

RESPIRATORY SYSTEM

PART - I

Points to be covered in this topic

- 1. INTRODUCTION
- 2. PROCESS OF RESPIRATION
- 3. TYPES OF RESPIRATION
- 4. ANATOMY OF RESPIRATORY ORGANS
AND THEIR FUNCTION
- 5. MECHANISM OF RESPIRATION
- 6. REGULATION OF RESPIRATION

□ INTRODUCTION

- 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** occur only through respiration.



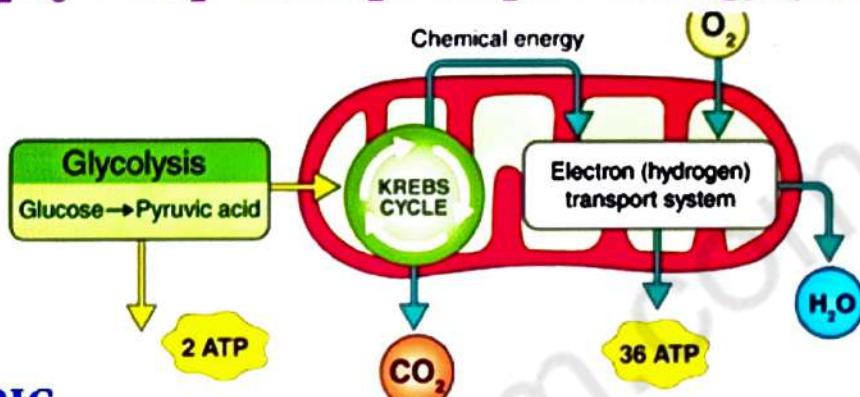
□ PROCESS OF RESPIRATION

- **Pulmonary Ventilation** :- Moving **air** into and out of the **lungs**.
- **External Respiration** :- Exchange of gases between the **lungs**, **blood** and **tissues**.
- **Internal Respiration** :- Diffusion of **gases** between the blood of the **systemic capillaries** and **cells**.

TYPES OF RESPIRATION

1. AEROBIC

- A metabolic process in which **energy is generated** from food molecules, involving a **series of oxidation reactions** during which oxygen is consumed and carbon dioxide is produced.

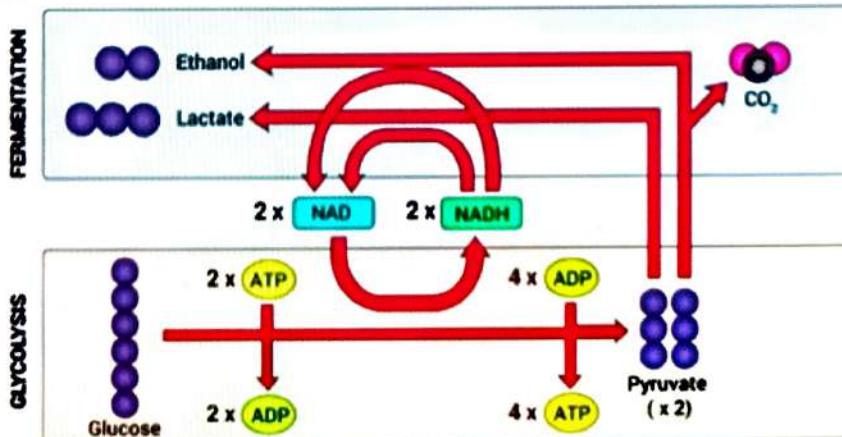


2. ANAEROBIC

- It is the type of respiration through which cells can **break down sugars** to generate energy in **absence of oxygen**.
- Yeast performs anaerobic respiration that is called alcoholic fermentation.



- The muscle cells respire anaerobically to release energy.
- It is called lactic acid fermentation.



❖ Classification of respiratory system

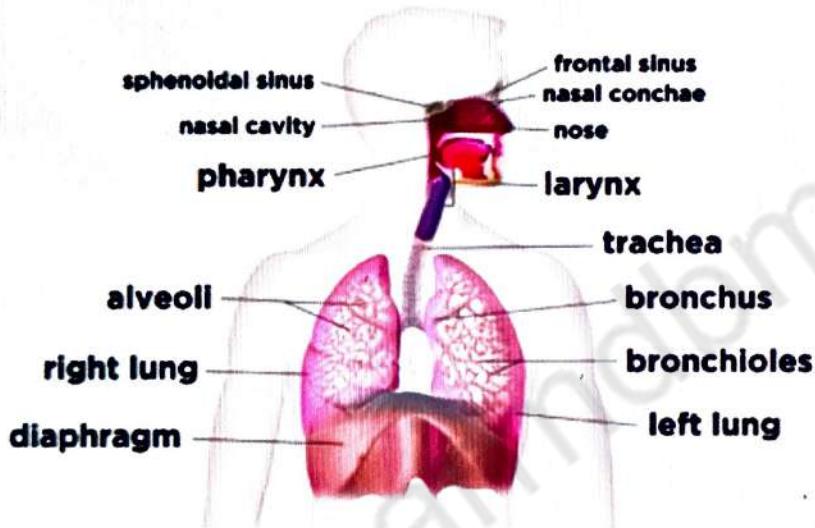
- Anatomically it is divided into

Respiratory System

Upper respiratory system
It consists of **Nose , Pharynx and Associated structure**

Lower respiratory system
It consists of **Trachea , Lungs Larynx, Bronchi**

The Respiratory System



Upper respiratory tract

Nasal cavity

Pharynx

Larynx

Lower respiratory tract

Trachea

Primary bronchi

Lungs

- Functionally it is divided into

Respiratory System

Conducting system

Associated with conduction of gases It consists of **Nose , Pharynx , Trachea, Bronchi, and Terminal Bronchioles**

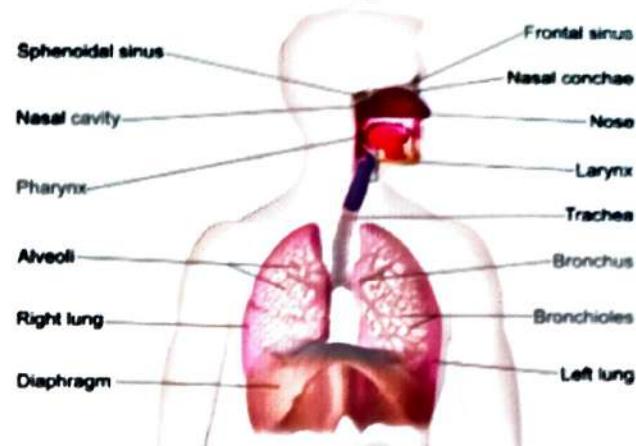
Respiratory system

Associated with Exchanges of gases. It consists of Respiratory **Bronchioles, Alveolar ducts, Alveoli**

ANATOMY OF RESPIRATORY ORGANS AND THEIR FUNCTION

✓ The respiratory system consists of the following structures

1. Nose & Nasal cavity
2. Pharynx
3. Larynx
4. Trachea
5. Bronchi
6. Bronchioles
7. Alveoli

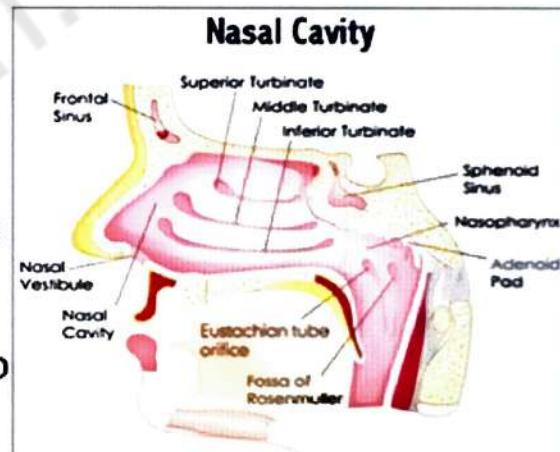


The Respiratory System

1. NASAL CAVITY

It is divided into right and left portions by means of **nasal septum** and lined by **mucous membranes**.

- The **entrance** to nasal cavity is formed by **anterior nostrils**.
- They contain small hairs which act as **filters** for dust
- The **back** of nasal cavities entrance to **nasopharynx** contain



➤ FUNCTIONS

1. Allows **air** to enter your body.
2. Filters and **cleans** air to remove particles and allergens.
3. Provides a **sense of smell**.
4. **Olfaction**, **respiration**, **warming of air**, **humidification of air**, **filtering of air**.
5. Warms and moistens air so it can move comfortably into your respiratory system.
6. It functions to **warm** and **moisturize** air breathed in through the nose and to serve as a chamber in which **speech resonates**.

2. PHARYNX

It is divided into **three parts**

1. **Nasopharynx** :- The upper part of **pharynx** that lies **posterior to Nasal cavity**.
2. **Oropharynx** :- The middle part of **pharynx** that lies **posterior to oral cavity**.
3. **Laryngopharynx** :-The lowest part of **pharynx** that lies just **superior** the larynx.

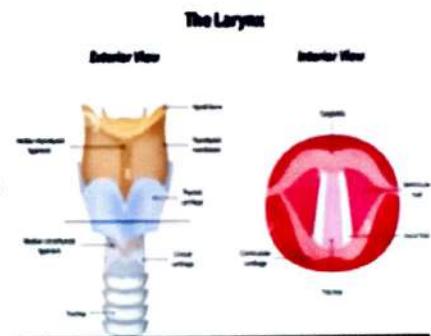
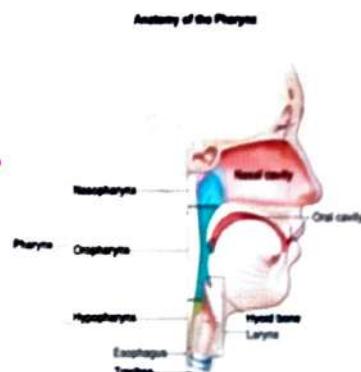
➤ FUNCTIONS OF PHARYNX

1. It helps in the **movement** of food to the esophagus.
2. Pharynx **amplifies** the **sound produced by the larynx**.
3. **Lymphoid tissues** present in the pharynx are the **first line of defence** against foreign pathogen.
4. The **passageway** for air, **food** and **liquid**.
5. Warming and humidifying the air.
6. **Taste, protection, speech.**

3. LARYNX

It lies between **pharynx** and **trachea**. It is formed by the following cartilages

- i) **Thyroid cartilage** which is the largest.
- ii) **Cricoid cartilage** which lies below the thyroid cartilage.
- iii) Two **arytenoid cartilages** at the back of cricoid
- iv) **Epiglottis** attached to the top of thyroid cartilage

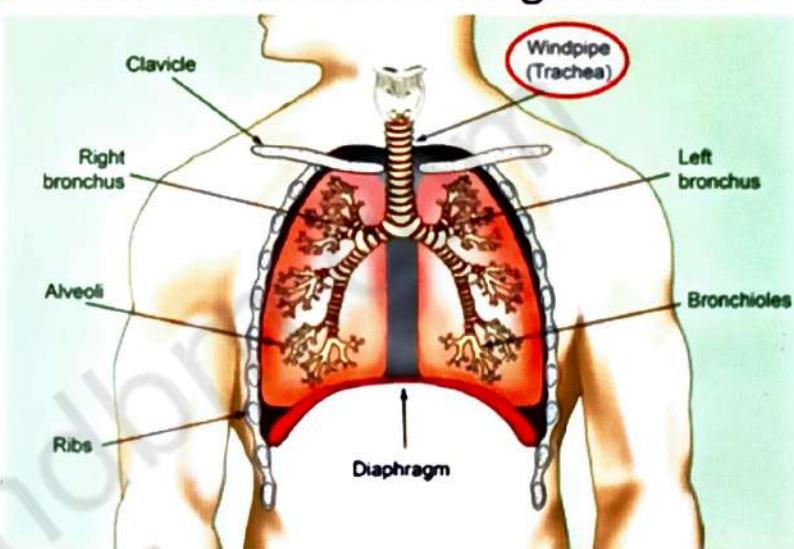


➤ **FUNCTIONS OF LARYNX**

1. Larynx produces **sound**. It facilitates **respiration**
2. Epiglottis **prevents** food from entering the **larynx** and **trachea**
3. Act as a **passageway of air.**
4. Warming and **humidifying** the air, **filtration**

4. TRACHEA (WIND PIPE)

- It is a **cylindrical tube** which is **12 cm** in length and **2.5 cm** in diameter.
- It begins at the **lower end of pharynx**.
- At the level of **5th thoracic vertebra**, it **divides** into **two bronchi**.
- It is made of sixteen to twenty **C-shaped** incomplete cartilages.
- These cartilages are **connected** by **fibrous tissue** at the back.
- It is Trachea is lined by **mucous membrane** made of **ciliated epithelium** tubular passage way of air.



➤ **FUNCTIONS OF TRACHEA**

1. It provides **clear** and **unhindered** way for air to enter and exit the lungs.
2. Small hairs present in the **inner walls** of trachea, **catches** dust and other contaminants from inhaled air, which are later **expelled via coughing**.

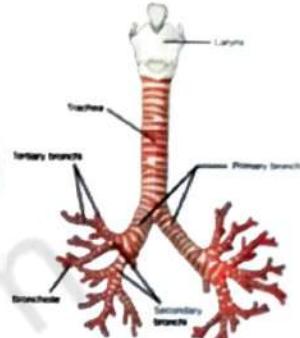
3. Muco cillary escalator:- Inside of the **conducting airways** and is made up of **mucus and cilia**, which moves the mucus up and out of the lungs where it can be expelled by coughing or swallowing.



4. Cough relax , warming and humidifying.

5. BRONCHI

- The trachea ends by dividing into **two bronchi** namely the right and the left bronchi.
- They pass into the corresponding **lungs**.
- The right bronchus is shorter and wider than the left.
- They are made up of **complete rings** of cartilage



➤ FUNCTIONS OF BRONCHI

1. It **connects** the wind pipe to the lungs.
2. It **allows air** from external respiratory openings to pass efficiently into the lungs.
3. The bronchi is to carry air between the **trachea** and **lungs**.

6. BRONCHIOLES

- Bronchi divide into **smaller branches** known as **bronchioles**.
- These bronchioles then divide to form **terminal bronchioles**
- Bronchioles **don't** have cartilage
- They are lined by **cuboidal epithelium**

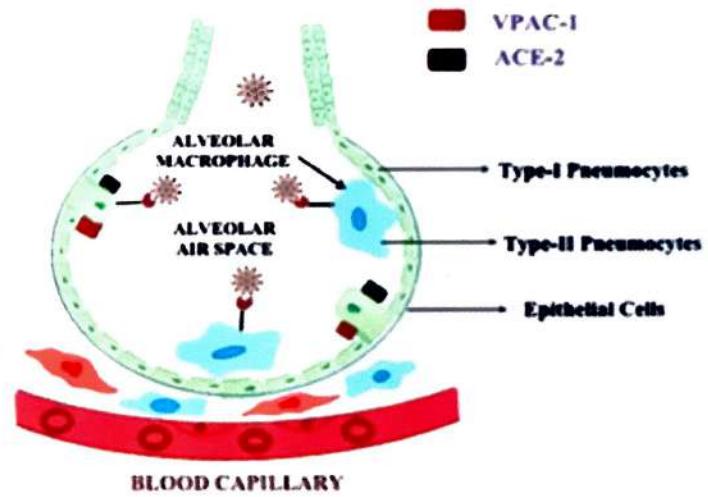
➤ FUNCTIONS OF BRONCHIOLES



- Bronchioles lead to **alveolar sacs**, together they form **alveoli**.

7. ALVEOLI (Air sacs)

- Alveoli are called **functional units** of the lung and consists of small hollow area of **gas exchange**.
 - They are lined with **simple squamous epithelium** that serves for gaseous exchange.
 - The alveolar wall contains two types of cells
 - A. Type 1 **(Pneumocytes)**
 - B. Type 2 **(Pneumocytes and Alveolar macrophages)**
- A. Type 1 **(Pneumocytes)** are cells of the simple squamous epithelium and highly permeable to gases.
- B. Type 2 **(Pneumocytes and Alveolar macrophages)**
- Pneumocytes secrete a **pulmonary surfactant** that helps to reduce the surface tension of the alveoli.
 - Alveolar macrophages are the **phagocytic cells** that removes debris and pathogens that have reached the alveoli.
- **FUNCTIONS OF ALVEOLI**
1. The alveoli are where the **lungs** and the **blood** exchange **oxygen** and **carbon dioxide** during the process of **breathing in and breathing out**.
 2. Oxygen breathed in from the air passes through the **alveoli** and into the **blood** and travels to the **tissues throughout the body**.



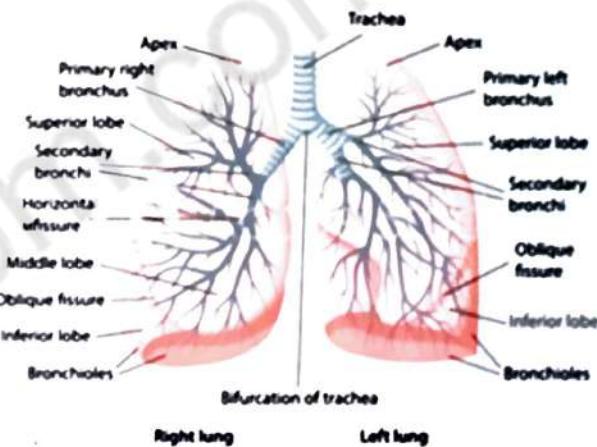
ANATOMY OF LUNGS

INTRODUCTION

- Lungs are the principle organ of **respiration**.
- The lungs are a **pair of spongy, air-filled cone shaped** organs located on either of the **chest (thorax)**.
- The lungs extend laterally from the heart to the ribs on both sides of the chest continue **posteriorly toward the spine**.
- The left lung is slightly **smaller than the right lung**.
- The right lung **is thicker and broader than left lung**

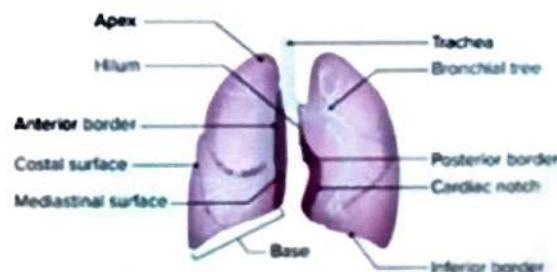


Lung anatomy



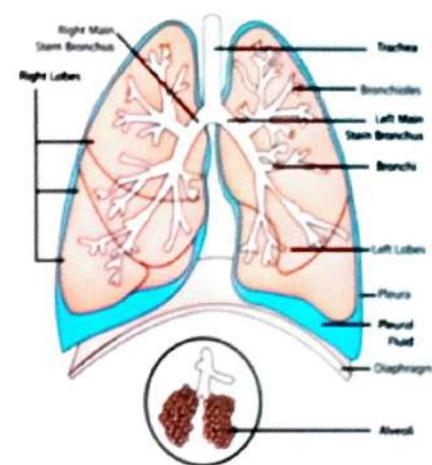
The Lungs are divided into

- a. **Apex:** The narrow **superior portion of lung** .
- b. **Base:** The **broad inferior portion of lung**.
- c. **Coastal surface:** The surface of lung **lying against the ribs**.
- d. **Medial surface:** It forms the lateral boundary of the mediastinum. The medial surface of each lung contains a **bronchi, pulmonary, blood vessels, lymphatic vessels and nerves** enter and exit.



- The Lung is surrounded by two layers of delicate serous membrane called as **Pleural Membrane**.
- The inner membrane which covers the lungs is called as **Visceral Pleura**
- The outer layer which is attached to the wall of thoracic cavity is called as **Parietal Pleura**.

Diagram of the Human Lungs



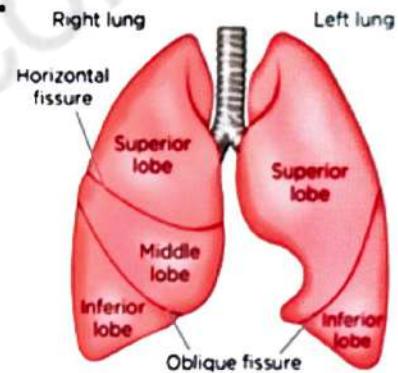
➤ Lobes of Lungs

The right lung is subdivided into 3 lobes:

- ✓ Superior lobe
- ✓ Middle lobe
- ✓ Inferior lobe

The left lung is subdivided into 2 lobes:

- ✓ Superior lobe
- ✓ Inferior lobe



➤ Fissures of Lungs

✓ Right lung: It has two fissures:

- **Oblique fissure:** It separates the **upper lobes** from the **lower lobes**
- **Horizontal fissure:** It separates the **right upper lobe** from the **lower lobes**.

✓ Left lung: It has one fissure:

- **Oblique fissure:** It separates **superior lobe** and **inferior lobe**.

MECHANISM OF RESPIRATION

1. Breathing (Pulmonary ventilation)
2. External Respiration
3. Internal Respiration
4. Transport of Oxygen and Carbon Dioxide

1. Breathing (Pulmonary ventilation)

- It has two phases - **inspiration** (or inhalation) and **expiration** (or exhalation). It is a mechanical process that depends on volume changes in the chest cavity. Rate of respiration **16 to 18 per min** in adult.
- These **actions increase the volume of the thoracic (chest) cavity**, and the air (oxygen) is forced into the **lungs**.
- Exhalation occurs when the **thoracic cavity is reduced**, and the air (carbon dioxide) is **expelled out**.

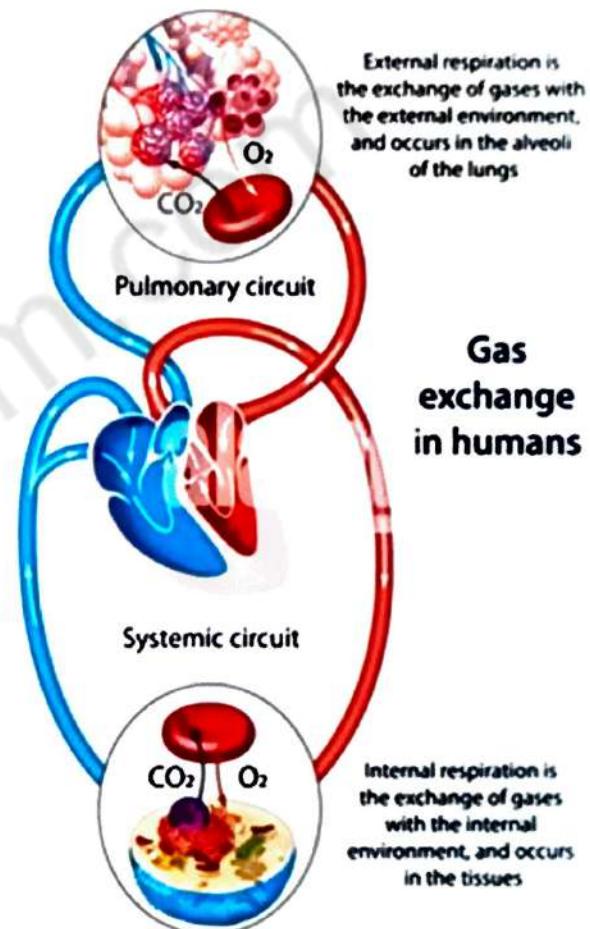
INSPIRATION AND EXPIRATION MECHANISM

- Muscles involved in quiet respiration
 - **Inspiration:** Diaphragm is the main muscle(75%) and external intercostal muscle (25%).
 - **Expiration:** No expiratory muscle (passive)
- ✓ **Muscles involved in forceful respiration**
- **Inspiration :** Scalene, sternocleido-mastoid
 - **Expiration :** Internal intercostal muscles, anterior abdominal muscle.



2. External Respiration (pulmonary gas exchange)

- Exchanges Gases (O_2 and CO_2) Between the **air spaces Lungs** and the **Bloodstream in pulmonary capillaries**.
- Inside the lungs, **oxygen is exchanged for carbon dioxide waste** through the process called **external respiration**.
- pulmonary capillary blood **gains O_2** and loses CO_2 .
- **Right ventricle:** It pumps **deoxygenated blood** to lungs for purification.
- **Left ventricle:** It pumps **oxygenated blood** to all other parts of the body.
- O_2 diffuses from alveolar air, partial pressure is 105 mm Hg, into the blood in pulmonary capillaries, where Pco_2 is only 40 mm Hg in resting person.
- Pco_2 of **deoxygenated blood** is **45 mm Hg** in a resting person, whereas Pco_2 of **alveolar air** is **40 mm Hg**.



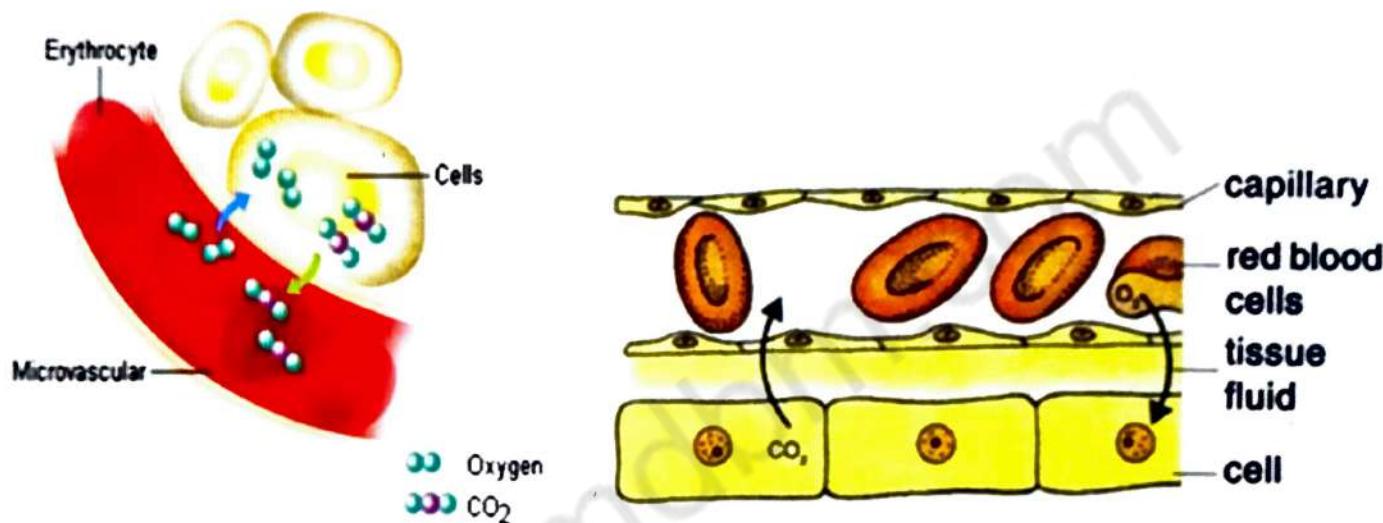
➤ Rate of external respiration depends on factors

- a. Partial pressure difference
- b. Surface area for gas exchange
- c. Diffusion distance
- d. Breathing rate and depth

3. Internal Respiration

- It is the exchange of gases between **the blood in systemic capillary and systemic**.
- systemic capillary gains CO_2 and loses O_2 .
- Internal respiration **conversion of oxygenated blood to deoxygenated blood.**

Internal Respiration = Systemic Capillaries \longleftrightarrow Body Tissue



- Oxygenated blood entering the tissue capillaries has a **Po₂ of 100 mm Hg**, whereas tissue cells have an average of **Po₂ of 40 mm Hg**.
- PCo₂ of **tissue cells** is **45 mm Hg** whereas, tissue capillary oxygenated blood is **40 mm Hg**.

4. Transport of Oxygen and Carbon dioxide

- When **O_2 and CO_2 enter the blood**, certain chemical reactions occur that **transport and gas exchange**.
- Transport of gases between **the lungs and body tissues** is a **function of blood**.

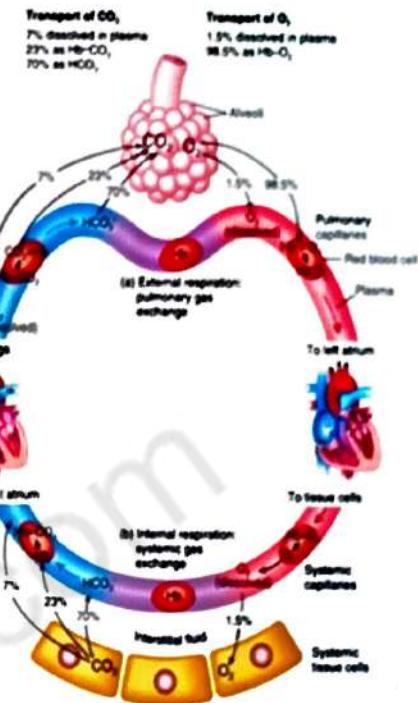
- Inhaled oxygen moves from the alveoli to the blood in the capillaries, and **carbon dioxide moves from the blood in the capillaries to the air in the alveoli.**

➤ The protein inside

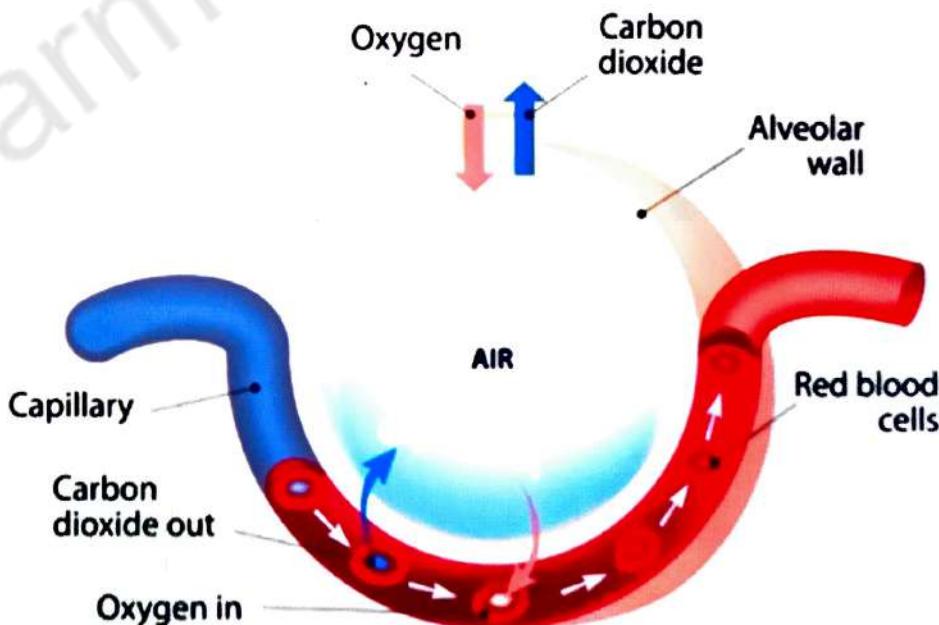
- (a) **Red blood cells** that carries oxygen to cells and carbon dioxide to the lungs.

(b) **Hemoglobin**

- (c) **Oxygen** is carried from the lungs to various body parts



- O₂** does not dissolve easily in water, only about 1.5% is dissolved in blood plasma.
- About 98.5% of O₂ transported to Hb, combines with it inside the red blood cell.
- Each 100 ml of oxygenated blood contains about 20 ml of oxygen, 0.3 ml dissolved in plasma and 19.7 ml bound to hemoglobin.



RESPIRATORY SYSTEM

PART - II

Points to be covered in this topic

→ 1. LUNG VOLUMES AND CAPACITIES

→ 2. ARTIFICIAL RESPIRATION

→ 3. RESUSCITATION METHODS

LUNG VOLUMES AND CAPACITIES

LUNG VOLUMES

- Lung volumes are also known as **respiratory volumes**.
- It refers to the **volume of gas in the lungs** at a **given time during the respiratory cycle**.
- Lung capacities are **derived from a summation of different lung volumes**.
- The **average total lung capacity** of an adult human male is about **6 litres of air**.

Two types

1. **Static Lung Volumes and Capacities:** **Time factor is not involved.** Expressed in mL or, L.
2. **Dynamic Lung Volumes and Capacities:** **Time dependent** Expressed in mL/min or, L/min.

➤ Types of Lung Volumes

1. Tidal Volume (TV)

2. Expiratory Reserve Volume (ERV)

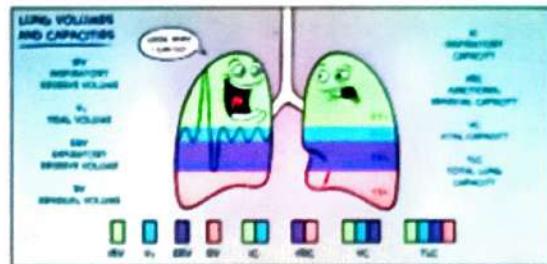
3. Inspiratory Reserve Volume (IRV)

4. Residual Volume (RV)

5. Closing volume

1. Tidal Volume: TV

- The amount of gas **inspired or expired** with each normal breath.
- **About 500 mL**



2. Expiratory Reserve Volume: ERV

- The **maximum volume of additional air** that can be expired from the end of a normal expiration. **ERV ~ 1,200 mL**

3. Inspiratory Reserve Volume: IRV

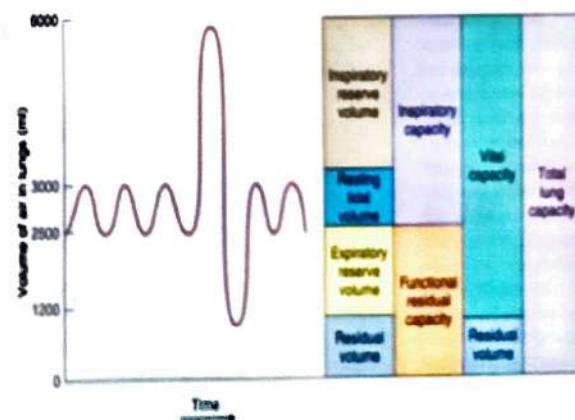
- Maximum amount of additional air that can be inspired from the end of a normal inspiration. **IRV ~ 3,000 mL**

4. Residual Volume: RV

- The volume of air remaining in the lung after a maximal expiration. This is **the only lung volume which cannot be measured with a spirometer**.

5. Closing volume

- The volume **towards the end of a forced expiration**, after which some airways have effectively closed and more of the expired gas comes more from the **relatively poorly ventilated regions of the lung**.



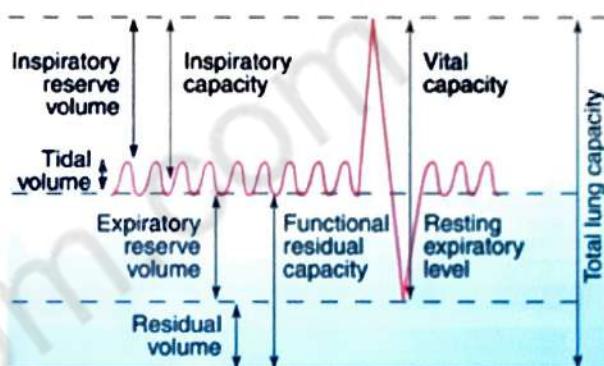
➤ Lung Capacities

1. Total Lung Capacity

- It represents the total volume of air that a person can **hold in its lungs after a forced inhalation.**
- It is the **sum of all volumes.**
- It is about **6000 ml in males and 4500 ml in females.**

2. Vital Capacity

- It is the amount of air that a person can **move in and out** of the lungs.
- It is the **sum of tidal volume, inspiratory reserve volume and expiratory reserve volume.**
- It is **4800 ml in males and 3400 ml in females.**



3. Inspiratory Capacity

- It is the amount of air that can be **inhaled after a tidal expiration.**
- It is a sum of **tidal volume and inspiratory reserve volume.**

4. Expiratory Capacity

- Normal inspiration, the **amount of air is exhaled by a person is called expiratory capacity (EC).**

5. Functional Residual Capacity

- It is the amount of air that **remains in lungs after a normal tidal expiration.**
- It is the **sum of expiratory reserve volume and residual volume.**

➤ Lung Volumes (ml)

MEASUREMENT	VALUE	DEFINITION
Tidal volume (TV)	500-750 milliliter s	It is the volume of air that enters the lungs normally during the quiet breathing .
Expiratory Reserve Volume (ERV)	1200 milliliter s	It is the volume of air which we can forcefully exhale after the normal tidal expiration.
Inspiratory Reserve Volume (IRV)	2000 milliliter s	It is the volume of air which we can forcefully inhale after the normal tidal inspiration.
Residual Volume (RV)	1300 milliliter s	It is the air that is left in lungs after a maximal exhalation. The residual volume prevents the collapsing of the alveoli and thus makes breathing easier.
Closing volume (cv)	Close to RV	It is the lung volume above the residual volume at which airway in the lower, dependent parts of the lungs begin to close off.

➤ Lung capacity (ml)

MEASUREMENT	VALUE	DEFINITION
Total lung capacity (TIC)	5000	= $(IRV + TV + ERV + RV)$
Vital capacity (VC)	3500	= $(IRV + TV + ERV)$
Inspiratory capacity (IC)	500	= $(TV + IRV)$
Expiratory capacity (EC)	1500	= $(TV + ERV)$
Functional residual capacity (FRC)	2500	= $(ERV + RV)$

ARTIFICIAL RESPIRATION

- Artificial respiration, breathing induced by some manipulative technique **when natural respiration has decreased or is faltering.**
- Artificial respiration must be given immediately when respiration fails.
- Most methods employed are designed **to increase and decrease the capacity of thorax.**
- It can prevent some deaths from drowning, **choking, strangulation, suffocation, carbon monoxide poisoning,** and **electric shock.**
- Two main methods of artificial respiration

1. Manual Methods

- (a) Schafer's Method
- (b) Sylvester's Method:
- (c) Holger-Nielson Method
- (d) Mouth-to-Mouth Method
- (e) EVE's Rocking Method

2. Instrumental Method

- (a) Drinker method
- (b) Tracheal intubation
- (c) Cricothyrotomy
- (d) Tracheotomy



1. Mannual Methods

The following are a few methods of artificial respiration:

(a) Schafer's method : compression of thoracic cavity by pressure against ribs. a method of artificial respiration in which the patient is placed **face downward**, pressure then being rhythmically applied with the **hands to the lower part of the thorax**. Also called **Schafer method**.

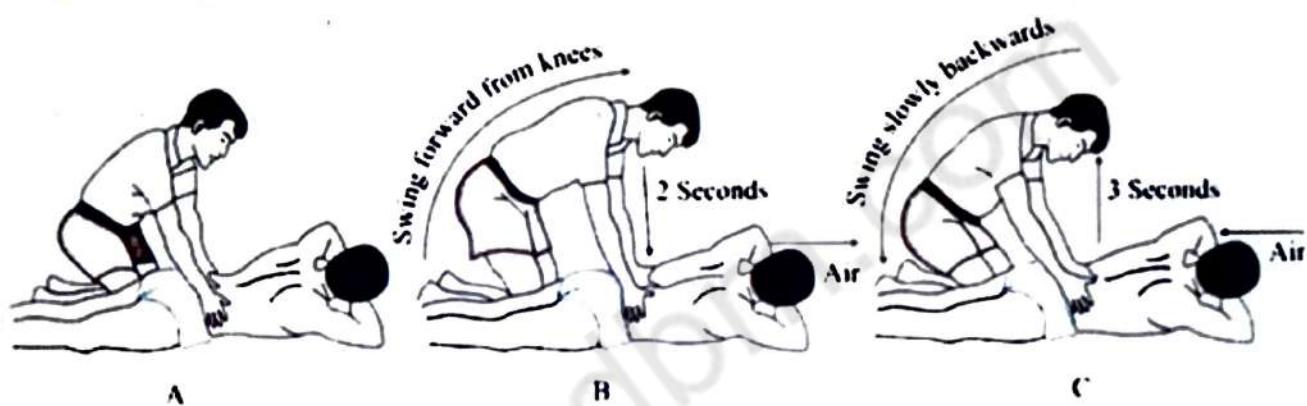
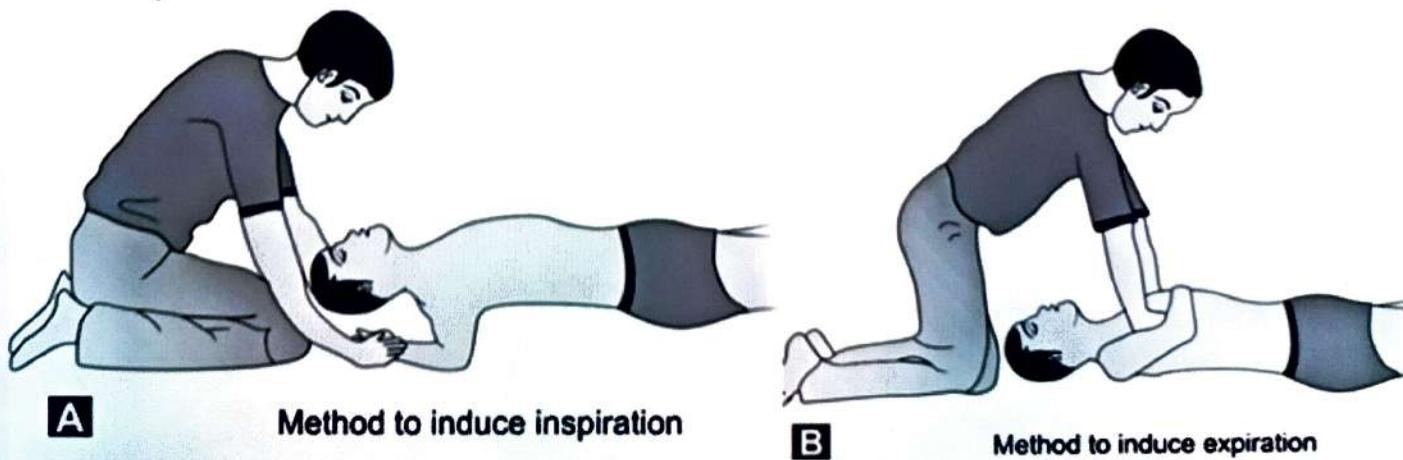


Fig. 8.43 Schafer's manual method for artificial respiration.

(b) Sylvester's Method: A method of artificial respiration in which the subject is **laid on his or her back** and air is expelled from the lungs by **pressing the arms over the chest** and **fresh air** drawn in by **pulling them above the head**.



(c) Holger Nielson method: artificial respiration where the person was laid on their front, with their head to the side, and a process of lifting their arms and pressing on their back .



(d) Mouth to mouth method: The person using mouth-to-mouth breathing places the victim on his back, clears the mouth of foreign material and mucus, lifts the lower jaw forward and upward to open the air passage, place.



(e) EVE Rocking method: This method is useful in children. The method consists of laying the patient on a stretcher, which is pivoted about its middle on a trestle and rocking up and down rhythmically so that the weight of the viscera pushes the flaccid diaphragm alternately up and down.



2. Instrumental Method

(a) **Drinker method**-Air is withdrawn mechanically to produce vacuum - creates **pressure-expands chest** and lead to **decrease intrapulmonary pressure**, and air flows into lungs. Then elastic coil of chest and lungs leads passive exhalation.

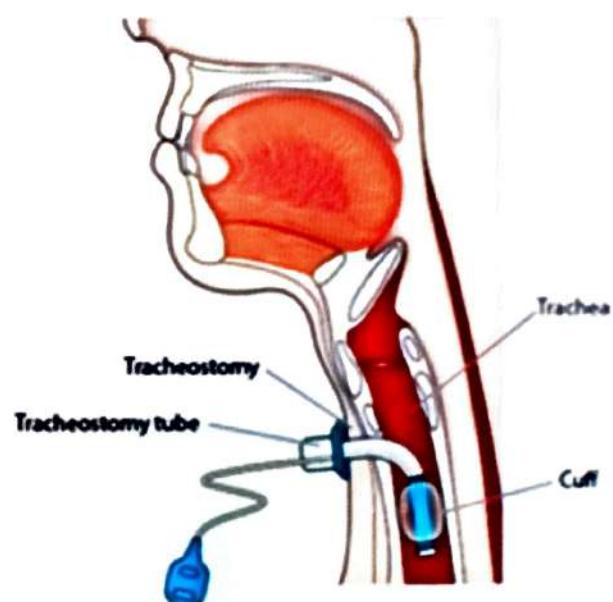
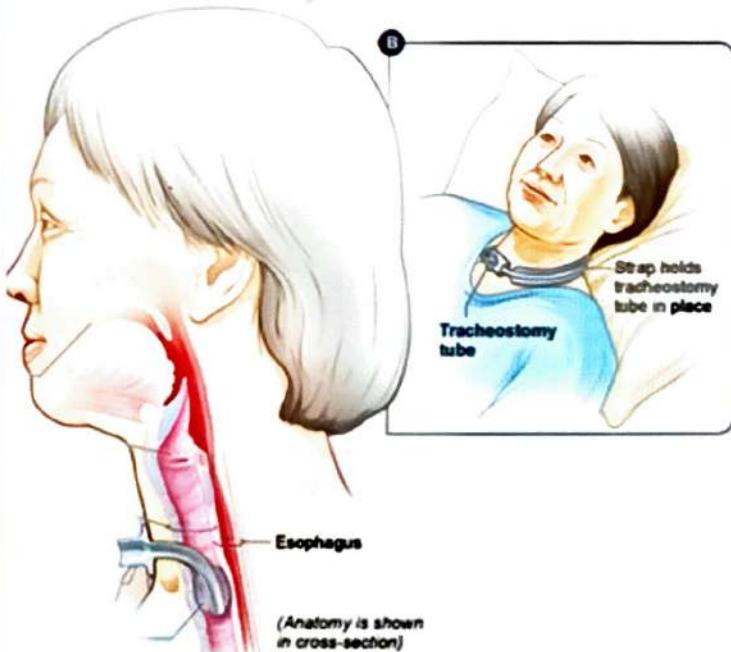
(b) **Tracheal intubation**- tube inserted to mouth/nose and advanced into trachea.



(c) **Cricothyrotomy** - airway inserted through surgical opening in cricothyroid membrane.



(d) **Tracheotomy** -is surgical procedure on neck to open direct air way through incision in trachea.



RESUSCITATION METHODS

- Resuscitation by inducing artificial respiration consists chiefly of two actions:

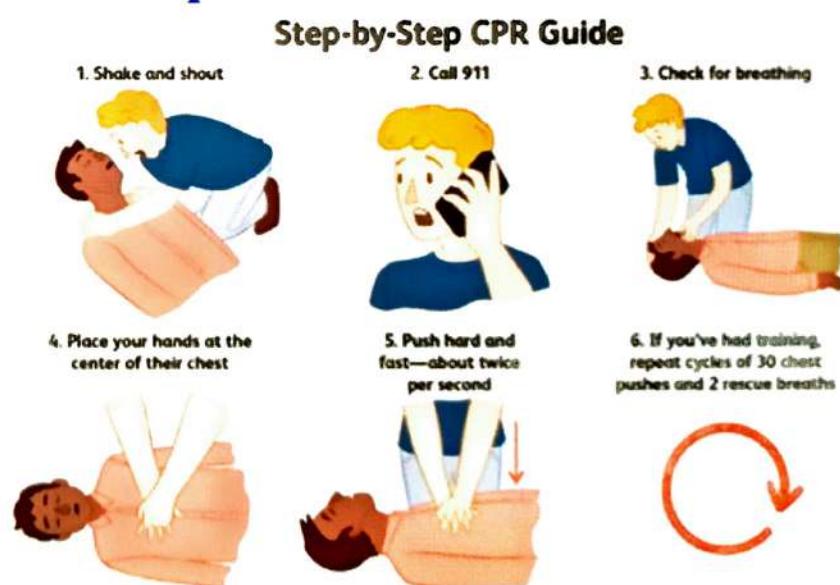
(1) Establishing and maintaining **an open air passage from the upper respiratory tract (mouth, throat, and pharynx) to the lungs.**

(2) **Exchanging air and carbon dioxide** in the terminal air sacs of the lungs while the heart.



❖ CPR Techniques

- High-Frequency Chest Compressions.
- High-frequency chest compression (typically at a frequency **>120 per minute**) has been studied as a technique for improving resuscitation from cardiac arrest.
- **Open-Chest CPR.**
- **Interposed Abdominal Compression-CPR.**
- **“Cough” CPR**
- **Prone CPR**
- **Precordial Thump**
- **Percussion Pacing.**



➤ Steps in Resuscitation

Warmth and stimulation and assessment for the 1' 30 seconds

Use warm cloth Replace when wet Rapidly assess

- Tone
- Colour
- Respiratory effort

□ MAIN STAGES OF RESUSCITATION

- (Airway) - Ensure open airway by prevention the falling back of tongue, tracheal intubation if possible.
- (Breathing) - Start artificial ventilation of lung
- (Circulation) - Restore the circulation by external cardiac massage.
- (Differentiation, drug, defibrillation) - Quickly perform differential diagnosis of cardiac arrest; use different medication and electric defibrillation in case of ventricular fibrillation.

❖ Equipment Needed for Resuscitation

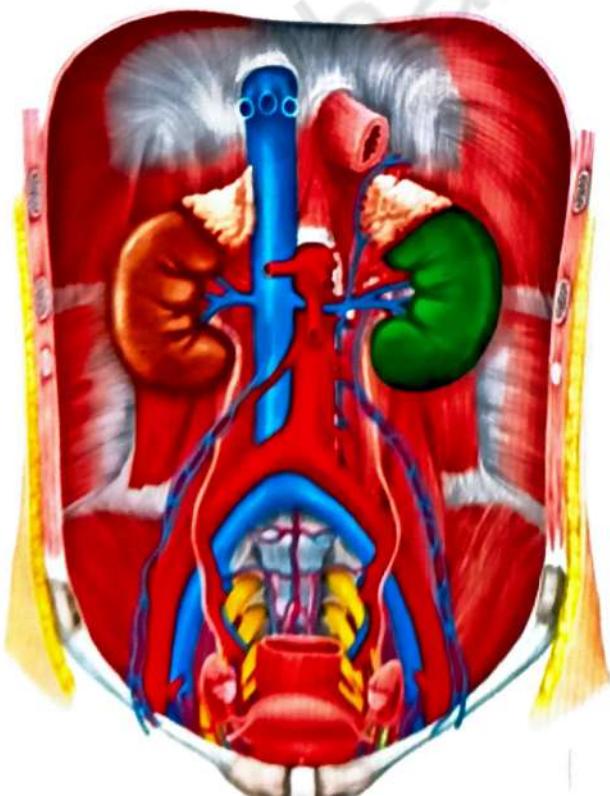
- Radiant warmer
- Warm towel and blankets
- Resuscitation bag and mask
- Self inflating bag Anesthetic bag
- Endo tracheal tube
- Laryngoscope
- Stethoscope
- Oxygen source and tubing
- Suction source and tubing
- Drugs and fluids
- Syringes, needles , cannula, IV lines
- Umbilical lines



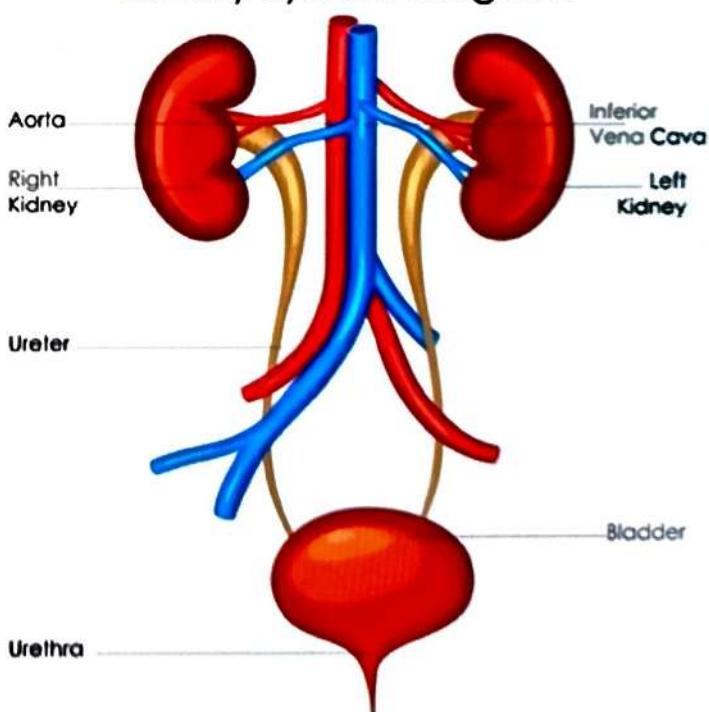
URINARY SYSTEM

Points to be covered in this topic

- 1. INTRODUCTION
- 2. PARTS OF URINARY SYSTEM
- 3. FUNCTIONS OF KIDNEY AND URINARY TRACT
- 4. PHYSIOLOGY OF URINE FORMATION
- 5. ROLE OF KIDNEY IN ACID BASE BALANCE
- 6. DISORDERS OF KIDNEY

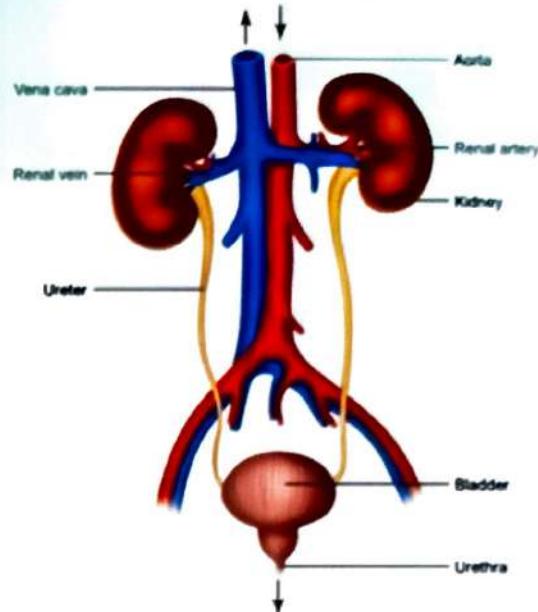


Urinary System Diagram



□ INTRODUCTION

- **Excretion** is the process by which the **unwanted substances** and **metabolic wastes** are eliminated from the body
- Various organs are involved in removal of **wastes** from the body, their excretory capacity is limited. But, **Urinary system** has maximum excretory capacity and so it plays a major role in **homeostasis**

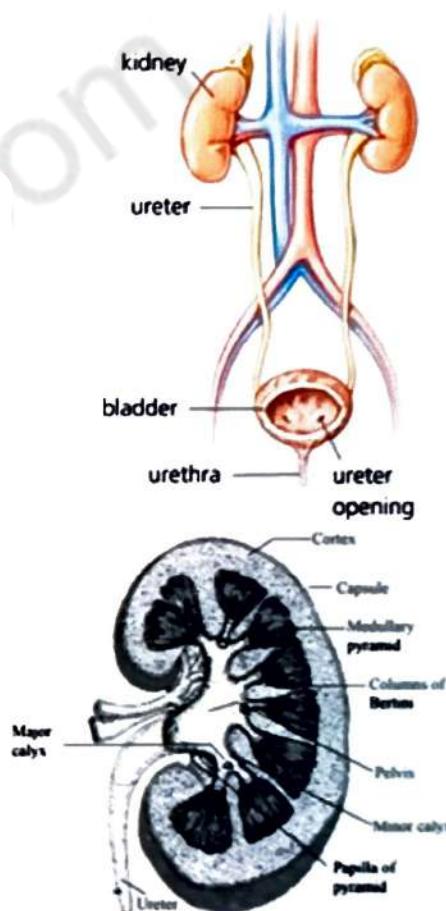


□ PARTS OF URINARY SYSTEM

1. A pair of kidneys
2. Ureters
3. Urinary bladder
4. Urethra

1. KIDNEY

- They are the **Two bean shaped** organ lying on the posterior abdominal wall , on each side of the vertebral column
- **Kidney** is a **compound tubular gland** covered by a **Connective tissue capsule**.
- There is a **depression** on the medial border of kidney called hilum, through which renal artery, renal veins, nerves and ureter pass



✓ DIFFERENT LAYERS OF KIDNEY

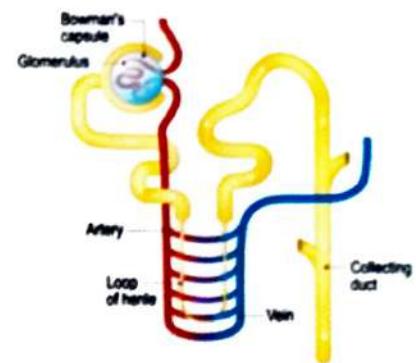
Components of kidney are arranged in **Three layers**:

- Outer cortex which is **reddish- brown** in colour
- Inner medulla which contains **pyramids** of the kidney
- Renal pelvis An Upper expanded part of ureter

✓ TUBULAR STRUCTURES OF KIDNEY

- Kidney is **made up of closely arranged** tubular structures called **Uriniferous tubules**

NEPHRON



- It includes:
 - **Nephrons** (formation of urine)
 - **Collecting ducts** (transporter of urine from nephrons to pelvis of ureter)

➤ NEPHRONS

- Nephron is defined as the **structural and functional unit** of kidney
- Each nephron is formed by **two** parts

i. Renal corpuscle or Malpighian corpuscle

- It is in the **cortex** of the kidney either near the **periphery** or near the **medulla**.
- Function of the renal corpuscle is the **filtration of blood** which forms the **first** phase of urine formation.

❖ STRUCTURE OF RENAL CORPUSCLE (two portions)

- a) **Glomerulus**- A bunch of capillaries
- b) **Bowman capsule**- An upper expanded end of the renal tubule

ii. Tubular portion of Nephron

- Tubular portion of nephron is the continuation of Bowman capsule.
- It is made up of **three parts**:

a) **Proximal convoluted tubule**- situated in the cortex

b) **Loop of Henle**- Present in medulla. It consists of:

- i. **Descending limb**
- ii. **Hairpin bend**
- iii. **Ascending limb**

c) **Distal convoluted tubule**- present in the cortex

➤ **Collecting duct**- Pass through the medulla and open into the pelvis of kidney

❖ **FUNCTIONS OF KIDNEY**

1. Role in homeostasis - It includes:

- i. **Excretion of Waste Products**
- ii. **Maintenance of Water- electrolyte Balance**
- iii. **Maintenance of Acid-Base balance**

2. Hemopoietic function - It produces

- i. Erythrocytes by secreting erythropoietin that stimulate **erythropoiesis**
- ii. Thrombopoietin which stimulates the production of **thrombocytes**

3. Endocrine function – It secretes

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- **Renin**
- **1,25-dihydroxycholecalciferol (calcitriol)**
- **Prostaglandin**

4. Regulation of Blood Pressure

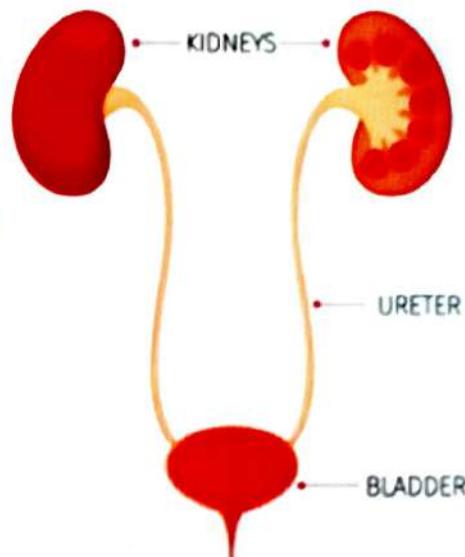
- i. By regulating the volume of **extracellular fluid**
- ii. Through **renin-angiotensin mechanism.**

5. Regulation of blood calcium level

- Kidneys play a role in the regulation of **blood calcium level** by activating 1,25-dihydroxycholecalciferol into vitamin D.
- **Vitamin D** is necessary for the absorption of calcium from intestine

2. URETERS

- The ureters are **narrow** tubes that carry **urine** from the kidney to the bladder
- There are **Two** ureters one for **each** kidney
- The ureter wall has **Three layers**
 - ✓ **Inner mucous layer**
 - ✓ **Outer fibrous layer**
 - ✓ **Middle muscular layer**



3. URINARY BLADDER

- It is a **pear shaped muscular sac** which acts as a **reservoir** for urine
- It lies in the **pelvic cavity** behind symphysis pubis
- The lowest part of bladder is called as **base** and upper part is called **Fundus**
- It has three openings two for ureter and one for urethra and the triangular area between these three openings is the **Trigone** of the bladder

It has four layers:
i. Outer serous coat
ii. Muscular coat
iii. Sub-mucous coat
iv. Mucous lining

4. Urethra

- It is a canal through which **urine** passes from the bladder to **outside**
- It **differs** in male and female
- A sphincter is present in both

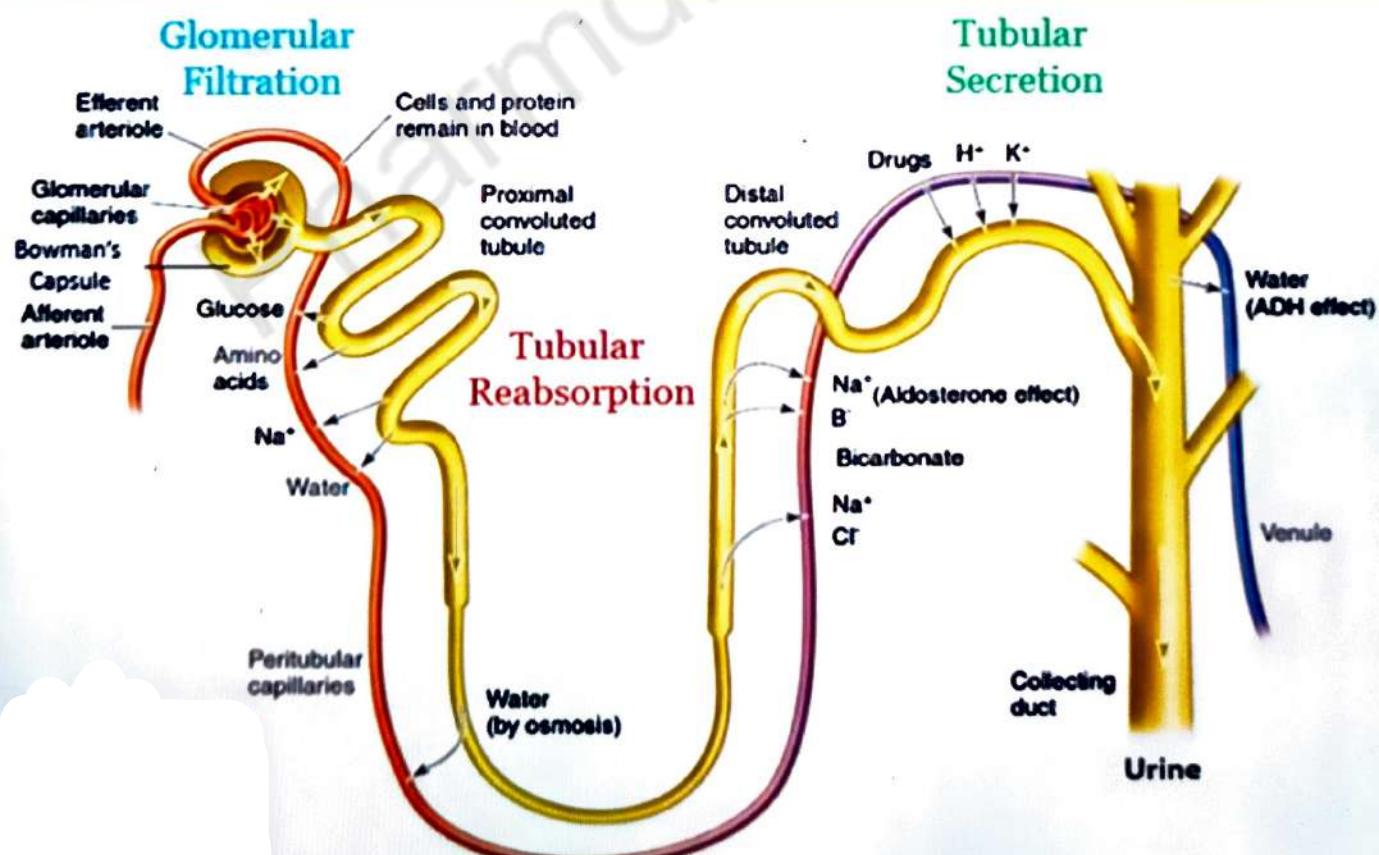
PHYSIOLOGY OF URINE FORMATION

- Urine formation is a **Blood Cleansing function**.
- Normally, about **1,300 mL** of **Blood** (26% of cardiac output) enters the kidneys.
- Kidneys excrete the **unwanted substances** along with water from the blood as urine.
- Normal urinary output is **1 L/day to 1.5 L/day**.

❖ **FORMATION OF URINE** – It involves Three processes:

1. Glomerular filtration
2. Tubular reabsorption
3. Tubular secretion

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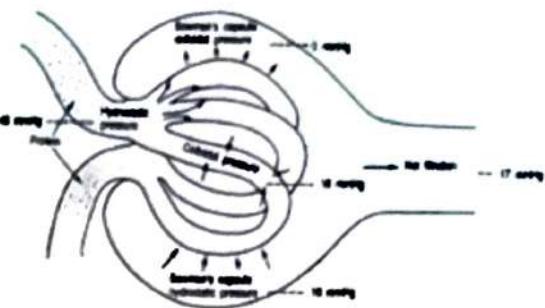
Urine Formation

1. Glomerular filtration

- It is the process by which the **blood** is **filtered** while passing through the **glomerular capillaries** by filtration membrane.
- It is the first process of urine formation.

➤ Process of Glomerular Filtration

- When blood passes through glomerular capillaries, the **plasma** is filtered into the **Bowman capsule**.
- All the substances of plasma are filtered except the plasma proteins. The filtered fluid is called **glomerular filtrate**.



➤ Glomerular Filtration Rate (GFR)

- It is defined as the **total quantity** of **filtrate** formed in all the nephrons of both the kidneys in the given unit of time. Normal GFR is **125 mL/minute or about 180 L/day**

❖ Factors affecting GFR

1. Renal Blood Flow
2. Tubuloglomerular Feedback
3. Glomerular Capillary Pressure
4. Colloidal Osmotic Pressure
5. Hydrostatic Pressure in Bowman Capsule

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2. Tubular reabsorption

- It is the process by which **water** and **other substances** are transported from renal tubules **back to the blood**.
- When the **glomerular filtrate** flows through the **tubular portion** of nephron, Large quantity of **water** (more than 99%), **electrolytes** and other substances are **reabsorbed** by the tubular epithelial cells.

- The reabsorbed substances move into the **interstitial fluid** of renal medulla.
- And then, the substances move into the blood in **Peritubular Capillaries**.
- Since the substances are taken back into the blood from the glomerular filtrate

➤ Selective Reabsorption

- **Tubular reabsorption** is known as **selective reabsorption** because the **tubular** cells reabsorb only the substances necessary for the body.
- **Essential substances** gets reabsorbed from renal tubule.
- the **unwanted substances** like metabolic waste products are not reabsorbed and **excreted** through urine

➤ Site of reabsorption

Sites	Reabsorbed substances
Proximal Convoluted Tubule	Glucose, amino acids, sodium, potassium, calcium, bicarbonates, chlorides, phosphates, urea, uric acid and water
Loop of Henle	Sodium and chloride
Distal Convoluted Tubule	Sodium, calcium, bicarbonate and water

3. TUBULAR SECRETION (Tubular excretion)

- It is the process by which the substances are transported from **blood** into **renal tubules**.
- Along with reabsorption from renal tubules, some substances are also **secreted** into the lumen from the peritubular capillaries through the **Tubular epithelial cells**.

➤ Substances secreted in different segments of renal tubules

Different segments of renal tubules

Substances secreted

Proximal and Distal convoluted tubules and
collecting ducts

Potassium

Proximal convoluted tubule

Ammonia

Proximal and Distal convoluted tubules

Hydrogen ions

Loop of Henle

urea

□ JUXTAGLOMERULAR APPARATUS

- It is a specialized organ situated near the glomerulus of each nephron

✓ Functions of juxtaglomerular apparatus

○ Secretion of hormones (Two hormones)

1. Renin

2. Prostaglandin

1. Renin

- Renin is a peptide with 340 amino acids.
- Renin with angiotensin forms the renin-angiotensin system (hormone system that plays an important role in the **maintenance of blood pressure**)

i. Stimulants for renin secretion- Four stimulants

a) Fall in arterial **blood pressure**

b) Reduction in the ECF volume

c) Increased **sympathetic activity**

d) Decreased load of **sodium and chloride** in macula densa (thick ascending segment before it opens into distal convoluted tubule.)

ii. Renin Angiotensin System

- When renin is released into the blood, it **acts** on a specific plasma protein called **angiotensinogen** or **renin substrate**
- Renin and angiotensinogen is converted into a **angiotensin I**
- Angiotensin I is converted into **angiotensin II**, by the activity of angiotensin-converting enzyme (**ACE**) secreted from lungs
- Angiotensin II(short half-life) and rapidly degraded into **angiotensin III** by **angiotensinases**, which are present in RBCs and vascular beds in many tissues.
- Angiotensin III is converted into **angiotensin IV**

1. Measurement of Glomerular Filtration Rate

- A substance that is **completely** filtered but neither **reabsorbed** nor **secreted** should be used to measure glomerular filtration rate (GFR).
 - **Inulin** is the ideal substance used to measure GFR.
- **Measurement of GFR is done by Two methods-**

i. Inulin clearance

A known amount of **inulin** is injected into the **body**. After sometime, the **concentration** of inulin in plasma and urine and the volume of urine excreted are estimated

ii. Creatinine clearance

Creatinine is already present in **body fluids** and its plasma concentration is **steady** throughout the day. It is **completely** filtered and being a metabolite it is neither reabsorbed nor secreted.

DISORDERS OF URINARY SYSTEM

1. Polycystic kidney disease

- Enlargement of kidneys because of the **presence of many cysts** within them, **slow, progressive disease**.
- Polycystic kidney disease (PKD) is an **inherited disorder** in which **clusters of cysts develop** primarily within your **kidneys**, causing your **kidneys to enlarge and lose function over time**.

2. Pyelonephritis

- Complicated urinary tract infection, **starts with a bladder infection** and **spreads to both kidneys**; can be acute or chronic.
- The **inflammation of the kidney** is due to a **specific type of urinary tract infection** (UTI). The UTI **usually begins in the urethra or bladder and travels to the kidneys**.
- The main cause of acute pyelonephritis is **gram-negative bacteria**, the most common being *Escherichia coli*. Other gram-negative bacteria which cause acute pyelonephritis include *Proteus*, *Klebsiella*, and *Enterobacter*.

3. Renal calculi

- Kidney stones; can become **lodged in ducts within kidneys or ureters**.
- Kidney stones are **hard deposits of minerals and acid salts that stick together** in concentrated urine.
- They can be **painful when passing through the urinary tract**, but usually **don't cause permanent damage**.
- Possible causes include **drinking too little water, exercise** (too much or too little), **obesity, weight loss surgery, or eating food with too much salt or sugar**.

4. Urinary tract infections

- Urinary tract infections UTIs are caused by **pathogenic microorganism** in the urinary tract (the normal urinary tract is sterile above the urethra)
- Urinary tract infections are more **common in women**.
- They usually occur in the **bladder or urethra**, but more serious infections **involve the kidney**.
- A bladder infection may **cause pelvic pain, increased urge to urinate**, pain with urination and blood in the urine.
- A kidney infection may cause **back pain, nausea, vomiting and fever**.
- Bacteria that **live in the vagina, genital, and anal areas** may enter the urethra, travel to the bladder, and cause an infection.

❖ CLASSIFICATION OF URINARY TRACT INFECTIONS

Urinary tract infection classified by location

1. The **lower urinary tract** include **bladder and below** (cystitis, prostatitis ,urethritis)
2. Upper urinary tract includes the **kidneys and ureters**

Also UTI classified as:

1. **Uncomplicated UTI:** Community-acquired infection; common in **young women and not usually recurrent**.
2. **Complicated UTI:** Often **nosocomial** (acquired in the hospital) and **related to catheterization**; occur in patients with urologic abnormalities, pregnancy, immunosuppression, DM,obstructions and are often recurrent.

5. Nephrotic syndrome

- Type of **renal failure** with **increased glomerular permeability and massive proteinuria**.
- Nephrotic syndrome is a **kidney disorder that causes your body to pass too much protein in your urine**.
- Nephrotic syndrome is often caused by **damage to small blood vessels in the kidneys** that **filter waste and excess water from the blood**.

6. Urinary incontinence - The **loss of bladder control** - is a common and often **embarrassing problem**. The severity ranges from occasionally **leaking urine when you cough or sneeze** to having an urge to **urinate that's so sudden and strong you don't get to a toilet in time**.

7. Kidney stones

- Kidney stones (also called renal calculi, nephrolithiasis or urolithiasis) are **hard deposits made of minerals and salts that form inside your kidneys**.
- **Diet, excess body weight, some medical conditions**, and certain supplements and medications are among the many causes of kidney stones.