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

External nostrils
Nasal cavity
Nasopharynx
Larynx
Trachea
Bronchi
} Conducting part

Bronchioles
Terminal bronchioles
Alveolar duct
Alveoli
} Exchange part

- **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_2 and CO_2 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_2 rich alveolar air is released out.
- 2. Diffusion of gases (O2 and CO2) 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 and resultant release of CO_2 (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_2** and of carbon dioxide as pCO2

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_2 is transported by RBC (binding with Hb)

O_2 can bind with haem`oglobin to form **oxyhaemoglobin.**

Each Hb molecule can carry a maximum of 4 molecules of O_2.

Factors affecting the binding of oxygen with Hb

1. Partial pressure of O_2.
2. Partial pressure of CO_2,
3. Hydrogen ion concentration
4. Temperature

OXYGEN DISSOCIATION CURVE

A sigmoid curve is obtained when percentage saturation of haemoglobin with O_2 is plotted against the pO_2. This curve is called the **Oxygen dissociation curve**

It is highly useful in studying the effect of factors like pCO_2, H+ concentration, etc., on binding of O_2 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 p**CO_2 is high** , **CO_2 diffuses into RBC and dissociates into $HCO3^-$ & 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_2 is carried in a dissolved state through **plasma**.

$CO_2 + H_2O \longrightarrow H_2CO_3$

Every 100 ml of deoxygenated blood delivers approximately 4 ml of CO_2 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_2 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_2 and H^+ 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