BREATHING AND EXCHANGE OF GASES

RESPIRATORY ORGANS

- Oxygen (O_2) is utilised by the organisms to indirectly break down of nutrient molecules like glucose and to derive energy for performing various activities. Carbon dioxide (CO_2) which is harmful is also released during the above catabolic reactions. It is, therefore, evident that O_2 has to be continuously provided to the cells and CO_2 produced by the cells have to be released out. This process of exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing, commonly known as Respiration.
- Respiration is for energy liberation.

Respiration involves the following steps :-

1. Breathing or puhmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out.
2. Diffusion of gases (O_2 and CO_2) across alveolar membrane.
3. Transport of gases by blood.
4. Diffusion of O_2 and CO_2 between blood and tissues.
5. Utilisation of O_2 by the cells for catabolic reactions and resultant release of CO_2.

Respiratory organs

- **Respiratory organs in different animals**

	Animal	Respiratory organ/System	Examples
1.	**Lower invertebrates**	No well-developed respiratory organ is present. Exchange of gases by simple diffusion.	Sponges, coelenterates, flatworms

		Moist, thin and vascular cuticle.	Earthworm
		Tracheal system (network of tubes)	Insects like cockroach.
		Gills- plate-like or filamentous and vascularised structures. Book lungs	Aquatic arthropods like cray fish, prawn and mollusks like unio. Arachnids.
2.	**Vertebrates**		
	Fishes	Gills	Cartilaginous and bony fishes
	Amphibians	Gills	Tadpole larva of frog.
		Moist skin, Lungs, Buccal cavity	Frogs, toads etc.
	Reptiles Birds Mammals	Lungs Lungs Lungs	Snakes, lizards etc Pigeon, sparrow etc Humans

- **Types of Respiration on the basis of organ involved**

Organ involved	Type of respiration
Skin	Cutaneous
Gills	Branchial
Lungs	Pulmonary
Trachea	Tracheal
Buccopharyngeal cavity (frog and toads)	Buccopharyngeal

Types of Respiration:

There are two types of respiration

A. Aerobic respiration
B. Anaerobic respiration

Difference between aerobic and anaerobic respiration

Aerobic respiration		Anaerobic respiration	
1.	Cells utilise molecular oxygen for oxidising nutrients	**1.**	Nutrients are oxidised without using molecular oxygen. Such a process is called **anaerobic metabolism** or **fermentation**
2.	An exchange of oxygen and carbon dioxide occurs between the organism and the surrounding medium	**2.**	There is no exchange between organism and surrounding medium.
3.	**e.g.** Tissue oxidations are carried out by **aerobic respiration.**	**3.**	**e.g.** Fermentation of glucose to ethanol; lactic acid bacteria ferment glucose and lactose to lactic acid.
4.	All higher organisms such as mammals perform this type of respiration.	**4.**	Lower organisms such as bacteria and yeast.

Aerobic respiration

- Aerobic respiration is carried out in two phases

(a) External respiration

Uptake of oxygen from the surrounding gaseous or liquid medium and elimination of carbon dioxide into that surrounding medium.

(b) Internal respiration

This is involves three activities:

1. Oxygen uptake by tissue cells.
2. Tissue oxidation by oxidising enzymes.
3. Carbon dioxide elimination from tissue cells.

- **Aerobic respiration can also be classified into the following two types:**

(a) Direct respiration

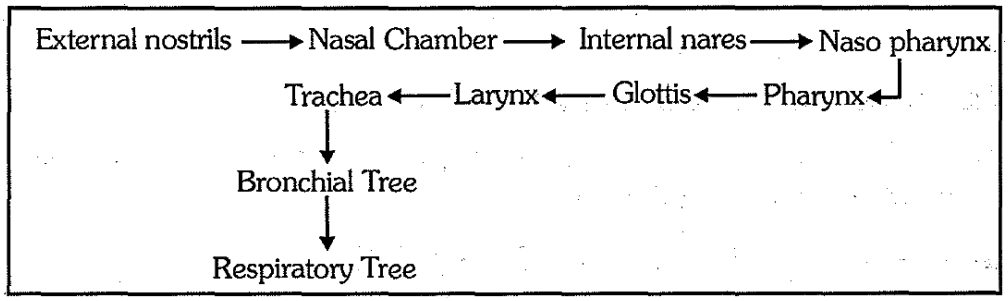
(b) Indirect respiration

Direct respiration	Indirect respiration
• It involves the exchange of environmental oxygen and carbon dioxide of the body cells.	• There is no direct contact between the environmental oxygen and body tissue cells.
• There is no blood (for the transport of gases) and special respiratory organs. It is based on the principle of diffusion.	• It involves special respiratory organs such as gills, skin, buccopharyngeal mucosa, lungs as wells as the blood.
• It occurs in aerobic bacteria, protists, sponges, cnidarians, flatworms, round worms and insects.	• It occurs in larger and complex animals like crustsceans, molluscs, larvae of insects, fishes, amphibians, reptiles, birds and mammals.

HIMAN RESPIRATORY SYSTEM

1. Respiratory tract.
2. Lungs

Respiratory tract – Apassage by which air enters into lungs



Nose and Nasal- passage-

Human have a pair of external nostrils opening out above the upper lip.

External nares open in vestibule region present in anterior part of nasal passage.

Vestibule posteriorly connected with nasal chambers.

Nasal passage is functionaly divided into 3 regions :

i. **Vestibular region :** Skin, hair, sebaceous glands.·
ii. **Respiratory region :** Lined by PSCCGE.
iii. **Olfactory region :** Lined by Neurosensory epithelium (Olfactory ithelium/ Schneidarian membrane)

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. 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 oro pharyngeal chamber, 2 slit like apertures are present. Dorsal-pore is called the gullet which opens into the oesophagus, 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 elastic cartilage called the Epiglottis is present. At the time of swallowing of food, this cartilagenous flap covers the glottis. During swallowing breathing stops.
- Pharynx is the only part where food and air passage mix together. (Pharynx is the common passage for food and air)

Larynx (voice producing organ) :- Larynx is a cartilagenous box which helps in sound production and hence called the sound box.

Larynx is made up of following cartilages :

1. **Thyroid cartilage :** Single, Largest, C-shaped, Dorsally incomplete, hyaline cartilage.
2. **Cricoid cartilage :** Single, Signet ring shaped, below thyroid cartilage, hyaline cartilage.
3. **Arytenoid cartilage :** One pair, pyramid shape cartilage, hyaline cartilage.
4. **Cartilage of Santorini :** One pair, node like cartilage, present at the end of arytenoids cartilage, Elastic cartilage

In larynx two pair of vocal cords are present for sound production :

1. 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 provide moisture to true vocal cords.
2. Posterior pair :- It is true vocal cords. They are composed of sheath of yellow fibrous connective tissue.

TRACHEA :

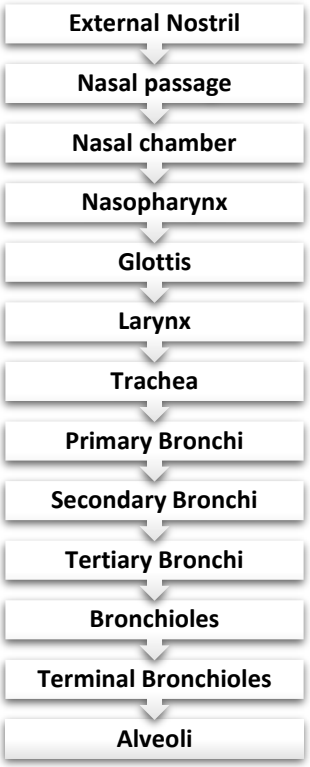
- It is a 10-12 cm long straight tube extending upto the mid thoracic cavity.
- In the trachea 16-20 'C' shaped cartilagenous rings are present which prevent trachea from collapsing. These rings are incomplete on dorsal surface of trachea.

Bronchial and Respiratory tree:

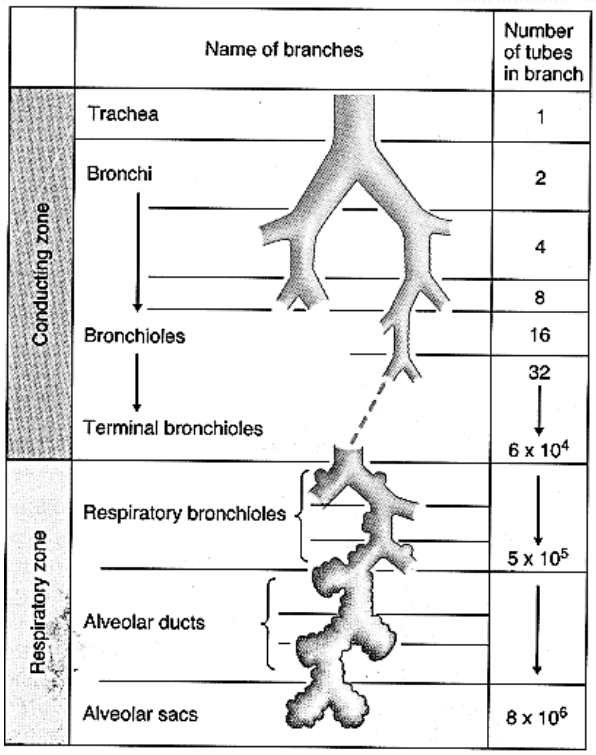
(a) **Bronchial tree:** The trachea runs through the neck in front of the oesophagus, enters the thorax and divides into the right and left **bronchi**. The bronchi branch repeatedly into smaller tubes called **bronchioles.** Each bronchi undergoes repeated divisions to form the

secondary and tertiary bronchi and bronchioles ending up in very thin terminal bronchioles.

(b) **Respiratory tree:** Each terminal bronchiole gives rise to a number of very thin, irregular-walled and vascularised bag-like structures called alveoli.



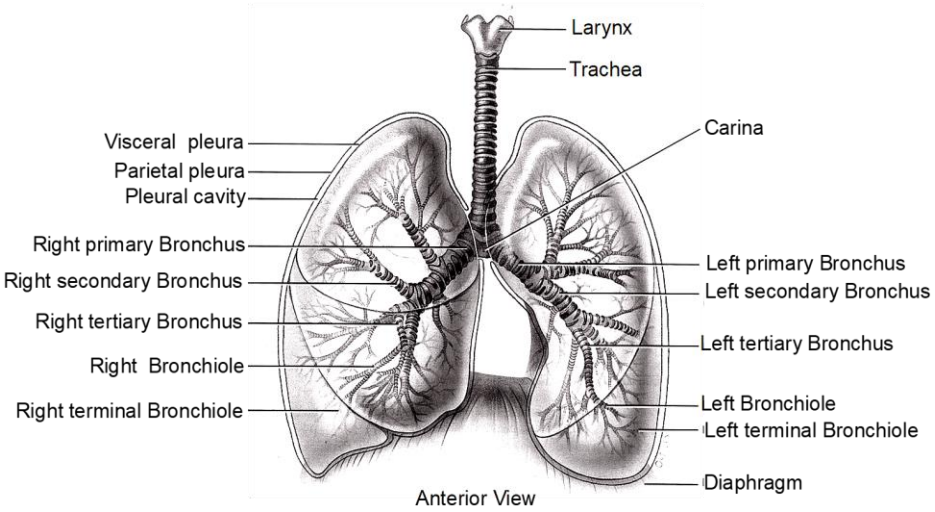
Respiratory Path



Two parts of human respiratory system are:

Conducting Part	Exchange or Respiratory part
• This part consists of external nostrils, nasal chamber, internal nares, nasopharynx, larynx, trachea, bronchi and brochioles (upto terminal bronchioles)	• It include alveoli and their ducts.
• The tracheae, primary, secondary and tertiary bronchi, and initial bronchioles are	• There is no cartilaginous rings.

supported by incomplete 'C' shaped cartilaginous rings.	
• It is lined by Pseudostratified ciliated columnar epithelium.	• It is lined by simple squamous epithelium.
Functions: • Conducts air from external nostrils upto bronchioles. • Clears the incoming air by trapping dust particles present in. • Makes the incoming air humid by providing moisture produced by epithelium of nasal cavities. • It brings the temperature of air upto the body temperature	**Functions:** • It is the main site of human respiratory system where diffusion of gases O_2 and CO_2 occurs

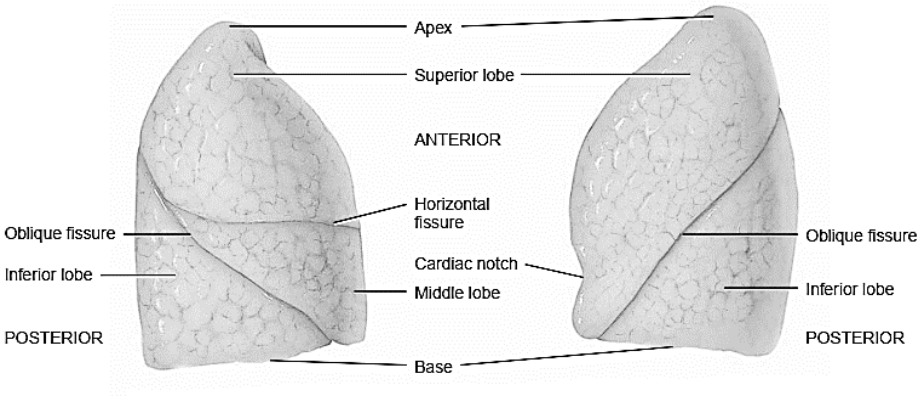


Bronchial tree in relation to the lungs
(The bronchial tree begins at the trachea and ends at the terminal bronchioles)

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. The outer pleural membrane is in close contact with the thoracic lining whereas the inner pleural membrane is

in contact with the lung surface. 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. Pleural fluid reduces friction on the lung surface. Sometimes due to bacterial infection the amount of this fluid increases. So, the organism feels a difficulty in breathing and sever chest pain (dyspnoea). This is termed as pleuricy or pleural effusion disease.

- In human right lung made up of 3 lobes & left lung made up of 2 lobes.



(a) Lateral view of right lung (b) Lateral view of left lung

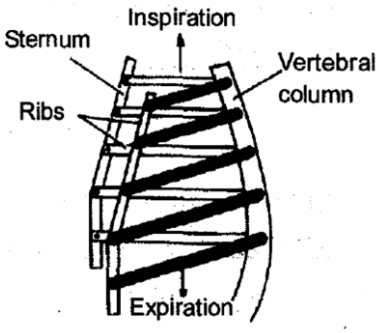
Structural & functional unit of lungs is called alveoli

- Approximately 300 million alveoli are present in both lungs in total.
- Inner (alveolar) surface area of both lungs is approximately 70-100 m^2 in total.
- Wall of alveoli consist of two layers, outer layer is composed of yellow fibrous C.T., inner layer is composed of simple squamous epithelium
- Squamous cells of alveoli are called as Pneumocytes.
- Most of these pneumocytes are type-I which help in gaseous exchange while few pneumocytes are type-II which are larger in size, secrete LECITHIN (Phospholipid) and this acts as surfactant which prevents collapsing of alveoli by reducing its surface tension.
- **Internal surface of alveoli is termed as the Respiratory surface.** It is derived from the endoderm of the embryo.
- Phagocyctic cells in alveoli are called dust cells.

- Mammalian lungs are solid and spongy. There is no central cavity.
- Muscles are absent in the lungs of mammals. So the power of self-contraction and self-expansion is absent in these lungs. (Sucken lungs)

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

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



Position of ribs (Thoracic respiration)

Diaphragm :- A muscular septum which is found only in mammals and crocodile. Normal shape of diaphragm is dome like which divides body cavity in two parts upper thoracic cavity & lower abdominal cavity.

Radial muscles are present in diaphragm. By the contraction in these muscles, diaphragm become flattened in shape, so, volume of thoracic cavity increases in anterior posterier axis.

Intercostal muscles (ICM) :-

Space between two ribs is called intercostal space in which 2 types of muscles are present

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

EICM :- By the contraction in this muscles, rib & sternum shifts upward and outward so thoracic volume increase in dorso-ventral axis. So they help in inspiration.

Steps involves in respiration:

Respiration is a complex process which occurs in number of steps. These are:

1. **Breathing:** It is simply the inhalation of atmospheric air and exhalation of CO_2 rich alveolar air. It is also known as pulmonary ventilation.
2. **Diffusion of gases between alveoli and blood:** Diffusion of gases O_2 and CO_2 takes place across the alveolar membrane to the blood capillaries surrounding it. The membrane is very thin and richly supplied with blood capillaries.
3. **Transport of gases:** Blood is the medium for transport of gases O_2 and CO_2, which transports O_2 to the body cells from alveoli and CO_2 from the body cells to alveoli.
4. **Diffusion of gases between blood and tissues:** O_2 is diffused from blood to tissues and CO_2 is diffused from tissues to blood.
5. **Utilisation of O_2:** O_2 is used by the body cells for the releases of energy. Breakdown of glucose occurs in presence of O_2 which produces CO_2, water and energy. This is also known as **cellular respiration** as it occurs inside the cells. It is a biochemical reaction. The CO_2 produced is eliminated out of the body.

Reaction involved is -

$$\underset{\text{Glucose (present inside the cells)}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} \longrightarrow \underset{\text{Eliminated out of the body}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \underset{\text{Utilised to perform bodily activities}}{\text{Energy}}$$