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REMEDIAL BIOLOGY

UNIT 2

TOPIC :

- **Breathing and respiration**

  Human respiratory system

  Mechanism of breathing and its regulation

  Exchange of gases, transport of gases and regulation of respiration

  Respiratory volumes

Respiratory System

→ Respiratory tract forms the path through which air passes from the nose to the lungs.

→ Exchange of gases during internal and external respiration is the major function of the respiratory system, along with this it also filters, warms, and humidifies the inhaled air.

→ Respiratory system includes the vocal cords for producing sound, lungs for controlling body pH levels, and the olfactory bulbs for smelling.

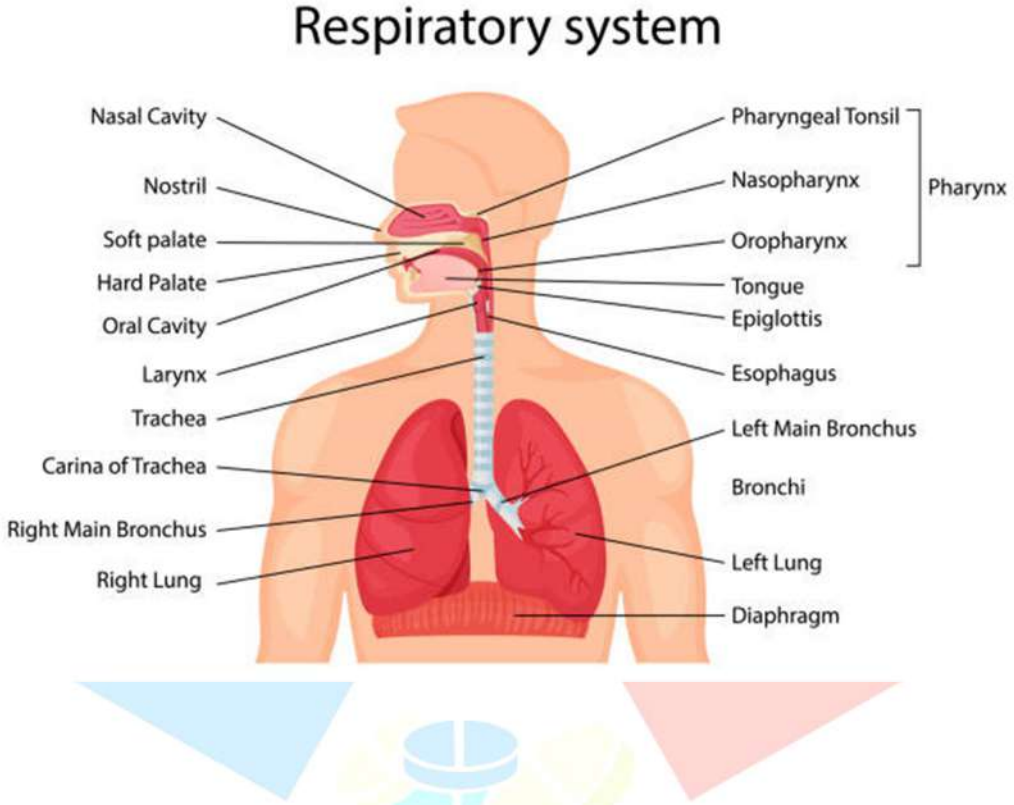
→ The cells demand a continuous supply of oxygen and in turn continuously eliminate carbon dioxide a metabolic waste product

Events during Respiration

1) Ventilation of lungs for inward and outward movement of air,
2) Exchange of gases between the blood and alveolar air
3) Excretion of water vapour, and
4) Supplying air to the larynx for voice production

Parts of Respiratory System

1. Nose
2. Pharyax (throat)
3. Larynx (Voice box)
4. Trachea (Wind pipe)
5. Bronchi and Bronchioles
6. Lungs, and
7. Alveoli



Based on its Function the respiratory system is divided into

- **Conducting Zone (Nose to Bronchioles) :** This zone consists of respiratory organs forming a path for the conduction of inhaled air into the terminal bronchioles. It transports atmospheric air to the alveoli, discards foreign particles from the inhaled air, also humidifying and maintaining its temperature.
- **Respiratory Zone (Alveolar Duct to Alveoli) :** This zone consists of the alveoli and their ducts. It forms the site where 02 and CO_2 gases are exchanged between the blood capillaries and alveoli.

Based on its anatomical structure, the respiratory system is divided into:

- **Upper Respiratory Tract :** This zone consists of the organs outside the chest cavity (thorax), i.e., nose, pharynx, and larynx.
- **Lower Respiratory Tract :** This zone consists of the organs within the chest cavity, i.e., trachea, bronchi, bronchiole, alveolar duct, and alveoli.

Nose

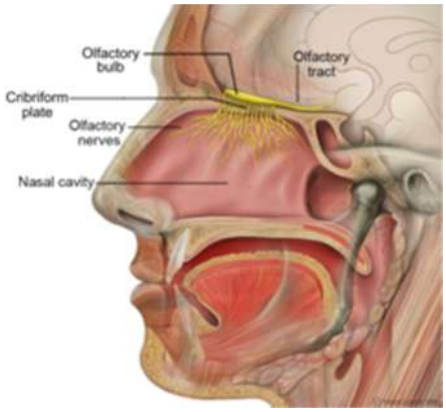
→ Nose is present between the forehead and the upper lip.

→ It is the first organ of the respiratory tract which receives the inhaled air and forms a passage for the air to reach the nasal cavity or nasal chamber.

→ Nose performs the process of warming, moistening, and filtering of the inhaled air.

Anatomy

- The structure of nose is divided into an external (the nose) and an internal (nasal cavities) part.
- Nasal cavity is a large irregularly-shaped cavity, divided into two equal halves by a septum.
- A perpendicular plate of ethmoid and vomer bones forms the posterior bony Part of the septum
- while its anterior part is formed by the hyaline cartilage.
- Nose is a bony and a cartilaginous structure.
- Its bony part is made up of the frontal, nasal, and maxillae bones .
- Its external cartilaginous part is made up of the septal cartilage, which forms the anterior portion. of the nasal septum; lateral cartilages form the inferior portion of the nasal bones; and alar cartilages form a portion of the nostrils.



Functions

- ✓ Respiration
- ✓ Air Conditioning
- ✓ Defence
- ✓ Vocal Resonance and Speech

Pharynx

→ Pharynx (throat) is a funnel-shaped tube extending from the internal nares to the posterior part of oesophagus and anterior part of larynx.

→ It is made up of skeletal muscles, is lined with mucous membrane and is divided into nasopharynx, oropharynx, and laryngopharynx.

→ The nasopharynx contributes to respiration, while oropharynx and laryngopharynx have respiratory as well as digestive functions

→ The pharynx walls have three tissue layers:

- Lining Membrane (Mucosa)
- Middle Layer
- outer layer

Anatomy

- **Nasopharynx :** This part of the pharynx lies immediately posterior to the nasal cavity.
- **Oropharynx :** This part of the pharynx lies immediately posterior to the oral cavity
- **Hypopharynx or Laryngopharynx :** This part of the pharynx lies just inferior to the oropharynx and superior to the oesophagus.
- Epiglottis is a flap of connective tissue found at the entrance of the larynx.
- Pharynx forms the pathway for the passage of both food and air.
- The respiratory and digestive pathways diverge at the larynx.
- The larynx forms the pathway for the entry of air which is then carried to the lungs, while the oesophagus forms the pathway for the entry of food and fluids into the stomach

Function

- ✓ Passageway for Air and Food
- ✓ Taste
- ✓ Warming and Humidifying
- ✓ Hearing
- ✓ protection
- ✓ speech

Larynx

→ Larynx is present as a triangular chamber in the front upper part of the neck.

→ A prominent elevation, called the Adam's apple is present just in front of the larynx.

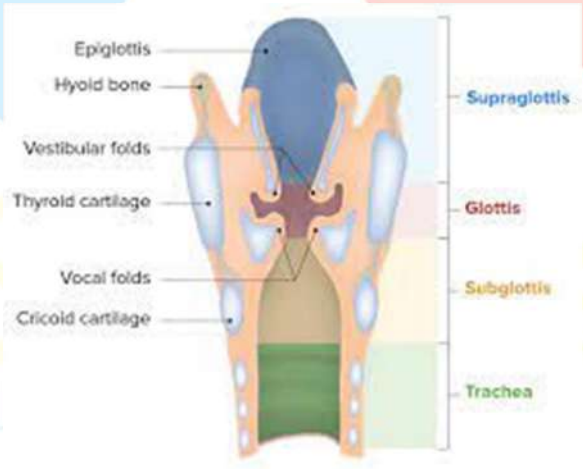
→ Its wall is made up of nine fibrocartilages connected by the ligaments and moved by the muscle

Anatomy

- ➢ **Thyroid Cartilage :** It is the largest cartilage (larger in men) which forms a covering around the anterior and lateral sides of larynx. This cartilage has the Adam's apple in its front part.
- ➢ **Cricoid Cartilage :** It is a signet ring-like cartilage present below the thyroid gland. It broader part lies towards the back.
- ➢ **Epiglottis :** It is a leaf-like cartilage which covers the larynx. It is anteriorly inserted in the thyroid cartilage; however its posterior part

lies free. It acts as a flap which covers the tracheal opening during swallowing so that the food does not enter the wind pipe but the food pipe.

- **Paired Caftilages**
  - **Arytenoids :** These are pyramid-shaped cartilages present on either side of cricoid cartilage.
  - **Corniculates :** These are very small and conical nodule-like cartilages present superiorly to the arytenoids.
  - **Cuneiforms :** These are narrow, elongated cartilages present on the sides above corniculates.



Function

- ✓ sound production
- ✓ speech
- ✓ Lower Respiratory Tract Protection
- ✓ Air Passageway
- ✓ Humidifying, Filtering, and Warming

Trachea

→ Trachea (or wind pipe) is a 10-11 cm long continuous pathway from the larynx, which extends downwards up to the 5^{th} thoracic vertebra

→ Here it splits at the carine into right and left bronchi, entering the respective lungs.

→ It lies in the medium plane in front of the oesophagus.

Anatomy

- The trachea cartilages are covered by the following three tissue layers:
- **Outer Layer :** This layer is made up of fibrous and elastic tissues enclosing the cartilages.
- **Middle Layer :** This layer is made up of cartilages and bands of smooth muscles winding around the trachea helically. This layer also contain aerolar tissue blood, lynph vessels, and autonomic nerves
- **Inner Layer :** This layer is made up of ciliated columnar epithelium, containing mucus-secreting goblet cells.

Function

- ✓ The cartilages and elastic tissues of trachea are arranged such that they prevent kinking and obstruction of the airway during head and neck movements.
- ✓ It acts as a mucociliary escalator due to synchronised and regular beating of the cilia of mucous membrane.
- ✓ It warms, humidifies, and filters the inhaled air.
- ✓ It generates cough reflex as the laryngeal, tracheal, and bronchial nerve endings (sensitive to irritation) give rise to nerve impulses conducted to the respiratory centres of brain stem via vagus nerves

Bronchi and Bronchioles

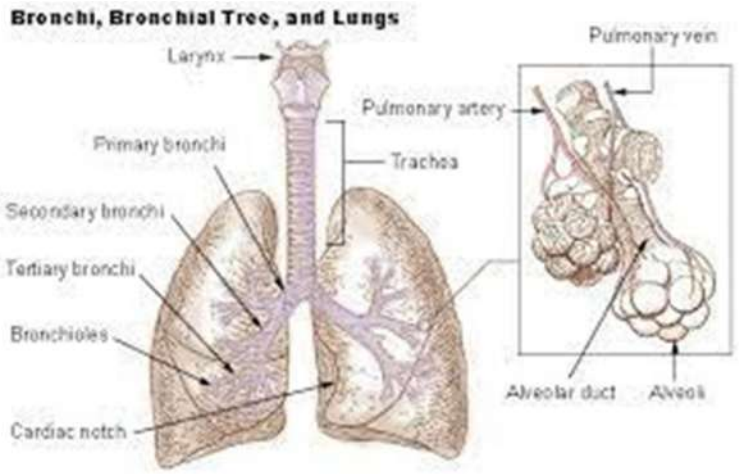
→ Bronchi (singular bronchus) are airway passages in the respiratory tract.

→ They carry the inhaled air into the lungs. They do not form the sites for gaseous exchange.

→ The two right and left bronchi are the primary ones and they enter the corresponding lungs Bronchioles are fine branches entering the lobules (basic units of lungs)

Anatomy

- Bronchi are made up of complete cartilage ring the right and left bronchus are different from each other as the former is shorter and wider.
- Each primary bronchus splits into three right secondary or lobar bronchi (entering the superior, middle, and inferior lobes of the right lung) and two left bronchi (entering the superior and inferior lobes of the left lung).
- The secondary bronchi further divide into tertiary or segmental bronchi which are distributed into bronchopulmonary segment.
- The tertiary or segmental bronchi then divide into smaller branches.
- Each bronchiole within the lobule divides into a number of terminal bronchioles which further sub-divide into two or more respiratory bronchioles.
- The final terminations of respiratory bronchioles are the alveolar ducts which in turn forms alveoli surrounded by capillaries



Functions

- ✓ They provide a passageway for the air.
- ✓ They regulate the volume of air entering the lungs by changing the diameter of respiratory passages due to contraction or relaxation of the muscles in their walls.
- ✓ They warm and humidify the inhaled air.
- ✓ They filter the air by removing Particulate matter.
- ✓ They generate cough reflex.

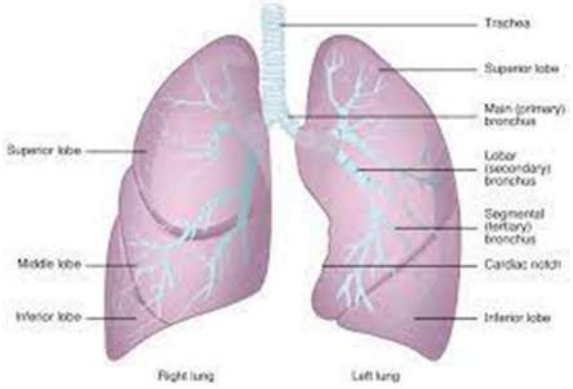
Lungs

→ Lungs are present in the thoracic cavity as two coneshaped lobes separated by the heart and other structures of mediastinum. These structures also divide the thoracic cavity into two structurally different chambers

Anatomy

- ➢ Lungs are present within the cavities located on either side of the heart.
- ➢ Each lung has lobes, which are further divided into lobules containing alveoli.
- ➢ The medial surface of the left lung has a cardiac notch, while the right lung does not have a notch.
- ➢ Lungs have following parts
    - Apex
    - Base
    - Costal Surface
    - Medial Surface
- ➢ Mediastinum is an area present between the lungs and is occupied by the heart great vessels, trachea, right and left bronchi, lymph nodes and nerves.
- ➢ Pleura and Pleural Cavity

- Each lung is enclosed within a pleural membrane , made up of double layered serous membrane.
- Parietal pleura (the outer layer) line the thoracic cavity wall, while visceral pleura (the deep layer) line the lungs.
- Pleural cavity is the space between the two layers and contains pleural fluid.
- Lobes, Fissures, and Lobules
- Each lung is divided into separate lobes, the left lungs is divided into two lobes and the right one into three
- These lobes are further divided into numerous lobules containing alveoli.
- These lobes are separated by fissures.
- The superior and inferior lobes of the left lungs are separately by the oblique fissure extending inferiorly and anteriorly.
- On the other hand in the right lung, the superior part of oblique fissure seperates the superior and the inferior lobe, while its inferior part seperates the inferior and the middle lobe.
- This middle lobe is superiorly lined by the horizontal fissure



Function

- ✓ They alter the blood pH by altering the partial pressure of carbon dioxide.
- ✓ They filter out small blood clots formed in the veins.
- ✓ They filter out gas micro-bubbles formed in the venous blood stream.

- ✓ They alter the blood concentration of some biological substances and drugs.
- ✓ They convert angiotensin I to angiotens II by the action of angiotensin-converting enzyme.
- ✓ They form a soft, shock-absorbent protective layer for the heart.

Alveoli

→ Alveoli (singular alveolus) are a hollow cavity found in the mammalian lungs.

→ Other vertebrates have different structure for gas exchange.

→ Pulmonary alveoli are the spherical projection of the respiratory bronchioles.

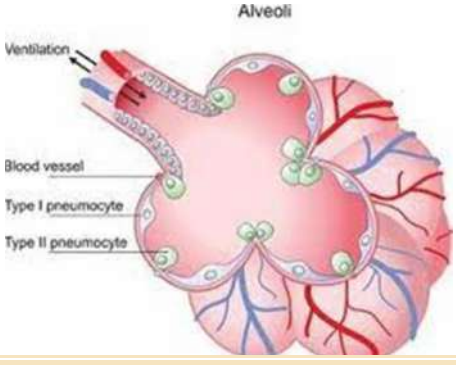
→ The alveolar membranes are the major sites where exchange of gases occurs with the blood.

→ Alveoli are lined with epithelium and are made up of some collagen and elastin fibres.

→ These fibres allow the alveoli to stretch when they fill with air during breathing and to spring back so that carbon dioxide-rich air is expelled

Anatomy

- ➢ A human lung has around 300 million alveoli, each of them covered with a fine mesh of capillaries occupying 70% of its area .
- ➢ An alveolus in an adult human has an average diameter of 200-300μ, which expands when air is inhaled.
- ➢ Alveoli are made up of an epithelial layer and extracellular matnx surrounded by capillaries.
- ➢ Some alveolar walls have Pores between the alveoli these pores are called pores of Kohn



Functions

- ✓ External Respiration: They aid in external respiration in which gaseous exchange occurs between the alveoli and blood by diffusion
- ✓ Protection Against Microbes

Mechanism of Breathing and Its Regulation

→ Respiration is the process of gaseous exchange in the body.
→ This process is divided into three basic steps:

1. Breathing or pulmonary ventilation :

- Breathing is composed of two processes: inhalation and exhalation.
- The act of taking air in or inflow of air, is called as inhalation.
- The act of throwing air out or outflow of air is called as exhalation.
- Thus, breathing involves the exchange of air between the atmosphere and air of the lungs.
- During breathing, air flows between the atmosphere and the lungs because of alternating pressure differences created by contraction and relaxation of respiratory muscles.

Mechanism of Breathing

- Inhalation and exhalation is dependent on pressure differences in lungs and atmosphere. The pressure difference is caused by changes in lung volume.
- The lungs must expand, for inhalation. Lung expansion increases lung volume and thus decreases the pressure in the lungs to below atmospheric pressure.
- The lungs expand with the help of contraction of the main muscles of inhalation, the diaphragm (the dome-shaped skeletal muscle that forms the floor of the thoracic cavity) and external intercostals (muscles present between ribs).
- Contraction of the diaphragm causes it to flatten, lowering its dome which increases the vertical diameter of the thoracic cavity. About 75% of the air that enters the lungs during quiet breathing due to contraction of diaphragm.

- Contraction of external intercostals elevate the ribs. As a result, there is an increase in the anteroposterior and lateral diameters of the chest cavity. About 25% of the air that enters the lungs during normal quiet breathing due to contraction of external intercostals.
- As the volume of the lungs increases in this way, the pressure inside the lungs, called the alveolar (intrapulmonic) pressure, drops. A pressure difference is thus established between the atmosphere and the alveoli.
- Because air always flows from a region of higher pressure to a region of lower pressure, inhalation takes place. Air continues to flow into the lungs as long as a pressure difference exists.
- The process of exhalation is also dependent on pressure gradient, but in this case the gradient is in the opposite direction: The pressure in the lungs is greater than the pressure of the atmosphere.
- As, no muscular contractions are involved, normal exhalation is a passive process.
- Exhalation starts when the inspiratory muscles relax. As the diaphragm relaxes, its dome moves superiorly owing to its elasticity.
- As the external intercostals relax, the ribs are depressed.
- These movements decrease the vertical, lateral, and anteroposterior diameters of the thoracic cavity, which decreases lung volume.
- In turn, the alveolar pressure increases. Air then flows from the area of higher pressure in the alveoli to the area of lower pressure in the atmosphere.

2. External (pulmonary) respiration or pulmonary gas exchange (Exchange of gases, transport of gases)

- It is the exchange of gases between the alveoli of the lungs and the blood.
- In this process, blood gains O_2 from inhaled air and loses CO_2 through exhaled air.
- External respiration in the lungs converts deoxygenated blood (depleted of some O_2 coming from the right side of the heart into oxygenated blood (saturated with O_2 that returns to the left side of the heart.

3. Internal (tissue) respiration or systemic gas exchange (Exchange of gases, transport of gases):

- Internal respiration is the exchange of gases between blood and tissue cells.
- During this process, blood loses O_2 as it is transferred to cells and CO_2 formed by cells is added to blood.
- The exchange of O_2 and CO_2 between systemic capillaries and tissue cells is called internal respiration.
- As O_2 leaves the bloodstream, oxygenated blood is converted into deoxygenated "blood. Unlike external respiration, which occurs only in the lungs, internal respiration occurs in tissues throughout the body.

Regulation of Respiration

- Respiratory center regulates the process of respiration. Respiratory center is widely dispersed group of neurons, located bilaterally in the medulla oblongata and pons of the brain stem.
- It can be divided into three areas:
    i. The medullary rhythmicity area in the medulla oblongata: It controls the basic rhythm of respiration.
    ii. The pneumotaxic area in the pons: It co-ordinates the transition between inhalation and exhalation.
    iii. The apneustic area, also in the pons: It co-ordinates the transition between inhalation and exhalation

Respiratory Volumes and Capacities

→ The dynamic or static lung volumes/capacities are measured at varying degrees of inspiration or expiration.

→ Dynamic lung volumes depend upon the air flow rate; while the static lung volumes (the maximum volume to which a lung can be expanded) sub-divide into four standard volumes (i.e., tidal, inspiratory reserve, expiratory reserve, and residual volumes), four standard capacities inspiratory, Functional residual and total lung capacities) and four non-overlapping volumes

1. **Tidal Volume (TV) :** It is the volume of air inspired or expired during a normal respiration. An average value for tidal volume is approximately 500ml i.e. a healthy man can inspire or expire approximately 6000-8000ml of air per minute

2. **Inspiratory Reserve Volume (IRV):** It is the additional volume of air, a person can inspire by a forcible inspiration. The average value for IRV is 2500-3000ml.
3. **Expiratory Reserve Volume (ERV):** It is the volume of air that a person can expire by a forcible expiration. The average value for ERV is 1000-llooml.
4. **Residual Volume (RV):** It is the volume of air remaining in the lungs even after a forcible expiration. This average value for RV is 1100 - 1200ml

Lung capacities are combination of two or more pulmonary volumes:

1. **lnspiratory Capacity (IC) :** It is the total volume of air a person can inspire after a normal expiration It includes TV + IRV. Its average value is about 3500ml
2. **Expiratory Capacity (EC) :** It is the total volume of air a person can expire after a normal inspiration. It includes TV + ERV. Its average value is about 1600ml
3. **Functional Residual Capacity (FRC} :** It is the volume of air that will remain in the lungs, after a normal expiration. It includes ERV+RV. Its average value is about 2300ml.
4. **Vital Capacity (VC) :** It is the maximum volume of air a person can breathe out after a forced inspiration. It includes ERV, TV, and IRV. Its average value is about 4600ml.
5. **Total Lung Capacity (TLC) :** It is the total volume of air accommodated in the lungs at the end of a forced inspiration. It include RV, ERV, TV. and IRV or VC ·+ RV. Its average value is about 5800ml TLC = VC + RV