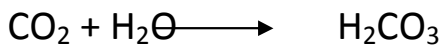
In tissue  **$pCO_2$  is high ,  $CO_2$  diffuses into RBC and dissociates into  $HCO_3^-$  &  $H^+$ .**

In alveoli 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  $CO_2$ .

### 3. As Carbonic acid

About 7 per cent of CO<sub>2</sub> is carried in a dissolved state through **plasma**.



Every 100 ml of deoxygenated blood delivers approximately 4 ml of CO<sub>2</sub> to the alveoli.

### REGULATION OF RESPIRATION

**respiratory rhythm centre** –present in medulla of the brain-controls respiration

**pneumotaxic centre** -present in the pons of the brain - moderate the functions of the respiratory rhythm centre. Reduces the duration of inspiration and thereby alter the respiratory rate.

A chemosensitive area is situated adjacent to the rhythm centre which is highly sensitive. Increase in CO<sub>2</sub> activates this centre- signal the rhythm centre to start expiration in the process by which these substances can be eliminated.

Receptors associated with **aortic arch** and **carotid artery** also can recognise changes in CO<sub>2</sub> and H<sup>+</sup> concentration and send necessary signals to the rhythm centre for remedial actions.

### DISORDERS OF RESPIRATORY SYSTEM

**1.ASTHMA**-Difficulty in breathing ,wheezing due to inflammation of bronchi & bronchioles

**2.EMPHYSEMA**-Chronic disorder in which alveolar walls are damaged due to which respiratory surface is decreased. Major cause of this is cigarette smoking.

### 3.OCCUPATIONAL RESPIRATORY DISORDERS

In certain industries, like involving grinding or stone-breaking, so much dust is produced that the defence mechanism of the body cannot fully cope with the



situation. Long exposure leads to inflammation and **fibrosis** (proliferation of fibrous tissues) Workers in such industries should wear protective masks

Silicosis

Asbetosis