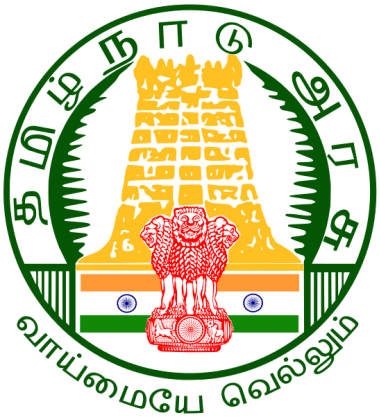


GOVERNMENT OF TAMILNADU

Department of Employment and Training

Course : TNPSC Group-II Mains Material

Subject : Biology

Topic : Respiratory System

Commissioner,

Department of Employment and Training

தமிழ்நாடு அரசு
வாய்மையே வெல்லும்

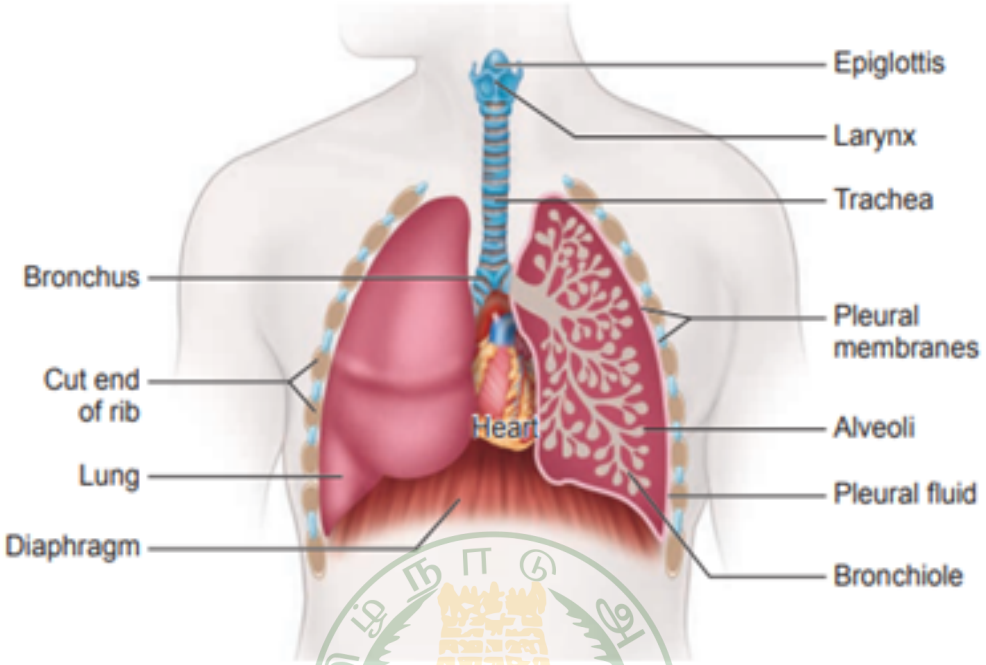
RESPIRATORY SYSTEM

RESPIRATION

- The term respiration refers to the exchange of oxygen and carbon dioxide between environment and cells of our body where organic nutrients are broken down enzymatically to release energy The five primary functions of the respiratory system are,
  1. To exchange O_2 and Co_2 between the atmosphere and the blood.
  2. To maintain homeostatic regulation of body pH.
  3. To protect us from inhaled pathogens and pollutants.
  4. To maintain the vocal cords for normal communication (Vocalization).
  5. To remove the heat produced during cellular respiration through breathing.

Human Respiratory System

- The respiratory system includes the external nostrils, nasal cavity, the pharynx, the larynx, the trachea, the bronchi and bronchiolus and the lungs which contain the alveoli.
- In human beings, air enters the upper respiratory tract through the external nostrils. The air passing through the nostrils is filtered by fine hairs and mucus lining the passage.
- The external nostrils lead to the nasal chamber which opens into the nasopharynx which opens through the glottis of the larynx region into the trachea.
- The ciliated epithelial cells lining the trachea, bronchi and bronchioles secrete mucus. Mucus membrane lining the airway contains goblet cells which secrete mucus, a slimy material rich in glycoprotein.
- Microorganisms and dust particles attach in the mucus films and are carried upwards to pass down the gullet during normal swallowing.
- During swallowing a thin elastic flap called epiglottis prevents the food from entering into the larynx and avoids choking of food.



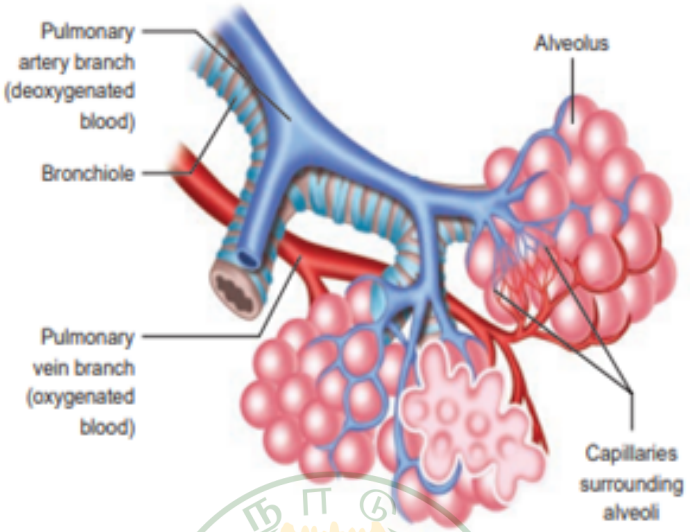
Human Respiratory System

Trachea

- The trachea is semi flexible tube supported by multiple cartilaginous rings which extends up to the mid thoracic cavity and at the level of the 5th thoracic vertebra where it divides into right and left primary bronchi, one bronchus to each lung.
- Within the lungs the bronchi divides repeatedly into secondary and tertiary bronchi and further divides into terminal bronchioles and respiratory bronchioles.
- Bronchi have 'C'-shaped curved cartilage plates to ensure that the air passage does not collapse or burst as the air pressure changes during breathing.
- The bronchioles are without cartilaginous rings and have rigidity that prevent them from collapsing but are surrounded by smooth muscle which contracts or relaxes to adjust the diameter of these airways.

Alveoli

- The fine respiratory bronchioles terminate into highly vascularised thin walled pouch like air sacs called alveoli meant for gaseous exchange.
- The diffusion membrane of alveolus is made up of three layers – the thin squamous epithelial cells of the alveoli, the endothelium of the alveolar capillaries and the basement substance found in between them.



Structure of alveoli

Surfactant

- They are the thin non–cellular films made of protein and phospholipids covering the alveolar membrane. The surfactant lowers the alveoli and prevents the lungs from collapsing. It also prevents pulmonary oedema.
- Premature babies have low levels of surfactant in the alveoli may develop the **new born respiratory distress syndrome** (NRDS). Because, the synthesis of surfactant begins only after the 25th week of gestation.
- The lungs are light spongy tissues enclosed in the thoracic cavity surrounded by an airtight space.
- The thoracic cavity is bound dorsally by the vertebral column and ventrally by the sternum, laterally by the ribs and on the lower side by the dome shaped diaphragm.
- The lungs are covered by double walled pleural membrane containing a several layers of elastic connective tissues and capillaries, which encloses the pleural fluid.
- Pleural fluid reduces friction when the lungs expand and contract.

The Steps Involved in Respiration

1. The exchange of air between the atmosphere and the lungs.
2. The exchange of O_2 and Co_2 between the lungs and the blood.

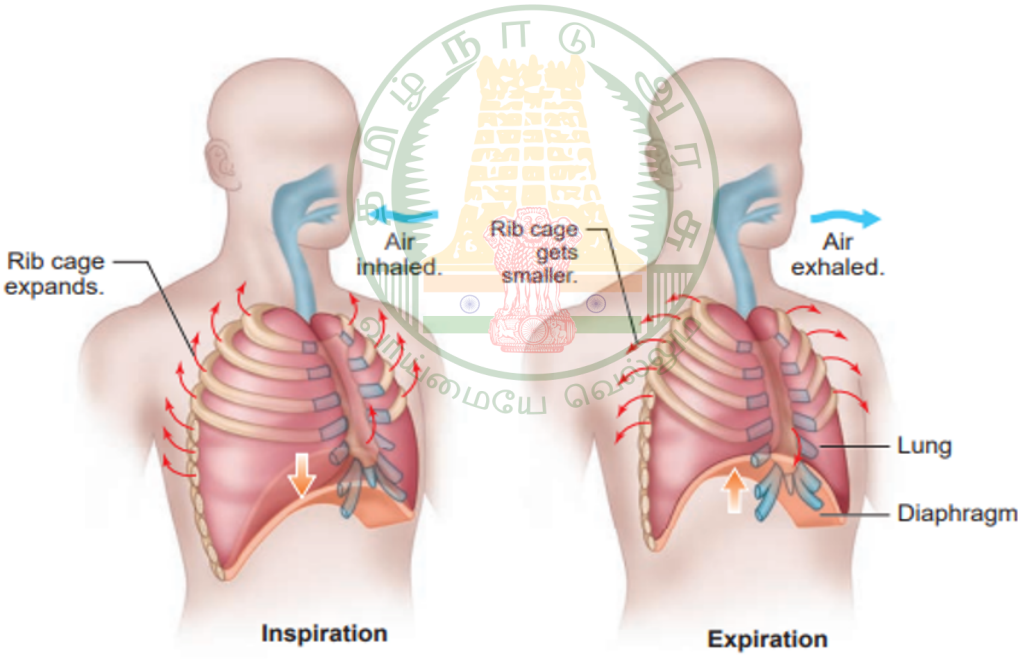
3. Transport of O_2 and Co_2 by the blood.
4. Exchange of gases between the blood and the cells.
5. Uptake of O_2 by the cells for various activities and the release of Co_2.

Characteristic Features of Respiratory Surface

- Surface area must be very large and richly supplied with blood vessels.
- Should be extremely thin and kept moist.
- Should be in direct contact with the environment.
- Should be permeable to respiratory gases.

Mechanism of Breathing

- The movement of air between the atmosphere and the lungs is known as ventilation or breathing.



Mechanism of Breathing

Respiratory Volumes

1. Tidal Volume (TV)

- Tidal volume is the amount of air inspired or expired with each normal breath. It is approximately 500 ml. i.e., A normal human adult can inspire or expire approximately 6000 to 8000 ml of air/minute. During vigorous exercise, the tidal volume is about 4–10 times higher.

2. *Inspiratory Reserve Volume (IRV)*

- Additional volume of air a person can inspire by forceful inspiration is called Inspiratory Reserve Volume. The normal value is 2500–3000 ml.

3. *Expiratory Reserve Volume (ERV)*

- Additional volume of air, a person can forcefully exhale by forceful expiration is called Expiratory Reserve Volume. The normal value is 1000–1100 ml.

4. *Residual Volume (RV)*

- The volume of air remaining in the lungs after a forceful expiration. It is approximately 1100–1200 ml.

Respiratory Capacities

1. *Vital Capacity (VC)*

- The maximum volume of air that can be moved out during a single breath following a maximal inspiration. A person first inspires maximally then expires maximally.
- VC = ERV + TV + IRV.

2. *Inspiratory Capacity (IC)*

- The total volume of air a person can inhale after normal expiration. It includes tidal volume and inspiratory reserve volume. IC = TV + IRV.

3. *Expiratory Capacity (EC)*

- The total volume of air a person can exhale after normal inspiration. It includes tidal volume and expiratory reserve volume. EC = TV + ERV.

4. *Total Lung Capacity (TLC)*

- The total volume of air which the lungs can accommodate after forced inspiration is called Total Lung Capacity. This includes the vital capacity and the residual volume. It is approximately 6000 ml.
- TLC = VC + RV.

5. *Minute Respiratory Volume*

- The amount of air that moves into the respiratory passage per minute is called minute respiratory volume.
    1. Normal TV = 500 ml.
    2. Normal respiratory rate = 12 times/minute.
    3. Therefore, minute respiratory volume = 6 Litres/minute (for a normal healthy man).

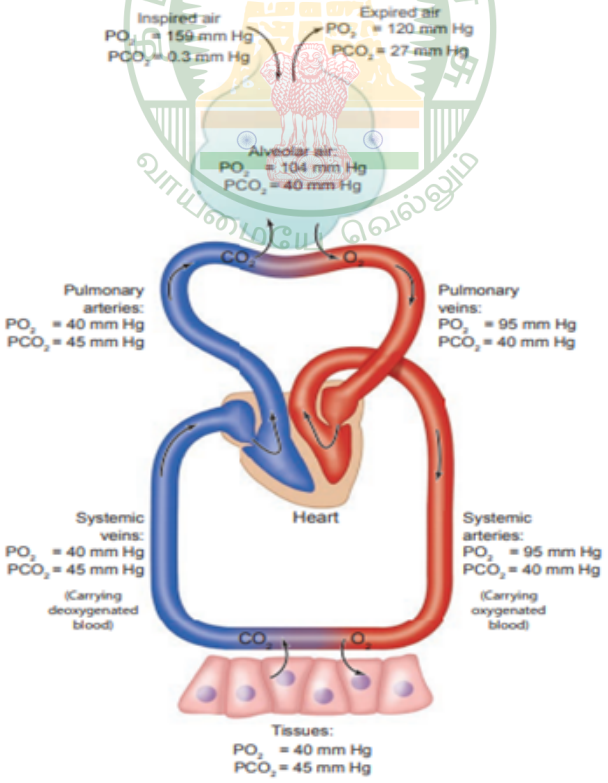
Dead Space

- Some of the inspired air never reaches the gas exchange areas but fills the respiratory passages where exchange of gases does not occur. This air is called dead space. Dead space is not involved in gaseous exchange. It amounts to approximately 150 ml.

Exchange of Gases

Transport of Oxygen

- The primary site for the exchange of gases is the alveoli. The uptake of O_2 and the release of Co_2 occur between the blood and tissues by simple diffusion driven by partial pressure gradient of O_2 and Co_2.
- Partial pressure is the pressure contributed by an individual gas in a mixture of gases. It is represented as pO_2 for oxygen and pCo_2 for carbon dioxide. Due to pressure gradients, O_2 from the alveoli enters into the blood and reaches the tissues.
- Co_2 enters into the blood from the tissues and reaches alveoli for elimination. As the solubility of Co_2 is 20–25 times higher than that of O_2, the partial pressure of Co_2 is much higher than that of O_2.



Exchange of gases at the alveolus and the tissue with blood and transport of oxygen and carbondioxide

Transport of Carbon Dioxide

Blood transports Co_2 from the tissue cells to the lungs in three way.

- At the tissues the pCo_2 is high due to catabolism and diffuses into the blood to form HCo_3^- and H+ ions. When Co_2 diffuses into the RBCs,
- It combines with water forming carbonic acid (H_2Co_3) catalyzed by carbonic anhydrase. Carbonic acid is unstable and dissociates into hydrogen and bicarbonate ions.

$$Co_2 + H_2O \xleftrightarrow{\text{Carbonic anhydrase}} H_2Co_3$$

$$H_2Co_3 \xleftrightarrow{\text{Carbonic anhydrase}} HCo_3 + H^+$$

Bohr Effect

- Increase in PCo_2 and decrease in pH decrease the affinity of haemoglobin for oxygen and shifts the oxyhaemoglobin dissociation curve to the right and facilitates unloading of oxygen from haemoglobin in the tissue. This effect of pCo_2 and pH on the oxyhaemoglobin dissociation curve is called the Bohr effect.

Haldane Effect

- The amount of carbon dioxide transported in blood is remarkably affected by the degree oxygenation of the blood. The lower the partial pressure of O_2 lower is the affinity of haemoglobin saturation with oxygen hence, more Co_2 is carried in the blood. This phenomenon is called Haldane effect.

Favours the Formation of Oxyhaemoglobin	Dissociation of Oxygen from Oxyhaemoglobin
• In the alveoli high pO_2.	• In the tissues low pO_2.
• Low pCo_2.	• High pCo_2.
• Low temperature and less H^+ concentration.	• High Temperature, High H^+ concentration.

Respiratory Pigments

1. Haemoglobin

- Haemoglobin belongs to the class of conjugated protein. The iron containing pigment portion haem constitutes only 4% and the rest colourless protein of the histone class globin.
- Haemoglobin has a molecular weight of 68,000 and contains four atoms of iron, each of which can combine with a molecule of oxygen.

2. Methemoglobin

- If the iron component of the haem moieties is in the ferric state, than the normal ferrous state, it is called methemoglobin. It does not bind O_2. Normally RBC contains less than 1% methemoglobin.
- A sigmoid curve (S–shaped) is obtained when percentage saturation of haemoglobin with oxygen is plotted against pO_2. This curve is called oxygen haemoglobin dissociation curve.
- This S–shaped curve has a steep slope for pO_2 values between 10 and 50 mm Hg and then flattens between 70 and 100 mm Hg.

Regulation of Respiration

- The medulla oblongata of the hindbrain called respiratory rhythm centre is responsible for this regulation.
- Pons varolii region of the brain moderates the function of the respiratory rhythm centre to ensure normal breathing.
- Receptors associated with the aortic arch and carotid artery send necessary signals to the rhythm centre for remedial action.
- The chemosensitive area found close to the rhythm centre is highly sensitive to Co_2, H^+ and H^+ are eliminated out by respiratory process.

Disorders of the Respiratory System

1. Occupational Respiratory Disorders

- The disorders due to one's occupation of working in industries like grinding or stone breaking, construction sites, cotton industries, etc., Dust produced affects the respiratory tracts. Long exposure can give rise to inflammation leading to fibrosis.
- Silicosis and asbestosis are occupational respiratory diseases resulting from inhalation of particle of silica from sand grinding and asbestos into the respiratory tract.

2. Tuberculosis

- Tuberculosis is caused by Mycobacterium tuberculosis. This infection mainly occurs in the lungs and bones. The World TB Day is March 24. **Direct Observation Therapy** (DOTs) can treat about 95% of the TB patients.
- French bacteriologists Albert Calmette and Camille Guérin, who named the product Bacillus Calmette-Guérin, or BCG. The vaccine is administered shortly after birth only in infants.

3. Emphysema

- Emphysema is chronic breathlessness caused by gradual breakdown of the thin walls of the alveoli decreasing the total surface area of a gaseous exchange.

- Widening of the alveoli is called emphysema. The major cause for this disease is cigarette smoking, which reduces the respiratory surface of the alveolar wall.

4. Asthma

- A condition in which a person's airways become inflamed, narrow and swell and produce extra mucus, which makes it difficult to breathe.
- Asthma may cause difficulty breathing, chest pain, cough and wheezing. The symptoms may sometimes flare up.
- Asthma is characterized by recurrent episodes of wheezing, shortness of breath, chest tightness, and coughing.

5. Bronchitis

- Inflammation of the lining of bronchial tubes, which carry air to and from the lungs. Acute bronchitis is often caused by a viral respiratory infection and improves by itself.
- Symptoms of bronchitis include coughing up thickened mucus and shortness of breath.
- Treatments usually includes soothing remedies to help with coughing, which may last weeks. Antibiotics are not usually recommended.

6. Pneumonia

- Pneumonia is an infection that inflames the air sacs in one or both lungs.
- The air sacs may fill with fluid or pus (purulent material), causing cough with phlegm or pus, fever, chills, and difficulty breathing. A variety of organisms, including bacteria, viruses and fungi, can cause pneumonia.

Effects of Smoking

- Lungs Damage: Smoking cigarettes affects lung health because a person breathes in not only nicotine but also a variety of additional chemicals.
- Smoking cigarettes can damage the heart, blood vessels, and blood cells.
- Smoking cigarettes can damage a female's reproductive system and make it more difficult to get pregnant. This may be because tobacco and the other chemicals in cigarettes affect hormone levels.
- Smoking cigarettes can weaken a person's immune system, making them more susceptible to illness.
- People, who smoke have double the risk of gum disease. This risk increases with the number of cigarettes a person smokes.
- Smoking tobacco can affect a person's skin and hair.

- A person who smokes may experience prematurely aged, wrinkled skin. They also have a higher risk of skin cancer, “especially on the lips.”
- In addition to the well-documented link with lung cancer, smoking cigarettes can also contribute to other forms of cancer.