Chapter

17 Breathing and Exchange of Gases

- Our body is made up of trillions of living cells. Each of these cells needs energy to carry out the various tasks that keep our bodies alive and functioning. For example, muscles need energy to contract, and all parts of our body need energy to synthesize needed molecules.
- Our body gets the energy it needs by combining food molecules with oxygen in a process called **cellular respiration.**

RESPIRATION AND BREATHING

- **Respiration** and **Breathing** is the oxidation of nutrients in the living cells to release energy for biological work. It takes place in all the cells of the body.

  Glucose + Oxygen → Carbon dioxide + Water
- Respiration also produces carbon dioxide, a toxic substance which is eliminated from the body. This, uptake of oxygen and removal of carbon dioxide is an essential requirement of all living animals.

Steps involved in respiration are:

1. **Gaseous exchange:** It involves exchange of gases between the cell and its surrounding medium. The cells obtain oxygen from the environment and return carbon dioxide and water vapour to it.
2. **Cellular respiration:** It is a complex and elaborated process, which occurs in the cytoplasm and the mitochondria.

   Thus ultimate goal of respiratory system is to provide oxygen to the tissues and removal of carbon dioxide from them.

   Thus, to carry out the process of respiration, we require:

   (i) A respiratory system for exchange of gases.

   (ii) A transporting medium, blood, which carries oxygen to all cells of the body.

   (iii) Food, which is chemically broken down in the cells to release energy.

- **Breathing** is the process by which oxygen rich air is taken inside the body of an organism and carbon dioxide rich air is expelled out from the body.

Difference between Respiration and Breathing

Breathing	Respiration
It is a physical process.	It is a chemical process, involving enzymes.
It involves gaseous exchange between the animal and its external environment.	It involves enzymatic breakdown of glucose and release of energy.
Energy is consumed during the process.	Energy is released during the process.
It takes place outside the cells.	It takes place inside the cells.

RESPIRATION IN ANIMALS

Gas exchange takes place by diffusion. Organs of the body carrying out the function of gas exchange are called respiratory organs. They could be skin, lungs, gills or bacteria. All respiratory organs have three features in common.

(i) They have large surface area to get maximum oxygen.

(ii) They have thin walls for easy diffusion of gases.

(iii) They have a rich supply of blood for transporting respiratory gases.

Respiratory Organs in different animals.

Respiratory Organs	Animals/Animals groups
1. Skin (cutaneous respiration)	Earthworm, Leech, Frog
2. Gills or Bronchin or Ctenidia. (Branchial respiration)	Annelids (Arenicda), Crustaceans (Prawn, Crab), Molluscs (Pila, Unio), Protochordates, Fishes, Amphibians.
3. Tracheal System	Insects, Arachnids.
4. Bucco-pharynx	Frog
5. Lungs (Pulmonary respiration)	Amphibians, Reptiles, Birds and Mammals.

TYPES OF RESPIRATION

On the basis of usage of oxygen, respiration is divided into two types:

(i) **Aerobic respiration (aerobic-with air):** It is the process of complete breakdown of food in the presence of oxygen. It is the most efficient form of respiration.

Aerobic respiration can be represented by the following equation:

Glucose (food) + oxygen → Carbon dioxide + water + energy

Key points of aerobic respiration

- It is most common in higher organisms (both plants and animals).
- In aerobic respiration, the glucose, food is completely broken down into carbon dioxide and water with the help of oxygen.
- It produces large amount of energy.
- The end products of aerobic respiration are carbon dioxide and water.

(ii) **Anaerobic respiration (anaerobic-without air):** It is the process of breakdown of food in the absence of oxygen.

Anaerobic respiration can be represented by the following equation:

In Yeast: Glucose (food) → Carbon dioxide + Alcohol + Energy

Yeast is an anaerobe. It can survive in the absence of oxygen.

In muscles: Glucose (food) →Lactic acid + energy

Key points of anaerobic respiration:

- It takes place in lower organisms such as bacteria, fungi, and in muscle cells of human where oxygen present is insufficient.
- It involves partial breakdown of food in the absence of oxygen.
- It produces small amount of energy as compared to aerobic respiration.
- The end products of anaerobic respiration may be ethyl alcohol and carbon dioxide (in yeast) or lactic acid (in human muscle cells).
- Anaerobic respiration is also known as **fermentation**. Fermentation is the process of converting complex organic substance (sugar) into simpler substance (alcohol and carbon dioxide) with the help of yeast or bacteria.

Anaerobic Respiration in Muscles

During exercise, the muscle cells respire more than they do at rest. This means:

- Oxygen and glucose must be delivered to them more quickly.
- Waste carbon dioxide must be removed more quickly.

This is usually achieved by increasing the breathing rate and the heart rate. The increase in heart rate can be detected by measuring the pulse rate.

HUMAN RESPIRATORY SYSTEM

The human respiratory system is composed of two main sections: Upper respiratory tract and lower respiratory tract.

Upper Respiratory Tract	Lower Respiratory Tract
Nasal cavity	Bronchi
Pharynx	Bronchioles
Glottis	Lungs/Alveoli
Epiglottis	Diaphragm
Larynx	
Trachea	

1. Upper Respiratory Tract

(a) **Nostrils:** Nostrils are pair of slits, which opens into left and right nasal chambers. When we take in air through our nostrils, and when we breathe in, air passes through our nostrils into the nasal cavity.

(i) Nasal cavity possesses a border of hairs that traps the dust particles and germs in the air and filters them.

(ii) Also, it is richly supplied with blood vessels that warm the incoming air.

(iii) The sticky mucus lining the nasal chamber moistens the air and filters dust particles.

Functions: To warm and moisten air as it comes into the body.

(b) **Pharynx:** It is commonly called the throat.

- Pharynx is the common passage at the back of the mouth for air and food. It connects the mouth with the windpipe.

  Function: It allows air to pass from mouth /nose to larynx and oesophagus.

(c) **Glottis:** Glottis is an opening into the trachea.

Function: It allows air to flow back from the pharynx into the trachea.

(d) **Epiglottis:** Epiglottis is a stiff flap like structure covering the glottis. It acts as a trapdoor to the trachea.

Functions: It prevents the food and other foreign particles from entering the trachea. It opens during the breathing but closes the passage of wind pipe while swallowing or drinking, thus preventing the food from entering the lungs.

(e) **Larynx:** At the top of the trachea is the larynx, which contains a flap like tissue called the vocal cords.

- Vocal cords open and close to make sounds. When you exhale air from the lungs, it comes through the trachea and larynx and reaches the vocal cords.
- If the vocal cords are closed and the air flows between them, the vocal cords vibrate and a sound is made.
- The pitch of sound is determined by the size of the larynx and the length of the vocal cords. Because men have larger larynx and longer vocal cords, their voices are usually lower than women's. The shorter vocal cords of a female vibrate faster so the sound has a higher pitch.

Function: It produces sound. When air passes over the vocal chords, larynx vibrates and produces sound, which we call as voice.

(f) Trachea: It is commonly known as wind pipe, and is located in the chest cavity.

- It is a membranous tube supported by "C" shaped cartilage ring. The cartilage ring protects the trachea from collapse and injury.
- It basically connects the pharynx to bronchi.
- The trachea is lined by pseudo stratified ciliated columnar epithelium bearing mucous glands.
- The secretion of mucous gland traps the foreign particles and prevents them from entering the lungs.

Function: Trachea allows air to pass from pharynx to bronchi.

2. Lower Respiratory Tract

(a) Bronchi (Singular- Bronchus): Trachea branches into two smaller tubes called bronchi at its lower end. One bronchus enters each lung.

Function: It brings air into the lungs.

(b) Bronchioles: Bronchioles are located in each lung.

- Each bronchus divide in lungs to form a large number of still smaller tubes called bronchioles.
- Each terminal bronchiole gives rise to a number of very thin and vascularised alveoli (in lungs).

Function: It brings air deep into all parts of the lungs.

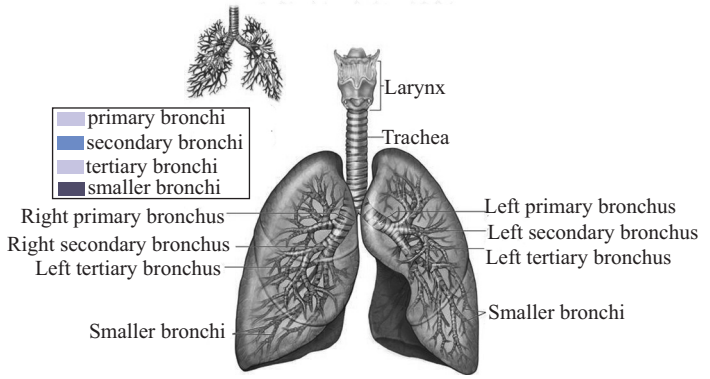


Fig. Human respiratory system

(c) Alveoli (Singular-Alveolus): Alveoli are pouch like air sacs found at the ends of the smallest bronchiole.

- They are thin walled sacs with a single layer of cells and heavily covered with blood capillaries.
- The exchange of gases between the air and blood takes place across the walls of the alveoli. O_2 from alveoli passes into capillaries and CO_2 from other capillaries diffuses into alveoli for being removed. Alveoli are the organs where the actual gaseous exchange occurs.
- Alveoli and their ducts form the respiratory or exchange part of the respiratory system.
- Alveoli are the structural and functional units of lungs.

Function: These are the sites of gas exchange (O_2 and CO_2) between the external environment and the blood stream.

(d) Lungs: The pair of lungs is conical in shape, and takes up most of the chest and thoracic cavity.

- The base of the lungs rests on the diaphragm.
- The left lung is slightly smaller than the right as the heart intrudes into the left lung area a bit.
- The left lung has two lobes, while the right one has three.
- The double layer pleural membrane covers the lungs for its protection.
- ***Lungs = Bronchi + bronchioles + alveoli.***
- It contains pleural fluid, which lubricates the surface of the lungs and prevents friction between the membranes.
- The two lungs are protected by the flexible ribcage and sternum on the front and the vertebral column at the back. Just beneath the lungs, there is a dome-shaped muscular sheet called diaphragm.
- There are about 350 million alveoli in each lung.

Function: Lungs are the main breathing organ. It is the main respiratory surface available for the exchange of gases (O_2 & CO_2).

(e) Diaphragm: The diaphragm is a curved sheet of muscle below the lungs. It the primary muscle of respiration.

Function: It helps in breathing by moving up and down.

(f) Ribs: The lungs are protected in the chest cavity by a set of rib bones.

- The tissues between the rib bones are called the rib muscles.
- The rib muscles move the rib bones and cause the chest cavity to enlarge and contract.

Function: The co-ordinated action of diaphragm and ribcage help in the mechanism of breathing in and breathing out.

Flow of Air From Atmosphere to Lungs:

External nostrils → nasal passage → nasal chamber (cavity) → nasopharynx (a part of pharynx) → glottis → larynx → trachea → primary bronchi → secondary bronchi → tertiary bronchi → bronchioles → terminal bronchioles → respiratory bronchiole → alveolar duct

STEPS INVOLVED IN RESPIRATION

(i) Breathing or pulmonary ventilation.
(ii) Diffusion of gases (O_2 and CO_2) across alveolar membrane.
(iii) Transport of gases by the blood.
(iv) Diffusion of O_2 and CO_2 between blood and tissues.
(v) Utilisation of O_2 by the cells for catabolic reactions and resultant release of CO_2– cellular or tissue respiration.

Mechanism of Breathing (Inspiration & Expiration)

- The process of breathing involves taking in oxygen-rich air and giving out carbon dioxide-rich air. This entire process occurs because of the actions of various organs of the respiratory system.
- We all know that we take in air through our nostrils, and when we breathe in, air passes through our nostrils into the **nasal cavity**.
- Air then reaches the lungs, which are located in the chest cavity. The actual mechanism of breathing involves the movement of the **rib cage** and the **diaphragm,** which are located around and at the base of the chest cavity respectively.

Breathing involves two main processes:

(a) Inspiration (Breathing IN)

- Inhalation is the active intake of air from atmosphere into lungs.
- During this, the diaphragm contracts (flattens) causing an increase in vertical volume (antero-posterior axis).
- Contraction of external inter-costal muscles (muscles found between ribs) lifts up the ribs and sternum causing an increase in thoracic volume in the dorso-ventral axis.
- These changes reduce pressure inside the thorax causing the expansion of lungs. Thus pulmonary volume increases resulting in decrease of intra-pulmonary pressure to less than the atmospheric pressure. So air moves into lungs.
- ***The path followed by fresh air (oxygen) is:***
  External nares → Nasal cavity → Internal Nares → Pharynx → Glottis →Larynx → Trachea → Bronchi → Bronchioles → Alveolar duct → Alveoli

(b) Expiration (Breathing OUT)

- It is the passive expelling of air from the lungs.
- During this, inter-costal muscles and diaphragm relax causing a decrease in thoracic volume and thereby pulmonary volume. So air moves out.
- During forceful expiration, abdominal muscles and internal inter-costal muscles contract.
- ***The path followed by foul air (carbon dioxide) is:***
  Alveoli → Alveolar duct → Bronchioles → Bronchi → Trachea → Larynx → Glottis Pharynx → Internal nares → Nasal cavities → External nares → Outside

Remember, in the process of breathing

(i) Size of the chest cavity changes when the diaphragm and rib muscle expand and contract.

(ii) Air pressure changes when there is a change in the size of the chest cavity.

(iii) Air moves in and out of the lungs when there is a change in the air pressure inside the chest cavity.

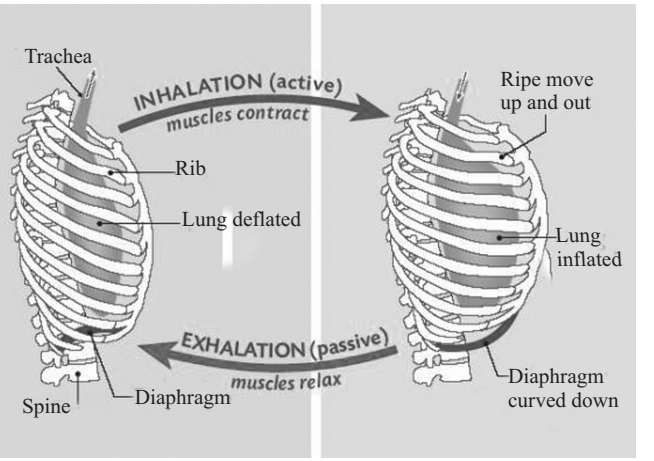


Fig. Mechanism of breathing

- One breathe involves one inhalation and one exhalation. Breathing rate changes from time to time as the requirement for oxygen changes in the body.
- Average breathing rates at rest vary with age. For example,
  - ➢ A new born baby takes about 40 breaths each minute.
  - ➢ A one-year-old child takes about 24 breaths per minute.
  - ➢ An adult takes about 12-16 breaths per minute.
  - ➢ However, during exercise or running, the rate can increase to over 100 breaths per minute.
- Spirometer (respirometer) is used to measure respiratory rate.

RESPIRATORY VOLUMES AND CAPACITIES

- **Tidal volume (TV):** It is the volume of air inspired or expired during a normal respiration (volume of air renewed in respiratory system during each breathing). It is about **500 ml.**
- **Inspiratory reserve volume (IRV) or complemental air**: It is the additional volume of air that can inspire by forceful inspiration. It is about **2500-3000 ml.**
- **Expiratory reserve volume (ERV) or supplemental air:** It is the additional volume of air that can expire by a forceful expiration. It is about **1000-1100 ml.**
- **Residual volume (RV**): It is the volume of air remaining in lungs even after a forcible expiration. It is about **1100-1200 ml.**
- **Inspiratory capacity (IC):** It is the volume of air inspired after a normal expiration (TV + IRV). It is about **3000-3500 ml.**
- **Expiratory capacity (EC):** It is the volume of air expired after a normal inspiration (TV + ERV). It is about **1500-1600 ml.**

- **Functional residual capacity (FRC):** It is the volume of air remaining in the lungs after a normal expiration (ERV + RV). It is about **2100-2300 ml.**
- **Vital capacity (VC):** It is the volume of air that can breathe in after a forced expiration or volume of air that can breathe out after a forced inspiration (ERV + TV + IRV). It is **3500-4500 ml.**
- **Total lung capacity (TLC):** It is the total volume of air in the lungs after a maximum inspiration. (RV + ERV + TV + IRV or VC + RV). It is about **5000-6000 ml.**
- The part of respiratory tract (from nostrils to terminal bronchi) not involved in gaseous exchange is called ***dead space***. **Dead air volume** is about **150 ml.**

RESPIRATORY QUOTIENT (RQ)

- Respiratory quotient is the ratio of the volume of carbon dioxide produced to the volume of oxygen consumed over a period of time in respiration.
- RQ = Volume of CO_2 evolved/ Volume of O_2 absorbed
- Respiratory quotient varied with different foods utilized in respiration.
  - ➢ For glucose, RQ= $6CO_2/6O_2$= 1
  - ➢ For fats, RQ= 0.7
  - ➢ For proteins, RQ= 0.9
  - ➢ In anaerobic respiration, RQ= infinity as there is no consumption of oxygen.

EXCHANGE OF GASES

Gas exchange occurs between
1. Alveoli and blood
2. Blood and tissues

1. Exchange of Gases Between Alveoli and Blood

- The exchange of gases between alveoli and pulmonary capillaries is called external respiration.
- Alveoli are the primary sites of gas exchange. O_2 and CO_2 are exchanged in these sites by simple diffusion based on
  - ➢ Pressure/ concentration gradient
  - ➢ Solubility of gases
  - ➢ Thickness of membranes
  - ➢ Surface area of respiratory membrane (lungs)
- *Steps involved:*

(i) Each alveolus has tiny blood vessels called capillaries running around it.

(ii) When the oxygen-rich air enters the lungs and travels to the millions of alveoli, the oxygen passes through the cell walls of the alveoli into the capillaries of the circulation system.

(iii) At the same time, carbon dioxide in the blood diffuses from capillary into an alveolus. This actually happens in the opposite direction to oxygen.

(iv) The carbon dioxide, the waste product is then sent back up the airways to be expelled to the outside.

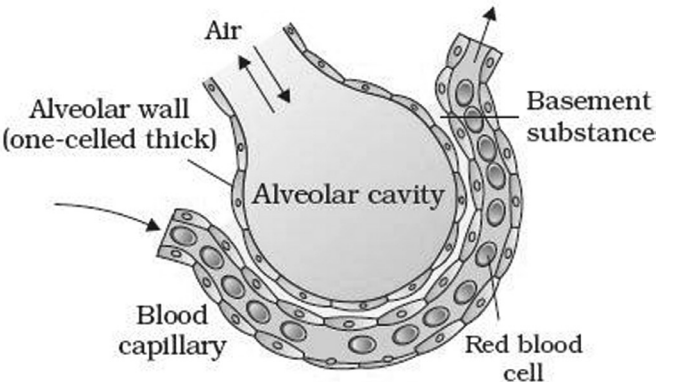


Fig. A Diagram of a section of an alveolus with a pulmonary capillary

Blood which contains carbon dioxide from the cells of the body will appear blue, while blood rich with fresh oxygen will be red. This exchange must happen quickly. That is why; there are many alveoli to allow greater area for exposure to capillaries.

- The **Partial pressures** (individual pressure of a gas in a gas mixture) of O_2 and CO_2 (pO_2 and pCO_2) are given below.

Respiratory Gas	pO_2 (in mm Hg)	pCO_2 (in mm Hg)
Atmospheric air	159	0.3
Alveoli	104	40
Deoxygenated blood	40	45
Oxygenated blood	95	40
Tissues	40	45

  - ➢ Since, ***p*O_2 in alveoli is more (104 mm Hg)** than that in the **blood capillaries (40 mm Hg)** so, O_2 diffuses into capillary blood.
  - ➢ Since, ***p*CO_2 in deoxygenated blood is more (45 mm Hg)** than that in the alveolus **(40 mm Hg),** so, CO_2 diffuses to alveolus.
- As the solubility of CO_2 is 20-25 times higher than that of O_2, the amount of CO_2 that can diffuse through the diffusion membrane per unit difference in partial pressure is much higher compared to that of O_2.
- The diffusion membrane is made up of three layers:
  - ➢ The thin squamous epithelium of alveoli
  - ➢ The endothelium of alveolar capillaries and
  - ➢ The basement substance between them.
- However, its total thickness is much less than a millimetre.

2. Exchange of Gases Between Blood and Tissue Cells

- The exchange of gases between tissue blood capillaries and tissue cells is called internal respiration.
- Since, pO_2 is higher (95 mm Hg) than that of the body cells (40 mm Hg), so, oxygen diffuses from the capillary blood to the body cells through tissue fluid.

- Since, pCO_2 is less (40 mm Hg) than that of the body cells (45 mm Hg), so, carbon dioxide diffuses from the body cells of the capillary blood *via* tissue fluid. Hence, the blood becomes deoxygenated.
- The deoxygenated blood is carried to the heart and hence to the lungs.

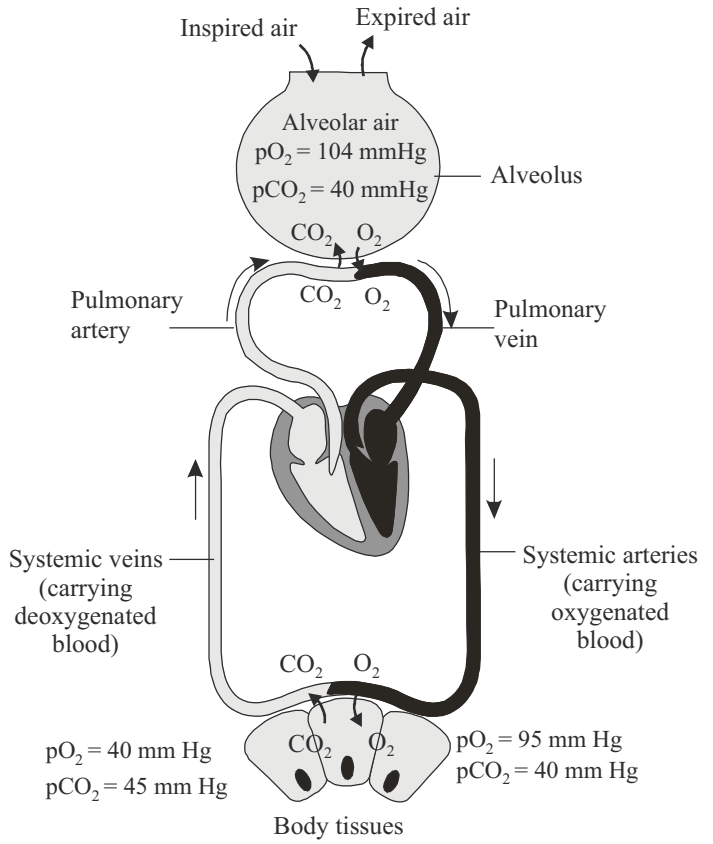


Fig. Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and carbon dioxide

GAS TRANSPORT (O_2 TRANSPORT & CO_2 TRANSPORT)

1. Transport of O_2

It occurs in two ways:

(a) As blood plasma: About 3% of O_2 is carried in a dissolved state through plasma.

(b) As oxyhaemoglobin: About 97% of O_2 is transported by RBC. O_2 binds with haemoglobin (red coloured iron containing pigment present in the RBCs) to form **oxyhaemoglobin.** This process is known as **oxygenation.**

$$Hb + O_2 \underset{\text{In tissues}}{\overset{\text{Reversible Reaction}}{\rightleftharpoons}} HbO_2$$
(In lungs)

Structure of haemoglobin (Hb)

- Hb consists of a protein portion called goblin and a pigment portion called heme.
- The heme portion contains four atoms of iron, each capable of combining with a molecule of oxygen. It means, each Hb molecule can carry 4 oxygen molecules depending upon the saturation with oxygen which depends on following factors.
  (i) Increases with the increase in pO_2 of alveolar air.
  (ii) Increases with the decrease in pCO_2 of blood.

$$Hb_4 + 4O_2 \underset{\text{Low } pO_2/\text{ High } pCO_2\text{ (Tissues)}}{\overset{\text{High } pO_2/\text{Low } pCO_2\text{ (lungs)}}{\rightleftharpoons}} Hb_4O_8$$

- ➢ In the alveoli, high pO_2, low pCO_2, lesser H^+ ion concentration and lower temperature exist. These factors are favourable for the formation of oxyhaemoglobin.
- ➢ In tissues, low pO_2, high pCO_2, high H^+ ions and high temperature exist. So Hb_4O_8 dissociates to release O_2.
- ➢ Every 100 ml of oxygenated blood can deliver around 5 ml of O_2 to the tissues under normal physiological conditions.

Oxygen-Haemoglobin Dissociation Curve

- It is a sigmoid curve showing the percent saturation of haemoglobin with the changes in pO_2 at constant pH.
- It shows that there is a progressive increase in the percent saturation of Hb with the increase in pO_2 upto a level when it becomes constant (*i.e.* 30 % saturation at 20 mm Hg, 75 % saturation at 40 mm Hg and 97 % saturation at 95 mm Hg).
- The oxygen dissociation curve is a sigmoid curve obtained when percentage saturation of oxyhaemoglobin is plotted against various partial pressures of oxygen.
- The curve shows the equilibrium of oxyhaemoglobin and haemoglobin at various partial pressures.
- In the lungs, the partial pressure of oxygen is high. Hence, haemoglobin binds to oxygen and forms oxyhaemoglobin.
- Tissues have a low oxygen concentration. Therefore, at the tissues, oxyhaemoglobin releases oxygen to form haemoglobin.
- The sigmoid shape of the dissociation curve is because of the binding of oxygen to haemoglobin. As the first oxygen molecule binds to haemoglobin, it increases the affinity for the second molecule of oxygen to bind. Subsequently, haemoglobin attracts more oxygen.

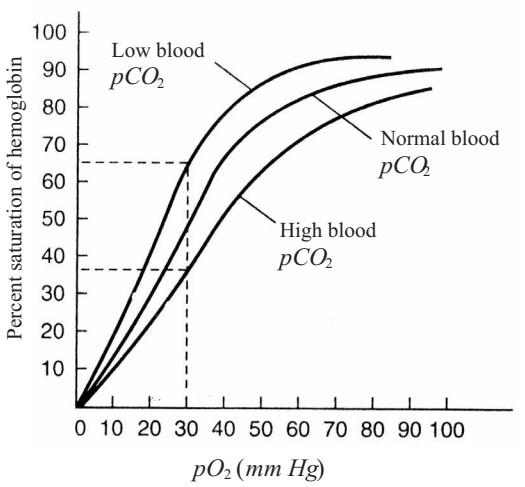


Fig. Effect of pCO_2 on affinity of haemoglobin for oxygen

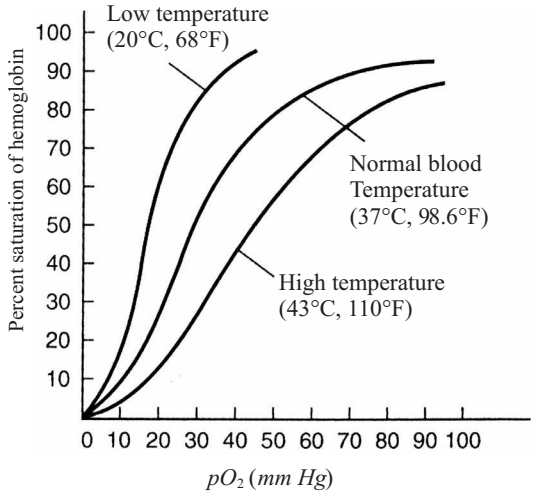


Fig. Oxygen-haemoglobin dissociation curve showing the relationship between temperature and haemoglobin saturation with O_2

Significance of oxygen dissociation curve: It is useful to study the effect of factors like pCO_2, H^+ concentration etc., on binding of O_2 with Hb.

Factors affecting oxygen dissociation curve:

(i) **pCO_2:** With increase in pCO_2, the oxygen dissociation curve turns to right side and oxygen binding capacity of Hg gets lowered. This is known as **Bohr's effect.** It is because; the higher concentration of CO_2 stimulates dissociation of oxyhaemoglobin.

(ii) **Temperature:** With increase in temperature, the oxygen dissociation curve turns to right side.

(iii) **pH:** with increase in acidity (*i.e.* decrease in pH), the oxygen dissociation curve turns to right.

2. Transport of CO_2

It is transported both by plasma and haemoglobin of blood.

It takes place in three 3 ways:

In tissues, pCO_2 is high and pO_2 is low. In lungs, pCO_2 is low and pO_2 is high. This favours CO_2 transport from tissues to lungs.

(a) **As carbonic acid:** In tissues, about 7% of CO_2 is carried in dissolved state through plasma. Carbon dioxide combines with water to form carbonic acid and is carried to lungs. This reaction mainly occurs in RBCs as it is catalyses by zinc-activated enzyme, carbonic anhydrase. Carbonic anhydrase is a zinc enzyme that speeds up the formation of carbonic acid.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

(Carbonic acid)

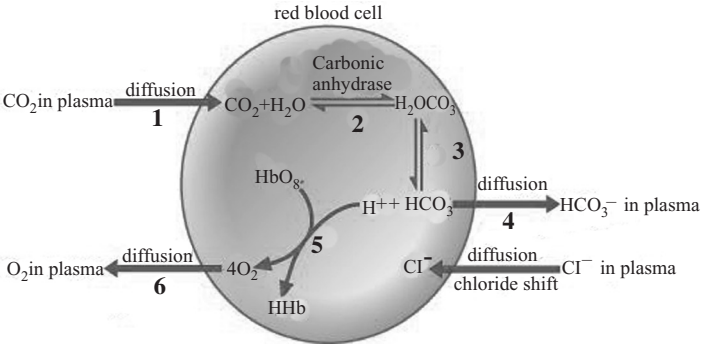
Since the process of forming carbonic acid is slow, only a small amount of carbon dioxide is carried this way.

(b) **As carbamino-haemoglobin:** About 20 – 25% of CO_2 is transported by the red blood cells as carbaminohaemoglobin. Carbon dioxide binds to the amino groups on the polypeptide chains of haemoglobin and forms a compound known as carbaminohaemoglobin.

(c) **As bicarbonates:** About 70% of carbon dioxide is transported as sodium bicarbonate. As CO_2 diffuses into the blood plasma, a large part of it combines with water to form carbonic acid in the presence of the enzyme carbonic anhydrase. This carbonic acid dissociates into bicarbonate (HCO_3^-) and hydrogen ions (H^+). The most of the bicarbonate ions diffuses into the plasma. To maintain electro neutrality, equal amounts of chloride ions diffuse inside the RBCs from the plasma. This exchange of HCO_3^- of RBCs and Cl^- of plasma is called chloride shift or Hamburger shift.

$$CO_2 + H_2O \xrightarrow{\text{Carbonic anhydrase}} H_2CO_3$$

$$CO_2 + H_2O \xrightarrow[\text{anhydrase}]{\text{Carbonic}} H_2CO_3$$



In alveoli, the above reaction proceeds in opposite direction leading to the formation of CO_2 and H_2O.

Every **100 ml of deoxygenated blood** delivers about **4 ml of CO_2** to the alveoli.

CELLULAR RESPIRATION

- Cellular respiration is the enzymatic breakdown of glucose ($C_6H_{12}O_6$) in the presence of oxygen (O_2) to produce cellular energy (ATP). It takes place in all types of living cells.

$$C_6H_{12}O_6 + 6CO_2 \xrightarrow[\text{Cell Respiration}]{\text{Mitochondria}} 6CO_2 + H_2O + ATP\ (energy)$$

- It involves:
  - **(i)** The uptake of oxygen by tissues
  - **(ii)** Stepwise breakdown of glucose molecules and other nutrients, and
  - **(iii)** Release of carbon dioxide and energy.
- This occurs in the mitochondria of the cells and is called cellular respiration.

REGULATION OF RESPIRATION

- Respiration is under both nervous and chemical regulation.

(i) Neural Regulation

It involves respiratory centers, afferent and efferent nerves.

- Respiratory centers are the centers in the medulla oblongata and pons that collects sensory information about the level of O_2 and CO_2 in the blood and determines the signals to be sent to the respiratory muscles.
- The stimulation of respiratory muscles provide respiratory movements which leads to alveolar ventilation.
- Respiratory centers are classified into two groups:
  - ➢ Medullary center, which is divided into Inspiratory center and expiratory center.
  - ➢ Pontine center, which is divided into Pneumotaxic center and apneustic center.
- Inspiratory center is concerned with inspiration.
- Expiratory center is inactive during quiet breathing. At that time inspiratory center is the active center.
- During forced breathing or when inhibitory center is inhibited, expiratory center becomes active.
- Pneumotaxic center: It controls medullary respiratory centers, particularly inspiratory center, so that duration of inspiration is controlled.
- Apneustic center: This center increases depth of inspiration by acting directly on the inspiratory center.

(ii) Chemical Regulation

- The chemical mechanism of regulation is operated through chemoreceptors.
- Chemoreceptors are classified into two groups:
  - ➢ **Central chemoreceptors:** The chemoreceptors present in the brain are called central chemoreceptors. They are situated in deeper part of medulla oblongata. This area is known as chemosensitive area and neurons are called chemoreceptors.
  - ➢ **Peripheral chemoreceptors:** The receptors present in the peripheral portions of the body are called peripheral chemoreceptors.
- Increase in the concentration of CO_2 and H^+ activates this centre, which in turn signals rhythm centre.
- **Receptors** associated with **aortic arch** and **carotid artery** also recognize changes in CO_2 and H^+ concentration and send necessary signals to the rhythm centre.

DISORDERS OF RESPIRATORY SYSTEM

1. Hypoxia

- It is a Condition of **oxygen shortage** in the tissues.

2. Asphyxia

- In this **O_2 content falls** whilst the **CO_2 content rises**

3. Asthma

- It is a disease caused due to an allergic reaction to foreign substances that affect the respiratory tract. In this, the airways and lungs of a person can become obstructed because they narrow and cut off air flow.
- Bronchioles can constrict (narrow) because of muscle spasms.
- Asthma can occur at any age.

Causes of Asthma

- The allergens, which cause allergy, stimulate the release the histamine from the mast cells. This causes the bronchiolar smooth muscles to contract.

Symptoms

- Coughing
- Wheezing
- Difficulty in breathing
- Excess amount of mucus is secreted on the wall of the respiratory tract.

Treatment for Asthma

- Drugs called ***bronchodilators*** (inhalers). These devices help dilate (open up) the bronchioles.

4. Bronchitis (Inflammation of the Bronchi)

- A condition where the bronchi and bronchioles get inflamed and their cavities become narrow so that air cannot pass in and out of lungs easily. The pathway gets constricted either due to accumulation of mucus on the walls of the bronchi or bronchioles.. Also infection of the accumulated mucus leads to inflammation of walls of the lungs and bronchi, which narrow the airways and cause difficulty in breathing.

Causes of Bronchitis

- Infection from coughs and colds.
- Smoking
- Exposure to air pollutant like carbon monoxide.

Symptoms:

- Regular coughing with thick greenish sputum.

Treatment for Bronchitis

- Antibiotics
- Stop smoking

5. Emphysema (Emphysema Means "Inflation").

- It is an inflation or abnormal distension of the bronchioles or alveolar sacs of the lungs. This causes some of them to burst resulting in a decrease of surface area for gas exchange.

Causes of Emphysema

- Cigarette smoking
- Inhalation of other smoke or toxic substances over a period of time.

Symptoms

- Difficulty in breathing

Treatment for Emphysema

- Stop smoking
- Exercise
- Drugs, to make alveoli work.
- Oxygen therapy

6. Occupational Respiratory Disorders

- This disorder is due to the occupation of the individual

Cause

- It is caused by the harmful substances such as fumes or dust, present in the environment where a person works.
  Examples:
  - ➢ **Silicosis:** Due to breathing of silica dust.
  - ➢ **Asbestosis:** Due to breathing in asbestos particle.

Symptoms:

- Inflammation of upper part of lungs.

Treatment:

- Minimize the exposure of harmful dust at working place.
- Workers must use the protective gears and clothing at the work place.
- Bronchodilators
- Antibiotics

BREATHING AND EXCHANGE OF GASES

Respiration

It is an exchange of environment O_2 and body's CO_2. Here, oxygen is utillized for the oxidation of food and production of energy.

Aerobic

It is the process in which oxidation of food takes place in the presence of O_2.
ex- occurs in most animals and plants

Direct

It is a process of exchange of O_2 with CO_2 of body cells without respiratory organ
ex-protists, sponges, colenterates, etc.

Indirect

It involves special respiratory organs, such as skin, buccopharyngeal lining, gills and lungs.

Anaerobic

It is the process in which, food is partially oxidized in the absence of oxygen called fermentation ex-occurs most in bacteria, yeast, etc.

Human Respiratory System

Mechanism of Breathing

It involves two phases- inspiration and expiration

Inspiration

It is a process when atmospheria air is drawn in.

Expiration

It is the process by which the alveolar air is released out.

Structure

It has two portions conducting and respiratory portion. Conducting portion consists nasapharynx, larynx, trachea, bronchi, bronchios, etc. and respiratory portion consists bronchioles, alveolar sacs and ducts.

Disorders

Some of the respiratory disorders are Asthma, emphysema, hypoxia, common cold, asphyxia, bronchitus, pneumonia, lung cancer, etc.

EXERCISE - 1
Conceptual Questions

1. Which one of the following organs in the human body is most affected due to shortage of oxygen?
(a) Intestine (b) Skin
(c) Kidney (d) Brain

2. What is the cause for the movement of oxygen through the alveolar blood capillaries of lungs ?
(a) Difference in the O_2 tension and partial pressure of these chambers
(b) Partial pressure of CO_2
(c) Union of O_2 with haemoglobin
(d) All of the above

3. Functional residual capacity can be represented as
(a) TV + ERV (b) ERV + RV
(c) RV + IRV (d) ERV + TV + IRV

4. Lungs in addition to the respiratory function also help in –
(a) Excretion
(b) Temperature regulation
(c) pH regulation
(d) Maintaining balance of body

5. If the thoracic wall but not lungs is punctured-
(a) The lungs get inflated
(b) The man dies as the lungs get collapsed
(c) The breathing rate decreases
(d) The breathing rate increases

6. During transportation of CO_2 when bicarbonate ions diffuses from RBC into plasma, the increased hydrogen ion concentration in RBC is balanced by the entry of which substance from plasma
(a) Water (b) Oxygen
(c) Hydroxyl ions (d) Chloride ions

7. Common feature of human and insect trachea is –
(a) Non-collapsible wall (b) Supporting rings
(c) Ectodermal origin (d) Endodermal origin

8. 6000 to 8000 ml of air is the
(a) Vital capacity of lungs
(b) Volume of normal expiration per minute
(c) Sum of IRV + ERV
(d) Inspiratory capacity of lungs

9. Which one of the following can respire in the absence of oxygen ?
(a) *Amoeba* (b) Tapeworm
(c) House fly (d) *Hydra*

10. The process of migration of chloride ions from plasma to RBC and carbonate ions from RBC to plasma is
(a) chloride shift (b) ionic shift
(c) atomic shift (d) Na^+ pump

11. In alveoli of the lungs, the air at the site of gas exchange, is separated from the blood by
(a) alveolar epithelium only
(b) alveolar epithelium and capillary endothelium
(c) alveolar epithelium, capillary endothelium and tunica adventitia
(d) alveolar epithelium, capillary endothelium, a thin layer of tunica media and tunica adventitia

12. The quantity 1500 ml in the respiratory volumes of a normal human adult refers to
(a) maximum air that can be breathed in and breathed out
(b) residual volume
(c) expiratory reserve volume
(d) total lung capacity

13. The volume of air that remains in the lungs after normal expiration is
(a) Residual volume
(b) Vital capacity
(c) Expiratory capacity
(d) Functional residual capacity

14. The carbon dioxide is transported via blood to lungs as
(a) dissolved in blood plasma
(b) in the form of carbonic acid only
(c) in combination with haemoglobin only
(d) carbaminohaemoglobin and as carbonic acid

15. Although much CO_2 is carried in blood, yet blood does not become acidic, because
(a) it is absorbed by the leucocytes
(b) blood buffers play an important role in CO_2 transport.
(c) it combines with water to form H_2CO_3which is neutralized by $NaCO_3$
(d) it is continuously diffused through tissues and is not allowed to accumulate

16. Air is breathed through
(a) Trachea — lungs — larynx — pharynx — alveoli
(b) Nose — larynx — pharynx — bronchus — alveoli — bronchioles
(c) Nostrils — pharynx — larynx — trachea — bronchi — bronchioles — alveoli
(d) Nose — mouth — lungs

18. Carbon dioxide is transported from tissues to respiratory surface by
(a) plasma and erythrocytes
(b) plasma
(c) erythrocytes
(d) erythrocytes and leucocytes

19. Which of the following breathing process in human is passiv?
(a) Expiration (b) Aspiration
(c) Inspiration (d) Forced breathing

20. Oxygenated blood from lungs is carried to the heart by –
(a) Pulmonary artery (b) Pulmonary vein
(c) Coronary vein (d) Pre-cavals

21. Which is correct ?
(a) Respiratory centres are not affected by CO_2
(b) In humans vital capacity is just double the expiratory volume
(c) A human lung has 10^3 alveoli
(d) During inspiration the lungs act as suction pump

22. Body tissues obtain oxygen from haemoglobin because of its dissociation in tissues caused by –
(a) Low oxygen concentration and high carbon dioxide concentration
(b) Low oxygen concentration
(c) Low carbon dioxide concentration
(d) High carbon dioxide concentration

23. When the carbon dioxide concentration in blood increases, the rate of breathing will –
(a) remain unaffected (b) decrease
(c) stop (d) increase

24. During inspiration –
(a) The diaphragm gets raised and ribs get lowered
(b) Both diaphragm and ribs get raised
(c) Both diaphragm and ribs get lowered
(d) The diaphragm get flattered and ribs get raised

25. A normal man at rest inspires and expires about 500 millilitres of air, this amount is known as –
(a) complemental volume of air
(b) tidal volume of air
(c) reserve volume of air
(d) residual volume of air

26. Every 100 ml of oxygenated blood delivers following amount of O_2 to the tissues under normal physiological contition
(a) 5 ml (b) 25 ml
(c) 50 ml (d) More the 50 ml

27. If O_2 concentration in tissues were almost as high as at the respiratory surface
(a) oxyhaemoglobin would dissociate to supply O_2 to the tissues
(b) haemoglobin would combine with more O_2 to the tissues
(c) oxyhaemoglobin would not dissociate to supply O_2 to the tissues
(d) CO_2 will interfere with O_2 transport.

28. The blood leaving the lungs has all its haemoglobin oxygenated and gives up oxygen to the tissues, because
(a) the tissues can absorb O_2 from oxyhaemoglobin
(b) O_2-concentration in tissues is higher and CO_2 concentration lower as compared to lungs
(c) oxyhaemoglobin undergoes reduction
(d) O_2-concentration in tissues is lower and CO_2 concentration higher than in lungs.

29. Combining of haemoglobin with O_2 in lungs can be promoted by
(a) decreasing O_2 concentration in blood
(b) increasing O_2 concentation in blood
(c) increasing CO_2 concentration in blood
(d) introducing CO into blood.

30. The pneumotaxic centre that can moderate the function of respiratory rhythm centre is located in
(a) Dorsal side of medulla
(b) Ventral side of medulla
(c) Aortic arch and carotid artery
(d) Pons

31. The impulse for voluntary forced breathing starts in
(a) medulla (b) vagus nerve
(c) spinal cord (d) cerebrum

32. Controlling centre of normal breathing (= respiratory centre) in mammals lies in
(a) cerebrum (b) cerebellum
(c) midbrain (d) medulla oblongata

33. What will be the pO_2 and pCO_2 in the atmospheric air as compared to that of alveolar air ?
(a) pO_2 lesser and pCO_2 higher
(b) pO_2 higher and pCO_2 lesser
(c) Both pO_2 and pCO_2 lesser
(d) Both pO_2 and pCO_2 higher

34. Asthma is caused due to
(a) Infection of lungs
(b) Spasm in bronchial muscles
(c) Bleeding into pleural cavity
(d) infection of trachea

35. Amount of O_2 normally carried by 100 ml. of pure blood
(a) 40 ml. (b) 20 ml.
(c) 10 ml. (d) 30 ml.

36. What would happen if human blood becomes acidic (low pH) ?
(a) Oxygen-carying capacity of haemoglobin decreases
(b) Oxygen-carrying capacity of haemoglobin increases
(c) RBC count increases
(d) RBC count decreases

36. Covering of the lungs is called
(a) pericardium (b) perichondrium
(c) peritoneum (d) pleural membrane

37. Ciliated epithelium in trachea of mammals helps in
(a) sucking inspired air in
(b) perceivings sense of smell
(c) pushing expired air out
(d) pushing mucus out

38. The disease that occurs when the haemoglobin content of the blood goes down is –
(a) plurisy (b) emphysema
(c) anaemia (d) pneumonia

39. The affinity of CO with Hb is more than oxygen by
(a) 2 times (b) 20 times
(c) 200 times (d) 2000 times

40. Emphysema developes mainly because of
(a) Allergy or hypersensitisation
(b) Spasm of the smooth muscles of bronchioles
(c) Cigarette smoking
(d) Inflammation of the alveoli

41. During respiration CO_2 is transported in the form of
(a) Disolved plasma
(b) Sodium carbonate
(c) $KHCO_3$
(d) Partly dissolved in plasma and partly in the form of sodium and potassium bicarbonate

42. Of the following, the one which is an example of buffer system in blood is
(a) Haemoglobin and oxyhaemoglobin
(b) Oxygen and carbon dioxide
(c) Albumin and globulin
(d) Sodium bicarbonate and carbonic acid

43. Which of the following enzymes is absent in mitochondria ?
(a) Aconitase (b) Malic dehydrogenase
(c) Hexokinase (d) None of these

44. If concentration of CO_2 is more the curve of oxygen will shift towards
(a) Right (b) Left
(c) Central (d) None of these

45. The amount of volume of air that can be inspired/expired normally is called
(a) Tidal volume (b) Vital capacity
(c) Residual volume (d) Normal volume

46. Vital capacity of the lung includes
(a) IRV + TV + ERV (b) ERV + RV
(c) ERV + TV (d) IRV + TV

47. Capacity of human lung is
(a) 3000 ml (b) 1500 ml
(c) 1000 ml (d) 500 ml

48. Identify the correct statement with reference to transport of respiratory gases by blood
(a) Haemoglobin is necessary for transport of carbon dioxide and carbonic anhydrase for transport of oxygen
(b) Haemoglobin is necessary for transport of oxygen and carbonic anhydrase for transport of carbon dioxide
(c) Only oxygen is transported by blood
(d) Only carbon dioxide is transported by blood

49. Which one of the following has the smallest diameter ?
(a) Right primary bronchus
(b) Left primary bronchus
(c) Trachea
(d) Respiratory bronchiole

50. The relative proportion between the volume of CO_2 released and O_2 absorbed in respiration is termed as
(a) Respiratory exchange (b) Respiratory quotient
(c) Respiratory phase (d) None of the above

EXERCISE - 2
Applied Questions

1. Which of the following are the correct statement for respiration in human ?
(a) Cigarette smoking may lead of inflammation of bronchi
(b) Neural signals from pneumotaxic centre in pons region of brain can increase the duration of inspiration
(c) Workers in grinding and stone - breaking industries may suffer from lung fibrosis
(d) About 90% of carbon dioxide (CO_2) is carried by haemoglobin as carbamino haemoglobin

2. Which one of the following is a possibility for most of us in regard to breathing, by making a conscious effort?
(a) One can breathe out air totally without oxygen.
(b) One can breathe out air through eustachian tubes by closing both the nose and the mouth.
(c) One can consiously breathe in and breathe out by moving the diaphragm alone, without moving the ribs at all.
(d) The lungs can be made fully empty by forcefully breathing out all air from them

3. Which one of the following mammalian cells is not capable of metabolising glucose to carbon-dioxide aerobically?
(a) Unstraited muscle cells (b) Liver cells
(c) Red blood cells (d) White blood cells

4. The 'blue baby' syndrome results from
(a) Excess of dissolved oxygen
(b) Excess of TDS (total dissolved solids)
(c) Excess of chloride
(d) Methaemoglobin

5. The patient has been inhaling polluted air containing unusually high content of
(a) carbon disulphide (b) chloroform
(c) carbon dioxide (d) carbon monoxide

6. People living at sea level have around 5 million RBC per cubic millimeter of their blood whereas those living at an altitude of 5400 metres have around 8 million. This is because at high altitude
(a) atmospheric O_2 level is less and hence more RBCs are needed to absorb the required amount of O_2 to survive
(b) there is more UV radiation which enhances RBC production
(c) people eat more nutritive food, therefore more RBCs are formed
(d) people get pollution - free air to breathe and more oxygen is available

7. Which of the following statements is not true ?
(a) The partial pressure of oxygen in deoxygenated blood is 40 mm Hg
(b) The partial pressure of oxygen in oxygenated blood is 95 mm Hg
(c) The partial pressure of oxygen in the alveolar air is 104 mm Hg
(d) The partial pressure of carbon dioxide in deoxygenated blood is 95 mm Hg

8. After taking a long deep breath we do not respire for some seconds due to
(a) More CO_2 in blood (b) More O_2 in blood
(c) Less CO_2 in blood (d) Less O_2 in blood

9. Ascent of high mountains may cause altitude sickness in men. Prime cause of this is
(a) Excess of CO_2 in blood
(b) Decreased eficiency of haemoglobin
(c) Decreased partial pressure of oxygen
(d) Decreased proportion of oxygen in air

10. In which disease, due to flattening of tracheal vessels, alveoli are deprived of oxygen ?
(a) Bronchitis (b) Asthma
(c) Pneumonia (d) Emphysema

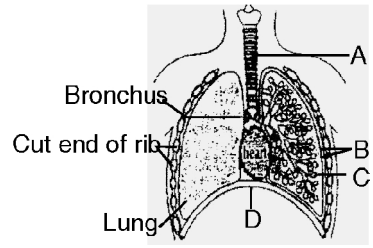
11. Which of the following conditions is responsible for increase in ventilation rate of lungs ?
(a) Increase of CO_2 content in inhaled air
(b) Increase of CO_2 content in exhaled air
(c) Decrease of O_2 content in inhaled air
(d) Decrease of O_2 content in exhaled air

12. Rate of breathing is controlled by
(a) The amount of freely available oxygen
(b) Amount of carbon dioxide
(c) Muscular function of the body
(d) Strees

13. In lungs there is definite exchange of ions between RBC and plasma. Removal of CO_2 from blood involves
(a) Influx of Cl^- ions into RBC
(b) Influx of HCO_3^- ions into RBC
(c) Efflux of Cl^- ions into RBC
(d) Efflux of HCO_3^- ions into RBC

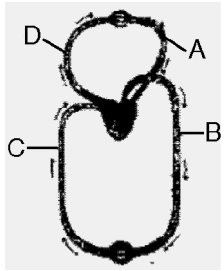
14. Maximum amount of oxygen is lost from the blood in the
(a) Capillaries surrounding the tissue cells
(b) Arteries of the body
(c) Capillaries surrounding the alveoli
(d) Left auricle of the heart

15. The figure shows a diagrammatic view of human respiratory system with labels A, B, C and D. Select the option which gives correct identification and main function and/or characteristics.



(a) B-pleural membrane-surrounds ribs on both sides to provides cushion against rubbing.
(b) C-Alveoli-thin walled vascular bag like structures for exchange of gases.
(c) D-Lower end of lungs-diaphragm pulls it down during inspiration
(d) A-trachea-long tube supported by complete cartilaginous rings for conducting inspired air.

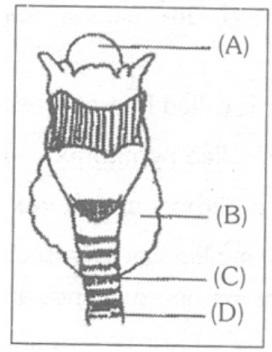
16. Figure shown schematic plan of blood circulation in humans with labels A to D. Identify the label and give its function's.



(a) B-Pulmonary artery-takes blood from heart to lungs, PO_2 = 90 mm Hg
(b) C-Vena Cava - takes blood from body parts to right auricle, PCO_2 = 45 mm Hg
(c) D - Dorsal aorta - takes blood from Heart to body Part PO_2 = 95 mm Hg
(d) A-Pulmonary vein - takes impure blood from body parts, PO_2 = 60 mm Hg

17. Which one of the following is one of the paths followed by air/O_2 during respiration in an adult male *Periplaneta americana* as it enters the animal body?
(a) Hypopharynx, mouth, pharynx, trachea, tissues
(b) Spiracle in metathorax, trachea, tracheoles, oxygen diffuses into cells
(c) Mouth, bronchial tube, trachea, oxygen enters cells
(d) Spiracles in prothorax, tracheoles, trachea, oxygen diffuses into cells

18. The diagram represents the human larynx. Choose the correct combination of labelling from the options given



(a) A – Larynx, B – Parathyroid, C – Tracheal cartilage, D – Trachea
(b) A – Naso Larynx, B – Thyroid, C – Tracheal cartilage, D – Trachea
(c) A – Trachea, B – Thyroid, C – Bronchiole, D – Tracheal cartilage
(d) A – Epiglottis, B – Thyroid, C – Tracheal cartilage, D – Trachea

19. Match Column I with Column II

	Column I		**Column II**
A.	Tidal volume	1.	2500 to 3000 ml
B.	Inspiratory reserve volume	2.	1000 ml of air
C.	Expiratory reserve	3.	500 ml of air
D.	Residual volume	4.	3400 to 4800 ml of air
E.	Vital capacity	5.	1200 ml of air

(a) A → 3; B → 4; C → 2; D → 1; E → 5
(b) A → 3; B → 1; C → 2; D → 5; E → 4
(c) A → 3; B → 1; C → 4; D → 5; E → 4
(d) A → 5; B → 4; C → 2; D → 1; E → 2

20. Listed below are four respiratory capacities (i–iv) and four jumbled respiratory volumes of a normal human adult:

Respiratory capacities		**Respiratory volumes**
(i)	Residual volume	2500 ml
(ii)	Vital capacity	3500 ml
(iii)	Inspiratory reserve volume	1200 ml
(iv)	Inspiratory capacity	4500 ml

Which one of the following is the correct matching of two capacities and volumes?

(a)	(ii)	2500 ml,	(iii)	4500 ml,
(b)	(iii)	1200 ml,	(iv)	2500 ml,
(c)	(iv)	3500 ml,	(i)	1200 ml,
(d)	(i)	4500 ml,	(ii)	3500 ml,

21. Which two of the following changes (a – d) usually tend to occur in the plain dwellers when they move to high altitudes (3,500 m or more)?
(1) Increase in red blood cell size
(2) Increase in red blood cell production
(3) Increased breathing rate
(4) Increase in thrombocyte count
(a) (2) and (3) (b) (3) and (4)
(c) (1) and (4) (d) (1) and (2)

22. Which of the following statements are true/false ?
(1) The blood transports CO_2 comparatively easily because of its higher solubility.
(2) Approximately 8.9% of CO_2 is transported being dissolved in the plasma of blood.
(3) The carbon dioxide produced by the tissues, diffuses passively into the blood stream and passes into red blood corpsucles and react with water to form H_2CO_3.
(4) The oxyhaemoglobin (HbO_2) of the erythrocytes is basic.
(5) The chloride ions diffuse from plasma into the erythrocytes to maintain ionic balance.
(a) (1), (3) and (5) are true, (2) and (4) are false.
(b) (1), (3) and (5) are false, (2) and (4) are true.
(c) (1), (2) and (4) are true, (3) and (5) are false.
(d) (1), (2) and (4) are false, (3) and (5) are true.

23. Statements
(1) Carbonic anhydrase is present in the erythrocytes.
(2) In erythrocytes the carbon dioxide combine with water and is transported.
(a) Statement (1) is correct and is responsible for statement (2)
(b) Statement (1) is not correct but statement (2) is correct
(c) Both statement (1) and (2) are wrong
(d) Statement (1) is correct but not involved in statement 2

DIRECTIONS for (Qs. 24 and 25) : Each questions contain STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.
(a) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1
(b) Statement -1 is True, Statement -2 is True ; Statement-2 is NOT a correct explanation for Statement - 1
(c) Statement - 1 is True, Statement- 2 is False
(d) Both the Statements are False.

24. **Statement 1 :** Forceful expiration occurs through expiratory muscles.
Statement 2 : Expiratory muscles expires quickly.

25. **Statement 1 :** Symptoms of emphysema develops when a person living on plains ascends and stays on a mountain.
Statement 2 : Air pressure and partial pressure of oxygen falls with the rise in altitude.

EXERCISE - 3
Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

1. Respiration in insects is called direct because
(a) the cells exchange O_2/CO_2 directly with the air in the tubes
(b) the tissues exchange O_2/CO_2 directly with coelomic fluid
(c) the tissue exchange O_2/CO_2 directly with the air outside through body surface
(d) tracheal tubes exchange O_2/CO_2 directly with the haemocoel which then exchange with tissues

2. Regarding the functions of our respiratory system mark the wrong entry.
(a) Humidifies air (b) Warms up the air
(c) Diffusion of gases (d) Cleans up the air

3. A person suffers punctures in his chest cavity in an accident, without any damage to the lungs its effect could be
(a) reduced breathing rate
(b) rapid increase in breathing rate
(c) no change in respiration
(d) cessation of breathing

4. It is know that exposure to carbon monoxide is harmful to animals because
(a) it reduces CO_2 transport
(b) it reduces O_2 transport
(c) it increases CO_2 transport
(d) it increases O_2 transport

5. Mark the true statement among the following with reference to normal breathing
(a) inspiration is a passive process whereas expiration is active
(b) inspiration is a active process whereas expiration is passive
(c) inspiration and expiration are active processes
(d) inspiration and expiration are passive processes

6. A person breathes in some volume of air by forced inspiration after having a forced expiration. This quantity of air taken in is
(a) total lung capacity
(b) tidal volume
(c) vital capacity
(d) inspiratory capacity

7. Mark the incorrect statement in context to O_2 binding to Hb
(a) higher pH (b) lower temperature
(c) lower pCO_2 (d) higher pO_2

8. Mark the correct pair of muscles involved in the normal breathing in humans.
(a) External and internal intercostal muscles
(b) Diaphragm and abdominal muscles
(c) Diaphragm and external intercostal muscles
(d) Diaphragm and intercostal muscles

9. Incidence of emphysema a respiratory disorder is high in cigarette smokers. In such cases
(a) the bronchioles are found damaged
(b) the alveolar walls are found damaged
(c) the plasma membrane is found damaged
(d) the respiratory muscles are found damaged

10. Respiratory process is regulated by certain specialised centres in the brain. One of the following listed centres can reduce the inspiratory duration upon stimulation.
(a) Medullary inspiratory centre
(b) Pneumotaxic centre
(c) Apneustic centre
(d) Chemosensitive centre

11. CO_2 dissociates from carbamino haemoglobin when
(a) pCO_2 is high and pO_2 is low
(b) pO_2 is high and pCO_2 is low
(c) pCO_2 and pO_2 are equal
(d) None of the above

12. In breathing movements, air volume can be estimated by
(a) stethoscope
(b) hygrometer
(c) sphygmomanometer
(d) spirometer

13. From the following relationships between respiratory volume and capacities, mark the correct option.
(i) Inspiratory Capacity (IC) = Tidal Volume + Residual Volume
(ii) Vital Capacity (VC) = Tidal Volume (TV) + Inspiratory Reserve Volume (IRV) + Expiratory Reserve Volume (ERV).
(iii) Residual Volum e (RV) = Vital Capacity (VC) – Inspiratory Reserve Volume (IRV)
(iv) Tidal Volume (TV) = Inspiratory Capacity (IC) – Inspiratory Reserve Volume (IRV)

Codes
(a) (i) Incorrect, (ii) Incorrect, (iii) Incorrect, (iv) Correct
(b) (i) Incorrect, (ii) Correct, (iii) Incorrect, (iv) Correct
(c) (i) Correct, (ii) Correct, (iii) Incorrect. (iv) Correct
(d) (i) Correct, (ii) Incorrect, (iii) Correct, (iv) Incorrect

14. The oxygen-haemoglobin dissociation curve will show a right shift in case of
(a) high pCO_2 (b) high pO_2
(c) low pCO_2 (d) less H^+ concentration

15. Match the following columns

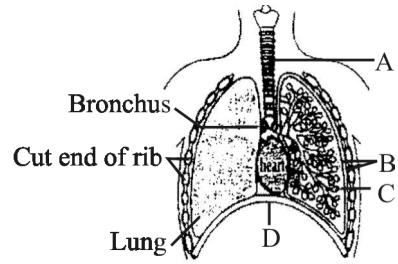
	Column I		Coulmn II
A.	Earthworm	1.	Moist cuticle
B.	Aquatic arthropods	2.	Gills
C.	Fishes	3.	Lungs
D.	Birds/Reptiles	4.	Trachea

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	1	4	2	3
(c)	1	3	2	4	(d)	1	2	4	3

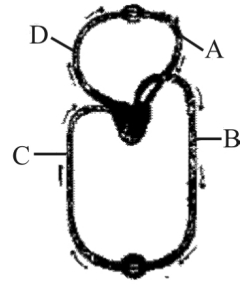
NEET/AIPMT (2013-2017) Questions

16. The figure shows a diagrammatic view of human respiratory system with labels A, B, C and D. Select the option which gives correct identification and main function and/or characteristics. ***[2013]***



(a) B-pleural membrane-surrounds ribs on both sides to provides cushion against rubbing.
(b) C-Alveoli-thin walled vascular bag like structures for exchange of gases.
(c) D-Lower end of lungs-diaphragm pulls it down during inspiration
(d) A-trachea-long tube supported by complete cartilaginous rings for conducting inspired air.

17. Figure shown schematic plan of blood circulation in humans with labels A to D. Identify the label and give its function's. ***[2013]***



(a) B-Pulmonary artery-takes blood from heart to lungs, PO_2 = 90 mm Hg
(b) C-Vena Cava - takes blood from body parts to right auricle, PCO_2 = 45 mm Hg
(c) D - Dorsal aorta - takes blood from Heart to body Part PO_2 = 95 mm Hg
(d) A-Pulmonary vein - takes impure blood from body parts, PO_2 = 60 mm Hg

18. Approximately seventy percent of carbon-dioxide absorbed by the blood will be transported to the lungs: ***[2014]***
(a) as bicarbonate ions
(b) in the form of dissolved gas molecules
(c) by binding to R.B.C.
(d) as carbamino - haemoglobin

19. When you hold your breath, which of the following gas changes in blood would first lead to the urge to breathe?
(a) rising CO_2 concentration ***[2015 RS]***
(b) falling CO_2 concentration
(c) rising CO_2 and falling O_2 concentration
(d) falling O_2 concentration

20. Name the pulmonary disease in which alveolar surface area involved in gas exchange is drastically reduced due to damage in the alveolar walls. ***[2015 RS]***
(a) Emphysema (b) Pneumonia
(c) Asthma (d) Pleurisy

21. Name the chronic respiratory disorder caused mainly by cigarette smoking ***[2016]***
(a) emphysema
(b) asthma
(c) respiratory acidosis
(d) respiratory alkalosis

22. Lungs are made up of air-filled sacs, the alveoli. They do not collapse even after forceful expiration, because of: ***[2017]***
(a) Inspiratory Reserve Volume
(b) Tidal Volume
(c) Expiratory Reserve Volume
(d) Residual Volume

Hints & Solutions

EXERCISE - 1

1. (d) Brain is the most vital organ. It stops functioning in the absence of O_2.
2. (a) 3. (b) 4. (c) 5. (b) 6. (d) 7. (a) 8. (b)
9. (b)
10. (a) During the transport of CO_2 through the blood, bicarbonate ions diffuse out of RBCs while chloride ions from plasma enter the RBCs to maintain ionic equilibrium. This is called chloride shift.
11. (b) Alveoli are the site of the respiratory exchange of gases. Oxygen from the alveolar air diffuses through the alveolar epithelium and the capillary endothelium into the capillary blood and carbon dioxide diffuses in the opposite direction.
12. (b) The total volume of air that can be expelled from the lungs after maximum inspiration and then expiring to the maximum is known as the vital capacity. The volume of air that remains inside lungs at the end of maximum forceful expiration is the residual volume. Expiratory reserve volume is the maximum extra volume of air that can be expired by forceful expiration after a normal tidal expiration. Total lung capacity is the maximum volume of air that can be contained in the lungs after maximum inspiration.
13. (d)
14. (d) Carbon dioxide is transported via blood to lungs mostly as carbaminohaemoglobin and carbonic acid. It is released in lungs in exchange with oxygen.
15. (b) CO_2 enters RBC and reacts with water to form carbonic acid. Carbonic acid dissociates to form bicarbonate and hydrogen ions. Some bicarbonate ions are transported in erythrocytes while some diffuse into the blood plasma. Exit of bicarbonate ions change the ionic balance between the plasma and erythrocytes. To restore this balance chloride ions diffuse from plasma into erythrocytes. Due to this the pH of blood is maintained.
16. (c) The pathway of inhaled air is - Nostrils - pharynx (common passage for food & air) - larynx (voice box) - trachea (the wind pipe) - bronchi (2 for each side lungs) - bronchioles (give arise to alveolar ducts) - alveoli (the exchange site for gases in the form of small sacs or pouches).
17. (a) CO_2 from the respiratory tissues to the lungs is transported by the blood in 3 ways :
    (i) **In dissolved state or as a solution :** Very small amount dissolved in plasma (7% *i.e.* $\cong$ 0.3 ml of CO_2 by each 100 ml of blood).
    (ii) **Bicarbonate ions :** $\cong$ 70% (i.e. ? 2.5 ml per 100 ml of blood) CO_2 diffuses in plasma & then into RBCs where it (in the presence of carbonic anhydrase) combines with H_2O to form carbonic acid which is almost spontaneously dissociated into hydrogen ion & bicarbonate ions.
    (iii) **Carbaminohaemoglobin :** $\cong$ 23% (*i.e.* 1 ml of CO_2 per 100 ml of blood) combines with haemoglobin forming an unstable compound.
18. (a) 19. (b) 20. (d) 21. (d) 22. (d)
23. (d) During inspiration the diaphragm get flattered and ribs get raised.
24. (b) 25. (a) 26. (c) 27. (d) 28. (a) 29. (d) 30. (d)
31. (d) 32. (b) 33. (b) 34. (b) 35. (a) 36. (d) 37. (d)
38. (c) The disease that occurs when the haemoglobin content of the blood goes down is anaemia.
39. (c) 40. (c)
41. (d) In the form of H_2CO_3 dissolved in plasma and $NaCO_3$ and $KHCO_3$ as bicarbonates.
42. (d) 43. (c)
44. (a) Oxygen tends to displace CO_2 so that the curve shifts more to the right.
45. (a) 46. (a) 47. (a) 48. (b) 49. (d)
50. (b) Respiratory quotient is the ratio of carbon dioxide released to oxygen usage during respiration.

$$\text{R. Q.} = \frac{\text{Volume of } CO_2 \text{ formed}}{\text{Volume of } O_2 \text{ utilized}}$$

EXERCISE - 2

1. (c)
2. (b) Eustachian tube connect middle ear cavity (tympanic cavity) with nasopharynx, approximately it is 35 mm long in adults, which helps in breathing out by closing both the nose and mouth.
3. (c) Since RBCs do not have mitochondria so they can respire only anaerobically.
4. (d) 5. (d)
6. (a) At the altitude of 5400 meters the low atmospheric pressure of O_2 will be too low so the solubility of oxygen in the blood will be very less hence the oxygen carried by each RBC will be too less. But to fulfill the oxygen requirement of the body blood has to carry more oxygen to the body tissue and this is done by the increased no. of RBCs.
7. (d) 8. (c) 9. (c)
10. (d) Emphysema is the respiratory disorder in which the septa between the alveoli are destroyed and much of the elastic tissue of the lungs is replaced by connective tissue. It is generally caused by a long term irritation. Air pollution, occupational exposure to industrial dust and cigarette smoke are the most common irritants.
11. (a) 12. (b) 13. (d) 14. (c)
15. (b) Alveoli are very thin, irregular walled bag like structures for gaseous exchange. Tracheae bronchi and bronchioles are supported by incomplete cartilaginous rings. Double layered pleural membrane surrounds the lungs with pleural fluid between them. It reduces friction on the lung surface.

16. (b) A is Pulmonary vein which takes pure blood from lungs to heart. B is dorsal aorta which takes pure blood from heart to various body parts. C is Vena cava which takes impure blood from various body pars to right auricle of heart. D is pulmonary artery which takes impure blood from heart to lungs.
17. (b) The number of spiracles in cockroach is 10-pairs (2-pairs in thoracic and 8-pairs in abdominal region). The thoracic pairs of spiracles are present on pleuron between prothorax - mesothorax and metathorax. Each spiracle opens into a chamber called atrium. After atrium the tracheal tube ramifies into fine branches of tracheae, and then tracheoles.
18. (d) 19. (b)
20. (c) The correct matching of respiratory capacities with their respiratory volumes are:

Respiratory Capacities	Respiratory Volumes
Residual volume	1200 ml
Vital capacity	4500 ml
Inspiratory reserve volume	2500 ml
Inspiratory capacity	3500 ml

21. (a) At high altitude, the body undergoes numerous changes in order to increase oxygen delivery to cells and improve the efficiency of oxygen usage. The early changes include increased breathing rate and increased red blood cell production.
22. (a) 23. (a)
24. (c) In forceful expiration requiring effort, a different group of intercostal and some abdominal muscles contract to reduce the volume of thorax more than that in ordinary respiration. So, a larger volume of air is breathed out, such muscles are called expiratory muscles.
25. (a) When a person living on plains ascend and stays on a mountain above 8000 feet from the sea level, he develops symptoms of mountain sickness which includes breathlessness, headache, dizziness, irritability, nausea, vomiting, mental fatigue and a bluish ting on the skin, nails and lips. The rise in altitude, consequently lowers the partial pressure of oxygen. This lowers the alveolar partial pressure of oxygen which causes reduction in the diffusion of oxygen from the alveolar air to the blood. so oxygenation of blood is decreased progressively, which produces the symptoms of mountain sickness, Emphysema.

EXERCISE - 3

Exemplar Questions

1. (d) Insects have a network of tracheal tubes for transport of atmospheric air within the body. These openings lead to trachea. The cells exchange O_2/CO_2 directly with the air in the spiracles present on insects body.
2. (c) Diffusion of gases is a physical phenomenon occuring between the tissue and the blood vessels, and does not occur during breathing whereas maintaining air to the body temperature, its cleaning and warming occurs during the process of breathing.
3. (d) The movement of air in and out of the lungs is performed by creating a pressure gradient between the lungs and the surrounding atmosphere. The pressure within the lungs is less than the atmospheric pressure so there is a negative pressure in the lungs with respect to atmospheric pressure.

   A puncture in the chest affects this pressure gradient maintained by the lungs and thus may cause cessation of breathing.
4. (b) Haemoglobin consists of a protein globin and pigment heme. The four portions of iron in heme combine with molecule of oxygen. It is an easy reversible reaction to form oxyhaemoglobin

$$Hb + O_2 \rightleftharpoons HbO_2$$

   Whereas, the complex formed by the reaction of carbon monooxide and haemoglobin is incredibly strong

$$\underset{\text{(Haemoglobin)}}{Hb} + CO \rightleftharpoons \underset{\text{(Carboxy haemoglobin)}}{HbCO}$$

   As a result of this strong between the haemoglobin and carbon monooxide the haemoglobin looses its affinity to oxygen thus may lead to choking or even death.
5. (b) Inspiration is an active process while expiration is a passive process. Inspiration occurs when the muscles of diaphragm contract to increase the overall volume of the thoracic cavity.

   Thus the pressure within the lungs or intra-pulmonary pressure is less in comparison to the atmospheric pressure, *i.e.*, there is a negative pressure in the lungs with respect to the atmospheric pressure inspiration is thus called an active process. As the muscles use energy for contraction. During expiration diaphragm muscles relax without the use of energy. Intra-pulmonary pressure becomes higher than the atmospheric pressure and air gushes out. Thus, it is a passive process.
6. (c) Vital capacity is the maximum volume of air that a person can breathe in after force expiration or the maximum volume of air that a person can breathe out after force inspiration

$$\underset{\text{(Inspiratory reserve volume)}}{VC = IRV} + \underset{\text{(Expiratory reserve volume)}}{ERV} + \underset{\text{(Tidal volume)}}{TV}$$

   The value of vital capacity ranges from 3400 mL to 4800 mL.

   Tidal volume is the air inspired or expired during normal breathing.

   Total lung capacity is the volume of air present in lungs and respiratory passage after maximum inspiration. While, inspiratory capacity is the total volume of air that a person can inspire after normal inspiration.
7. (d) There are various factors which affect the binding of O_2 with Hb.

These factors include:
(i) Low temperature
(ii) Low H^+ concentration (low pH)
(iii) Low diphosphoglyceraldehyde
Thus the incorrect statement is higher pO_2

8. (d) The diaphragm and a specialised set of muscles, called **external muscles** present between the ribs are involved in the normal breathing process in humans. They are involved in generating a pressure gradient of air between the lungs and the atmosphere, to facilitate the intake of air.

9. (b) **Emphysema** is a chronic disorder of the lungs in which alveolar walls are damaged due to the infacation or obsomal distersion. It is a respiratory disorder due to caused due to cigarette smoking and inhalation of smoke or toxic substences over a prolonged period of time.

10. (b) **Pneumotaxic Centre** is located in the dorsal part of pons varoli of the brain. It can reduce the duration of inspiration and thus alter the respiratory rate.
Apneustic Centre responsible for promoting inspiration process is located in the lower part of pons varoli.
Chemosensitive Centre which is highly sensitive to CO_2 and hydrogen ions is situated adjacent to the rhythm centre. Increase in CO_2 and H^+ in body activates this centre for the elimination of CO_2 and H.
Medullary Inspiratory Centre is a specialised region present in the medulla of the brain, and is primarily responsible for regulating the respiratory rhythm.

11. (b) When, the pCO_2 is low and pO_2 is high as in the lung alveoli, dissociation of CO_2 from carbamino-haemoglobin takes place, CO_2 which is bound to haemoglobin from the tissue is delivered at the alveoli, to maintain the concentration of CO_2 thus increasing pCO_2.
Exchange of gases takes place between the tissue capillary and the tissue cells. Capillary cells with high pO_2 causes diffusion of O_2 into tissue cells via tissue fluid. High pCO_2 in the tissue cells causes diffusion of CO_2 into tissue capillary via tissue fluid.

12. (d) **Spirometer** is a device used to measure the volume of air involved in breathing movements and it also helps in clinical assessment of pulmonary functions.
Stethoscope is a medical device used for listening to the internal sounds of an animal or human body.
Hygrometer is a device used for measuring the moisture content in the atmosphere, or humidity.
Sphygmomanometer is a device that is used to measure **blood pressure**.

13. (b) (i) **Inspiratory Capacity** (IC) = Tidal Volume + Inspiratory Reserve Volume (TV+ IRV).
(ii) **Vital Capacity** (VC) = Tidal Volume + Inspiratory Reserve Volume + Expiratory Reserve Volume (TV + ERV + IRV)
(iii) Residual Volume (RV) = Volume of air remaining in the lungs after a forcible expiration.
(iv) Tidal Volume (TV) = Volume of air inspired or expired during a normal respiration.

14. (a) A **sigmoid curve** is obtained when percentage saturation of haemoglobin with O_2 is plotted against the pO_2.
Under the following conditions the oxygen haemoglobin dissociation curve is shifted to right
(i) Decrease in partial pressure of oxygen.
(ii) Increase in partial pressure of carbonoxide.
(iii) Increase in hydrogen concentration.
(iv) Decrease in pH activity.
(v) Increased body temperature.

15. (b) Earthworm respire through their moist cuticle while aquatic arthropods respire through trachea.
Fishes respire through gills, and birds/reptiles respire through **lungs**.

NEET/AIPMT (2013-2017) Questions

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(iii) Carbaminohaemoglobin : ≅ 23% (i.e. ≅ 1 ml of CO_2 per 100 ml of blood) combines with haemoglobin forming an unstable compound.

19. (a) Chemoreceptors in the medulla get stimulated by increase in CO_2 concentration in the blood of arteries. Decrease in O_2 concentration has no significant effect on chemoreceptors.

20. (a) In the disease emphysema, alveolar surface area is reduced due to destruction of alveolar walls.

21. (a) Emphysema results when the delicate linings of the air sacs in the lungs become damaged beyond repair. Most commonly, the toxins in cigarette smoke create the damage. Emphysema is called smoker's disease.

22. (d) Volume of air present in lungs after forceful expiration as residual volume prevents the collapsing of alveoli.