<u>**Breathing and exchange of gases**</u>

Animals require energy for their life activities. They get this energy from nutrient molecules like glucose. In cells nutrients are broken down into smaller subunits, this breakdown releases energy. The process of breakdown of food in cell is called **cell respiration**.

The process of exchange of O_2 from the atmosphere with CO_2 produced by the cell is called **breathing**.

It occurs in two stages of inspiration and expiration. During inspiration air enters the lungs from atmosphere and during expiration air leaves the lungs.

Breathing	**Respiration**
a. It is simply an intake of fresh air and removal of foul air. **b.** It is a physical process. **c.** No energy is released. **d.** It is an extracellular process.	**a.** It is the oxidation of food to form carbon dioxide, water and energy. **b.** It is a biochemical process. **c.** Energy is released in form of ATP. **d.** It is an intracellular process.

Living organisms are divided into two basic types based on how they release energy from food in the cells (cellular respiration). They are

i. **Anaerobic respiration:** Break down of food in the absence of oxygen. There are two types of anaerobic respiration based on the end products-

a. <u>Lactic acid fermentation</u>-The end products of cellular respiration is lactic acid and energy (ATP). This type of cell respiration occurs in muscles and in lacto bacillus bacteria.

$C_6H_{12}O_6 \rightarrow$ Lactic acid + ATP(Energy)

b. <u>Alcoholic fermentation</u>-The end product of cellular respiration is Ethyl alcohol and energy (ATP). This type of cell respiration is seen in yeast.

$C_6H_{12}O_6 \rightarrow C_2H_5OH$ + ATP(Energy)

ii. **Aerobic respiration:** Break down of food in cells in presence of oxygen. The end products are carbon dioxide, water and energy (ATP).

$$C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6H_2O + ATP(Energy)$$

Respiratory organs:

Different animals have different types of respiratory organs.

Lower organisms like Porifera, Cnidaria and Ctenophora exchange of gases occurs through general body surface by diffusion.

Parasitic Platyhelminth and Aschelminth are anaerobic organisms, while free living organisms exchange of gases occurs by diffusion through general body surface.

Phylum Annelida moist skin acts as respiratory organs.

Different members of Phylum Arthropoda have different respiratory organs-

Insects- Tracheal tubes

Crustacea- Gills or book gills

Arachnida- Book lungs

In Phylum Mollusca ctenidia, pulmonary sacs and general body surface helps in gas exchange.

Phylum Echinodermata exchange of gases occurs with the help of dermal gills.

Members of Phylum Hemichordate, Protochordates, Class Cyclostomes and Superclass Pisces respiration is with the help of gills.

In Amphibians respiration is with the help of Gills, Lungs, skin or buccal cavity.

Reptiles, Birds and Mammals have lungs as respiratory organs.

Respiration with the help of skin is called **Cutaneous respiration**.

Respiration with the help of gills is called **Branchial respiration**.

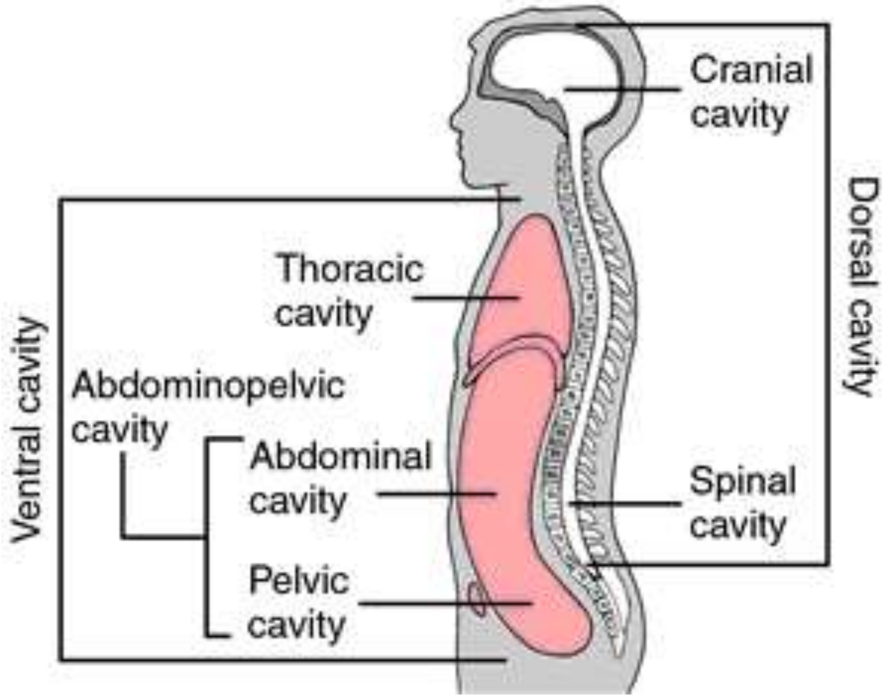
Respiration with the help of lungs is called **Pulmonary respiration**.

Lungs:

Human respiratory organs consist of a pair of lungs.

Lungs are present in an air tight chamber called thoracic cavity or chest cavity.

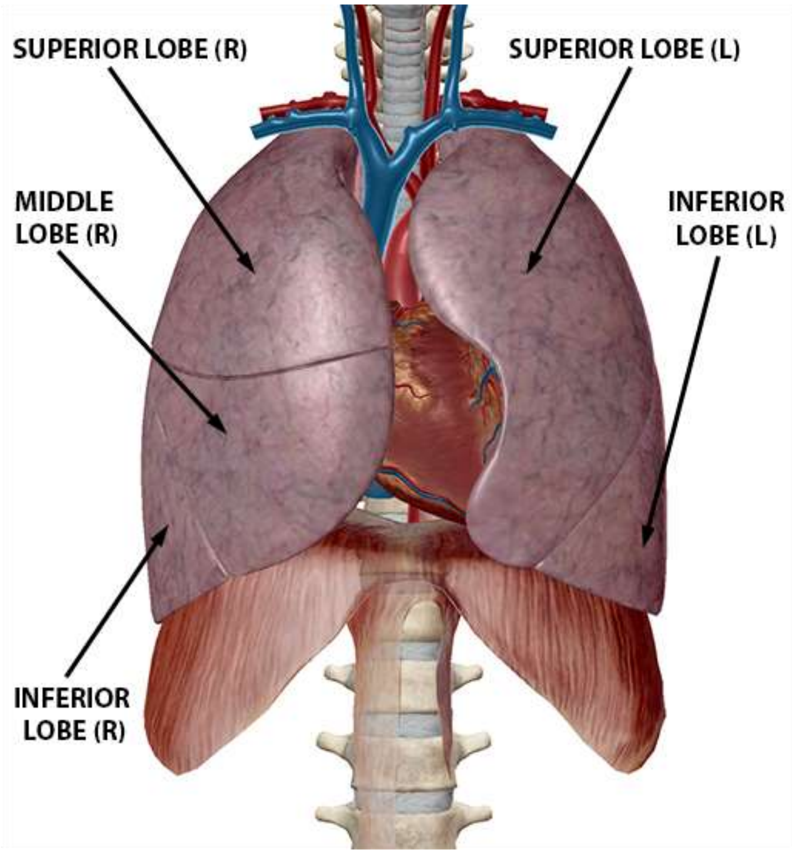
Thoracic cavity if formed dorsally by the vertebral column, ventrally by sternum and laterally by the ribs.



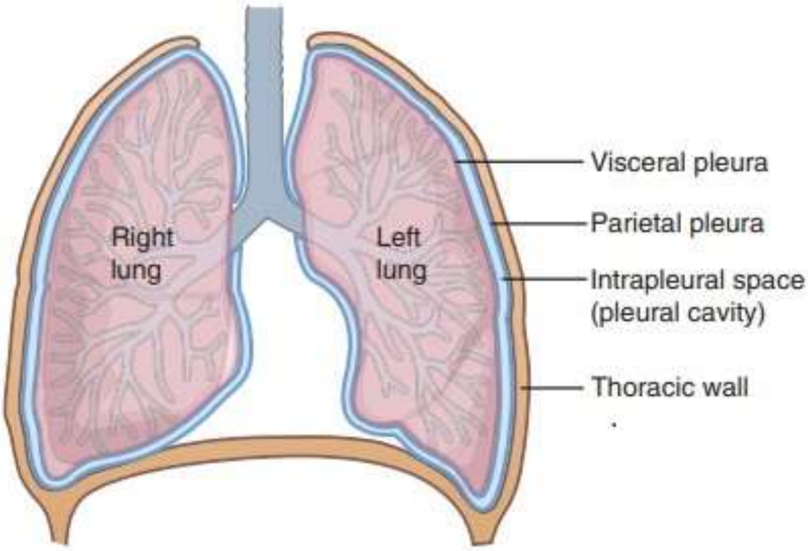
The lower side thoracic cavity is guarded by a muscle band called diaphragm, it separates the thoracic and abdominal cavity.

Lungs:

Right lung is bigger than the left lung. Right lung is formed of three lobes- Superior lobe, middle lobe and inferior lobe. The left lung is formed of two lobes, superior and inferior lobes. Left lung is longer and narrower because it has the cardiac notch for accommodating heart.



Lungs are externally protected by two layered membrane called pleura. The space between the pleural membrane is called pleural cavity, it is filled with a fluid called pleural fluid. It lubricates the pleural membrane. The pleural membrane in contact with lungs is called visceral pleura and the layer in close contact with thoracic lining (outer layer of pleura) is called parietal pleura.



<u>Human respiratory system:</u>

Human respiratory system consists of respiratory passage and respiratory organs. It consists of –

External nostrils, Nasal chambers, internal nares, nasopharynx, larynx, Trachea, Bronchi, bronchioles, Alveolar ducts and alveoli.

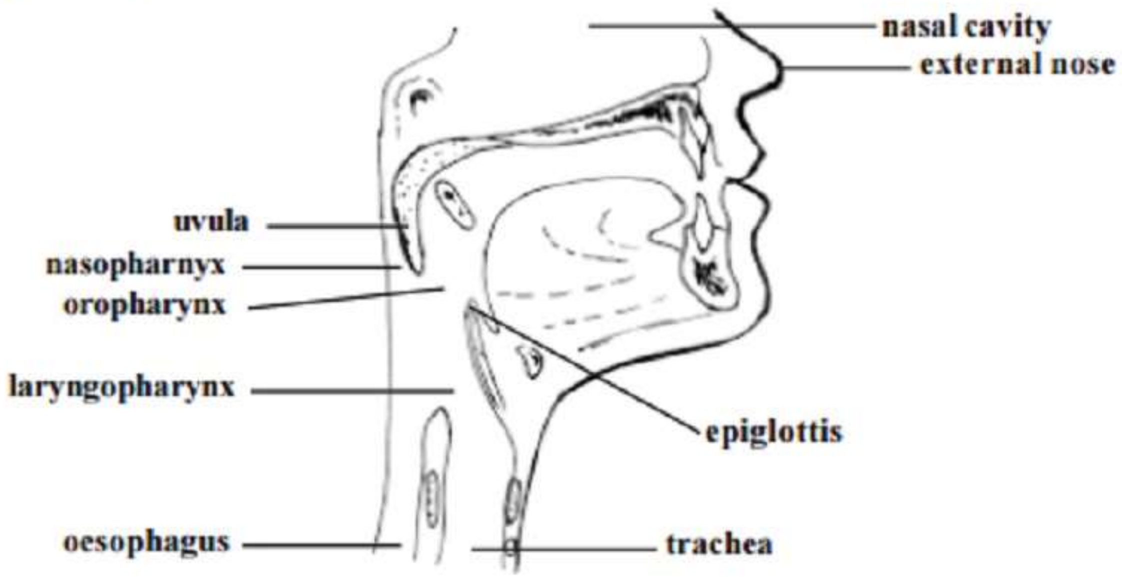
<u>External Nostrils:</u> It is the first part of respiratory system. Air enters into the respiratory system through external nostrils. Inner region is lined with hairs and mucus cells to prevent the entry of dust particles. It opens in to the nasal chamber through the nasal passage.

<u>Nasal chambers:</u> They are two in number. Inner lining is richly supplied with blood vessels and mucus cells.

<u>Internal nares:</u> They are posterior opening s of nasal chambers which opens into the nasopharynx.

<u>Nasopharynx:</u> Part of the pharynx into which internal nares open is called nasopharynx. Only air passes through nasopharynx. It opens into the trachea through glottis of larynx region. Glottis is the upper part of larynx.

Upper respiratory tract.



<u>Larynx:</u> it is also known as voice box. It is made up of cartilage and is seen in the upper part of trachea. During swallowing glottis is covered by epiglottis

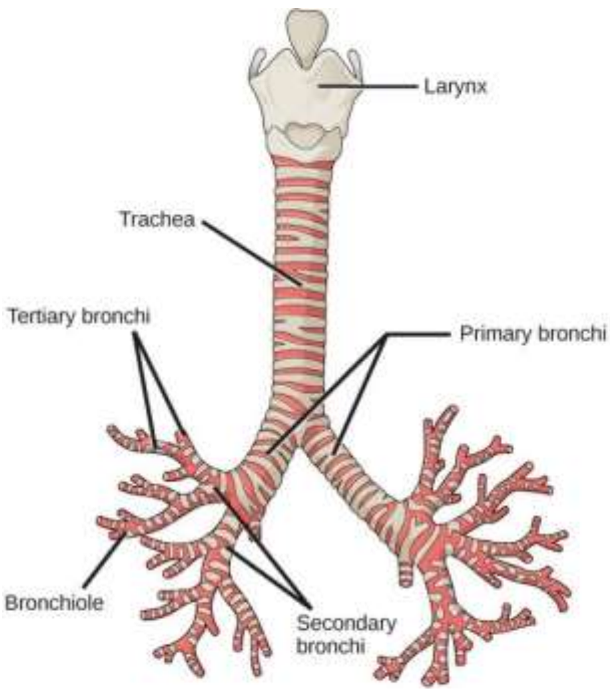
(cartilaginous flap made up of elastic cartilage). Epiglottis prevent the entry of food into the larynx. Larynx has vocal cords and vibrations of vocal cords during exhalation produces sound. The pitch of sound is determined by the tension on the vocal cords – greater the tension higher the pitch.

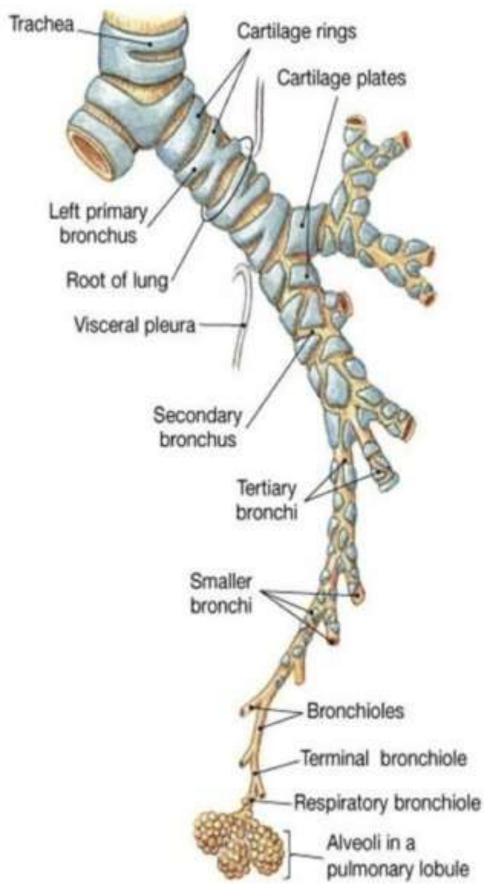
Larynx is formed of three paired and three unpaired cartilages. Thyroid cartilage (Adam's apple), Cricoid cartilage and Epiglottis are unpaired. Whereas Arytenoid cartilage, Corniculate cartilage and Cuneiform cartilage are paired cartilages.

Trachea: It is also known as wind pipe. It is lined by 16 to 20 incomplete rings of cartilage. These cartilage rings prevent trachea from collapsing during breathing. Trachea divides into right and left bronchi at the region of fifth thoracic vertebrae.

Bronchi and bronchioles: Each bronchus undergo repeated divisions to form the secondary and tertiary bronchi and bronchioles ending in very thin terminal bronchioles.

The trachea, primary, secondary and tertiary bronchi and initial bronchioles are supported by incomplete cartilaginous rings.

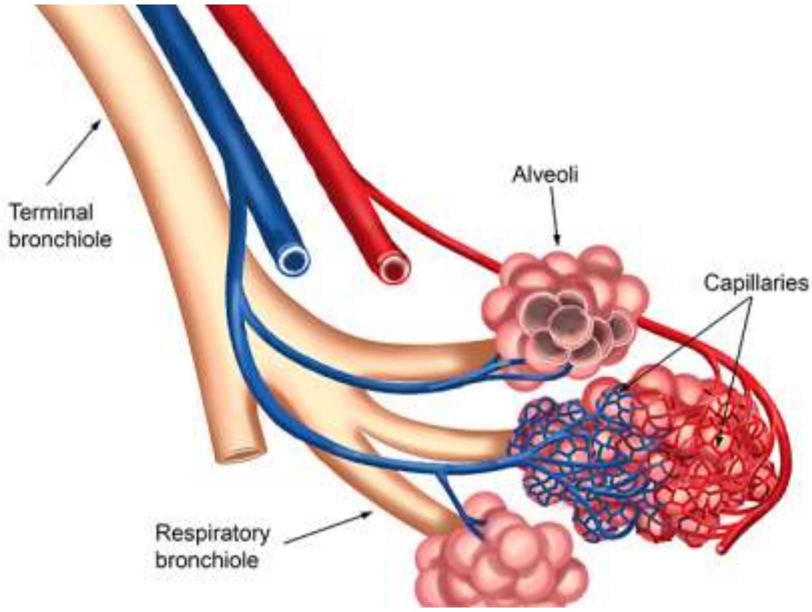




Alveoli: Each terminal bronchiole give rise to a number of very thin, irregular-walled and vascularized bag like structures called alveoli. There are about 300 million of alveoli in two lungs. Due to very close contact of blood vessels with alveoli, the exchange of gases takes place easily.

Special cells in the alveolar walls called type II cells secrete a surface-active agent called Lecithin, which helps to reduce surface tension between the alveolar fluid and air. It prevents collapsing of lung alveoli.

The Herring–Breuer inflation reflex, is a reflex triggered to prevent the over-inflation of the lung. Pulmonary stretch receptors present on the wall of bronchi and bronchioles of the airways respond to excessive stretching of the lung during large inspirations.



The branching network of bronchi, bronchioles and alveoli together forms the lungs.

Human respiratory system is divided into two parts-

a. **Conducting part:** The part starting from external nostrils up to the terminal bronchioles is the conducting part.

This part helps to transport the atmospheric air to the alveoli, clears the inspired air from foreign particles, humidifies the inspired air and conducting part also helps to bring the inspired air to body temperature.

b. **Exchange part:** Alveoli and their ducts forms the exchange part. Exchange of gases occurs in this part. It is the actual site of diffusion of O_2 and CO_2 between blood and atmospheric air.

Process of respiration:

Steps involved in respiration are-

1. Breathing or pulmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out.
2. Diffusion of gases (oxygen and carbon dioxide) across alveolar membrane.
3. Transport of gases by blood.
4. Diffusion of oxygen and carbon dioxide between blood and tissues.
5. Utilization of oxygen by the cells for breakdown of food resulting in the release of carbon dioxide.

Mechanism of breathing –

Breathing involves two stages-

1. Inspiration or inhalation: During this process atmospheric air is drawn in. Inspiration can occur if the pressure within the lungs (intra pulmonary pressure) is less than the atmospheric pressure.
2. Expiration or exhalation: The process by which alveolar air is released out. Expiration occurs when the pressure within the lungs (intra pulmonary pressure) is higher than the atmospheric pressure. There is a negative pressure in the lungs with respect to atmospheric pressure.

Muscles involved in respiration- there are mainly three muscles that help in respiration. They are

1. **Diaphragm-** It is a muscle band that separates thoracic and abdominal cavity. When relaxed diaphragm is dome shaped and when contracted diaphragm becomes flattened.

   Contraction of diaphragm causes it to become flat and lowered down, thereby increasing the volume of thoracic cavity in antero-posterior axis and resulting in inspiration.

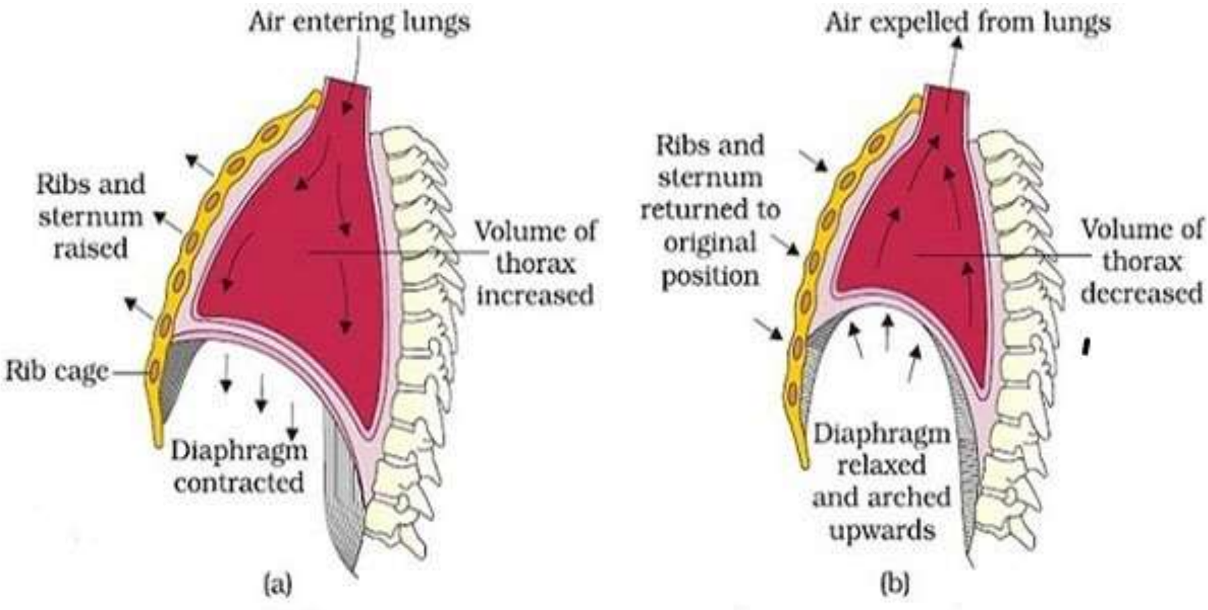
Relaxation of diaphragm muscles bring diaphragm back to normal position (dome shape), which reduces the volume of thoracic cavity resulting in expiration.

2. **<u>Intercostal muscles:</u>** They are muscles present between the ribs. There are two types of intercostal muscles they are –

a. <u>External Intercostal muscles:</u> Contraction of these muscles lift the ribs and sternum upward and outward causing an increase in the volume of the thoracic cavity in the dorsoventral axis (backward and forward direction). These muscle contraction results in inspiration.

b. <u>Internal intercostal muscles:</u> Contraction of these muscles leads to the pulling of ribs downward and inward, decreasing the volume of thoracic cavity, resulting in expiration.

3. **Abdominal muscles-** We have the ability to increase the strength of inspiration and expiration with the help of additional muscles of abdomen. These muscles mainly help in forced expiration.



Mechanism of Breathing
a. Inspiration
b. Expiration

Intra pleural pressure: intrapleural pressure refers to the pressure within the pleural cavity.

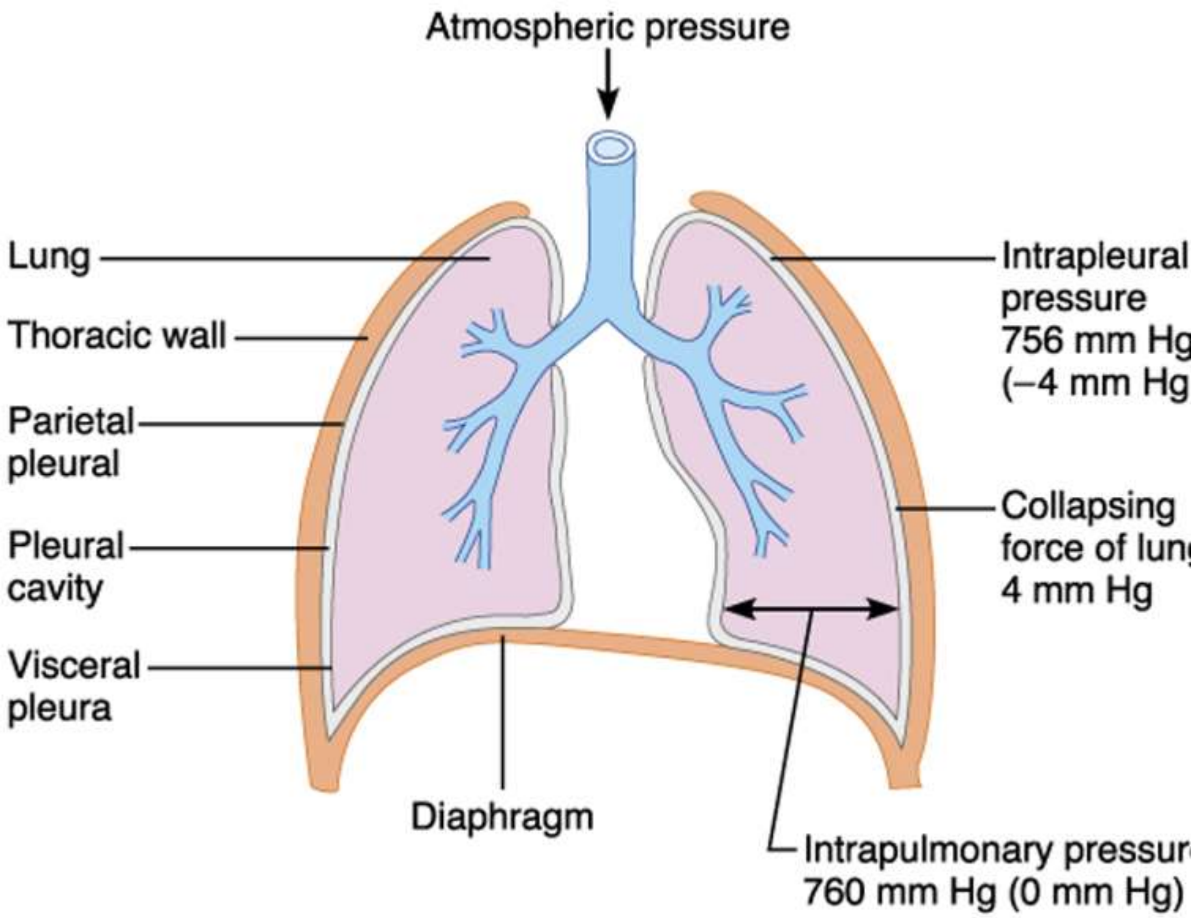
Normally, the pressure within the pleural cavity is slightly less than the atmospheric pressure, which is known as ***negative pressure*** (**756mmHg**), 4mmHg less than atmospheric pressure (760mmHg).

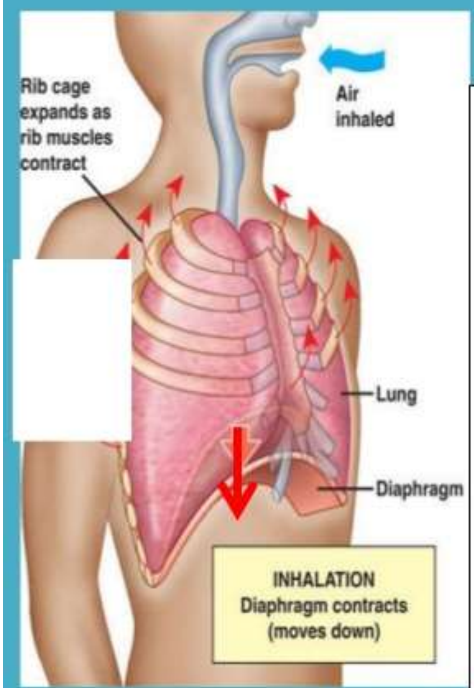
Intrapleural pressure is different from intrathoracic pressure.
Intrapleural pressure depends on the ventilation phase, atmospheric pressure, and the volume of the intrapleural cavity.

At rest, there is a negative intrapleural pressure(-4mmHg). This provides a transpulmonary pressure causing the lungs to expand.

The relationship between the intra-pulmonary pressure and intra-pleural pressure is that the pressure becomes more negative during inspiration and allows air to get sucked in (inspiration).

If humans didn't maintain a slightly negative pressure even when exhaling, their lungs would collapse on themselves because all the air would rush towards the area of lower pressure. Intra-pleural pressure is sub-atmospheric.





INHALATION

Internal intercostal muscle relaxed

↓

External intercostal muscle contract

↓

Rib cage moves upwards & outwards

↓

Diaphragm contracts & flattens

↓

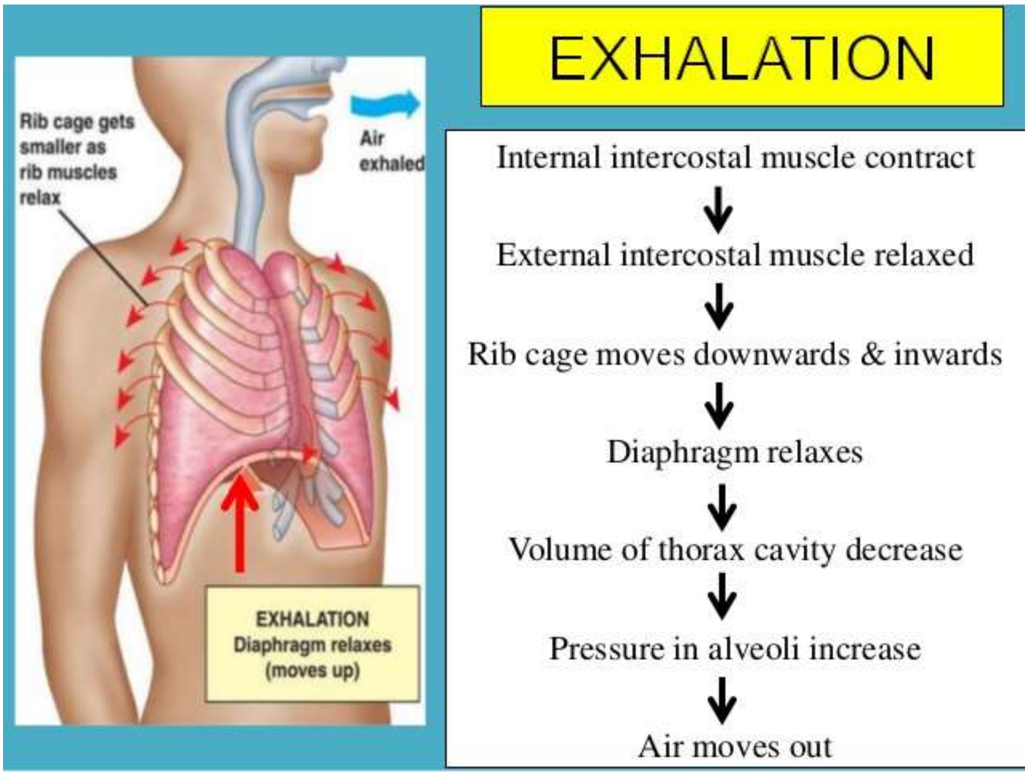
Volume of thorax cavity increase

↓

Pressure in alveoli decrease

↓

Air moves in



	Stage of breathing	Muscles involved	Contraction/ relaxation	Volume of thoracic cavity
1	Normal inspiration	i. Diaphragm ii. External intercostal muscles	Both contracts	Increases
2	Normal expiration	i. Diaphragm ii. External intercostal muscles	Both relaxes	Decreases
3	Forceful expiration	i. Internal inter costal muscles ii. Abdominal muscles	Both contracts	Decreases

On an average a healthy human breathes <u>12-16 times/ minute</u>. The volume of air involved in breathing movements can be estimated by using a **<u>spirometer</u>**, which helps in clinical assessment of pulmonary functions.

<u>Respiratory Volume and Capacities</u>

Tidal volume (TV) – volume of air inspired or expired during a normal respiration. It is about 500mL in healthy man.

Minute volume/Pulmonary ventilation- Volume of air inspired or expired in a minute. TV*Breathing rate. = (500*12-16) = 6000-8000mL.

Inspiratory Reserve Volume (IRV) – additional volume of air a person can inspire by forceful inspiration. It is about 2500 mL to 3000mL.

Expiatory Reserve Volume (ERV) – additional volume of air a person can expire by forceful expiration. It is about 1000 mL to 1100mL.

Residual Volume (RV) – volume of air remaining in lungs even after a forcible expiration. It is about 1100mL to 1200mL.

Inspiratory Capacity (IC) – Total volume of air a person can inspire after a normal expiration. TV + IRV = IC=3000-3500mL.

Expiratory Capacity (EC) – Total volume of air a person can expire after a normal inspiration. TV + ERV=EC=1500-1600mL.

Functional Residual Capacity (FRC) – volume of air remaining in lungs even after normal expiration. ERV + RV=FRC=2100-2300mL.

Vital Capacity (VC) – maximum volume of air a person can breathe in after a forceful expiration or maximum volume of air a person can breathe out after a forceful inspiration. ERV+ TV+ IRV=VC=4000-4600mL.

Total Lung Capacity (TLC) – total volume of air accommodated in lung at the end of forced inspiration. RV+ ERV+ TV+ IRV or Vital capacity + Residual Volume. TLC=5100-5800mL.

<u>Exchange of gases:</u>

Gases are exchanged by simple diffusion mainly based on pressure or concentration gradient.

The pressure exerted by an individual gas in a mixture of gases is called partial pressure of that gas. Partial pressure of oxygen is represented by **pO_2** and that of carbon dioxide by **pCO_2**.

Factors that affect the rate of diffusion-

1. Solubility of gases: A gas with high solubility diffuses at faster rate than the gas having low solubility. For example, CO_2 is 20-25 times higher than that of O_2, hence the amount of CO_2 that diffuses across diffusion membrane is much higher than that of O_2.
2. Partial pressure: The diffusion of gases takes place from a region of their higher partial pressure to a region of their lower partial pressure.
3. Thickness of diffusion membrane: More the thickness of membrane less will be the rate of diffusion. Thinner the membrane thickness more will be the rate of diffusion.

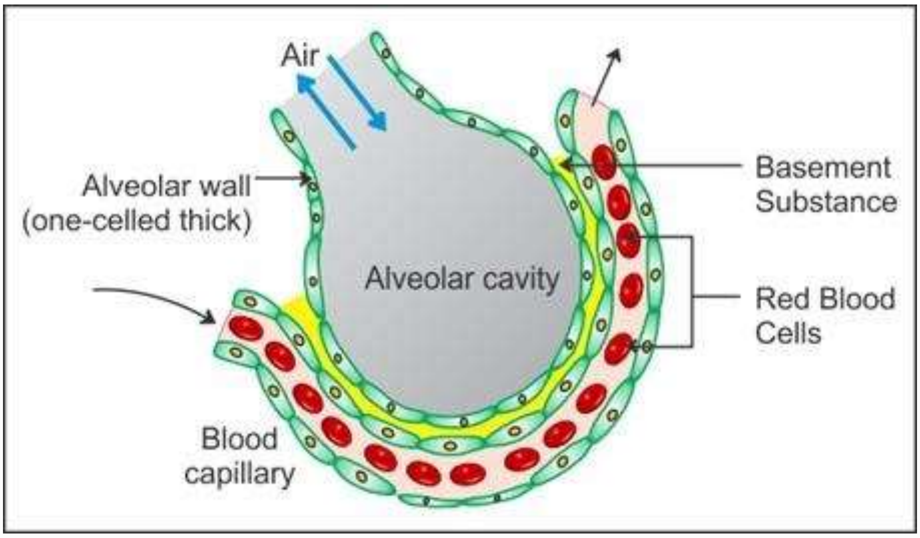
There are two sites where exchange of gases takes place, they are

a. Exchange of gases between alveoli and blood.
b. Exchange of gases between blood and tissues.

Exchange part of alveolus and blood capillary:

Exchange of gases (oxygen and carbon dioxide) occurs between alveoli and blood by mechanism of diffusion.

Diffusion occurs across **diffusion membrane**, diffusion membrane is made up of thin squamous epithelium of alveoli, the endothelium of alveolar capillaries and the basement membrane present between them. The total thickness of the diffusion membrane is less than a millimetre.



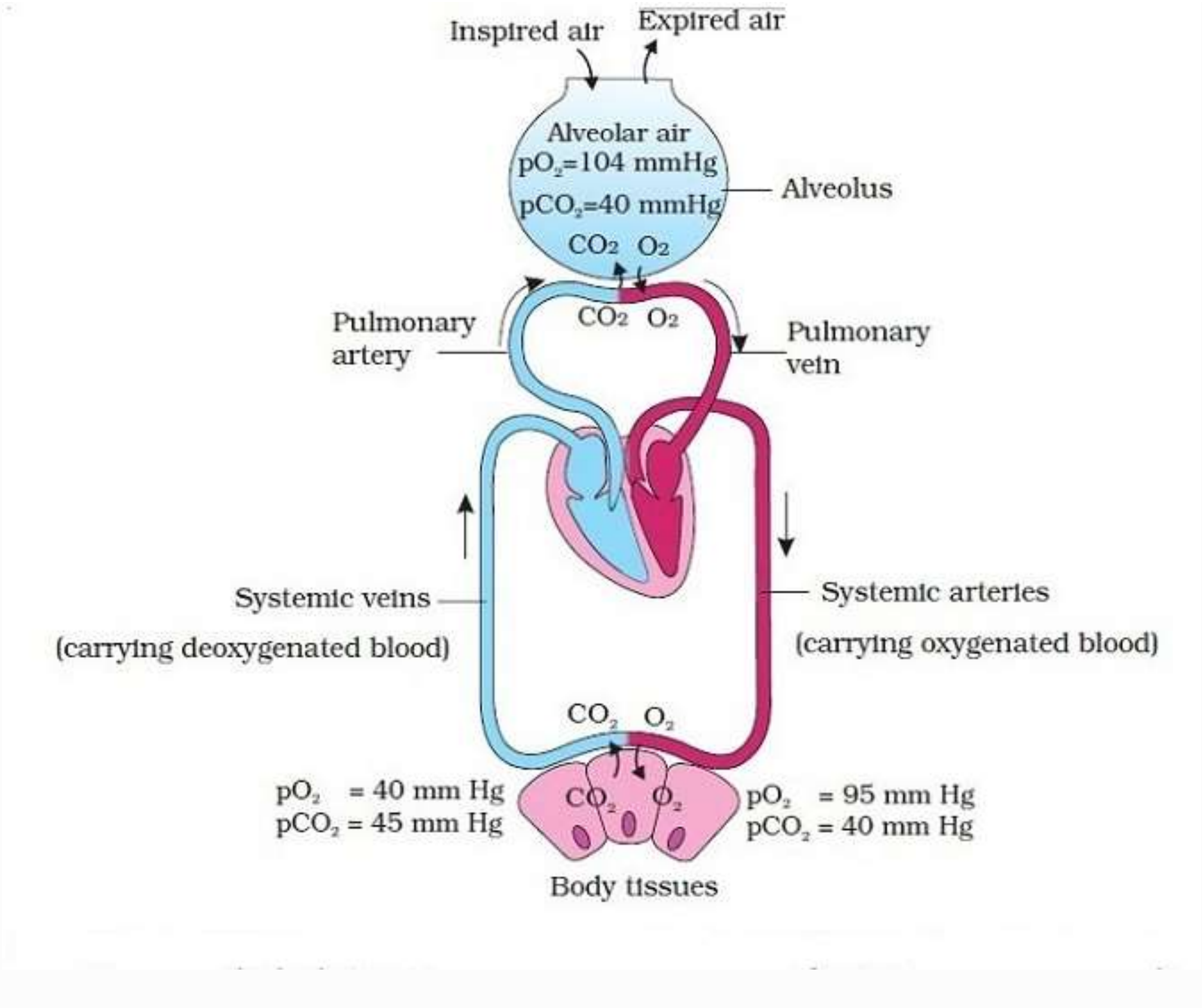
The partial pressure of oxygen (pO_2) in atmospheric air is higher, i.e., **159mmHg** than that in the alveoli, i.e., **104mmHg.** The partial pressure of oxygen (pO_2) in alveoli is higher than that in the deoxygenated blood, i.e., **40mmHg**.

Gases diffuse from the region of higher partial pressure to the region of lower partial pressure. Therefore, oxygen diffuses from atmospheric air in alveoli to blood.

The partial pressure of carbon dioxide (pCO_2) in deoxygenated blood is higher, i.e., **45mmHg** than that in the alveoli, i.e., **40mmHg.** And it is further low in atmospheric air **0.3mmHg**. So, carbon dioxide moves from deoxygenated blood to alveoli and finally to atmosphere.

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

Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and caron dioxide is given below-



<u>Transport of respiratory gases</u>

The main respiratory gases are oxygen and carbon dioxide.

Oxygen is transported from atmosphere to alveoli (by inspiration), then diffused to blood and blood carries oxygen to the tissues where oxygen diffuses to the tissues. Tissues uses this oxygen for cell respiration.

Carbon dioxide produced as a biproduct of cell respiration is transported from tissues to alveoli through blood and then to atmosphere (by expiration).

Transport of oxygen:

Most of oxygen (97%) is transported through RBC and remaining 3% by blood plasma.

Haemoglobin (Hb) is a protein found in the red blood cells that carries oxygen in your body and gives blood its red colour. A healthy individual has **12 to 16**

grams of haemoglobin in every 100 mL of blood. Haemoglobin has an oxygen-binding capacity of **1.34 mL O_2 per gram**.

The haemoglobin molecule is an assembly of four globular protein subunits.

Each subunit is composed of a protein chain tightly associated with a non-protein prosthetic haem group.

A haem group consists of an iron (Fe) ion held in a heterocyclic ring, known as a porphyrin.

This porphyrin ring consists of four pyrrole molecules cyclically linked together (by methine bridges) with the iron ion bound in the centre.

Haemoglobin (Hb) in RBC combines with O_2 to form **Oxyhaemoglobin** (Hb,4O_2). Each haemoglobin can combine with four oxygen molecules**.**

[Hb + 4O_2 → Hb.4O_2].

97% of oxygen is transported by this mechanism.

3% of oxygen from alveoli diffuses into the blood plasma, it remains in the plasma and plasma carries this oxygen to the tissues.

Transport of carbon dioxide:

70% of carbon dioxide is transported as bicarbonate,
20-25% of CO_2 is transported by RBC as carbamino haemoglobin and
rest 7% is transported in dissolved state by blood plasma.

Transport of carbon dioxide as bicarbonates:

RBCs contain a very high concentration of the enzyme, **carbonic anhydrase** and minute quantities of the same is present in the plasma too.

This enzyme facilitates the following reaction in both directions.

$CO_2 + H_2O \xrightarrow{\textit{Carbonic anhydrase}} H_2CO_3 \xrightarrow{\textit{Carbonic anhydrase}} HCO_3^- + H^+$

At the tissue site where partial pressure of CO_2 is high due to catabolism, CO_2 diffuses into blood (RBCs and plasma) and forms HCO_3^- and H^+.

At the alveolar site where pCO_2 is low, the reaction proceeds in the opposite direction leading to the formation of CO_2 and H_2O.

Thus, CO_2 trapped as bicarbonate at the tissue level and transported to the alveoli is released out as CO_2.

Hamburger Phenomenon: Bicarbonate ion diffuses into the plasma from RBC, causing a negative charge loss in RBC. To rectify this negative charge loss negatively charged Cl^- ions move from plasma to the RBC, this movement is called hamburger phenomenon.

The bicarbonate ion in plasma combines with Na+ ions and form sodium bicarbonate ions. This bicarbonate ion is carried to the region of lungs through plasma.

At the region of lungs sodium bicarbonate dissociates and bicarbonate ion re-enters in to the alveoli, causing outward movement of chloride ion.

Bicarbonate ion in RBC recombine with hydrogen ion in presence of carbonic anhydrase enzyme and form carbonic acid.

The newly formed carbonic acid dissociates to carbon dioxide and water. This carbon dioxide is released to atmosphere by expiration.

<u>Transport of carbon dioxide as carbaminohaemoglobin:</u>

20-25% of carbon dioxide from tissues diffuses into the RBC and in RBC combines with Hb to form carbamino haemoglobin, on reaching the region of lungs carbaminohaemoglobin dissociates and carbon dioxide diffuses into the alveoli from blood.

Carbaminohaemoglobin is a compound of haemoglobin and carbon dioxide, and is one of the forms in which carbon dioxide exists in the blood. Twenty-five percent of carbon dioxide is carried in blood this way.

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

<u>Transport of carbon dioxide through plasma:</u>

5-7% of carbon dioxide from tissues diffuses into the blood plasma, it remains in the plasma and plasma carries this carbon dioxide to the alveoli. From the alveoli by the process of expiration carbon dioxide is released to the atmosphere.

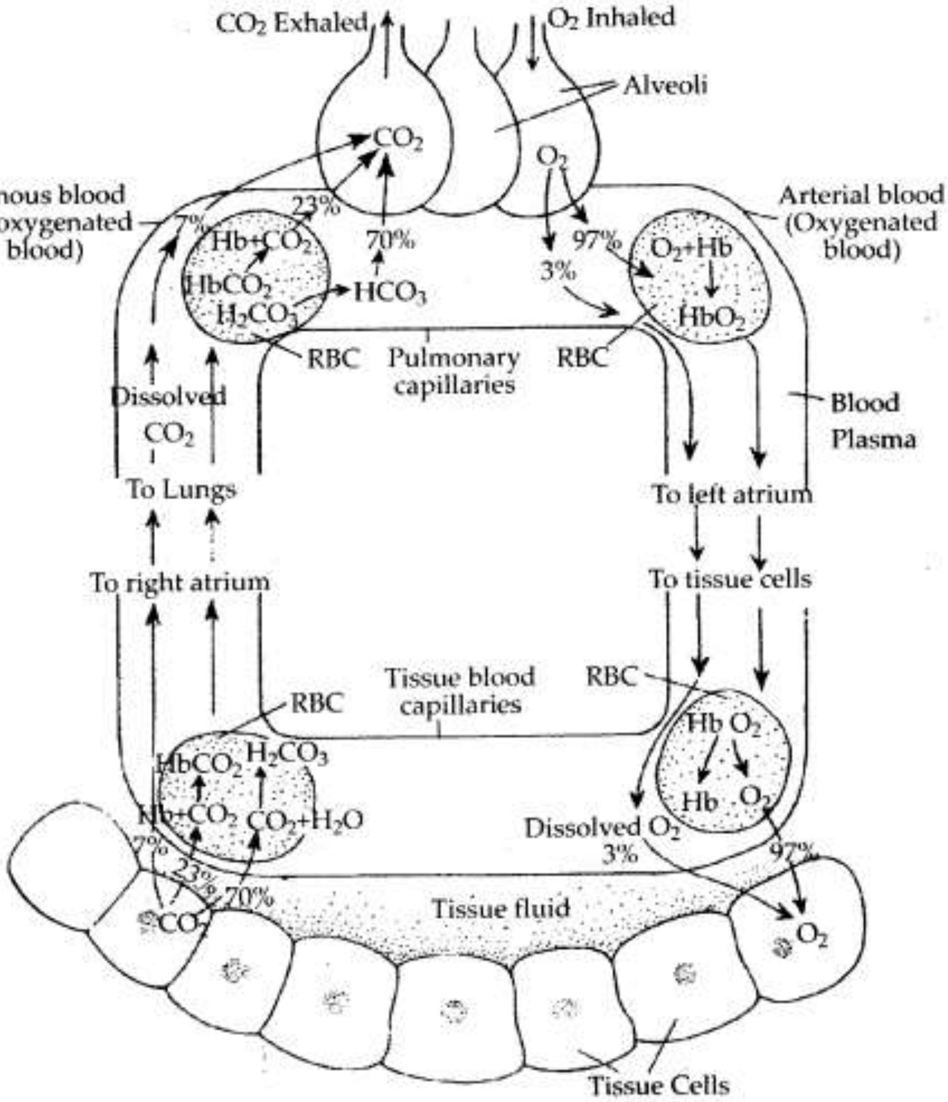


Fig.: Transport of oxygen and carbon dioxide

Every 100mL of blood carry 20mL of oxygen to the tissues.

During normal physiological condition tissue requires 5mL of oxygen from every 100mL of blood.

And during exercise tissue require 15mL of oxygen from every 100mL of blood.

<u>Oxygen dissociation curve:</u>

It is a graph plotted with partial pressure of oxygen in the x axis and percentage of saturation of haemoglobin with oxygen in the y axis.

The graph obtained is a sigmoid curve (‘S’ shaped).

This curve is an important tool for understanding how our blood carries and releases oxygen.

the oxyhaemoglobin dissociation curve describes the relation between the partial pressure of oxygen (x axis) and the oxygen saturation (y axis).

Haemoglobin's affinity for oxygen increases as successive molecules of oxygen bind.

More molecules bind as the oxygen partial pressure increases until the maximum amount that can be bound is reached. As this limit is approached, very little additional binding occurs and the curve levels out as the haemoglobin becomes saturated with oxygen. <u>Hence the curve has a sigmoidal or S-shape</u>.

At pressures above about 60 mmHg, the standard dissociation curve is relatively flat, which means that the oxygen content of the blood does not change significantly even with large increases in the oxygen partial pressure.

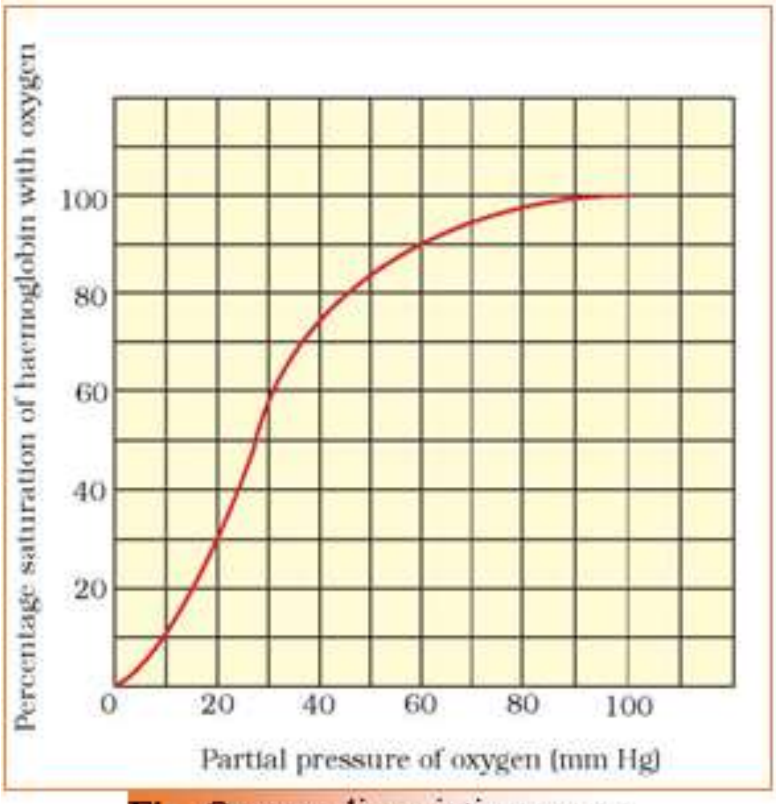


Fig: Oxygen dissociation curve

P_{50} value: The partial pressure of oxygen in the blood at which the haemoglobin is 50% saturated, typically about 26.6 mmHg for a healthy person, is known as the P_{50}. The P_{50} is a conventional measure of haemoglobin affinity for oxygen.

An increased P_{50} indicates a rightward shift of the standard curve, which means that a larger partial pressure is necessary to maintain a 50% oxygen saturation. This indicates a decreased affinity. Conversely, a lower P_{50} indicates a leftward shift and a higher affinity.

Factors affecting oxygen dissociation curve:

The strength with which oxygen binds to haemoglobin is affected by several factors.

These factors shift or reshape the oxyhaemoglobin dissociation curve.

A **rightward shift** indicates that the haemoglobin under study has a decreased affinity for oxygen.

This makes it more difficult for haemoglobin to bind to oxygen (requiring a higher partial pressure of oxygen to achieve the same oxygen saturation), but it makes it easier for the haemoglobin to release oxygen bound to it.

A **leftward shift** indicates that the haemoglobin under study has an increased affinity for oxygen so that haemoglobin binds oxygen more easily, but unloads it more reluctantly.

Left shift of the curve is a sign of haemoglobin's increased affinity for oxygen

- Left shift: higher O_2 affinity
- Right shift: lower O_2 affinity
- foetal haemoglobin has higher O_2 affinity than adult haemoglobin

Partial pressure of oxygen, partial pressure of carbon dioxide, H^+ ion concentration, temperature, 2,3-Bisphosphoglycerate or 2,3-BPG (formerly named 2,3-diphosphoglycerate or 2,3-DPG) and pH are the major factors that affects oxygen dissociation curve.

pO_2: Increased partial pressure of oxygen increases the affinity of haemoglobin to oxygen. When oxygen concentration is high haemoglobin shows more affinity to oxygen resulting in the leftward shift of the curve.

pCO_2 : Increased partial pressure of carbon dioxide reduces the affinity of haemoglobin to oxygen. At high CO_2 concentration dissociation curve shifts to the right.

H^+ ion concentration: At higher H+ ion concentration affinity of haemoglobin to oxygen decreases, and the curve shifts to right.

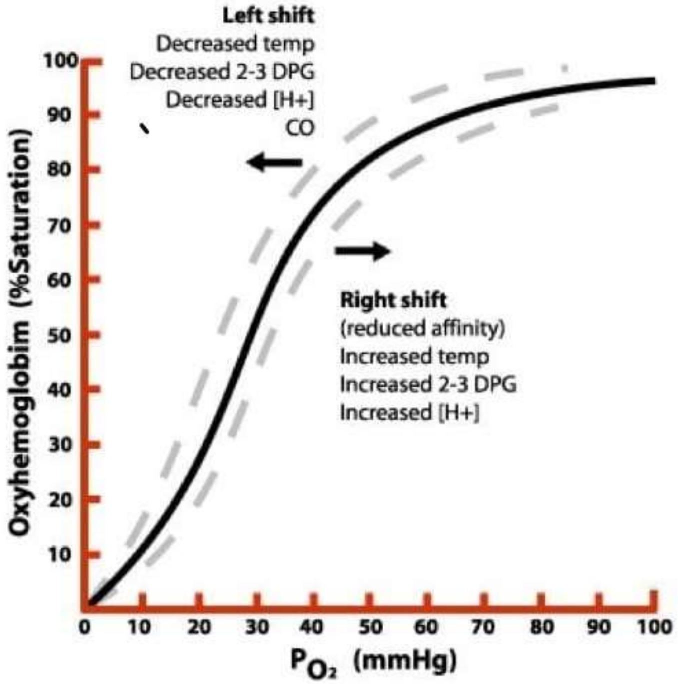
Temperature: Increase in temperature leads to the breakage of oxygen haemoglobin bond. At high temperature dissociation curve shift to the right.

2,3-Bisphosphoglycerate or 2,3-BPG: (formerly named 2,3diphosphoglycerate or 2,3-DPG) is an organophosphate formed in red blood cells during glycolysis.

Increased glycolysis increases the carbon dioxide level in cell and reduces the oxygen's affinity to haemoglobin.

High levels of 2,3-BPG shift the curve to the right while low levels of 2,3-BPG cause a leftward shift

pH: A decrease in pH (increase in H^+ ion concentration) shifts the standard curve to the right, while an increase shifts it to the left.



Control factors	Change	Shift of curve
Temperature	↑ increases	→ Right
	↓decreases	← Left
pO_2	↑ increases	← Left
	↓decreases	→ Right
2,3-BPG	↑ increases	→ Right
	↓ decreases	← Left
pCO_2	↑ increases	→ Right
	↓ decreases	← Left

Acidity $[H^+]$	↑ increases	→ Right
	↓ decreases	← Left
pH	↑ increases	→ Right
	↓ decreases	← Left

Bohr effect:

The **Bohr effect** is a phenomenon first described in 1904 by the Danish physiologist Christian Bohr. Haemoglobin's oxygen binding affinity is inversely related both to acidity and to the concentration of carbon dioxide.

The Bohr effect refers to the shift in the oxygen dissociation curve caused by changes in the concentration of carbon dioxide or the pH of the environment.

Carbon dioxide reacts with water to form carbonic acid, an increase in CO_2 results in a decrease in blood pH ,resulting in haemoglobin releasing their load of oxygen. Conversely, a decrease in carbon dioxide provokes an increase in pH, which results in haemoglobin picking up more oxygen.

Haldane effect:

The Haldane effect describes the ability of haemoglobin to carry increased amounts of carbon dioxide (CO_2) in the deoxygenated state as opposed to the oxygenated state.

A high concentration of CO_2 facilitates dissociation of oxyhaemoglobin.

Regulation of respiration:

The respiratory rhythm centre present in the medulla region of the brain is primarily responsible for the regulation of respiration. The respiratory center is involved in the minute-to-minute control of breathing.

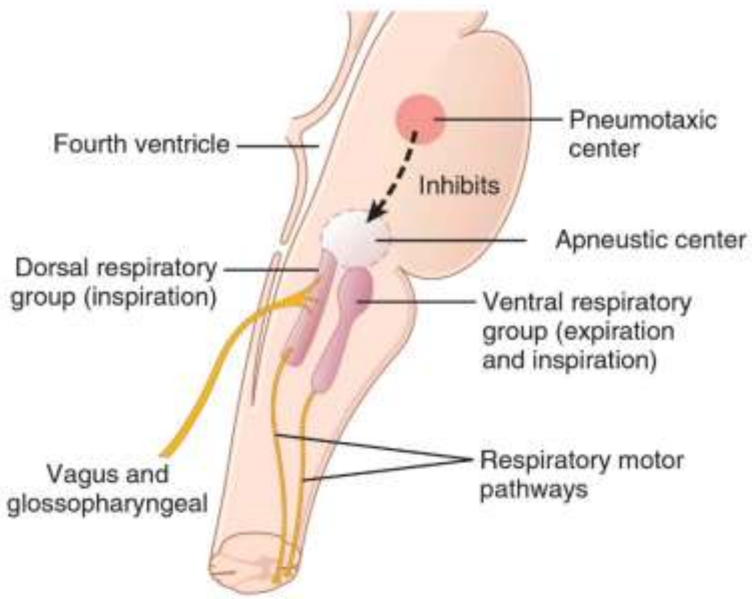
There are four respiratory groups, two in the medulla and two in the pons.

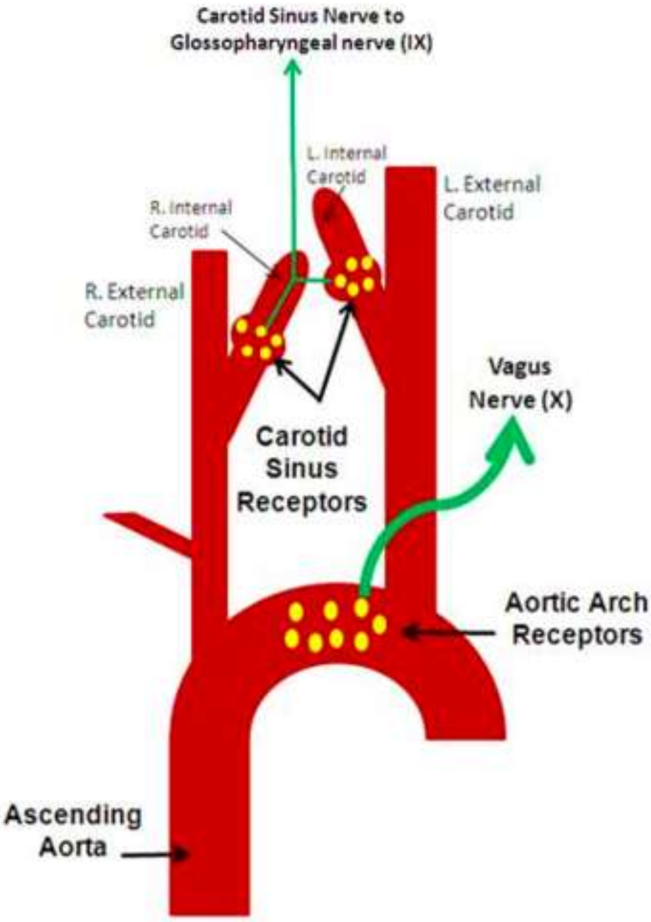
1. Dorsal respiratory group – in the medulla. The dorsal respiratory group controls mostly movements of inhalation and their timing.
2. Ventral respiratory group – in the medulla. The ventral respiratory group controls voluntary forced exhalation and acts to increase the force of inhalation.
3. Pneumotaxic center – various nuclei of the pons. Coordinate the speed of inhalation and exhalation, sends inhibitory impulses to the inspiratory area and Involved in fine tuning of respiration rate. The pneumotaxic centre can alter the function performed by the respiratory rhythm centre by signalling to reduce the inspiration.

4. Apneustic center – nucleus of the pons. coordinates speed of inhalation and exhalation. Sends stimulatory impulses to the inspiratory area – activates and prolongs inhalations.

Central chemoreceptors of the central nervous system, located on the ventrolateral medullary surface, are sensitive to the pH of their environment The chemo sensitive region present near the respiratory centre is sensitive to carbon dioxide and hydrogen ions. This region then signals to change the rate of expiration for eliminating the compounds.

Peripheral chemoreceptors act most importantly to detect variation of the PO2 in the arterial blood, in addition to detecting arterial PCO2 and pH. The receptors present in the carotid artery and aorta detect the levels of carbon dioxide and hydrogen ions in the blood. As the level of carbon dioxide increases, the respiratory centre sends nerve impulses for the necessary changes.





Mountain Sickness is the condition characterised by the ill effect of hypoxia (shortage of oxygen) in the tissues at high altitude commonly to person going to high altitude for the first time.

Symptoms-

- Loss of appetite, nausea, and vomiting occurs due to expansion of gases in digestive system.
- Breathlessness occurs because of pulmonary oedema.

- Headache, depression, disorientation, lack of sleep, weakness and fatigue.

Disorder of Respiratory System

1. **Asthma**– it is due to allergic reaction to foreign particles that affect the respiratory tract. The symptoms include coughing, wheezing and difficulty in breathing. This is due to excess of mucus in wall of respiratory tract.
2. **Emphysema**– is the inflation or abnormal distension of the bronchioles or alveolar sacs of lungs. This occurs due to destroying of septa between alveoli because of smoking and inhalation of other smokes. The exhalation becomes difficult and lung remains inflated.

3. **Occupational Respiratory Disorders**– occurs due to occupation of individual. This is caused by inhalation of gas, fumes or dust present in surrounding of work place. This includes **Silicosis, Asbestoses** due to exposure of silica and asbestos particles respectively. **Byssinosis**, caused due to the accumulation of cotton fibres in the lungs. **Anthracosis**, is caused due to accumulation of coal particles in lungs. The symptom of these disease includes proliferation of fibrous connective tissue of upper part of lung causing inflammation.

4. **Pneumonia**– it is acute infection or inflammation of the alveoli of the lungs due to bacterium *streptococcus pneumoniae.* Alveoli become acutely inflamed and most of air space of the alveoli is filled with fluid and dead white blood corpuscles limiting gaseous exchange.

5. **Pleurisy**- caused due to inflammation of pleural membrane.

6. **Bend's disease or dysbarism:** Decompression sickness, also called generalized barotrauma or the bends, refers to injuries caused by a rapid decrease in the pressure that surrounds you, of either air or water. It occurs most commonly in scuba or deep-sea divers, although it also can occur during high-altitude or unpressurized air travel.

7. **Atelectasis:** is a complete or partial collapse of the entire lung or area (lobe) of the lung. It occurs when the tiny air sacs (alveoli) within the lung become deflated or possibly filled with alveolar fluid.

Terms associated with Breathing:

1. **Anoxia:** Absence of oxygen in inspired air, arterial blood or tissues.
2. **Asphyxia:** a condition arising when the body is deprived of oxygen, causing unconsciousness or death; suffocation.
3. **Hypoxia:** a condition where not enough oxygen makes it to the cells and tissues in the body.
4. **Hypercapnia:** is a build-up of carbon dioxide in your bloodstream.
5. **Eupnoea:** Normal breathing.
6. **Hypopnea:** Slow breathing.
7. **Hyperpnea:** Rapid breathing.
8. **Apnoea:** No breathing.
9. **Dyspnoea:** Painful breathing.
10. **Orthopnoea:** Difficulty to breathe except in upright position.