UNIT 15

RESPIRATORY SYSTEM

- Respiratory system is the system of respiratory passages, lungs and respiratory muscles of the body.
- It is responsible for exchange of gases between the body cells and external environment. In the process, body cells gains oxygen and gets rid of carbon dioxide.

FUNCTIONS OF THE RESPIRATORY SYSTEM

1. It transports air into the lungs and to facilitate the diffusion of oxygen into the blood stream (circulating blood).
2. It involves exchange of gases between the atmosphere and the blood.
3. It regulates homeostatic of pH.
4. It protects body from inhaled pathogens and irritating substances.
5. It excretes carbon dioxide and water vapour.
6. It maintains acid base in the blood.
7. The first part of respiratory system (nose) also works as a smelling organ.

ORGANS OF THE RESPIRATORY SYSTEM

- Nose
- Pharynx
- Larynx

} Upper respiratory tract

- Trachea
- Bronchi
- Bronchioles
- Lungs

} Lower respiratory tract

- Diaphragm
- Intercostal Muscles

} Respiratory muscles

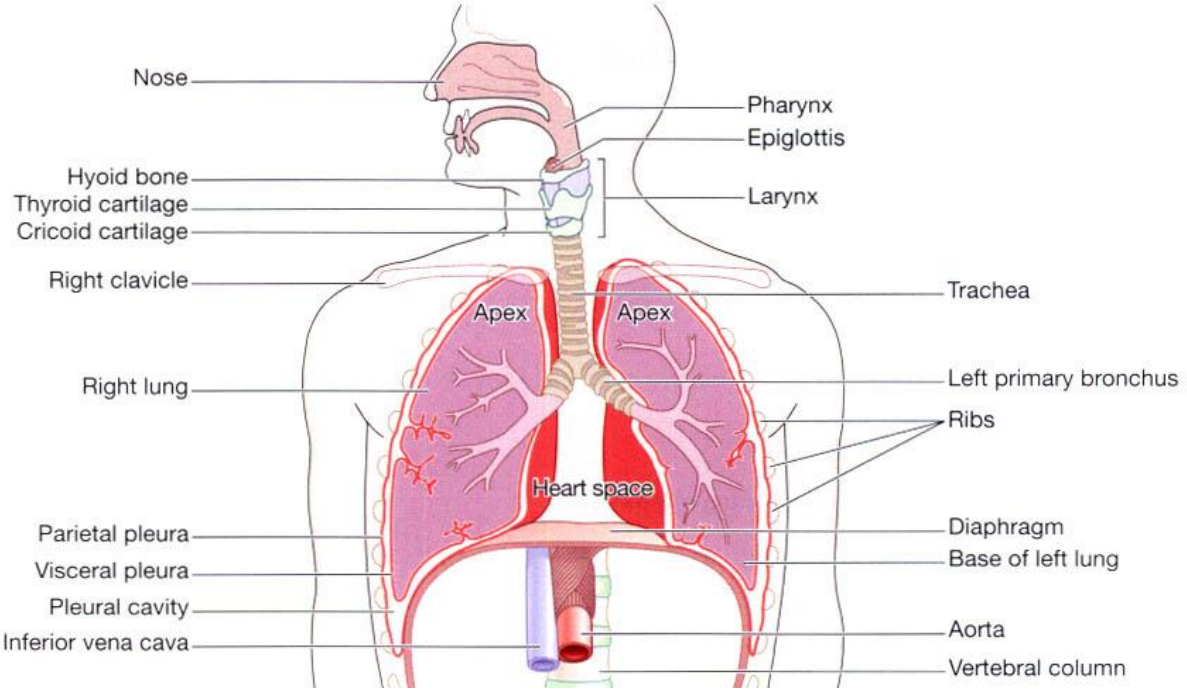


Fig. Organs of respiratory System

NOSE

- Nose is the first part of the respiratory tract, situated just above the mouth.

- It is the main route of air entry, and consists of a large irregular cavity divided into two equal passages by a septum.
- The nasal cavity is lined by mucous membranes.
- The entrance to nasal cavity is form by nostrils. They contain small hairs which act as filters for dust.

Functions of Nose

1. It provides passages of air enter into the body.
2. It is an organ of smelling.
3. It helps in producing resonance of sound.

PHARYNX

- Pharynx is a wide muscular tube like organ.
- It is situated from the base of the skull to the level of 6th cervical vertebra. It lies behind the nose, mouth and larynx.

Structure/ Parts of Pharynx

The cavity of pharynx is divided into three parts:

1. **Nasopharynx:** The upper or nasal part of pharynx is known as nasopharynx. It lies behind the nasal cavity.
2. **Oropharynx:** The middle or oral part of pharynx is known as oropharynx. It lies behind the mouth.
3. **Laryngopharynx:** The lower or laryngeal part of pharynx is known as laryngopharynx. It lies behind the larynx.

Functions of Pharynx

1. It provides passageway for air and food.
2. It helps to warm and moist the inhaled air.
3. It helps in vocalization.

LARYNX

- Larynx is the organ for production of voice.
- It is also known as voice box.
- It is situated in the anterior midline of the neck, extending from the roof of the tongue and hyoid bone to the trachea.
- **Size:** Male: 44 mm Female: 36 mm

It is larger in males, called Adam's apple.

Structure of Larynx

- The larynx is composed of several irregularly shape of cartilages attached to each other by ligaments and membranes.
- The larynx contains nine cartilages which are three unpaired and three paired.

Unpaired cartilage

1. Thyroid cartilage
2. Cricoid cartilage
3. Epiglottis

Paired cartilages

1. Arytenoid cartilages
2. Corniculate cartilages
3. Cuneiform cartilage

Functions of Larynx

1. It provides passageway for air from pharynx to trachea.
2. It produces voice and also varying loudness and pitch.
3. It protects trachea from foreign objects and particles.
4. It plays an important role in controlling airflow for breathing.

TRACHEA

- The trachea is the flexible tube like organ.
- It is also known as wind pipe.
- It is a continuation of the larynx and extends to approximately at the level of the 5th thoracic vertebra.

Structure of Trachea

- The trachea is composed of three layers of tissue and held open by 16-20 incomplete "c"shaped rings of hyaline cartilage lying one above the other.
- The rings are incomplete in posteriorly.
- The cartilage of trachea is covered by three layers of tissue.
  - The outer layer consists of fibrous and elastic tissue.
  - The middle layer consists of cartilages and bands of smooth muscle.
  - The inner layer consists of ciliated columnar epithelium tissue.

Functions of Trachea

1. It provides passage way or pipe to enter the air into the bronchi.
2. It helps in cough reflex mechanism.

BRONCHI AND BRONCHIOLES

The trachea is divided at the level of 5th thoracic vertebrae, and then bronchi are formed.

Types of Bronchi

1. **Right bronchus:** It is wider, shorter and more vertical than the left bronchus. It is approximately 2.5cm long. After entering the right lung at the hilum, it divides into three branches, one to each lobe.
2. **Left bronchus:** It is narrower, longer and more horizontal than the right bronchus. It is approximately 5 cm long. After entering the lung at the hilum it divides into two branches one to each lobe.

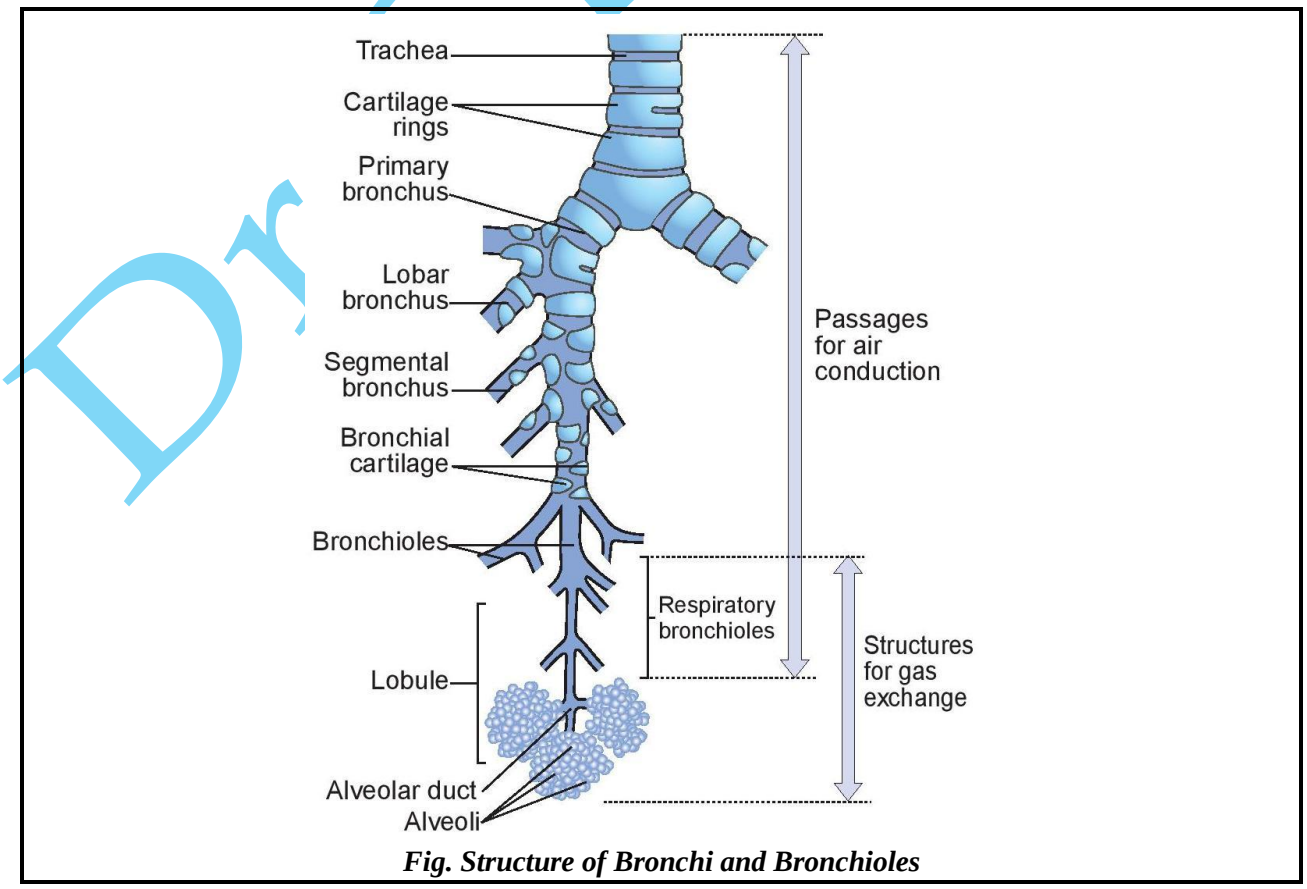


Fig. Structure of Bronchi and Bronchioles

Functions of Bronchi and Bronchioles

1. It prevents infection due to the presence of lymphocyte & leucocytes.
2. It regulates volume of air enters to the lung.
3. It helps in cough reflex mechanism.
4. It helps in external respiration.

LUNGS

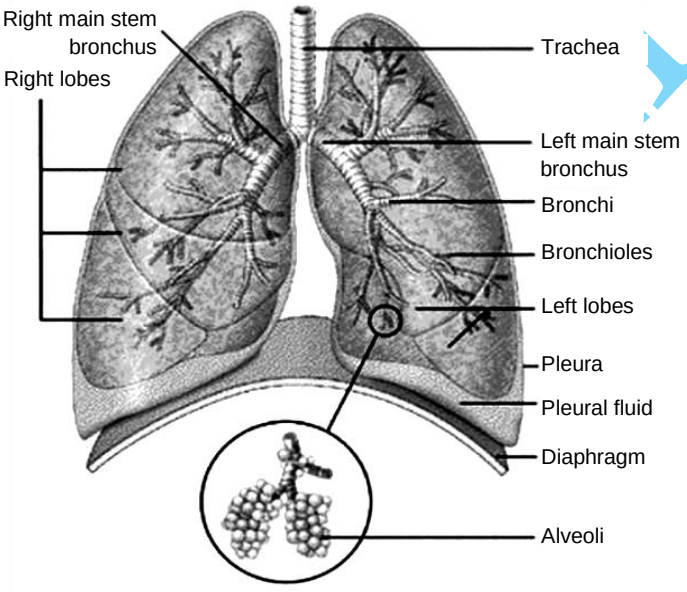
- Lungs are the spongy, cone shaped, paired, air filled respiratory organs.
- It is situated in thoracic cavity.
- There are two lungs such as right lung and left lung.

Weight:

- Right lung: 625gm
- Left lung: 575 gm (50 gm lesser)

Structure of Lungs

The lungs are composed of the bronchi and smaller air passages, alveoli, connective tissue, blood vessels, lymph vessels and nerves, all embedded in an elastic connective tissue matrix. Each lobe is made up of a large number of lobules.



Lobes of Lungs

1. Right lung

a. Upper lobe
b. Middle lobe
c. Lower lobe

2. Left lung

a. Upper lobe
b. Lower lobe

Functions of Lungs

1. It exchanges respiratory gases.
2. It excretes volatile substances like ammonia, ketone bodies, alcohol etc.
3. It excretes water vapour leading to loss of heat from the body.
4. It maintains acid base balance.
5. It converts angiotensin I to angiotensin II by the action of angiotensin-converting enzyme.

ALVEOLI

The end of each alveolar duct there are a number of sac-like structures known as alveoli.

Location of Alveoli

The alveoli are located in the respiratory zone of the lungs, at the distal termination of the alveolar ducts and atria.

Functions of Alveoli

1. It increases the surface area of volume ratio (increasing the rate of diffusion of gases
2. It gives the oxygen and the carbon dioxide a short pathway for diffusion (making it diffuse faster).

PLEURA

- Each lung is covered by a serous membrane known as pleura.
- The pleura are composed of flattened epithelial cells, which lie on a basement membrane.
- There are two layers of membrane.
    a. **Visceral pleura:** It is inner layer of lungs.
    b. **Parietal pleura:** It is outer layer of lungs.

There is a potential space between two layers of pleura known as pleural cavity or pleural space. This space contains a thin film of serous fluid secreted by the visceral layer of the pleura is called pleural fluid. It functions as the lubricant to prevent friction between the two layers.

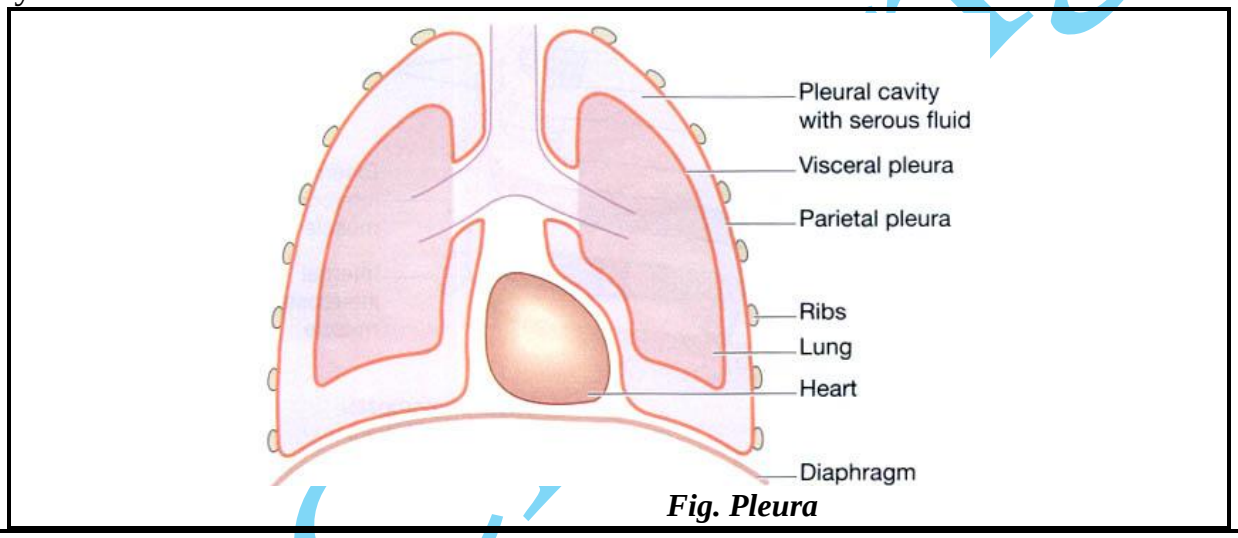


Fig. Pleura

DIAPHRAGM

- The diaphragm is the major muscle of inspiration.
- It is a dome-shaped muscular structure.
- It lies between the thoracic and abdominal cavities.
- The nerve supply for diaphragm is done by phrenic nerves.

Functions of Diaphragm

1. It helps in breathing (during inhalation).
2. It separates thoracic cavity and abdominal cavity.
3. It helps in expel vomit, faeces, and urine from the body by increasing intra-abdominal pressure.

INTERCOSTAL MUSCLES

- The intercostal muscles are several groups of muscles.
- It is situated in the intercostals space (space between two ribs); there are eleven pairs of intercostals muscles.
- The intercostal muscles are of two types.
    1. External intercostal muscles
    2. Internal intercostal muscles

Functions of Intercostal Muscles

- It helps in inspiration and expiration.
- It protects organs of thoracic cavity.

MECHANISM OF RESPIRATION/RESPIRATORY CYCLE

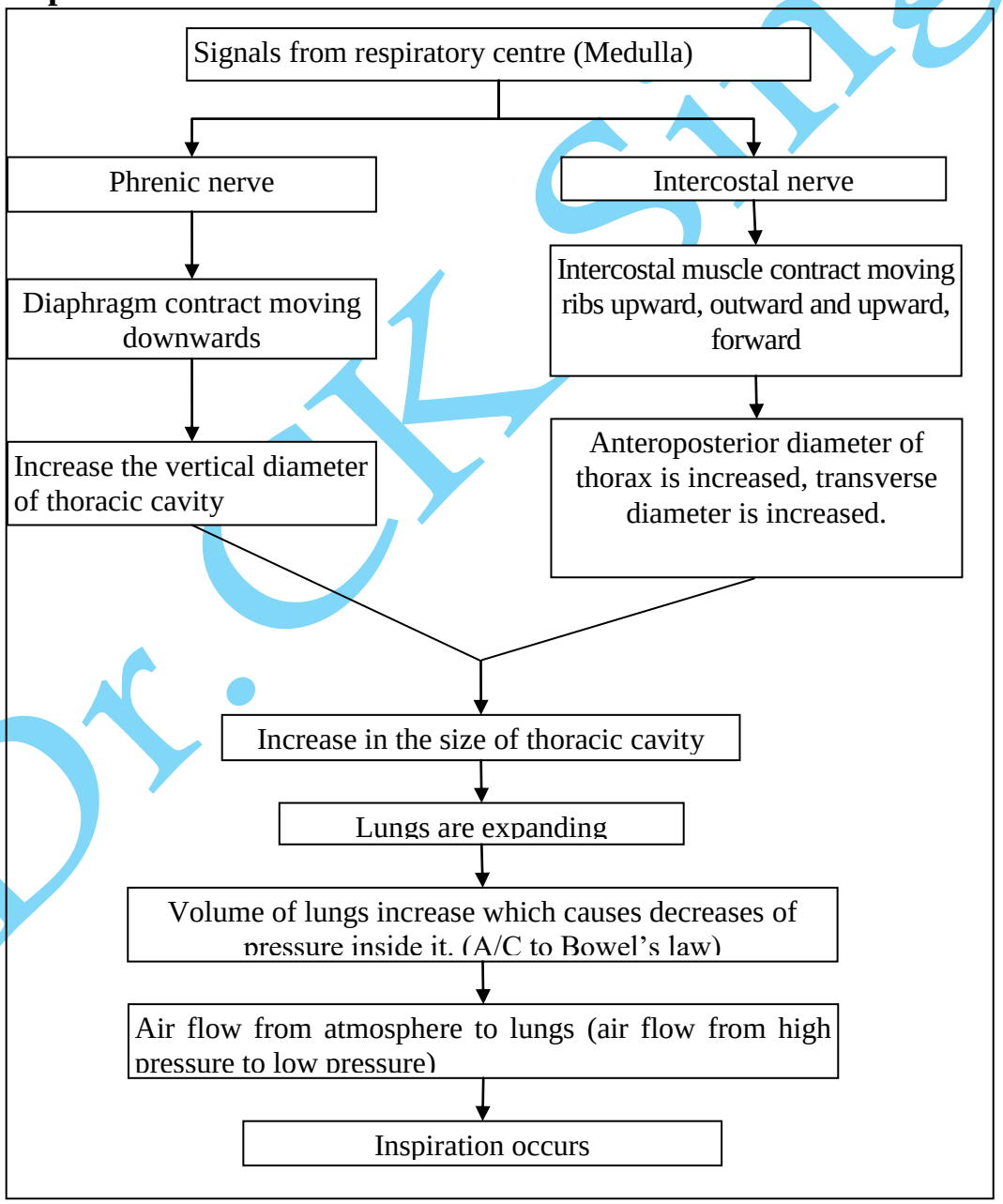
The movements of air inside the lungs and outside the lungs are known as breathing. The normal breathing rate is about 15-20/minute. The process of respiration involves the breathing in the oxygen rich air from outside (inspiration) and breathing out the air loaded with carbondioxide (expiration). The complete breathing consists of:

- Inspiration
- Expiration
- Pause

1. Inspiration:

The movement of air inside the lungs is known as inspiration. It is the active process.

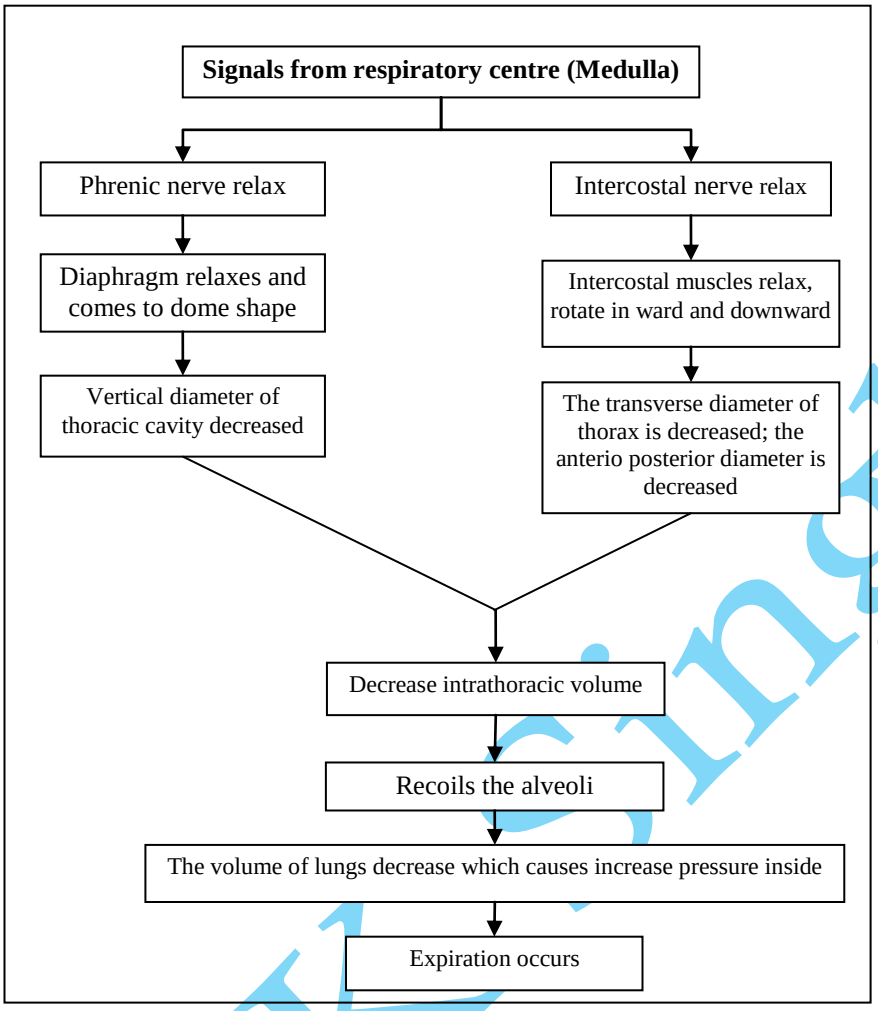
During inspiration



2. Expiration:

The movement of air outside the lungs is known as expiration. It is the passive process.

During expiration



3. **Pause:**
   After each inspiration and expiration there is a small rest known as pause, then inspiration and expiration is continued.

Composition of air

	Inspired air	Expired air
Oxygen	21 %	16%
Carbon dioxide	0.04%	4%
Nitrogen and rare gases	78%	78%
Water vapour	variable	saturated

RESPIRATION (EXCHANGE OF RESPIRATORY GASES)

Respiration is defined as the exchange of gases between body tissues and the external environment. Supply of oxygen to the tissues and excretion of carbon dioxide occurs only through respiration. The normal respiratory rate is about 15 to 20 /minutes.

Types of Respiration

1. **External/Pulmonary respiration*:*** The exchange of respiratory gases i.e. oxygen (O_2) and carbondioxide (Co_2) between the alveoli of lungs and blood is known as external respiration or pulmonary respiration. In this phase, O_2 is absorbed from the air and taken to the blood vessels and Co_2 is excreted from the blood capillaries to alveoli and taken to the air.
2. **Internal/Cellular/Tissue respiration:** The exchange of respiratory gases i.e. oxygen (O_2) and carbondioxide (Co_2) between the blood and tissues is known as internal respiration or cellular respiration. In this phase, O_2 is transferred from the blood capillaries to the body cells and Co_2 is given up from body cells to blood capillaries so that the body cells get oxygen.

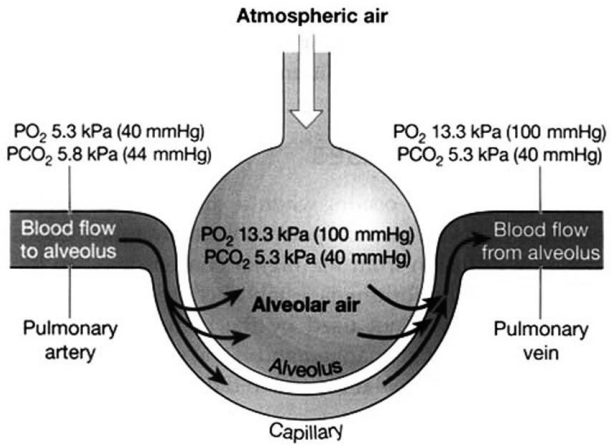


Fig: Pulmonary respiration

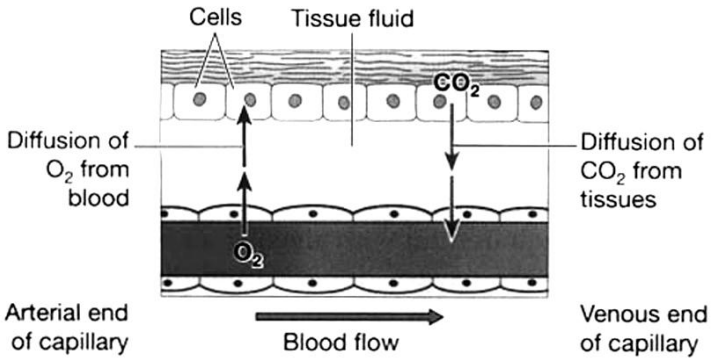


Fig: Cellular respiration

TRANSPORTS OF RESPIRATORY GASES (O_2 & CO_2)

Blood serves to transport the respiratory gases. Oxygen, which is essential for the cells, is transported from alveoli of lungs to the cells and carbon dioxide, which is the waste product in cells, is transported from cells to lungs.

1. **TRANSPORT OF OXYGEN (O_2)**
   The oxygen is transport in the blood in two forms:
   - **a. As simple solution:** 3% of oxygen dissolves in water of plasma and is transported in this physical form.
   - **b. In combination with haemoglobin:** The 97% of oxygen combines with haemoglobin in blood and is transported as a form of oxyhaemoglobin. The transport of oxygen in this form is important because maximum amount of oxygen is transported by this method.
2. **TRANSPORT OF CARBONDIOXIDE (CO_2)**
   The carbondioxide is transport in the blood in four ways:
   - a. **As dissolved form:** 7 % of carbondioxide diffuse into blood and dissolves in the fluid of plasma forming simple solutions.
   - b. **As carbonic acid (negligible):** Part of dissolved carbondioxide in plasma, combines with the water to form carbonic acid. Transport of carbondioxide in this form is negligible.

     $$Co_2 + H_2o \longrightarrow H_2Co_3 \text{(carbonic acid)}$$
   - c. **As bicarbonate:** About 63% of carbondioxide is transported as bicarbonate.

     $$Co_2 + H_2o \longleftrightarrow H_2Co_3 \longleftrightarrow H^+ + Hco_3^-$$
   - d. **As carbamino compounds:** About 30% of carbondioxide is transported as carbamino compounds. The amino acid present in the red blood cells get oxidized to release amino group ($-NH_2$) and carboxyl group (-COOH)

     $$Hb.NH_2 + CO_2 \longleftrightarrow HbNHCOOH$$

REGULATION OF RESPIRATION

Respiration is regulated by two processes:

- Nervous control
- Chemical control

1. **Nervous control:** It is exerted by respiratory centre in the medulla oblongata of brain. From these centre afferent impulses pass to:
   - Diaphragm through phrenic nerve.
   - Intercostal muscle through intercostal nerves.

These impulses cause rhythmic contraction of diaphragm and intercostal muscles. Afferent impulses arise due to the distention of air sacs. They are carried by vagus nerve to the respiratory centre.

2. **Chemical controls**: It is affected through carbon dioxide contents of blood. An increase in the level of carbon dioxide produces stimulation of the respiratory centre. The decrease in carbon dioxide level produces the opposite effect.

LUNGS VOLUME AND CAPACITIES

LUNG VOLUMES

The lung volumes are of four types:

1. **Tidal volume (TV):** Tidal volume (TV) is the volume of air breathed in and out of lungs in a single normal quiet respiration.
   - Normal value: 500ml (0.5liters).
2. **Inspiratory reserve volume (IRV):** Inspiratory reserve volume (IRV) is an additional volume of air that can be inspired forcefully after the end of normal inspiration.
   - Normal value: 3300ml (3.3liters).
3. **Expiratory reserve volume (ERV):** Expiratory reserve volume is the additional volume of air that can be expired out forcefully, after normal expiration.
   - Normal value:-1000ml (1Liter).
4. **Residual volume (RV):** Residual volume (RV) is the volume of air remaining in lungs even after forced expiration. Normally, lungs cannot be emptied completely even by forceful expiration. Some quantity of air always remains in the lungs even after the forced expiration. Normal value: -1200ml (1.2Liter).

LUNG CAPACITIES

The lung capacities are the combination of two or more lung volumes. The lung capacities are of four types:

1. **Inspiratory capacity (IC):** Inspiratory capacity is the maximum volume of air that is inspired after normal expiration (end expiratory position). It includes tidal volume and inspiratory reserve volume.

   IC = TV + IRV (500 + 3,300 = 3,800 ml)

2. **Vital capacity (VC):** Vital capacity (VC) is the maximum volume of air that can be expelled out forcefully after a deep (maximal) inspiration. VC includes inspiratory reserve volume, tidal volume and expiratory reserve volume.

   VC=IRV+TV+ERV (3300+500+1000=4800 ml)

3. **Functional residual capacity (FRC):** Functional residual capacity (FRC) is the volume of air remaining in lungs after normal expiration (after normal tidal expiration). Functional residual capacity includes expiratory reserve volume and residual volume.

   FRC=ERV+RV (1000+1200=2200ml)

4. **Total lungs capacity (TLC):** Total lung capacity (TLC) is the volume of air present in lungs after a deep (maximal) inspiration. It includes all the volumes.

   TLC=IRV+TV+ERV+RV (3300+500+1000+1200=6000 ml)

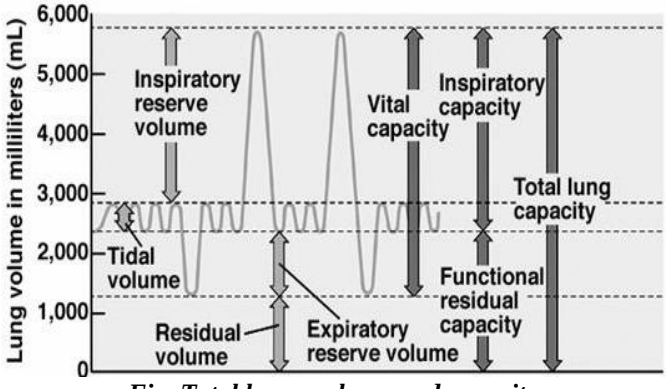


Fig. Total lungs volume and capacity