RESPIRATORY SYSTEM

Respiration –

A process in which oxidation of organic compounds occurs in cell and energy is released is called as respiration.

Stages of Respiration - According to scientist G.S. Carter there are three stages in respiration-

(i) External Respiration (Ventilation) –Gaseous exchange between environment and lung.

(ii) Internal Respiration –

(1) Gaseous exchange between lungs and blood.

(2) Gaseous exchange between blood and tissue fluid.

(iii) Cellular Respiration – Oxidation of organic compounds in cell in which energy is released

STRUCTURE OF RESPIRATORY

(1) Respiratory Tract (Conducting Zone)

(2) Lungs (Exchange zone)

Respiratory tract - A passage from external nostrils to lungs

or

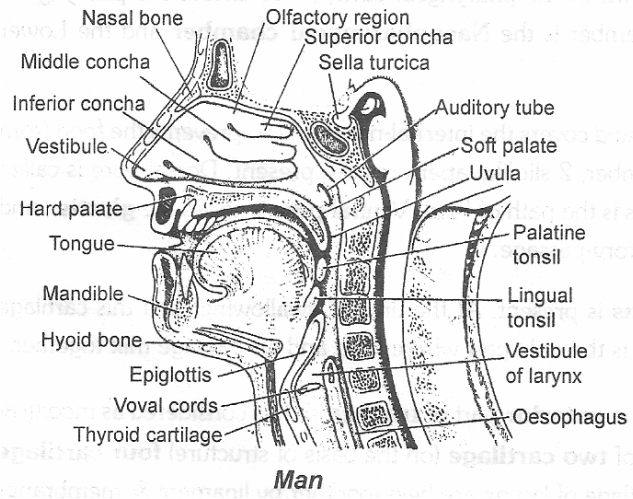
- A passage by which air enters into lungs

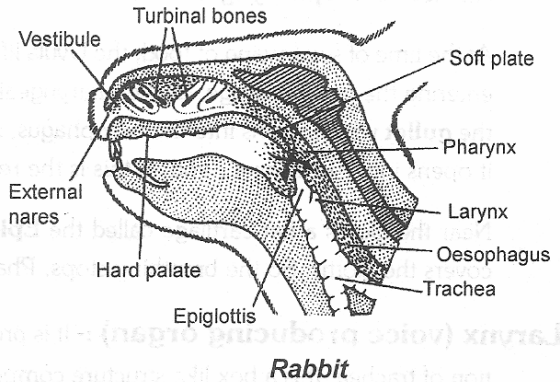
Lungs – Anatomical organ which is the actual site for exchange of gases.

External nostrils → Vestibule → Nasal Chamber → Internal nares → Naso pharynx

↓

Respiratory Tree ← Bronchial Tree ← Trachea ← Larynx ← Glottis ← Pharynx





1. Nose and Nasal – Passage-

The respiratory path begins from the Nose and the Nasal passage. In rabbit, at the apex of nose, a pair of external-nares are present. This is termed as **Dirhynous condition.** Each external nare opens into a **nasal passage or Nasal Chamber.** Both the Nasal Chamber are separated from each other by hyaline cartilage. The snterior small part of each Nasal Chamber is called **Nasal vestibule.**

It is formed by the invagination of the skin in embryonic stages ; so this part contains hair and sebaceous glands. In this manner dust particles can not enter in. The remaining part of the nasal-passage is surrounded by 3 types of bones, namely the nasal, maxilla & Ethamoid.

At several places in the nasal-passage these bones form out growths. These outgrowths are called **Turbinal bones or Tubinates or chonchae.** Due to these outgrowths the nasal-passage is long and spiral. This helps in making the temperature of air equal to the body temperature before it reaches the lungs and does not allow unwanted materials like dust to reach the lungs. A coat of apithelium is present on the turbinals bones of maxilla and ethmoid. This is **pseudo stratified columnar ciliated glandular epithelium = PSCCGE.**

PSCCGE is a simple epithelium i.e., made up of only 1 layer of cells; but it appears to be stratified becayse it has cells of varying length. This epithelium has **Golet Cells,** Which secrete **mucous.** This mucous binds the dust particles and bacterias. The cilia present on the epithelium continuously propel the mucous into the pharyngeal cavity. On the turbinals bone of nasal-bone a hair less cillialess membraneous covering is present, known as **Schneidarian membrane.** This membrane is **Olfactory.** Both the nasal-passages, through a pair of **internal-nares or choanae** open into the Naso pharyngeal cavity.

Functional division of Nasal Passage

(i) Vestibular Region :- skin, hairs, sebaceous glands.

(ii) Resoiratory Region :- PSCCGE, Goblet Cells.

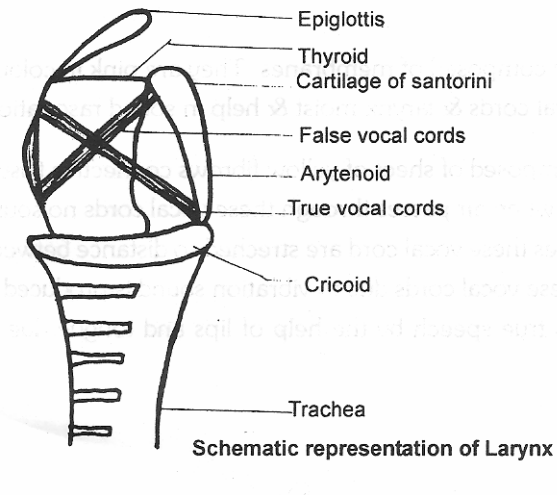
(iii) Olfactory Region :- Schneidarian membrane or neuro sensory Epithelium

2. Bucco-pharyngeal cavity –

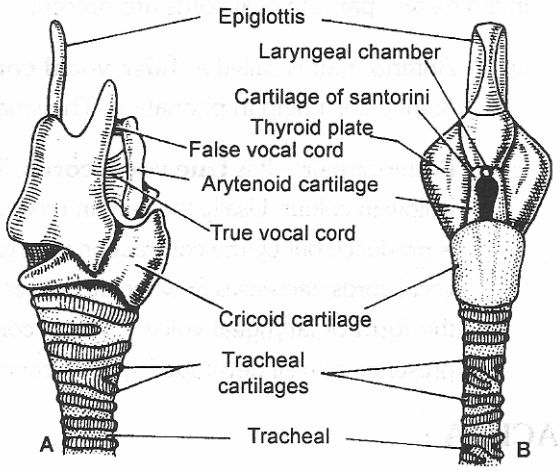
It is divided into two parts. Anterior part is called the **Buccal-cavity** and the posterior part is called **Pharyngeal-cavity.** Between the buccal and the Nasal cavity hard palate followed by soft palate is present. The terminal part of soft plate is called **Uvula.** Uvula is bent towards the pharyngeal cavity. This divides the pharyngeal-cavity incompletely into two chambers. Upper chamber is the **Nasopharyngeal chamber** and the Lower chamber is **Oropharyngeal chamber.**

At the time of swallowing of food, the Uvula lifts up and covers the internal-nares and so prevents the food from entering the nasal-passage. In the phyaryngeal chamber, 2 slit like apertures are present. Dorsal-pore is called the **gullet** which opens into the oesop[hagus, so this is the path of food. Ventral-pore is called the **glottis** ; and it opens into the Larynx ; and so this is the respiratory-passage.
Near the glottis a flat cartilage called the **Epiglottis** is present. At the time of swallowing food this cartilage covers the glottis, So the breathing stops. Pharynx is the only part where food air passage mix together.

Larynx (voice producing organ) :- It is present in **anterior** part of **trachea** so it is considered as modification of trachea. It is a box like structure composed of **two cartilage** (oc the basis of structure) **four cartilage** (in shape) & **six cartilage** (in number). These cartilage of larynx are held together by ligament & membranes



Schematic representation of Larynx



Thyroid cartilage :

1. Largest cartilage of larynx.
2. Composed of hyaline cartilage.
3. It is 'C' shaped cartilage so, incomplete cartilage.
4. Ventrally it is broad & laterally it is narrow but absent on surface. So this cartilage makes complete ventral surface & few part of each lateral surface of larynx.
5. On anterior part of thyroid epi-glottis is attached which is composed of **elastic cartilage.**
6. In human males, ventral surface of thyroid makes a process called as ADAM'S APPLE which is a secondary sexual character of male.

Cricoid cartilage :

1. It is composed of **hyaline** cartilage.
2. It is **signet ring shape** cartilage.
3. Present just below thyroid cartilage.
4. Dorsal surface of this cartilage is broad and ventral surface is narrow.

Arytenoid cartilage :

1. Two in number.
2. Paired cartilage of larynx.
3. Composed of **hyaline** cartilage.
4. Pyramid shape cartilage which is broad in base & pointed on ends.
5. They are present just upon cricoid cartilage in the doesal surface of larynx.
6. One end of vocal cords is attached with arytenoids & other end is attached with thyroid cartilage.

Cartilage of Santorini :

1. It is composed of **elastic cartilage.**
2. Two in number.
3. Present in the form of node like structure at the end of arytenoids so they are called as bands of arytenoids.
4. When epiglottis closes the glottis, it falls on cartilage of santorini so, this protects epiglottis from falling inside the glottis cavity.

In larynx two pair of vocal cords are present.

(i) Anterior pair is called as **false vocal cord** these are composed of membranes. They are pink in colours & they don't help in phonation. They make true vocal cords & larynx moist & help in sound resonation.

(ii) Posterior pair :- It is **true vocal cords.** They are composed of sheet of yellow fibrows connective tissue, yellow in colour. Usally they are in relax position so, when air passes through these vocal cords no sound is produced but by the contraction in laryngeal muscles these vocal cord are stretched so distance between vocal corddecreases & when air passes through these vocal cords due to vibration sound is produced in the form of laryngeal voice which is converted into true speech by the help of lips and tongue due to presence of well developed speech centre in brain.

TRACHEA :

It is a 10 – 12 cm long tube like structure present in complets length of neck upto anterior part of thoracic cavity

In complete length of trachea 16-20 'C; shape rings are present which prevent trachea from collapsing. These are composed of hyaline cartilage. These rings are incomplete on dorsal surface of trachea. On dorsal suface, trachealaris muscles are present which are involuntary in nature & help in the dialation of trachea during forceful breathing.

In the histology of wall of trachea 4 layers are present. (Inside to outwards)

1. **MUCOSA :-** 3 sub layer

   - Epithelium : PSCCGE
   - Lamina propria : Reticular fibrous connective tissue
   - Muscularis mucosa : longitudinal & circular muscle fibres.

2. **SUBMUCOSA :-** areolar connective tissue

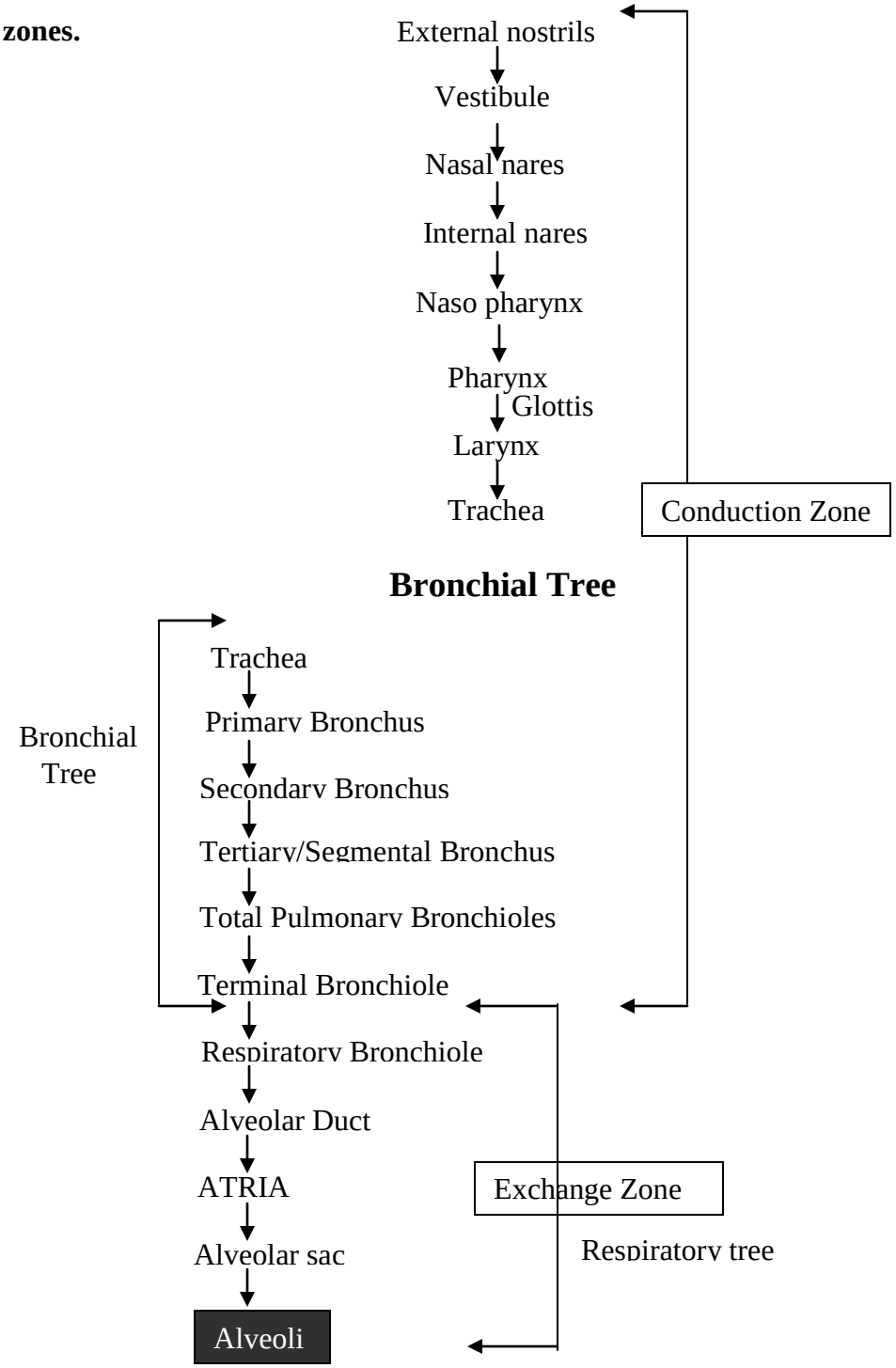
3. **CARTILAGENOUS LAYER :-** ;C; shape rings of hyaline cartilage.

4. **TUNICA ADVENTIA :-** White fibrous connective tissue

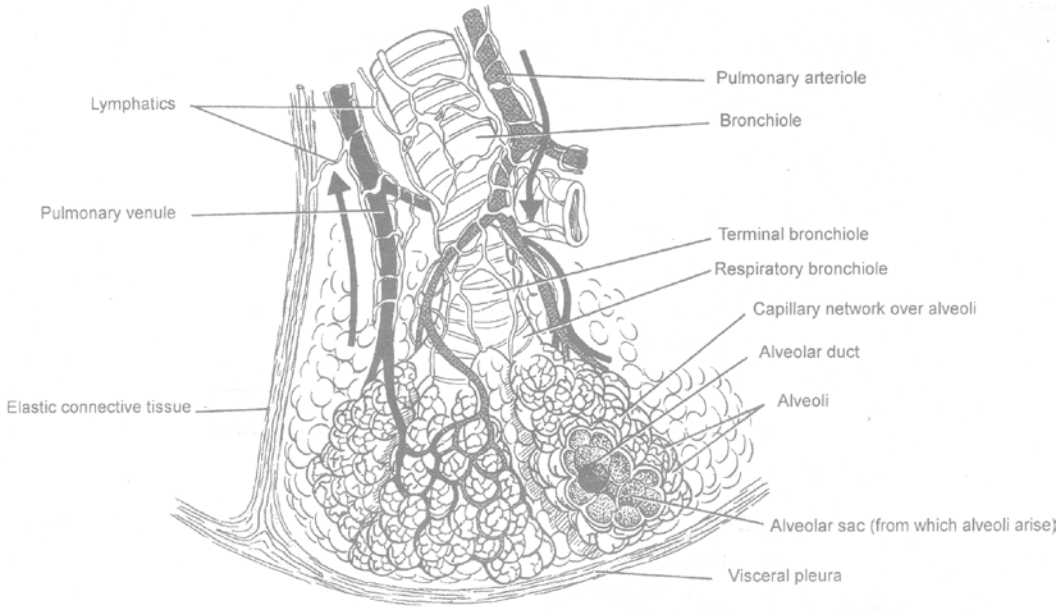
Bronchial tree (B. T.) & Respiratory Tree (R. T.)

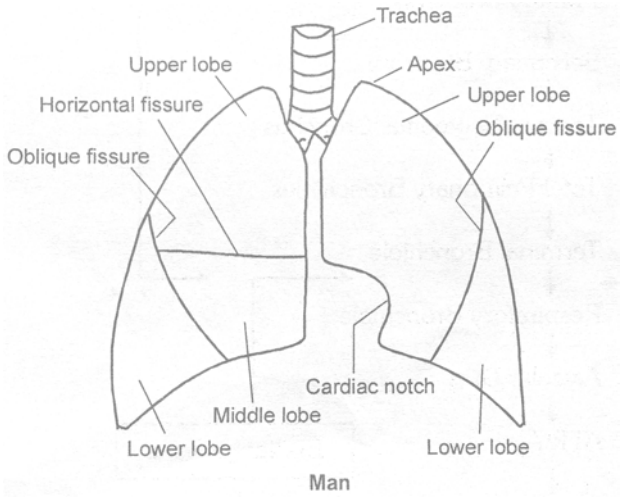
- When trachea enter in to thoracic cavity, it divides in two branches called as primary bronchus. Bronchus. Branches of Primary bronchus upto terminal bronchioles makes **bronchial tree**
- Terminal bronchioles divide to form respiratory bronchioles & branches of respiratory bronchioles makes **respiratory tree.**
- In bronchiole tree, cartilage rings are present, while these are absent in respiratory tree.
- Gaseous exchange occurs in respiratory tree while it is absent in bronchial tree.
- Volume of air which is filled in B.T. is a part of **dead space volume.** Which doesn't take a part in gaseous exchange. (150 ml)

There are two zones.

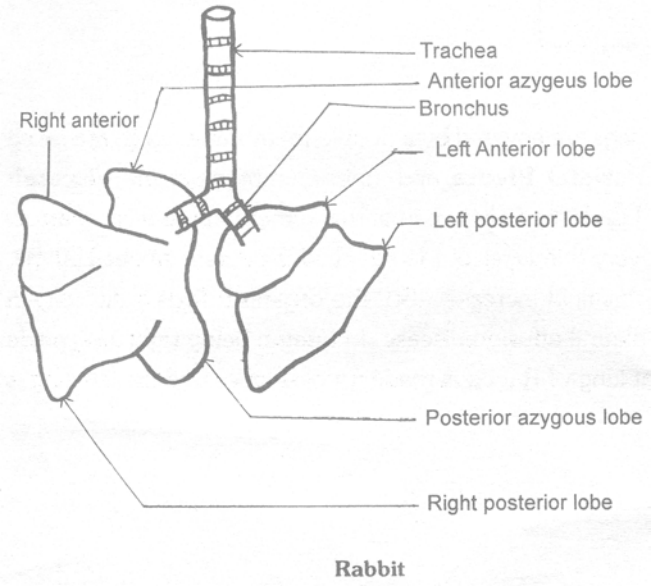


Lungs : A pair of lungs are present in the thoracic-cavity. Lungs are covered by a double-membrane which are called the **Pleural-membranes.** Outer membrane is the **Parietal Pleura** and inner-membrane is the **Visceral-pleura** Both these membranes are derived from the Mesoderm. In between both the membranes a very narrow cavity called Pleural-cavity is present. In this cavity, a very thin layer of Pleural Fluid is present (about 150 ml). Sometimes due to bacterial infection the amount of this fluid increases. So, the organism feels a difficulty in breathing **(dyspnoea).** This is termed as Pleuricy or pleural effusion disease. In human being right lung made up of 3 lobes & left lung made up of 2 lobes. The right lung of Rabbit is made up of 4 lobes and the left lung is made up of 2 lobes.

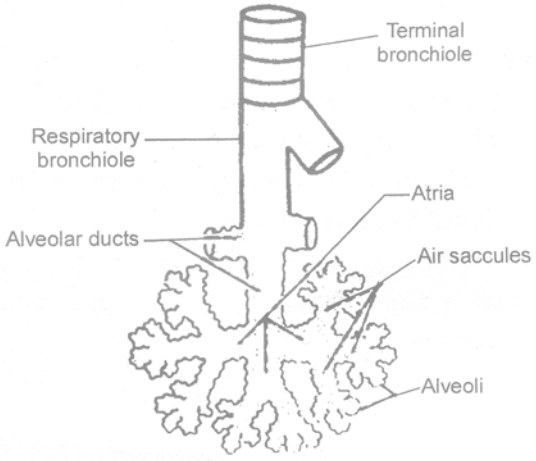




Man



Rabbit



Man

RABBIT

Right lung	**Left lung**
4 lobes	2 lobes
anterior azygous	left anterior
Right anterior	left posterior
Right posterior	
Posterior azygous	

HUMAN

Right lung	**left lung** (575 gm)
3 lobes	2 lobes
anterior lobe	left anterior
middle lode	left posterior
posterior lobe	

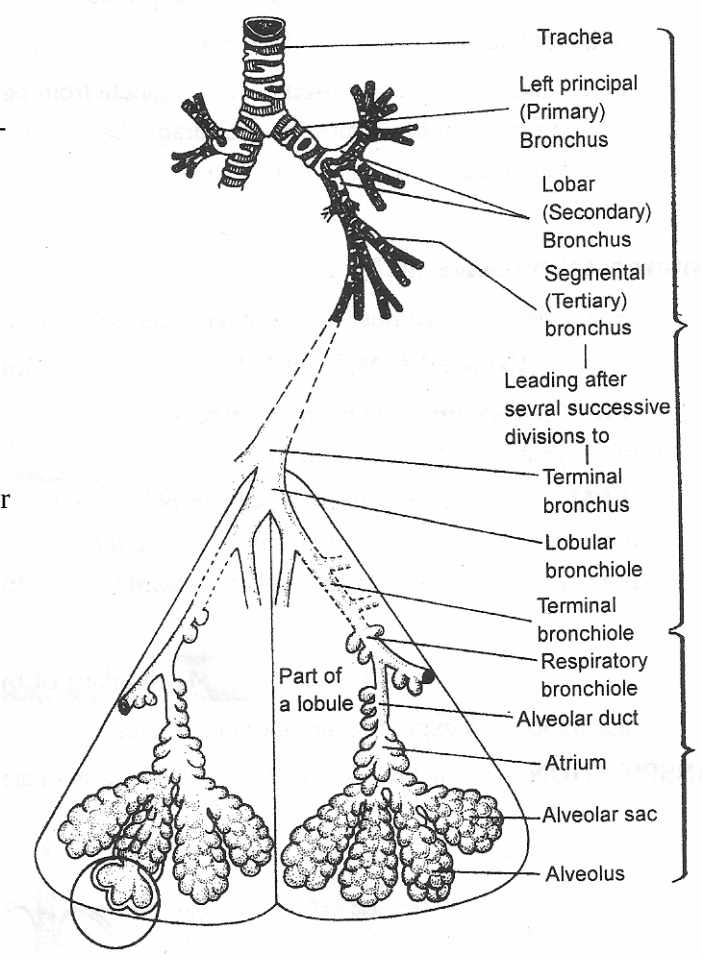
Alveoli : Each lobe is further divided into several lobules by septas of connective tissue. Each lobule is further divided into several air-sacs ; and in the end, each air-sac is lastly divided into 3 or 4 alveolis ; which are also termed as the units of lungs.

Structural & functional unit of lungs is called

Alveoli

Approximately 300 million alveoli are present in Both lung. Inner (Alveolar) surface area of both lungs is approximately 100 m^2. Wall of alveoli consist two layers, outer layer is composed of yellow fibrous C.T. Inner layer is composed of Simple Squamous Epithelium

- squamous cells are called as **pneumocytes.**
- most of these Pneumocytes help in gaseous exchange while few pneumocytes which are larger in size secrete LECITHIN (Phospholipid) this acts as surfactant which prevents alveoli from reaming collapse by reducing its surface tension.

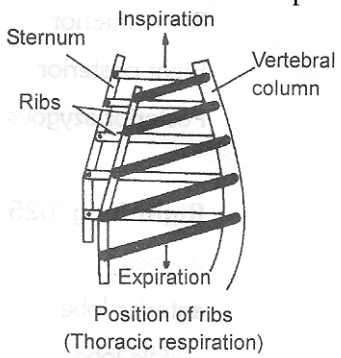


Alveolis internal surface is termed as the Respiratory surface. It is derived from the endoderm of the embryo. Rest whole lung is mesodermal. The middle part of alveoli wall is made up of connective tissue. It is richly supplled with blood capillaries, a dense network of blood capillaries is found in alveoli.

These blood capillaries come from pulmonary artery, Pulmonary artery divides in to blood capillaries after reaching in lungs. These capillaries from a dense network in the walls of alveoli. All these capillaries combine to form pulmonary vein at the another end. These veins carries pure blood to the auricle of the heart. There

are small present in the walls of alveoli. These pores make diffusion of gases easy. These pores are called **pores of Kuhn.** It is the characterstic feature of mammalian lungs, that there is no central cavity. Mammalian lungs are **solid spongy.**

Muscles are absent in the lungs of mammals. So the power of self-contraction and self-expension is absent in these lungs. (Sucken lungs)



Position of ribs
(Thoracic respiration)

Thoracic cage :- Covering of thoracic cavity makes thoracic cage.

Anterior surface:-		Clavical bones, Neck
Posterior surface	:-	Diaphragm.
Dorsal surface	:-	Vertebral column & Ribs
Ventral surface	:-	Sternum & ribs.
Lateral surface	:-	Ribs

Diaphragm :- A musciar septum which is found only in mammals (and crocodile). Normal shape of ot is dome like which divides body cavity in two parts upper thoracic cavity lower abdominal cavity. In central region of diaphragm central tendon is present it is pierced by 3 structures :

(i) Oesophagus (ii) Aorta (iii) Post. vena cava

In it radial muscles are present. They originate from periphery & inserted in central region of diaphragm. By the contraction in these muscles, diaphragm become flatten in shape. So, volume of thoracic cavity increases Therefore, diaphragm helps in inspiration.

Intercostal muscles (ICM) :-

Space between two ribs in called inter costal space in which 2 types of muscles are present

- External ICM. (EICM) - Internal ICM. (IICM)

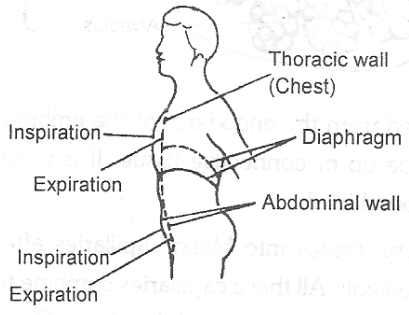
EICM :- They originate from dorsal part of upper rib & insert on ventral part of lower rib. By the contraction in this muscles, rib & sternum shifts upward & outward. So they helps in inspiration.

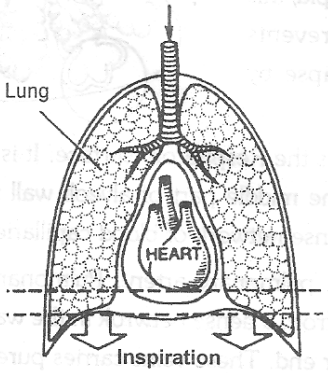
IICM :- They originate from dorsal part of lower rib & insert in ventral part of upper rib. By the contraction in these muscles, ribs & sternum shifts downward & inward respectively. So it helps in forceful expiration which is a voluntary activity, So contraction of IICM is under the control of cerebrum.

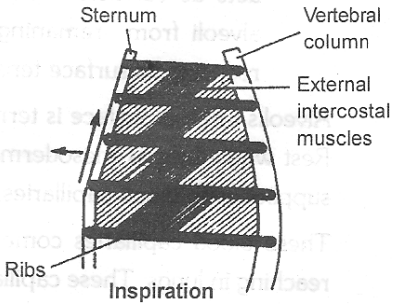
Mechanism of breathing

Inspiration and expiration are included in breathing. Normal breathing is termed **Eupnoea.**

INSPIRATION :- At the time of inspiration, contraction in diaphragm and external intercostals muscles takes place.

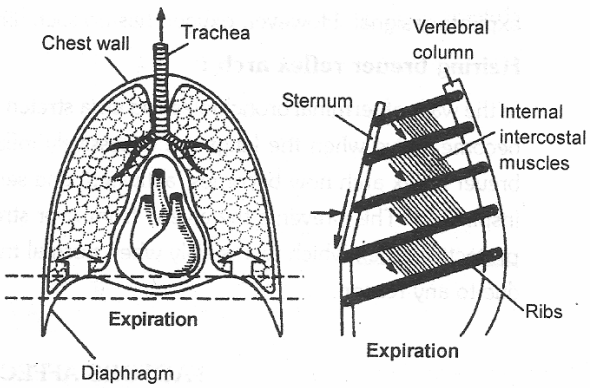






- Diaphragm becomes flat and is pushed towards abdominal cavity6.
- Sternum moves towards ventral and anterior direction.
- Ribs move towards outside and ventral side. As a result of all these reactions, the volume of thoracic cavity is increased. So the pressure of coelomic fluid over lungs is decreased. Due to the spongy nature, lungs expand. As a result of this, air pressure in the lungs is decreased by 1-3 mm mercury column as compared to atmospheric pressure. Now air rushes from outside, through respiratory track and fills the lungs. Inspiration is an active process. Normally it takes around 2 seconds.

EXPIRATION



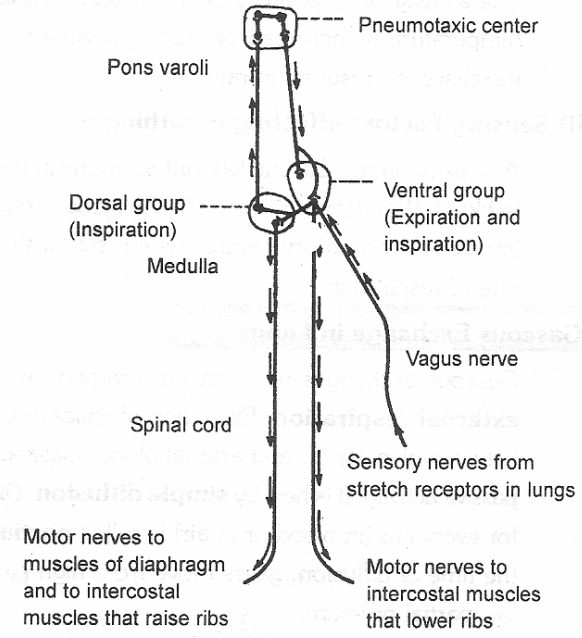
Normal expiration is a passive activity. It takes around 3 seconds. During expiration, contraction (in any muscle) does not take place. During expiration, relaxation in diaphragm and external intercostals muscles takes place. As a result of this relaxation, diaphragm, sternum and ribs attain their actual (normal) position. Due to which the volume of thoracic cavity is decreased, and pressure of thoracic cage on lung is increased. Thus air which was filled in lungs goes outside through respiratory tract.

Expiration during sneezing, coughing and yogabhyas is called **forceful expiration.** It is an active process. During forceful expiration Internal intercostals muscles contrace. At this time these contracted muscle pull the ribs inwards, thus the volume of thoracic cavity is highly decreased and the air which was filled in lungs rushes towards outside. Normal breathing is also called **Abdominal breathing.**

REGULATION OF RESPIRATION

NERVOUS CONTROL

The respiratory rhythm is controlled by the nervous system. The rate of respiration can be enhanced as poer demand of the demand of the body during strenuous physical exercises. A number of groups of neurons located bilaterally in the medulla oblongata control the respiration. These are called **respiratory centres.** Three groups of respiratory centres have been in dentified, namely : dorsal respiratory group, ventral respiratory group and pneumotaxic centre



The **dorsal respiratory group** is present in the dorsal portion of medulla oblongata. The signals from these neurons generate the basic respiratory rhythm. The nervous singal released from this group is transmited to the diaphragm, which is the primary inspiartory muscle & EICM.

The **ventral respiratory group** of neurons are located anterolateral to the dorsal respiratory group. During normal respiration ,this remains inactive and even does not play any role.

In the enhanced respiratory drive, the respiratory signal of this group contributes to fulfil the demand by regulating both inspiration and expiration. Few of the neurons of this group control inspiration, while few other control expiration, thus regulatingboth. The **pneumotaxic centre** is located dorsally in the upper pons. It transmits signals top the inspiartory area. Primarily, it controls the switch off point of inspiration. When this signal is strong(high frequency), the inspiration lasts for a shorter duration and lungs are filled partially. During weak pneumotaxic signal, inspiration lasts for a longer duration resulting into complete filling of lungs. The strong signal (high frequency) causes increased rate of breathing, because duration of inspiration as well as expiration, is shortened. The concentration of CO_2 and H^+ cause increased strength of inspiartory, as well as expiratory signal. However, oxygen has no such direct effect.

Heiring breuer reflex arch :

In the walls of terminal bronchioles and atria stretch receptors are present, Which are normally inactive but they become active when the lungs are excessively inflated due to failure of switch off of inspiration. The heiring breuer reflex arch now becomes activated and sends inhibitory signals to the inspiartory centre to switch off inspiration. The prevents the alveoli from over stretching and bursting. Thus Heiring Breuer reflex arch is a protective reflex which only when normal mechanism of switch off of inspiration does not work timely due to any reason.

FACTORS AFFECTING BREATHING

I) Chemical Factors Affecting breathing :-

There are so many factors which affect the activity of respiratory centre. Respiratory centre is sensitive to CO_2 – concentration in the blood and pH of blood. Respiratory centre is not sensitive for O_2 concentration in blood. Whenever, in the blood, CO_2 concentration is increased, or pH is decreased, or acidity is increased, then respiratory centre becomes more activated and increases the rate of respiration. Normal breathing rate of rabbit is **36-38 per minute.** For human it is 14-18 per minute.

II) Physical Factors affecting breathing :-

The activity of respiratory centre is also affected by body temperature and blood pressure. Whenever body temperature is increased or blood pressure goes high, respiratory centre becomes more activated and this increases the respiration rate.

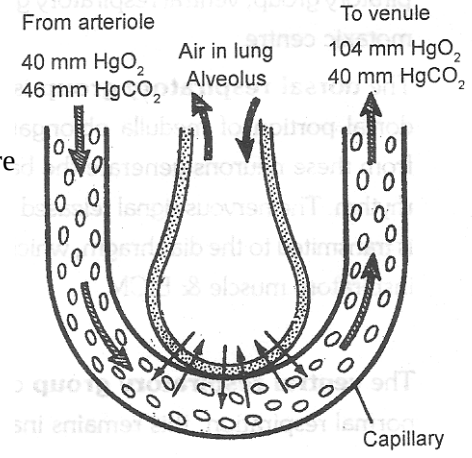
III) Sensory Factors affecting breathing :-

A sensory organ-Carotid labyrinth is found in the walls of Carotid arteries. This is sensitive for O_2-concentration in blood. Whenever O_2- concentration in blood is reduced, this sensory organ becomes activated and sends sensory impulse to respiratory centre. As a result of this respiratory centre. becomes activated and this increases the rate of respiration.

Gaseous Exchange in Lungs:-

Gaseous exchanges between environment and lungns is called **external respiration.** Exchange of gases in the lungs is done between alveolar air and arterial blood. Gaseous exchange is a passive activity. It is held by **simple diffusion.** Diffusion pressure for every gas (in blood or in air) is called **partial pressure.** At the time of diffusion, gases move from high partial pressure to low partial pressure.

The partial pressure of O_2 in alveolar air [PO_2] is 104 mm **mercury column,** its value in arterial blood is 40 mm mercury column (Hg). So oxygen goes from alveolar air to arterial air



** In alveolar air, partial pressure of CO_2[PCO_2] is 40 mm Hg and its value in arterial blood is 45-46 mm Hg. So CO_2 moves from arterial blood to alveoli. In this way, according to partial pressure exchange of gases takes place in the lungs.

Table of partial pressures and percentage concentrations (in brackets) of gases in various airs

Gas	**Atmospheric air**	**Inspired (=humidified air)**	**Functional residual Alveolar air**	**Expired air**
N_2	597.0(78.62%)	563.4(74.09%)	569.0(74.9)	566.0(74.5%)
O_2	159.0(20.84%)	149.3(19.67%)	104.0(13.6%)	120.0(15.7%)
CO_2	0.3(0.04%)	0.3(0.04%)	40.0(5.3%)	27.0(3.6%)
H_2O	3.7(0.5%)	47.0(6.2%)	47.0(6.2%)	47.0(6.2%)
	760.0(100%)	760.0(100%)	760.0(100%)	760.0(100%)

Partial Pressure	Alveolar air	Pulmonary Arterial Blood	Pulmonary Venous Blood
PO_2	104 mm Hg	40 mm Hg	95-104 mm Hg
PCO_2	40 mm Hg	45-46 mm Hg	40 mm Hg

Thus partial pressure of O_2 in pure blood PO_2= 104 mm Hg and PCO_2= 40 mm Hg

Pure blood goes to tissues from heart. Inspirated air contains 19.6%. Oxygen and expirated air has 15.7% O_2 .

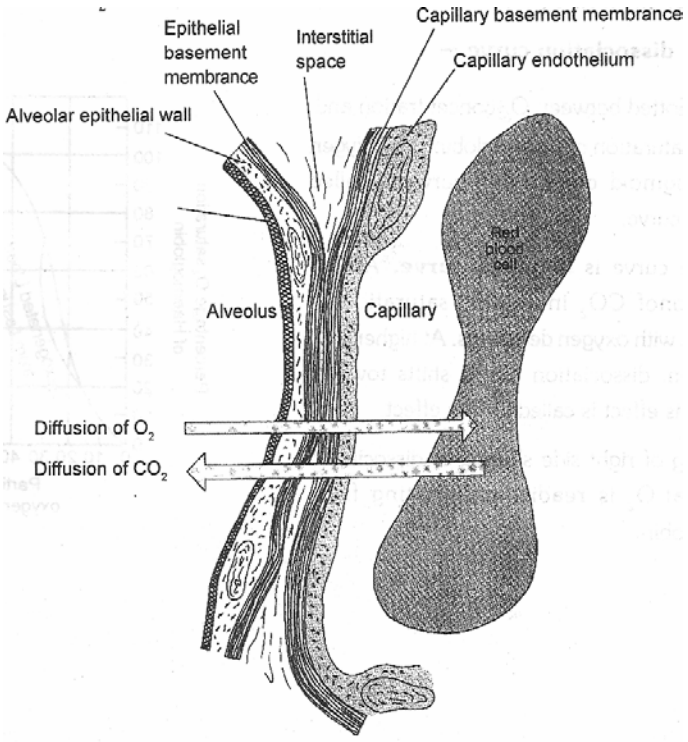
So approximately 4% oxygen goes to blood form air. In the same way inspirited air contains CO_2 0.04% and expirated air has 3.6% CO_2 so approximately 3.56% goes to air from blood.

Diffusing Capacity : Volume of gas that diffuses though the membrane per minute for a difference of 1 mm Hg. It is 21 ml/mt/mm Hg for O_2

Diffusing capacity depends on solubility of diffusing gases.

DC of CO_2 is 20 times more than O_2.

DC of O_2 is twice more than N_2



Respiratory Membrane (0.2 mm thick) : Alveolar epithelium + Epithelial basement membrane + thin interstitial space + capillary basement membrane + capillary endothelial membrane.

TRANSPORT OF GASES IN BLOOD

Transport of oxygen

As much oxygen comes in the blood from air, it is approximately 3 % dissolves in the blood plasma. Remaining 97% oxygen combines with haemoglobin to form oxyhaemoglobin. One molecule of haemoglobin combines with 4 molecules of oxygen Haemoglobin is made up of 4 units. Every unit of it, reacts with one molecule of oxygen. 1 gm of haemoglobin transports 1.34 ml of oxygen. 100 ml of blood contains normally 15 gm of haemoglobin. So 100 mlblood transports approximately 20 ml of oxygen. Oxygen does not oxidize haemoglobin. Formation of oxyhaemoglobin is a process of oxygenation. The valency of iron is 2 in oxyhaemoglobin. Some gases (e.g. Ozone) oxidize haemoglobin. This oxidized haemoglobin is called Methamoglobin. This is a colourless compound. This type of gasses are environmental pollutant. At the time, oxyhaemoglobin reaches upto the tissue it dissociates. O_2 freed from it goes into the tissue fluid from blood. In place of it, CO_2 from tissue fluid comes into blood. Gaseous exchange between blood and tissue is called internal respiration or tissue respiration. It is also done by simple diffusion. In a conducting cycle blood given its 25% O_2 to tissues. Dissociation of oxyhaemoglobin is affected by so many factors -

1. **Low partial pressure of oxygen :-** Combination of oxygen with haemoglobin is a reversible reaction. Low partial pressure of O_2 activates dissociation of Oxyhaemoglobin.

2. **High Concn of :-** High conc^n of CO_2 also activates the dissociation of oxyhaemoglobin. The effect of CO_2 conc^n on dissociation of oxyhaemoglobin is called **Bohr's effect.**

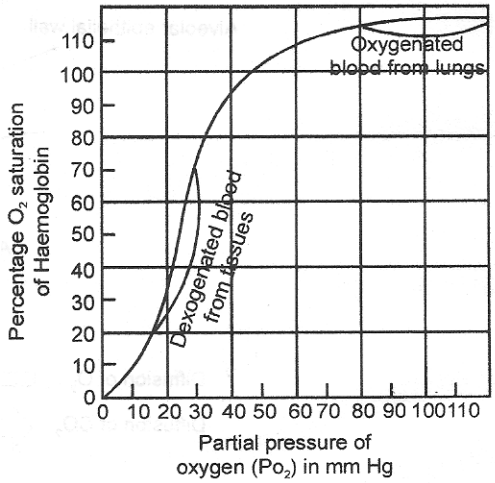
3. **Low pH value of tissue fluid :-** Acidity activates dissociation of oxyhaemoglobin. The effect of pH on dissociation of oxyhaemoglobin is called **Root effect.**

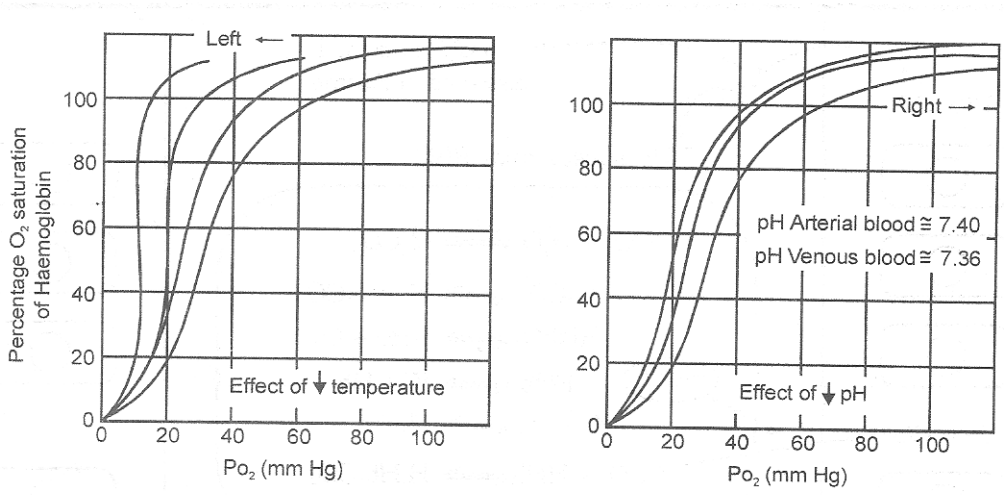
Oxyhaemoglobin dissociation curve :-

A graph is plotted between O_2 concentration and percentage saturation of haemoglobin with oxygen (we get a sigmoid curve), this curve is called Dissociation curve.

Dissociation curve is **sigmoid curve.** As the concentration of CO_2 increases, saturation of haemoglobin with oxygen decreases. At higher CO_2 concentration, dissociation Curve shifts towards rightside. This effect is called Bohr's effect.

The meaning of right side shifting of dissociation curve is that, CO_2 is readily dissociating from oxyhaemoglobin.





Shift to left Means that higher saturation levels of Hb with oxygen (forming oxyhaemoglobin) can be achived at lower PO_2 This is due to increase in affinity between and Hb (which may be due to↑ pH, ↓ temp, ↓ CO_2)

Shift to Right Means that higher PO_2 leveare required to achieve the same saturation level which was previously being achieved at lower PO_2 This is due to decrease in affinity between O_2 & Hb. (which may be due to ↑ pH, ↓ temp, ↓ CO_2)

Hb can not take up O_2 beyond a saturation level of 97%.
Hb is 50% saturated with O_2 at 30mm Hg
P_{50} - PO_2 at which the Hb is 50% saturated with O_2. Higher the P_{50} lower is the affinity of Hb for O_2.
2, 3 diphosphoglycreate (2, 3 DPG)- a substance formed during glycolysis.
↑ 2, 3, DPG will cause shift to right.

Transport of Carbon dioxide

The blood transports carbon dixide comparatively easily because of its higher solubility. There are three ways of transport of carbon dioxide by which 100 ml of blood manages to deliver about 4 to 4.2 ml of carbondioxide to the alveoli.

(a) **In dissolved state:** Approximately 5-7 per cent of carbon dixide is transported, being dissolved in the plasma of blood. Hence 0.3 ml of carbon dioxide is transported per 100 ml of blood plasma.

(b) **In the form of bicarbonate :** Carbon dioxide produced by the tissues, diffuses passively into the blood stream and passes into the red blood corpuscles, where it reacts with water to form carbonic acid (H_2CO_3). This reaction is catalysed by the enzyme, carbonic anhydrase, found in the erythrocytes, and takes less than one second to complete the process. Immediately after its formation, carbonic acid dissociates into Hydrogen (H^+) and bicarbonate ($HC\ O^-_2$) ions.

The oxyhaemoglobin ($Hb\ O_2$) of the erythrocytes is weekly acidic and remains in association with K^+ ions as $KHbO_2$. The hydrogen ions (H^+) released from carbonic acid combine acid combine with haemoglobin after its dissociation from the potassium ions.

The majority of bicarbonate ions ($HC\ O^-_3$) formed within the erythrocytes diffuse out into the plasma along a concentration gradient. H^+ combine with haemoglobin to form the haemoglobinic acid (H.Hb).

on language.

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r