Unit 10

Human Respiratory System

STUDENTS LEARNING OUTCOMES (SLO's)

After studying this unit, the students will be able to

- *Define the respiratory surface and list its properties*
- *Describe the main structural features and functions of the components of human respiratory system.*
- *Explain the ventilation mechanism in humans.*
- *Describe the transport of oxygen and carbon dioxide through blood.*
- *Outline the role of respiratory pigments.*
- *State the causes, symptoms and treatment of upper Respiratory Tract Infections (sinusitis, otitis media) and lower Respiratory Tract Infections (pneumonia, pulmonary tuberculosis).*
- *Describe the disorders of lungs (emphysema and COPD).*

INTRODUCTION

You have studied in your previous class how organisms get energy out of food molecules. For this purpose, organisms carry out catabolic processes in their cells, collectively called cellular respiration (glycolysis, Krebs cycle, and electron transport chain) These processes use oxygen and produce carbon dioxide. The term external respiration is used for the uptake of oxygen from the environment and the disposal of carbon dioxide into the environment at the body system level. It involves breathing and the exchange of oxygen and carbon dioxide in the capillaries. The organs which carry out these processes constitute the respiratory system. The theme of this chapter is to explain the respiratory system of humans and important respiratory disorders.

10.1 RESPIRATORY SYSTEM OF MAN

It consists of the organs that carry out external respiration (uptake of oxygen and disposal of carbon dioxide) at the body system level. The main organs of respiratory systems are the lungs which provide suitable respiratory surface for this gaseous exchange.

Q 1. What is meant by the respiratory surface, and what are the properties that enable it to effectively perform gaseous exchange?

Ans. Respiratory Surface

The respiratory surface refers to the area where the actual gas exchange occurs between the environment and the blood. This gaseous exchange takes place through the process of diffusion. In humans and other vertebrates that breathe in air, oxygen from the air diffuses into the blood, and carbon dioxide diffuses from the blood into the air.

Properties of the Respiratory Surface

The following properties enable respiratory surfaces to effectively carry out the diffusion of gases across them.

1. **It is moist and permeable** – so that gases may pass through it.
2. **It is thin** – so that gases have to travel a minimum distance.
3. **It has a blood supply** – so that gases can diffuse in and out of the blood.
4. **It has structural support** – so that it remains open and does not collapse.
5. **It is located internally** – so that its moist surface does not lose water to the atmosphere.
6. **Air ventilates over it** – i.e., moves towards and away from it.
7. **Air reaches it after passing a branched tubular way** – so that air becomes saturated with water vapour before reaching it.

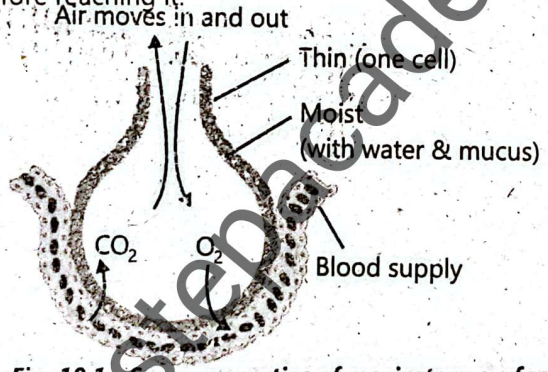

Fig. 10.1 – Some properties of respiratory surface

Our cells obtain oxygen from the blood. The blood obtains this oxygen from air present in our lungs. Oxygen diffuses across the wet membranes of the lungs, which are filled with air in the process of breathing.

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MCQs

1. **What is the function of the respiratory surface?**
   A). To store oxygen
   B). To transport oxygen to tissues
   C). To exchange gases between the environment and blood ✓
   D). To absorb nutrients

2. **How does gaseous exchange occur at the respiratory surface?**
   A). Through active transport B). Through osmosis
   C). Through diffusion ✓ D). Through filtration

3. **In humans, which gas diffuses from the blood into the air?**
   A). Oxygen B). Nitrogen
   C). Carbon dioxide ✓ D). Hydrogen

4. **What property of the respiratory surface allows gases to pass through it?**
   A). It is dry and thick
   B). It is moist and impermeable
   C). It is moist and permeable ✓
   D). It is rigid and dry

Why should the respiratory surface be thin?

A). To retain water
B). So, gases travel a minimum distance ✓
C). To allow blood circulation
D). To prevent air entry

What is the importance of blood supply to the respiratory surface?

A). To warm the surface
B). To supply nutrients
C). So, gases can diffuse in and out of blood ✓
D). To remove waste

What keeps the respiratory surface open and prevents it from collapsing?

A). Blood vessels
B). Structural support ✓
C). Cilia
D). Mucus

Why is the respiratory surface located internally in vertebrates?

A). To avoid air contact
B). To reduce heat loss
C). So, it does not lose water to the atmosphere ✓
D). To make breathing difficult

9. What is meant by air ventilates over the respiratory surface?

A). Air flows only once through it
B). Air becomes stagnant
C). Air moves towards and away from it ✓
D). Air is completely filtered

10. Why does air pass through a branched tubular way before reaching the respiratory surface?

A). To remove oxygen
B). To cool it down
C). So, air becomes saturated with water vapour ✓
D). To reduce pressure

1. What is meant by the respiratory surface?

Ans. Respiratory surface means the area where actual gas exchange occurs between the environment and the blood. This gaseous exchange occurs through diffusion. In humans and other vertebrates which breathe in air, oxygen from the air diffuses into the blood and carbon dioxide diffuse from the blood to air.

2. How does gas exchange occur at the respiratory surface?

Ans. Gas exchange at the respiratory surface occurs through the process of diffusion. In this process, oxygen from the air diffuses into the blood, and carbon dioxide diffuses from the blood into the air. This exchange of gases happens at the respiratory surface, which serves as the interface between the environment and the circulatory system.

3. Why must the respiratory surface be moist and permeable?

Ans. The respiratory surface must be moist and permeable so that gases may pass through it. Moisture helps dissolve gases, which is essential for their diffusion across cell membranes. Permeability allows the respiratory surface to facilitate the movement of oxygen into the blood and carbon dioxide out of the blood.

4. What structural features support efficient gas exchange at the respiratory surface?

Ans. Several structural features support efficient gas exchange at the respiratory surface. It is thin, so that gases have to travel a minimum distance. It has a blood supply, so that gases can diffuse in and out of the blood. It also has structural support so that it remains open and does not collapse. These features collectively enable effective diffusion of gases.

5. How is the respiratory surface protected from drying out, and how is air prepared before reaching it?

Ans. The respiratory surface is located internally so that its moist surface does not lose water to the atmosphere. Air ventilates over it, i.e., moves towards and away from it. Moreover, air reaches the respiratory surface after passing a branched tubular way, so that air becomes saturated with water vapour before reaching it. These adaptations help maintain moisture and protect the respiratory surface from drying out.

2. What is the Upper Respiratory Tract and what are the roles and structures of its components?

Ans. Components of Human Respiratory System

The organs of the respiratory system form a continuous system of passages, called the **respiratory tract**, through which air flows into and out of the body. The respiratory tract has two major divisions: the upper respiratory tract and the lower respiratory tract.

Upper Respiratory Track

It consists of nasal cavity, pharynx and larynx. These organs are involved in the movement of air into and out of the body. They also clean, humidify, and warm the incoming air. No gas exchange occurs in these organs.

Nasal Cavity

- The external openings of the nose, called **nostrils**, lead to a **nasal cavity**.
- It is a large, air-filled space behind the nose and is partitioned by a **nasal septum** (a part of the nasal bone).
- As inhaled air flows through the nasal cavity, it is **warmed and humidified** by blood vessels present very close to its surface.

- **Hairs in the nose** and **mucous** produced by mucous membranes trap larger foreign particles in the air before they go deeper into the respiratory tract.
- In addition to its respiratory functions, the nasal cavity also contains **chemoreceptors** needed for the sense of smell, and contributes to the sense of taste.

2. Pharynx

- The **pharynx** is a tube-like structure that connects the nasal cavity and oral cavity to the **larynx** and **oesophagus**.
- Both air and food pass through it, so it is part of both the **respiratory** and the **digestive systems**.
- **Air** passes from the nasal cavity through the pharynx to the larynx (as well as in the opposite direction).
- **Food** passes from the mouth through the pharynx to the oesophagus.

3. Larynx

- The **larynx** connects the pharynx and trachea. It is composed of muscles and cartilages.
- It is also called the **voice box**, because it contains two bands of smooth muscles called **vocal cords**.
- The vocal cords vibrate when air flows over them and so produce **sound**.
- The **epiglottis** is a cartilaginous flap that extends in front and above the opening of the larynx, called the **glottis**.
- When air enters the larynx, the epiglottis remains standing upwards to allow air passage.
- When we swallow, the backward motion of the tongue raises the larynx.
- This causes the epiglottis to be forced downwards, closing the glottis.
- This action prevents swallowed material from entering the larynx.

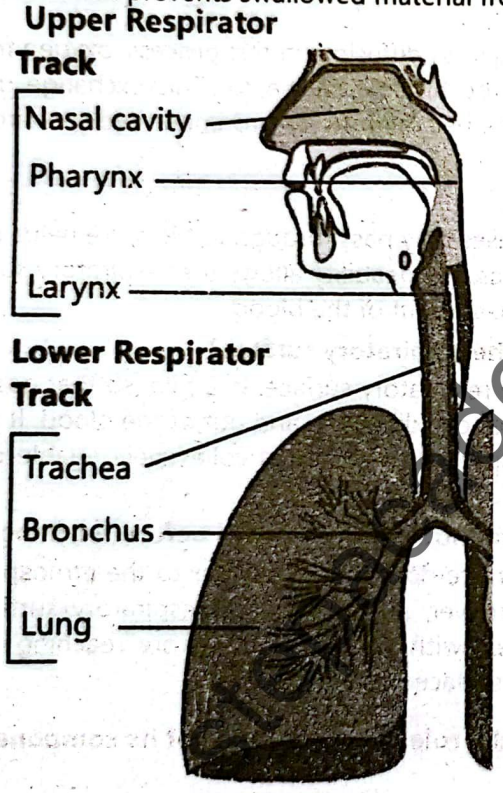


Fig. 10.2 – Respiratory Tract

Muscles in the larynx move the vocal cords apart to allow breathing. Other muscles in the larynx move the vocal cords together to allow the production of vocal sounds. The latter muscles also control the pitch of sounds and help control their volume.

If swallowed material does start to enter the larynx, it irritates the larynx and stimulates a strong cough reflex. This generally expels the material out of the larynx, and into the throat.

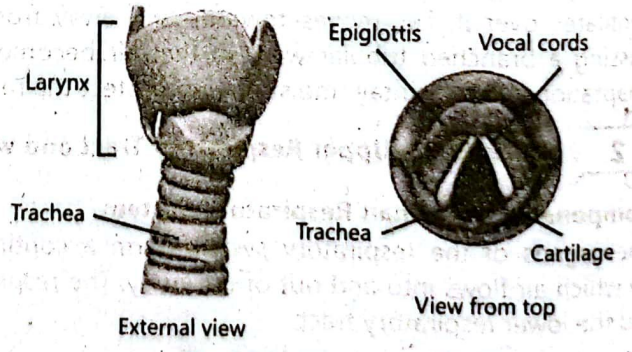


Fig. 10.3 - Larynx and Trachea

MCQs ✓

1. **Which of the following is *not* a part of the upper respiratory tract?**
   A) Nasal cavity B) Pharynx
   C) Trachea ✓ D) Larynx

2. **What is the main function of the organs in the upper respiratory tract?**
   A) Gas exchange B) Transport of nutrients
   C) Movement of air, cleaning, humidifying, and warming it ✓
   D) Circulation of blood

3. **The nasal cavity is partitioned by?**
   A) Nasal membrane B) Mucous gland
   C) Nasal septum ✓ D) Vocal cord

4. **What happens to air as it passes through the nasal cavity?**
   A) It is exhaled immediately
   B) It becomes dry
   C) It is warmed and humidified ✓
   D) It is used for gas exchange

5. **What structures trap foreign particles in the nasal cavity?**
   A) Blood vessels and muscles B) Bones and cartilage
   C) Hairs and mucous ✓ D) Cartilage and glottis

6. **What sensory functions are associated with the nasal cavity?**
   A) Sight and touch B) Hearing and balance
   C) Smell and taste ✓ D) Taste and hearing

7. **The pharynx connects the nasal and oral cavities to the?**
   A) Nasal septum and trachea
   B) Larynx and oesophagus ✓
   C) Epiglottis and glottis
   D) Trachea and bronchi

8. **Which statement about the pharynx is true?**
   A) It is only part of the respiratory system
   B) It allows only food to pass through
   C) It is part of both respiratory and digestive systems ✓
   D) It connects the mouth to the nasal cavity only

9. **Why is the larynx also called the voice box?**
   A) It filters air B) It allows tasting
   C) It contains vocal cords that produce sound ✓
   D) It connects to the stomach

10. **What prevents food from entering the larynx during swallowing?**
    A) Vocal cords B) Nasal septum
    C) Glottis D) Epiglottis ✓

SQ

1. **What organs make up the upper respiratory tract and what are their functions?**
   Ans. The upper respiratory tract consists of the nasal cavity, pharynx, and larynx. These organs are involved in the movement of air into and out of the body. They also clean, humidify, and warm the incoming air. No gas exchange occurs in these organs.

2. **What are nostrils and what do they lead to?**
   Ans The external openings of the nose are called nostrils. These nostrils lead to a nasal cavity, which is a large, air-filled space behind the nose.

3. **What is the structure and role of the nasal septum?**
   Ans The nasal cavity is partitioned by a nasal septum, which is a part of the nasal bone. This septum divides the nasal cavity and helps support the structure of the nose.

4. **How does the nasal cavity condition the inhaled air?**
   Ans As inhaled air flows through the nasal cavity, it is warmed and humidified by blood vessels present very close to its surface. This conditioning helps prepare the air before it enters the lower respiratory tract.

5. **What role do hairs and mucous in the nasal cavity play?**
   Ans. Hairs in the nose and mucous produced by mucous membranes trap larger foreign particles in the air before they go deeper into the respiratory tract. This helps to clean the air.

6. **Besides respiration, what sensory functions does the nasal cavity perform?**
   Ans. In addition to its respiratory functions, the nasal cavity also contains chemoreceptors needed for the sense of smell, and it contributes to the sense of taste.

7. **What is the pharynx and what systems is it part of?**
   Ans. The pharynx is a tube-like structure that connects the nasal cavity and oral cavity to the larynx and oesophagus. Both air and food pass through it, so it is part of both the respiratory and the digestive systems.

8. **How do air and food pass through the pharynx?**
   Ans. Air passes from the nasal cavity through the pharynx to the larynx, as well as in the opposite direction. Food passes from the mouth through the pharynx to the esophagus.

9. What is the structure and function of the larynx?

Ans. The larynx connects the pharynx and trachea. It is composed of muscles and cartilages. It is also called the voice box because it contains two bands of smooth muscles called vocal cords. The vocal cords vibrate when air flows over them and so produce sound.

10. What is the function of the epiglottis and how does it work?

Ans. The epiglottis is a cartilaginous flap that extends in front and above the opening of the larynx called the glottis. When air enters the larynx, the epiglottis keeps standing upwards to give way to air. When we swallow something, the backward motion of the tongue raises the larynx. Due to it, the epiglottis is forced downwards to close the glottis. It prevents swallowed material from entering the larynx.

Q 3. Describe in detail the structure and function of the Lower Respiratory Tract?

Ans. Lower Respiratory Tract

The **lower respiratory tract** includes trachea, bronchi, bronchioles, and lungs. The trachea, bronchi, and bronchioles conduct air from the upper respiratory tract into the lungs. These passages make a tree-like shape, with repeated branching. There are an astonishing **2,414 kilometers** of airways conducting air through the human respiratory tract! It is only in the lungs, however, that gas exchange occurs between the air and blood.

1. Trachea

Structure

The trachea, or windpipe, is about **1 inch wide** and **4–6 inches long**.

Its walls are made of smooth muscles and C-shaped rings of cartilage.

Function

Connects the **larynx** to the lungs for the passage of air.

It is the widest passageway in the respiratory tract.

Lining and Protection

The trachea is lined with **mucus** and **cilia**.

The **cilia** propel foreign particles trapped in the mucus toward the **pharynx**.

Support

The **C-shaped cartilage rings** provide strength and support to keep the trachea open.

Branching

At its lower end, the trachea branches to form two **bronchi**.

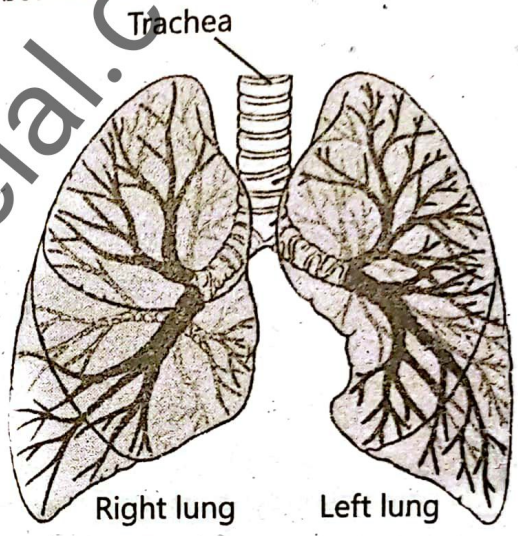


Fig. 10.4 – Tree-like branching of the lower respiratory tract

2. Bronchi, Bronchioles, and Alveoli

Primary Bronchi

There are two **primary bronchi** (singular: bronchus): the **right** and **left**.

These bronchi enter the lungs and branch into **secondary bronchi**.

Secondary Bronchi

The right lung has three secondary bronchi, and the left lung has two.

In the secondary bronchi, the **C-shaped cartilage rings** are replaced with **cartilage plates**.

Tertiary Bronchi and Bronchioles

The secondary bronchi branch into **tertiary bronchi**.

These further branch into smaller tubes called **bronchioles**.

Bronchioles do **not** have cartilage plates.

They divide many times and give rise to **terminal bronchioles**.

Alveoli

Terminal bronchioles end in **alveolar ducts**, which terminate in clusters of tiny air sacs called **alveoli** (singular: alveolus).

Alveoli are the primary sites for **gas exchange** in the lungs.

3. Lungs

Structure and Membranes

The lungs are the largest organs of the respiratory tract. The outside of each lung is covered by two membranes. First membrane, visceral pleura, lines the lungs while the second membrane, parietal pleura, lines the inner wall of thoracic cavity. The small space between these two membranes, called **pleural cavity**, is filled with fluid. This fluid allows the lungs to expand and contract freely during breathing.

Lobes

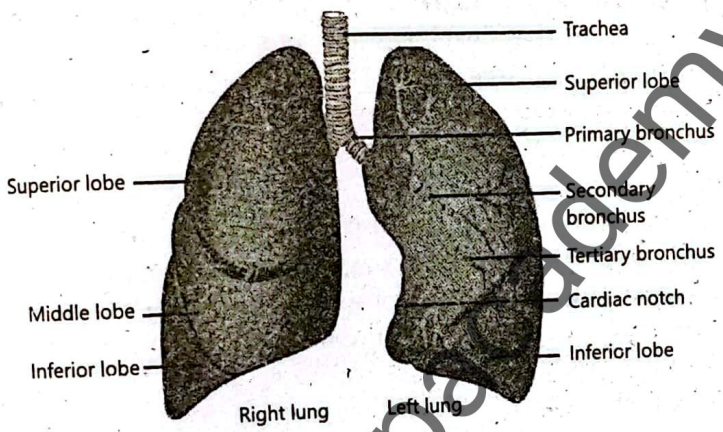
Each lung is divided into lobes. The right lung is larger and contains three lobes. The left lung is smaller and contains two lobes. The smaller left lung allows room for the heart, which is just left of the center of the chest.

Alveoli and Bronchioles

As mentioned previously, the terminal bronchi end in alveolar ducts. Each alveolar duct opens in a cluster of alveoli. These clusters make the bulk of the lung and are surrounded by blood capillaries. Each cluster contains **20–30 alveoli**. An alveolus is made of moist epithelial tissue **(only 0.1 micrometre thick).** So, they provide the respiratory surface where gas exchange takes place between the air and blood. The alveoli are the functional units of the lungs where gas exchange takes place.

Gas Exchange

Lungs contain approximately **480 million alveoli (range: 274–790 million)** per lung pair in adult humans. They provide a huge total surface area for gas exchange. When we breathe in, the alveoli fill with air, making the lungs expand. Oxygen in the air inside the alveoli is absorbed by the blood via diffusion in the network of tiny capillaries that surround them. The blood in these capillaries also releases carbon dioxide (also by diffusion) into the air inside the alveoli. When we breathe out, air leaves the alveoli and rushes into the outside atmosphere, carrying carbon dioxide with it.



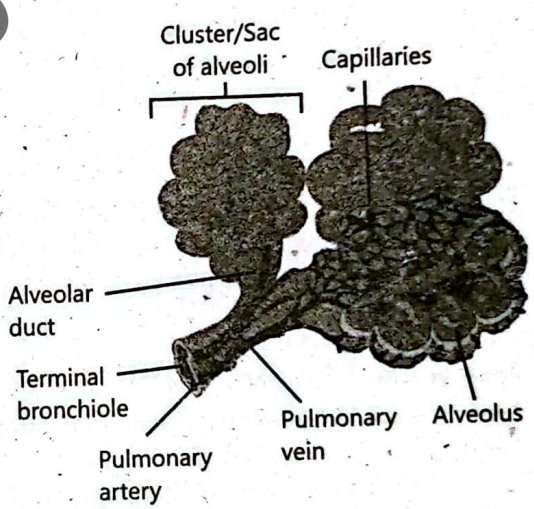


Fig. 10.6 - Clusters of alveoli

You have studied that pulmonary arteries carry deoxygenated blood to the lungs. This blood absorbs oxygen in the lungs and pulmonary veins carry the oxygenated blood back to the heart to be pumped throughout the body. The lungs also receive oxygenated blood from the heart that provides oxygen to the cells of the lungs for cellular respiration.

Some epithelial cells of alveoli secrete a liquid called surfactant, which lines the inside of alveoli. It prevents the constantly alveoli from collapsing and sticking together when air moves out of them. In healthy lungs, surfactant is secreted reabsorbed.

1. **Which of the following structures is not part of the lower respiratory tract?**
   a) Trachea b) Bronchi
   c) Larynx ✓ d) Lungs
2. **What is the function of cilia lining the trachea?**
   a) They produce mucus b) They absorb oxygen
   c) They propel foreign particles trapped in mucus toward the pharynx ✓
   d) They exchange gases
3. **The trachea branches at the bottom to form?**
   a) Alveoli b) Two bronchi ✓
   c) Two lungs d) Two pleurae
4. **How many secondary bronchi are found in the right lung?**
   a) One b) Two
   c) Three ✓ d) Four
5. **Which of the following structures lack cartilage plates?**
   a) Primary bronchi b) Secondary bronchi
   c) Tertiary bronchi d) Bronchioles ✓
6. **The terminal bronchioles end in?**
   a) Alveolar sacs b) Alveolar ducts ✓
   c) Secondary bronchi d) Pleural cavities
7. **What covers the outer surface of the lungs?**
   a) Parietal pleura b) Bronchioles
   c) Visceral pleura ✓ d) Alveoli
8. **Why is the left lung smaller than the right lung?**
   a) It has fewer lobes b) It has less oxygen
   c) To make space for the heart ✓
   d) It contains fewer bronchi
9. **What is the thickness of the epithelial tissue that makes up an alveolus?**
   a) 1 micrometre b) 0.5 micrometre
   c) 0.1 micrometre ✓ d) 2 micrometres
10. **How does gas exchange occur in the alveoli?**
    a) Active transport b) Osmosis
    c) Diffusion between alveoli and surrounding capillaries ✓
    d) Secretion of enzymes

SQ

1. **What structures are included in the lower respiratory tract?**

Ans. The lower respiratory tract includes trachea, bronchi, bronchioles, and lungs. The trachea, bronchi, and bronchioles conduct air from the upper respiratory tract into the lungs. These passages make a tree-like shape, with repeated branching. There are an astonishing 2,414 kilometres of airways conducting air through the human respiratory tract! It is only in the lungs, however, that gas exchange occurs between the air and blood.

2. **What is the structure and function of the trachea?**

Ans. Trachea, or windpipe, connects the larynx to the lungs for the passage of air. It is the widest passageway in the respiratory tract. It is about 1 inch wide and 4–6 inches long. Its walls are made of smooth muscles and C-shaped rings of cartilage. The trachea is lined with mucus and cilia. The cilia propel foreign particles trapped in the mucus toward the pharynx. The C-shaped cartilage provides strength and support to the trachea to keep the passage open. The trachea branches at the bottom to form two bronchi.

3. **How are the bronchi structured and how do they branch?**

Ans. There are two primary bronchi (singular, bronchus). The right and left bronchi enter the lungs and branch into smaller, secondary bronchi. There are two secondary bronchi in left lung while three in right lung. In secondary bronchi, the C-shaped cartilages are replaced with cartilage plates.

4. **What are tertiary bronchi and how do they lead to alveoli?**

Ans. The secondary bronchi branch into still smaller tertiary bronchi, which branch further into very small bronchioles. The bronchioles do not have cartilage plates. They divide many times and make terminal bronchioles. The terminal bronchioles end in alveolar ducts, which terminate in clusters of tiny air sacs, called alveoli (singular, alveolus), in the lungs.

5. **What are the lungs and how are they protected?**

Ans. The lungs are the largest organs of the respiratory tract. The outside of each lung is covered by two membranes. First membrane, visceral pleura, lines the lungs while the second membrane, parietal pleura, lines the inner wall of thoracic cavity. The small space between these two membranes, called pleural cavity, is filled with fluid. This fluid allows the lungs to expand and contract freely during breathing.

6. **How are the lungs divided and what is the difference between the right and left lungs?**

Ans. Each lung is divided into lobes. The right lung is larger and contains three lobes. The left lung is smaller contains two lobes. The smaller left lung allows room for the heart, which is just left of the centre of the ches

7. How do terminal bronchioles connect to alveoli?

Ans. As mentioned previously, the terminal bronchi end in alveolar ducts. Each alveolar duct opens in a cluster of alveoli. These clusters make the bulk of the lung and are surrounded by blood capillaries. Each cluster contains 20–30 alveoli.

8. What is the structure of an alveolus?

Ans. An alveolus is made of moist epithelial tissue (only 0.1 micrometre thick). So, they provide the respiratory surface where gas exchange takes place between the air and blood. The alveoli are the functional units of the lungs where gas exchange takes place.

9. How many alveoli are present in human lungs and what is their function?

Ans. Lungs contain approximately 480 million alveoli (range: 274–790 million) per lung pair in adult humans. They provide a huge total surface area for gas exchange.

10. How does gas exchange take place in the alveoli?

Ans. When we breathe in, the alveoli fill with air, making the lungs expand. Oxygen in the air inside the alveoli is absorbed by the blood via diffusion in the network of tiny capillaries that surround them. The blood in these capillaries also releases carbon dioxide (also by diffusion) into the air inside the alveoli. When we breathe out, air leaves the alveoli and rushes into the outside atmosphere, carrying carbon dioxide with it.

4. What is the Mechanism of Breathing or Ventilation?

Ans. The movement of the air in and out of the body is called **breathing or ventilation.** Our lungs do not draw in air or push it out. Rather, it is done by creating negative and positive pressures in the lungs.

This role is played by two sets of muscles i.e.,

1. diaphragm (dome-like large skeletal muscle that separates thoracic cavity and abdomen) and
2. the intercostal muscles (present between each pair of ribs).

Inspiration

Definition

Taking in of air is called inspiration or inhalation.

Role of Diaphragm

For this purpose, the diaphragm contracts. It causes the diaphragm to lower and take a more flattened shape.

Role of Intercostal Muscles

At the same time, the intercostal muscles contract. It raises the ribs and expands the rib cage.

Resulting Changes in Thorax

These contractions increase the space in the thorax. As a result, lungs expand because of the adherence of the visceral and parietal pleural membranes.

Change in Pressure and Air Entry

The expansion of lungs lowers the air pressure inside them. The pressure in lungs becomes lower than the atmospheric pressure and the air enters the lungs.

Atmospheric pressure is lower at high altitudes. It means a greater increase in thorax is required to make the pressure in lungs lower than the atmospheric pressure. That is why it is harder to breathe at high altitudes. The body adapts mechanisms to improve oxygen uptake under these conditions, which is why athletes often undertake high altitude training prior to competitions.

Birds have lungs as well as air sacs in their body. Air flows in one direction. It flows from outside to posterior air sacs. For here, the air goes to the lungs, then to anterior air sacs, and then outside. The flow of air is in the opposite direction from blood flow. So, gas exchange takes place much more efficiently. This type of breathing enables birds to obtain the required oxygen, even at high altitudes where oxygen concentration is low.

Expiration

Definition

Moving the air out of lungs is called **expiration** or **exhalation.**

Elastic Tension from Inspiration

Expansion of the thorax and lungs during inspiration places these structures under elastic tension.

Muscle Relaxation

This elastic tension is relieved by the relaxation of the intercostal muscles and diaphragm.

Role of Diaphragm

When diaphragm relaxes, it assumes its dome-like shape.

Role of Intercostal Muscles

Similarly, when intercostal muscles relax, the ribs lower and rib cage moves inward.

Reduction in Thoracic Space and Lung Recoil

These movements decrease the space in thorax and allow the lungs to recoil.

Change in Pressure and Air Exit

So, the pressure inside lungs becomes more than the atmospheric pressure and the air moves out of the lungs.

How is Breathing Controlled?

Each breath is initiated by neurons in a respiratory centre located in the medulla oblongata i.e., a part of the brain stem. These neurons send impulses to the diaphragm and intercostal muscles, stimulating them to contract, causing inspiration. When these neurons stop producing impulses, the diaphragm and intercostal muscles relax and expiration occurs.

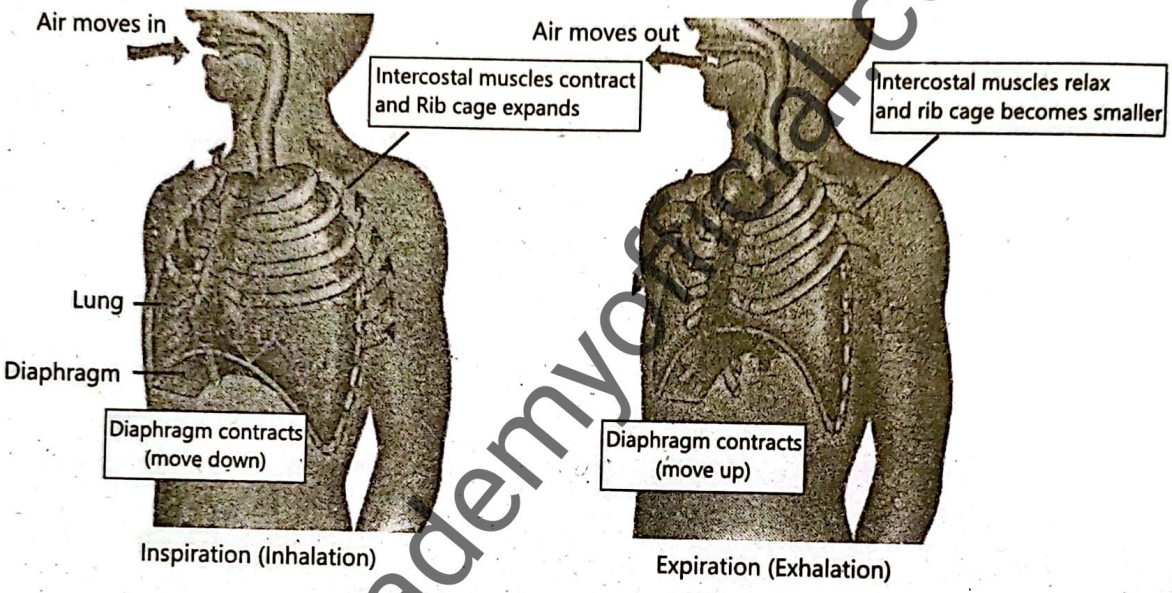


Fig. 10.7 - Mechanism of breathing

For Board Exam & MDCAT MCQs

1. **What is breathing or ventilation?**
   a) Movement of food in the digestive tract
   b) Movement of air in and out of the body ✓
   c) Movement of blood in arteries
   d) Movement of muscles during exercise
2. **Which muscle separates the thoracic cavity and abdomen?**
   a) Intercostal muscle b) Diaphragm ✓
   c) Cardiac muscle d) Skeletal muscle of the arm
3. **What is the role of the diaphragm in breathing?**
   a) It relaxes to inhale air
   b) It contracts and lowers to help inspiration ✓
   c) It contracts to push air out of the lungs
   d) It moves the ribs outward
4. **What do the intercostal muscles do during inspiration?**
   a) Relax and lower the ribs
   b) Contract and raise the ribs ✓
   c) Contract and lower the diaphragm
   d) Expand the abdominal cavity
5. **What happens to the thoracic space during inspiration?**
   a) It decreases b) It remains the same
   c) It increases ✓ d) It collapses
6. **Why do the lungs expand during inspiration?**
   a) Because the ribs lower
   b) Due to the adherence of visceral and parietal pleural membranes ✓
   c) Due to contraction of the heart muscles
   d) Because the diaphragm relaxes
7. **When the lungs expand during inspiration, what happens to the air pressure inside them?**
   a) It increases above atmospheric pressure
   b) It remains equal to atmospheric pressure
   c) It decreases below atmospheric pressure ✓
   d) It becomes zero

8. **What is expiration?**
a) Taking air into the lungs
b) Moving air out of the lungs ✓
c) Exchanging oxygen in the alveoli
d) Contraction of the diaphragm

9. **What causes the elastic tension in the lungs during breathing?**
a) Expansion of thorax and lungs during inspiration ✓
b) Contraction of abdominal muscles
c) Pressure from outside air
d) Movement of blood in lungs

10. **What happens to the diaphragm during expiration?**
a) It contracts and flattens
b) It relaxes and assumes dome-like shape ✓
c) It raises the ribs
d) It expands the thoracic cavity

11. **What is the movement of the ribs during expiration?**
a) Ribs move outward b) Ribs move upward
c) Ribs lower and rib cage moves inward ✓
d) Ribs do not move

12. **How does lung recoil affect air pressure inside the lungs?**
a) Decreases pressure below atmospheric
b) Pressure stays the same
c) Increases pressure above atmospheric ✓
d) No effect on pressure

13. **Where is the respiratory centre controlling breathing located?**
a) Cerebellum b) Medulla oblongata ✓
c) Cerebrum d) Spinal cord

14. **What triggers inspiration in the breathing process?**
a) Relaxation of intercostal muscles
b) Neurons in the respiratory centre sending impulses to diaphragm and intercostal muscles ✓
c) Increase in carbon dioxide in lungs
d) Pressure changes in the alveoli

15. **What causes expiration to occur?**
a) Continuous impulses from the brain
b) Relaxation of diaphragm and intercostal muscles ✓
c) Contraction of diaphragm only
d) Air pressure outside becoming lower than inside lungs

SQ

1. **What is breathing or ventilation?**
Ans. The movement of the air in and out of the body is called breathing or ventilation. Our lungs do not draw in air or push it out. Rather, it is done by creating negative and positive pressures in the lungs.

2. **Which muscles are involved in the mechanism of breathing?**
Ans. Two sets of muscles play a role in breathing: (i) the diaphragm, which is a dome-like large skeletal muscle that separates the thoracic cavity and abdomen, and (ii) the intercostal muscles, which are present between each pair of ribs.

3. **What happens during inspiration or inhalation?**
Ans. During inspiration or inhalation, the diaphragm contracts, causing it to lower and take a more flattened shape. At the same time, the intercostal muscles contract, raising the ribs and expanding the rib cage. These contractions increase the space in the thorax, causing the lungs to expand due to the adherence of the visceral and parietal pleural membranes.

4. **How does the expansion of lungs during inspiration affect air pressure inside the lungs?**
Ans. The expansion of the lungs lowers the air pressure inside them. The pressure in the lungs becomes lower than the atmospheric pressure, and as a result, air enters the lungs.

5. **What is expiration or exhalation?**
Ans. Expiration or exhalation is the process of moving air out of the lungs.

6. **How does the elastic tension create during inspiration influence expiration?**
Ans. The expansion of the thorax and lungs during inspiration places these structures under elastic tension. This elastic tension is relieved by the relaxation of the intercostal muscles and diaphragm, allowing expiration to occur.

7. **What changes occur in the diaphragm and intercostal muscles during expiration?**
Ans. When the diaphragm relaxes, it assumes its dome-like shape. Similarly, when the intercostal muscles relax, the ribs lower and the rib cage moves inward. These movements decrease the space in the thorax and allow the lungs to recoil.

8. **How does lung recoil affect air pressure and air movement during expiration?**
Ans. The recoil of the lungs increases the pressure inside the lungs, making it more than the atmospheric pressure. This causes the air to move out of the lungs.

9. **Where is the control center for breathing located?**
Ans. The control center for breathing is located in the medulla oblongata, which is a part of the brain stem.

10. How do neurons in the medulla oblongata control the process of breathing?

Ans. Neurons in the respiratory centre of the medulla oblongata send impulses to the diaphragm and intercostal muscles, stimulating them to contract, which causes inspiration. When these neurons stop producing impulses, the diaphragm and intercostal muscles relax, and expiration occurs.

10.2 TRANSPORT OF GASES

The process known as gas transport is an essential component of respiration. Oxygen is transported from lungs to all tissues and, at the same time, carbon dioxide is transported from tissue to the lungs. The following is a brief description of the mechanisms by which gases are transported in human body.

5. How does oxygen move from the alveoli into the blood, and how much oxygen dissolves in blood plasma compared to the total oxygen carried by blood? Also write a note on the factors affecting the transport of oxygen?

Ans. Transport of Oxygen

Diffusion and Binding

The partial pressure of oxygen in alveoli allows to diffuse through alveoli into pulmonary capillaries. Inside the blood, small amount of oxygen dissolves in the blood plasma. Blood plasma can dissolve a maximum of only about **3 mL O_2 per litre**. Yet whole blood carries almost **200 mL O_2 per litre**! The reason is that most of the oxygen is not dissolved in blood plasma but is bound to molecules of haemoglobin inside the **RBCs.**

Formation and Role of Oxyhaemoglobin

The partial pressure of oxygen in alveoli (at sea level) is approximately **105 mm Hg**, which is less than the partial pressure of oxygen in the atmosphere. So, about **97%** of the haemoglobin within **RBCs** combines with oxygen and becomes oxyhaemoglobin. This molecule has a bright red, tomato juice colour. As the blood travels through the blood capillaries, some of the oxyhaemoglobin releases oxygen and becomes a dark red coloured deoxyhaemoglobin.

Oxygen Release and Reserve

Consequently, when blood leaves the tissue in the veins, it has a low partial pressure of oxygen **(40 mm Hg).** Here, **75%** of haemoglobin is saturated in the form of oxyhaemoglobin. It means that **22% (97% minus 75%)** of the oxyhaemoglobin has released its oxygen to the tissues, leaving **78%** oxyhaemoglobin in the blood as a reserve. This large reserve of oxygen enables the blood to fulfil the body's oxygen needs during exercise as well as at rest.

Factors Affecting Oxygen Transport

Effect of Exercise on Oxygen Unloading

During exercise, the muscles use more oxygen from the capillary blood. It decreases the venous blood partial pressure of oxygen to **20 mm Hg**. In this case, the percent saturation of haemoglobin drops from **75% to 35%.** Because arterial blood still contains **97%** oxyhaemoglobin, the amount of oxygen unloaded is now **62% (97% minus 35%),** instead of the **22%** at rest.

Role of pH and Temperature (Bohr Effect)

The **CO_2** produced by tissues lowers the pH of blood. This lowered pH reduces haemoglobin's affinity for oxygen and thus causes it to release oxygen more readily. The effect of pH on haemoglobin's affinity for oxygen is known as the Bohr effect. Increasing temperature has a similar effect on haemoglobin's affinity for oxygen. During exercise, skeletal muscles produce more heat, haemoglobin unloads a higher percentage of the oxygen.

Oxyhaemoglobin is bright red while deoxyhaemoglobin is dark red. But deoxyhaemoglobin imparts a bluish tinge to tissues. Because of these color changes, vessels that carry oxygenated blood are always shown with a red color, and vessels that carry oxygen-depleted blood are indicated with a blue color.

The oxygen reserve also ensures that the blood contains enough oxygen to maintain life for four to five minutes if breathing is interrupted or if the heart stops pumping.

For Board Exam & MDCAT MCQs

1. What allows oxygen to diffuse from alveoli into pulmonary capillaries?

a) High oxygen concentration in blood
b) Partial pressure of oxygen in alveoli ✓
c) Carbon dioxide levels in alveoli
d) Temperature of the blood

2. **How much oxygen can blood plasma dissolve per litre?**
a) About 200 Ml
b) About 105 mL
c) About 3 mL ✓
d) About 50 mL

3. **Why does whole blood carry much more oxygen than what dissolves in plasma?**
a) Because of dissolved carbon dioxide
b) Because oxygen binds to haemoglobin inside RBCs ✓
c) Because plasma has high oxygen affinity
d) Because of blood pressure

4. **What is the partial pressure of oxygen in alveoli at sea level?**
a) Approximately 40 mm Hg
b) Approximately 105 mm Hg ✓
c) Approximately 75 mm Hg
d) Approximately 200 mm Hg

5. **What percentage of haemoglobin combines with oxygen in the alveoli?**
a) 40%
b) 75%
c) 97% ✓
d) 22%

6 **What colors does oxyhaemoglobin have?**
a) Dark red
b) Bright red (tomato juice color) ✓
c) Blue
d) Yellow

7. **What happens to oxyhaemoglobin as blood passes through the tissue capillaries?**
a) It binds more oxygen
b) It releases oxygen and becomes deoxyhaemoglobin ✓
c) It changes to plasma
d) It changes to carbon dioxide

8. **How much haemoglobin is saturated in venous blood leaving the tissues?**
a) 22%
b) 75% ✓
c) 97%
d) 35%

9. **During exercise, what happens to the percent saturation of haemoglobin in venous blood?**
a) It increases to 97%
b) It decreases to 35% ✓
c) It stays at 75%
d) It drops to 22%

10. **What is the Bohr's effect?**
a) Effect of oxygen pressure on haemoglobin
b) Effect of temperature on oxygen transport
c) Effect of pH on haemoglobin's affinity for oxygen ✓
d) Effect of carbon dioxide on blood plasma

SQ

1. **How does oxygen move from alveoli into pulmonary capillaries?**
Ans. The partial pressure of oxygen in alveoli allows oxygen to diffuse through alveoli into pulmonary capillaries.

2. **How much oxygen dissolves in blood plasma?**
Ans. Inside the blood, a small amount of oxygen dissolves in the blood plasma. Blood plasma can dissolve a maximum of only about 3 mL O2 per litre.

3. **How much oxygen does whole blood carry, and why is it more than what dissolves in plasma?**
Ans. Whole blood carries almost 200 mL O2 per litre. The reason is that most of the oxygen is not dissolved in blood plasma but is bound to molecules of haemoglobin inside the RBCs.

4. **What is the partial pressure of oxygen in alveoli at sea level?**
Ans. The partial pressure of oxygen in alveoli (at sea level) is approximately 105 mm Hg.

5. **How does the partial pressure of oxygen in alveoli compare to that in the atmosphere?**
Ans. The partial pressure of oxygen in alveoli is less than the partial pressure of oxygen in the atmosphere.

6. **What percentage of haemoglobin within RBCs combines with oxygen in the alveoli?**
Ans. About 97% of the haemoglobin within RBCs combines with oxygen and becomes oxyhaemoglobin.

7. **What is the color of oxyhaemoglobin?**
Ans. Oxyhaemoglobin has a bright red, tomato juice colour.

8. **What happens to oxyhaemoglobin as blood travels through the blood capillaries?**
Ans. Some of the oxyhaemoglobin releases oxygen and becomes a dark red coloured deoxyhaemoglobin.

9. **What is the partial pressure of oxygen in blood leaving the tissue in veins?**
Ans. When blood leaves the tissue in the veins, it has a low partial pressure of oxygen of about 40 mm Hg.

10. **What percentage of haemoglobin remains saturated in the form of oxyhaemoglobin in venous blood?**
Ans. About 75% of haemoglobin is saturated as oxyhaemoglobin in venous blood.

11. **How much oxyhaemoglobin releases oxygen to tissues at rest?**
Ans. About 22% (97% minus 75%) of the oxyhaemoglobin releases its oxygen to the tissues at rest.

12. **How much oxyhaemoglobin remains in the blood as a reserve after oxygen release at rest?**
Ans. About 78% of oxyhaemoglobin remains in the blood as a reserve.

13. **Why is this large reserve of oxygen important?**
Ans. This large reserve of oxygen enables the blood to fulfil the body's oxygen needs during exercise as well as at rest.

14. What happens to oxygen use by muscles during exercise?

Ans. During exercise, the muscles use more oxygen from the capillary blood.

15. How does exercise affect the partial pressure of oxygen in venous blood?

Ans. Exercise decreases the venous blood partial pressure of oxygen to about 20 mm Hg.

16. How does the percent saturation of haemoglobin change during exercise?

Ans. The percent saturation of haemoglobin drops from 75% to 35% during exercise.

17. What is the percentage of oxygen unloaded during exercise compared to rest?

Ans. The amount of oxygen unloaded is 62% (97% minus 35%) during exercise, instead of 22% at rest.

18. How does carbon dioxide produced by tissues affect blood pH?

Ans. The CO2 produced by tissues lowers the pH of blood.

19. What effect does lowered pH have on haemoglobin's affinity for oxygen?

Ans. The lowered pH reduces haemoglobin's affinity for oxygen and thus causes it to release oxygen more readily.

20. What is the Bohr's effect and how does temperature influence haemoglobin's oxygen affinity?

Ans. The effect of pH on haemoglobin's affinity for oxygen is known as the Bohr's effect. Increasing temperature has a similar effect on haemoglobin's affinity for oxygen. During exercise, skeletal muscles produce more heat, and haemoglobin unloads a higher percentage of oxygen.

6. Write a detailed note on the transport of carbon dioxide?

Ans. Introduction

Blood capillaries deliver oxygen to the tissues and remove carbon dioxide from tissues. The partial pressure of **CO_2** is higher in tissues than in blood. This causes carbon dioxide to enter from tissues into the blood. Conversely, in the lungs, the partial pressure of **CO_2** is lower in the alveoli than in the blood, so carbon dioxide moves out of the blood into the alveoli. Blood transports carbon dioxide from tissues to lungs in three different ways:

1. Transport as Bicarbonate Ions

Approximately **72% of carbon dioxide** is carried in the blood as **bicarbonate ions**.

- Carbon dioxide enters the red blood cells **(RBCs)** and combines with water to form **carbonic acid (H_2CO_3)** in the presence of the enzyme **carbonic anhydrase**.
- Carbonic acid **(H_2CO_3)** dissociates to form **hydrogen ions (H^+)** and **bicarbonate ions (HCO_3^-)**.
- The hydrogen ion readily associates with **oxyhaemoglobin**, and the oxygen of oxyhaemoglobin is released to the tissue.
- The **bicarbonate ions (HCO_3^-)** move out from **RBCs** into plasma.
- This movement is facilitated by a **transporter** that exchanges one **chloride ion (Cl^-)** for a bicarbonate ion—this process is called the **"chloride shift" or "Hamburger phenomenon"**.

2. Transport as Carboxyhaemoglobin

About 20% of carbon dioxide is carried as carboxyhaemoglobin.

- When the **partial pressure of CO_2** is higher in blood than tissues, **CO_2** combines with the **globin chains of haemoglobin** and forms **carboxyhaemoglobin**.

3. Transport as Dissolved CO_2 in Plasma

- When CO_2 enters the blood, **a little amount dissolves in the water of blood plasma**.
- About **8% of CO_2** is carried this way.

Conversion of Carbon Dioxide in Lungs

- The blood carries **CO_2** in these three forms to the lungs.
- The **lower partial pressure of CO_2 (PCO_2)** in the air inside the **alveoli** causes the conversion of **H_2CO_3 into H_2O and CO_2**.
- The **CO_2 diffuses out of the blood into the alveoli**, so that it can **leave the body in the next exhalation**.

The formation of carbonic acid is important in maintaining the acid base balance of the blood, because bicarbonate serves as the major buffer of the blood plasma.

CO_2 binds to the protein portion of haemoglobin while O_2 binds to the haem irons. So, both do not compete for attachment to haemoglobin.

Carbon Monoxide Poisoning Incomplete combustion of fuels such as wood, gasoline, propane, or natural gas produces **CO** gas. If gas heaters are left burning overnight in closed environments, **CO** accumulates in the room. It enters the body through inhalation and binds to haemoglobin with a much higher affinity than oxygen. This binding reduces the amount of haemoglobin available to transport oxygen to the body's tissues, leading to tissue hypoxia (oxygen deprivation). It leads to **CO** poisoning. Symptoms of **CO** poisoning may include headache, dizziness, weakness, nausea, confusion, shortness of breath, chest pain, and loss of consciousness. In severe cases, it can cause permanent brain damage, and even death.

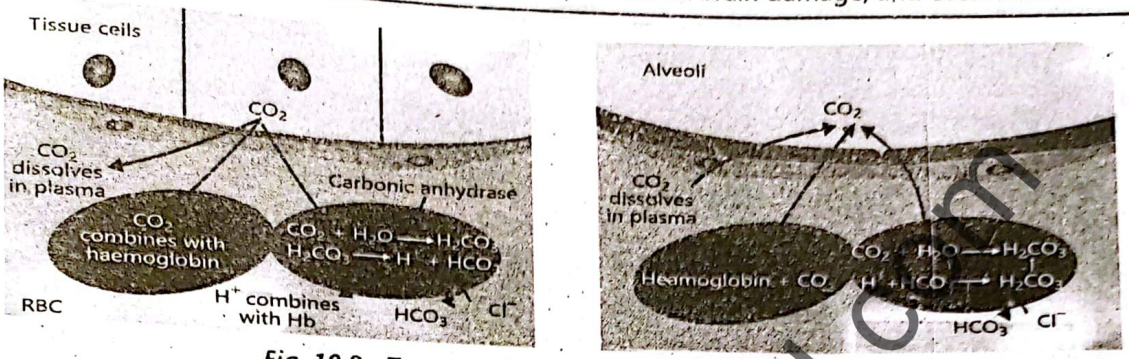


Fig. 10.8 - Transport of Carbon dioxide by blood

For Board Exam & MDCAT MCQs

1. **What causes carbon dioxide to enter the blood from tissues?**
   A) Higher partial pressure of CO_2 in blood
   B) Lower partial pressure of CO_2 in tissues
   C) Higher partial pressure of CO_2 in tissues ✓
   D) Equal partial pressure of CO_2 in blood and tissues
2. **In lungs, why does carbon dioxide move out of the blood?**
   A) Because oxygen concentration is high in alveoli
   B) Because blood pressure is high
   C) Because partial pressure of CO_2 is lower in alveoli than in blood ✓
   D) Because CO_2 is actively transported
3. **Which of the following forms carries the highest percentage of CO_2 in the blood?**
   A) Carboxyhaemoglobin B) Dissolved in plasma
   C) Bicarbonate ions ✓ D) Carbamino acid
4. **What enzyme helps CO_2 combine with water to form carbonic acid in RBCs?**
   A) Catalase B) Amylase
   C) Carbonic anhydrase ✓ D) Lipase
5. **What happens to carbonic acid inside red blood cells?**
   A) It evaporates
   B) It combines with oxygen
   C) It disassociates into hydrogen and bicarbonateions ✓
   D) It forms glucose
6. **What is the term for the exchange of bicarbonate and chloride ions across the RBC membrane?**
   A) Bohr's effect B) Salt bridge
   C) Proton pump
   D) Chloride shift or Hamburger phenomenon ✓
7. **How much carbon dioxide is transported as carboxyhaemoglobin?**
   A) 8% B) 72%
   C) 20% ✓ D) 50%
8. **With what part of haemoglobin does CO_2 combine to form carboxyhaemoglobin?**
   A) Iron B) Heme
   C) Globin chains ✓ D) Oxygen
9. **What percentage of carbon dioxide is transported dissolved in plasma?**
   A) 10% B) 72%
   C) 20% D) 8% ✓
10. **How is carbon dioxide finally removed from the body?**
    A) Through urine B) Absorbed by muscles
    C) Diffuses into alveoli and is exhaled ✓
    D) Stored in liver cells

SQ

1. **How do blood capillaries contribute to the exchange of gases in tissues?**
   Ans. Blood capillaries deliver oxygen to the tissues and remove carbon dioxide from tissues. The partial pressure of CO_2 is higher in tissues than in blood. It causes the carbon dioxide to enter from tissues into blood.
2. **What happens to carbon dioxide in the lungs in terms of partial pressure?**
   Ans. The process reverses in lungs where the partial pressure of CO_2 is lower in alveoli than in blood. This causes carbon dioxide to move out of the blood into the alveoli.
3. **How does blood transport carbon dioxide from tissues to lungs?**
   Ans. Blood transports carbon dioxide from tissues to lungs in three ways:
   1. As bicarbonate ions,
   2. As carboxyhaemoglobin, and
   3. As dissolved CO_2 in plasma.

4. How is carbon dioxide transported in the form of bicarbonate ions?

Ans. Approximately 72% of carbon dioxide is carried in the blood as bicarbonate ions. CO_2 enters the RBCs and combines with water to form carbonic acid (H_2CO_3) in the presence of enzyme carbonic anhydrase. Carbonic acid (H_2CO_3) disassociates to form hydrogen ions (H^+) and bicarbonate ions (HCO_3^-). The hydrogen ion readily associates with oxyhaemoglobin and oxygen of oxyhaemoglobin is released to the tissue. While the bicarbonate ions (HCO_3^-) move out from RBCs into plasma.

5. What is the role of the "chloride shift" or "Hamburger phenomenon" in carbon dioxide transport?

Ans. The movement of bicarbonate ions (HCO_3^-) out from RBCs into plasma is facilitated by a transporter that exchanges one chloride ion (Cl^-) for a bicarbonate ion. This is called the "chloride shift" or "Hamburger phenomenon".

6. How much carbon dioxide is carried as carboxyhaemoglobin, and how is it formed?

Ans. About 20% of CO_2 is carried as carboxyhaemoglobin. When partial pressure of CO_2 is higher in blood than tissues, CO_2 combines with the globin chains of haemoglobin and forms carboxyhaemoglobin.

7. How is carbon dioxide transported in dissolved form in blood plasma?

Ans. When CO_2 enters blood, a little amount dissolves in the water of blood plasma. About 8% of CO_2 is carried this way.

8. In what forms is CO_2 carried by the blood to the lungs?

Ans. The blood carries CO_2 to the lungs in three forms: as bicarbonate ions, as carboxyhaemoglobin, and as dissolved CO_2 in plasma.

9. What happens to carbonic acid in the lungs during the removal of carbon dioxide?

Ans. The lower PCO_2 of the air inside the alveoli causes the conversion of H_2CO_3 into H_2O and CO_2.

10. How is carbon dioxide finally removed from the body?

Ans. The CO_2 diffuses out of blood into the alveoli, so that it can leave the body in the next exhalation.

10.3 RESPIRATORY PIGMENTS

Respiratory pigments are special proteins in blood or tissues and are involved in transporting oxygen throughout body. They also serve for other purposes e.g., **O_2** storage, **CO_2** transport, and transport of substances other than respiratory gases. The two well-known respiratory pigments are haemoglobin and myoglobin.

7. Describe the structure and function of Haemoglobin and Myoglobin in detail.

Ans. Haemoglobin

Structure of Haemoglobin

Haemoglobin is a protein present in **RBCs.** A haemoglobin molecule is composed of four globin (globular) polypeptide chains **(two α chains and two β)** and four haem groups. There are **141 and 146** amino acids in the **α** and **β chains**, respectively. Each polypeptide chain is folded in such a way that it contains a pocket where the heme group binds. So, each chain is associated with a haem group.

Haem Group Composition

A haem group consists of an iron ion held in a porphyrin ring. The iron ion is attached with four nitrogen atoms of the polypeptide chain.

Oxygen Binding

Under higher partial pressure of oxygen, iron ion attaches a molecule of **O_2.** In this way, one haemoglobin molecule can carry up to four **O_2** molecules.

Myoglobin

Definition and Location

Myoglobin is the oxygen-binding protein in skeletal and cardiac muscle cells of vertebrates. It gives a distinct red or dark gray colour to muscles.

Structure of Myoglobin

It is a monomer, composing of a single polynucleotide chain **(made of 153 amino acids)** and contains a single haem group. Therefore, it is capable of binding with a single **O_2** molecule.

Function of Myoglobin

The binding affinity of myoglobin is high as compared to that of haemoglobin. As a result, myoglobin serves as the oxygen-storing protein in muscles. It releases oxygen when the partial pressure of oxygen is below **20 mm Hg.** In this way, myoglobin provides oxygen to the muscles when they need.

Haemoglobin	Myoglobin
Consists of four polypeptide chains.	Consists of one polypeptide chain.
Possesses four haem groups.	Possesses one haem group.
Found in blood (RBCs).	Found in skeletal and cardiac muscles.
Can attach four O_2 molecules.	Can attach one O_2 molecule.
Transports oxygen.	Stores oxygen.
Has less affinity with oxygen.	Has more affinity with oxygen.
Loses oxygen at PO_2 60 mm Hg.	Loses oxygen at PO_2 20 mm Hg.

Table 10.1: Differences between Haemoglobin and Myoglobin

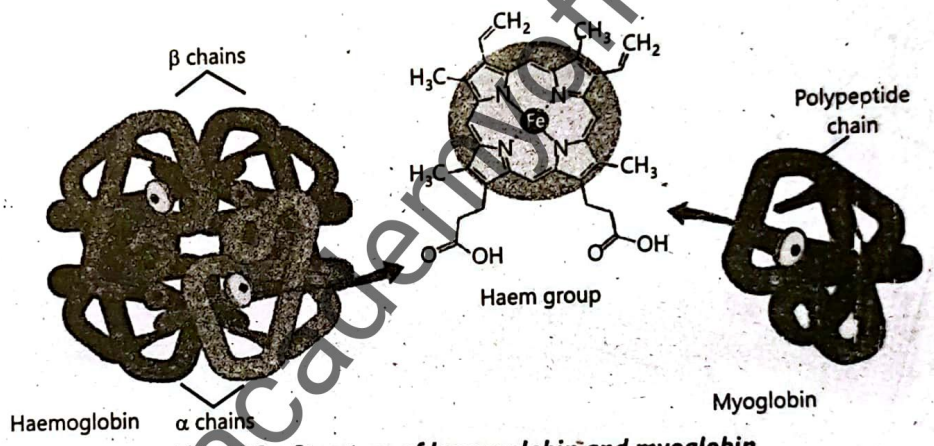


Fig. 10.9 - Structure of haemoglobin and myoglobin

The four polypeptide chains of haemoglobin are bound to each other by salt bridges, hydrogen bonds, and hydrophobic effect.

For Board Exam & MDCAT

MCQs

1. **What is the composition of a haemoglobin molecule?**
   A) Two β chains and two γ chains
   B) Four β chains
   C) Two α chains and two β chains ✓
   D) One α chain and one β chain

2. **How many amino acids are there in the α and β chains of haemoglobin respectively?**
   A) 120 and 130 B) 141 and 146 ✓
   C) 100 and 104 D) 153 and 160

3. **Where does the haem group bind in the haemoglobin molecule?**
   A) Inside the nucleus B) In the blood plasma
   C) In a pocket within each polypeptide chain ✓
   D) Between two globin chain

4. **What does the haem group consist of?**
   A) A calcium ion in a protein ring
   B) An iron ion held in a porphyrin ring ✓
   C) A potassium ion in a lipid ring
   D) A magnesium ion in a glucose ring

5. **How many oxygen molecules can one haemoglobin molecule carry?**
   A) One B) Two

C) Three D) Four ✓

6. **Under what condition does iron ion attach a molecule of oxygen?**
   A) Under lower partial pressure of oxygen
   B) At night only
   C) Under higher partial pressure of oxygen ✓
   D) Only during respiration

7. **What is myoglobin?**
   A) A blood protein in white blood cells
   B) A hormone in the brain
   C) The oxygen-binding protein in skeletal and cardiac muscle cells ✓
   D) A digestive enzyme

8. **What is the structural composition of myoglobin?**
   A) Four globin chains and four haem groups
   B) Two α chains and one haem group
   C) A single polynucleotide chain with a single haem group ✓
   D) Two β chains and two haem groups

9. **How many amino acids are present in the polynucleotide chain of myoglobin?**
   A) 141 B) 146
   C) 153 ✓ D) 160

10. **When does myoglobin release oxygen to the muscles?**
    A) When partial pressure of oxygen is above 40 mm Hg
    B) When partial pressure of oxygen is below 20 mm Hg ✓
    C) During digestion only
    D) Only when haemoglobin is absent

SQ

1. What is haemoglobin and what is its molecular structure?

Ans. Haemoglobin is a protein present in RBCs. A haemoglobin molecule is composed of four globin (globular) polypeptide chains (two α chains and two β) and four haem groups. There are 141 and 146 amino acids in the α and β chains, respectively. Each polypeptide chain is folded in such a way that it contains a pocket where the heme group binds. So, each chain is associated with a haem group.

2. What is a haem group and how does it contribute to oxygen transport in haemoglobin?

Ans. A haem group consists of an iron ion held in a porphyrin ring. The iron ion is attached with four nitrogen atoms of the polypeptide chain. Under higher partial pressure of oxygen, iron ion attaches a molecule of O_2. In this way, one haemoglobin molecule can carry up to four O_2 molecules.

3. What is myoglobin and where is it found in the body?

Ans. Myoglobin is the oxygen-binding protein in skeletal and cardiac muscle cells of vertebrates. It gives a distinct red or dark gray colour to muscles.

4. What is the structure of myoglobin and how does it differ from haemoglobin structurally?

Ans. It is a monomer, composing of a single polynucleotide chain (made of 153 amino acids) and contains a single haem group. Therefore, it is capable of binding with a single O_2 molecule.

5. What is the function of myoglobin and when does it release oxygen?

Ans. The binding affinity of myoglobin is high as compared to that of haemoglobin. As a result, myoglobin serves as the oxygen-storing protein in muscles. It releases oxygen when the partial pressure of oxygen is below 20 mm Hg. In this way, myoglobin provides oxygen to the muscles when they need.

10.4 RESPIRATORY DISORDERS

A range of disorders can affect the respiratory system and interfere with respiration. These respiratory disorders can range from mild and self-limiting conditions such as the common cold to more severe diseases such as sinusitis, otitis media, pneumonia, pulmonary tuberculosis, emphysema and COPD.

8. Describe Upper Respiratory Tract Infections and explain Sinusitis and Otitis Media in detail, including their symptoms and treatments.

Ans. Upper Respiratory Tract Infections (URIs)

Upper Respiratory-tract infections (URIs) affect the nose, throat, sinuses, and larynx and can be easily transmitted from person to person through respiratory droplets.

1. Sinusitis

Definition

It is the inflammation of the lining of the sinuses (four paired air-filled spaces that surround the nasal cavity i.e., under the eyes; above the eyes; between the eyes and behind the eyes). It may be **acute (lasts for 7 to 10 days)** or **chronic (lasts longer than 12 week)**.

Causes

Most cases of sinusitis are due to **viral infections**; some may be due to **bacterial infections** and rare cases may also involve **fungal infections**.

Symptoms of Sinusitis include

- Fever
- Plugged nose
- Pus-like nasal discharge
- Loss of sense of smell
- Facial pain
- A feeling that phlegm is falling from the back of nose into throat
- Headache that is sometimes aggravated by bending over

Treatment

- Most cases are caused by viruses and resolve without antibiotics.
- If it is due to a bacterial infection, antibiotics or sulpha drugs are usually prescribed.
- Besides it, the physician may also prescribe **nebulization**, which can be useful in **reducing inflammation in the sinuses and nose** and to **accelerate recovery**.
- For chronic or recurring sinusitis, treatment may include nasal surgery in which the pathogens and mucous are removed.

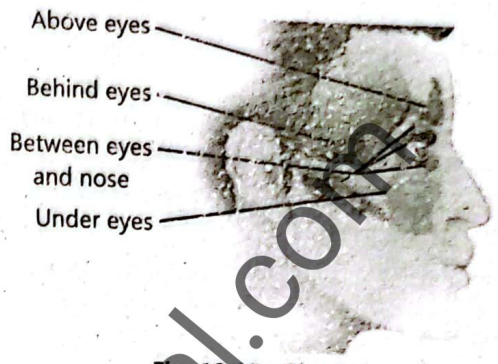


Fig. 10.10 - Sinuses

2. Otitis Media

Definition

It is the inflammation of the middle ear. Otitis may be acute (rapid onset) or chronic (lasts more than six weeks).

Causes

The common cause of otitis media is **accumulation of fluid in Eustachian tube**, which cannot be drained from the middle ear. When this fluid is not drained, it allows the **growth of bacteria and viruses in the middle ear** that lead to otitis media.

Symptoms of Otitis Media include

- Severe ear pain
- Pulling at one or both ears
- Fever
- Fluid draining from ear(s)
- Loss of balance
- Hearing difficulties

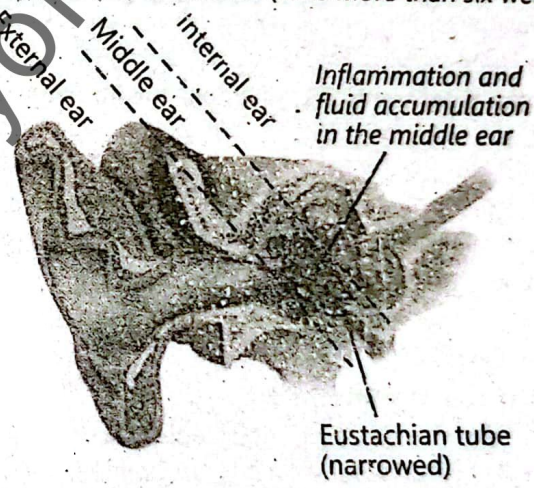


Fig. 10.11 - Otitis media

Treatment

Treatments include **oral and topical pain killers** and **antibiotics** (if caused by bacterial infection).

For Board Exam & MDCAT MCQs

1. **Which parts of the body are affected by Upper Respiratory-tract Infections (URIs)?**
   (a) Lungs and bronchi
   (b) Nose, throat, sinuses, and larynx ✓
   (c) Esophagus and stomach
   (d) Kidneys and bladder
2. **How are Upper Respiratory-tract Infections usually transmitted?**
   (a) Through food (b) Through skin contact
   (c) Through respiratory droplets ✓
   (d) Through contaminated water
3. **What is sinusitis?**
   (a) Inflammation of the lungs
   (b) Inflammation of the sinuses' lining ✓
   (c) Blockage in the bronchioles
   (d) Swelling of vocal cords
4. **Where are the sinuses located?**
   (a) Inside the lungs (b) Around the stomach
   (c) Surrounding the nasal cavity ✓
   (d) At the back of the throat
5. **How long does acute sinusitis typically last?**
   (a) 2 to 3 days (b) 7 to 10 days ✓

(c) Over 12 weeks (d) 1 to 2 months

6. **Which type of infection most commonly causes sinusitis?**
   (a) Bacterial (b) Fungal
   (c) Viral ✓ (d) Parasitic

7. **What is the most common treatment for viral sinusitis?**
   (a) Antibiotics (b) Surgery
   (c) Resolves without antibiotics ✓
   (d) Chemotherapy

8. **What is otitis media?**
   (a) Infection of the throat
   (b) Inflammation of the sinuses
   (c) Inflammation of the middle ear ✓
   (d) Infection of the outer ear

9. **What causes otitis media?**
   (a) Dust allergy
   (b) Fluid accumulation in the Eustachian tube ✓
   (c) High blood pressure (d) Smoking

10. **Which of the following is NOT a symptom of otitis media?**
    (a) Severe ear pain (b) Loss of balance
    (c) Plugged nose ✓ (d) Hearing difficulties

SQ

1. What areas of the body are affected by Upper Respiratory-tract Infections (URIs)?

Ans. Upper Respiratory-tract Infections (URIs) affect the nose, throat, sinuses, and larynx and can be easily transmitted from person to person through respiratory droplets.

2. What is sinusitis?

Ans. Sinusitis is the inflammation of the lining of the sinuses (four paired air-filled spaces that surround the nasal cavity i.e., under the eyes; above the eyes; between the eyes and behind the eyes). It may be acute (lasts for 7 to 10 days) or chronic (lasts longer than 12 week).

3. What are the causes of sinusitis?

Ans. Most cases of sinusitis are due to viral infections; some may be due to bacterial infections, and rare cases may also involve fungal infections.

4. What are the symptoms of sinusitis?

Ans. Symptoms of sinusitis include fever, plugged nose, pus-like nasal discharge, loss of sense of smell, facial pain, a feeling that phlegm is falling from the back of nose into throat, and headache that is sometimes aggravated by bending over.

5. What treatments are available for sinusitis?

Ans. Most cases are caused by viruses and resolve without antibiotics. If it is due to a bacterial infection, antibiotics or sulpha drugs are usually prescribed. Beside it, the physician may also prescribe nebulization which can be useful in reducing inflammation in the sinuses and nose and to accelerate recovery. For chronic or recurring sinusitis, treatment may include nasal surgery in which the pathogens and mucous are removed.

6. What is otitis media?

Ans. Otitis media is the inflammation of the middle ear. Otitis may be acute (rapid onset) or chronic (lasts more than six weeks).

7. What causes otitis media?

Ans. The common cause of otitis media is accumulation of fluid in Eustachian tube, which cannot be drained from the middle ear. When this fluid is not drained, it allows the growth of bacteria and viruses in the middle ear that lead to otitis media.

8. What are the symptoms of otitis media?

Ans. Symptoms of otitis media include severe ear pain, pulling at one or both ears, fever, fluid draining from ear(s), loss of balance, and hearing difficulties.

9. How is acute otitis media different from chronic otitis media?

Ans. Acute otitis media has a rapid onset, while chronic otitis media lasts more than six weeks.

10. What treatments are used for otitis media?

Ans. Treatments include oral and topical pain killers and antibiotics (if caused by bacterial infection).

Q 9. What are Lower Respiratory Tract Infections and which diseases do they include?

Ans. Lower Respiratory-tract Infections include pneumonia, pulmonary tuberculosis, lung abscess and bronchitis.

Pneumonia

Pneumonia is a form of acute respiratory infection. It can cause mild to life-threatening illness. In pneumonia, the alveoli of one or both lungs are inflamed and are filled with pus and fluid. It makes breathing painful and limits

oxygen intake. Pneumonia is most commonly caused by viruses or bacteria. It is the single largest infectious cause of death in children worldwide.

Causes

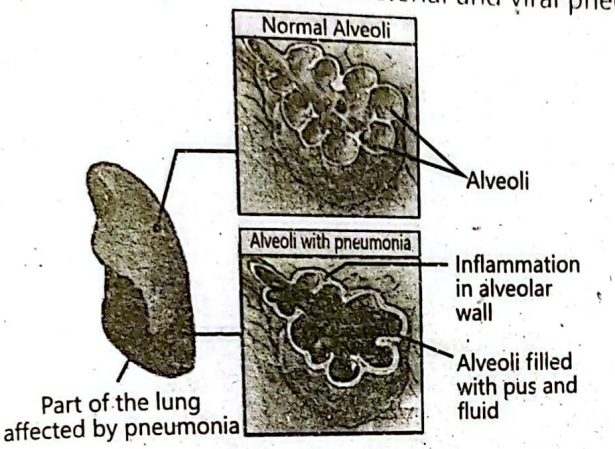
A variety of organisms, primarily bacteria (particularly ***Streptococcus pneumoniae***) or viruses (e.g., human rhinovirus) and less commonly fungi, can cause pneumonia.

Symptoms

Its symptoms include cough with phlegm, shortness of breath, chest pain, fever, blueness of skin, loss of appetite, high heart rate, and fatigue.

Treatment

Specific antibiotics are used to treat bacterial pneumonia. Analgesics are also used to reduce fever and pain. Vaccination prevents against certain bacterial and viral pneumonias both in children and adults.



Pneumonia killed more than 808 000 children under the age of 5 in 2017, accounting for 15% of all deaths of children under 5 years.

Fig. 10.12 - Pneumonia

Pulmonary Tuberculosis

Tuberculosis (TB) is a chronic infection caused by bacteria ***Mycobacterium tuberculosis***. It can affect many parts of the body but generally affects the lungs.

Cause and Transmission

The tuberculosis of the lungs is called **pulmonary tuberculosis**. It is highly contagious and spreads through cough or sneezes. The bacteria enter the lungs, multiply and cause inflammation and damage to the lung tissue, including the alveoli.

Effects on Lungs

The damage to the alveoli can lead to the formation of small cavities or holes in the lung tissue, which can make it difficult for the lungs to function properly. In advanced stages, the alveoli are so damaged that the lungs may become unable to supply the body with enough oxygen.

Complications

This can lead to a condition called **respiratory failure,** which is a medical emergency.

Symptoms

Major symptoms of pulmonary tuberculosis are cough with blood, intermittent fever usually in the evening, night sweats, weight loss, anorexia, depression, weakness, dry cough, and chest pain due to inflammation of the pleura of the lungs.

Treatment

Treatment includes the use of multiple antibiotics over a long period of time (for 9 Months) regularly.

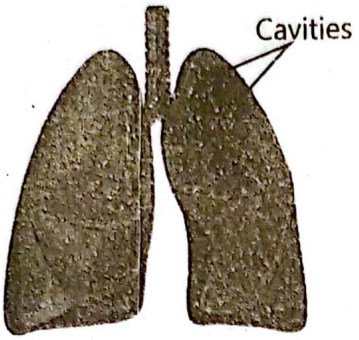


Fig. 10.13 - A lung affected with TB

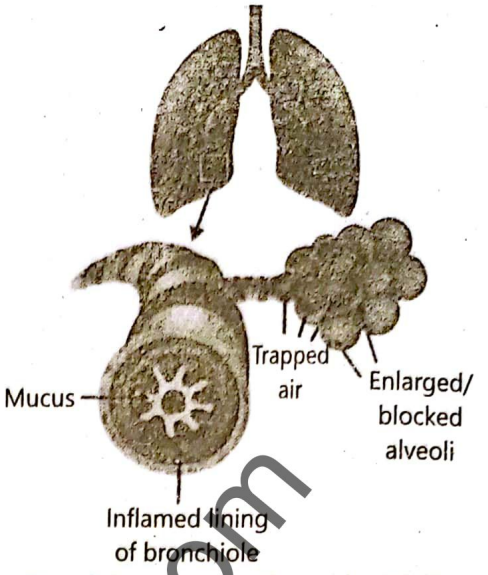


Fig. 10.14 - A lung affected by COPD

MCQs

1. **What does pneumonia affect in the lungs?**
   a) Bronchi only b) Alveoli ✓
   c) Trachea d) Nasal cavity
2. **Pneumonia can cause?**
   a) Mild illness only
   b) Life-threatening illness only
   c) Mild to life-threatening illness ✓
   d) No symptoms
3. **Which of the followir g is the primary bacterial cause of pneumonia?**
   a) Mycobacterium tuberculosis
   b) Streptococcus pneumoniae ✓
   c) Human rhinovirus d) Candida albicans
4. **Pneumonia can be caused by?**
   a) Only bacteria b) Only viruses
   c) Bacteria, viruses, and sometimes fungi ✓
   d) Only fungi
5. **What are common symptoms of pneumonia?**
   a) Cough with phlegm and chest pain ✓
   b) Rash and itching
   c) Diarrhea and vomiting d) Joint pain and swelling
6. **What treatment is used for bacterial pneumonia?**
   a) Antifungal drugs b) Specific antibiotics ✓
   c) Vaccination only d) Pain killers only
7. **What is tuberculosis?**
   a) An acute respiratory infection
   b) A chronic infection caused by bacteria ✓
   c) A fungal infection of lungs
   d) A viral infection of nose
8. **Which bacteria causes tuberculosis?**
   a) Streptococcus pneumoniae
   b) Mycobacterium tuberculosis ✓
   c) Haemophilus influenzae
   d) Staphylococcus aureus
9. **How does pulmonary tuberculosis spread?**
   a) Through contaminated water
   b) Through skin contact
   c) Through cough or sneezes ✓
   d) Through insect bites
10. **What does tuberculosis do to the lung tissue?**
    a) Causes inflammation and damage including cavities ✓
    b) Causes formation of scar tissue only
    c) Only affects the bronchi
    d) Causes lung cancer
11. **What is a serious complication of advanced pulmonary tuberculosis?**
    a) Respiratory failure ✓ b) Diabetes
    c) Liver failure d) Kidney failure
12. **Which symptom is typical of pulmonary tuberculosis?**
    a) Night sweats ✓ b) Joint swelling
    c) Hair los d) Blurred vision
13. **What symptom involves coughing blood?**
    a) Pneumonia
    b) Pulmonary tuberculosis ✓
    c) Bronchitis d) Sinusitis
14. **How long is the treatment for pulmonary tuberculosis usually?**
    a) 1 month b) 3 months
    c) 6 months d) 9 months ✓
15. **What does pneumonia cause in the alveoli?**
    a) Thickening of the walls only
    b) Filling with pus and fluid ✓
    c) Complete destruction of alveoli
    d) Dryness of alveoli
16. **Which of the following is NOT a symptom of pneumonia?**
    a) Fever b) Loss of appetite
    c) Blueness of skin d) Skin rash ✓
17. **What is a common symptom of pneumonia related to breathing?**
    a) Shortness of breath ✓ b) Excessive sweating
    c) Numbness of limbs d) Nose bleeding

18. **What role does vaccination play in pneumonia?**
a) It cures pneumonia after infection
b) It prevents certain bacterial and viral pneumonias ✓
c) It has no role in pneumonia
d) It is used only for fungal infections

19. **Which part of the lung is most affected by tuberculosis?**
a) Bronchi
b) Alveoli ✓
c) Pleura only
d) Trachea

20. **Which of the following is NOT a treatment for pneumonia?**
a) Specific antibiotics
b) Analgesics
c) Antiviral drugs
d) Chemotherapy ✓

Q 1. What are lower respiratory-tract infections and which diseases do they include?

Ans. Lower Respiratory-tract Infections include pneumonia, pulmonary tuberculosis, lung abscess, and bronchitis. These infections affect the lower parts of the respiratory system such as the lungs and bronchi.

2. **What is pneumonia and what happens to the lungs during pneumonia?.**

Ans. Pneumonia is a form of acute respiratory infection that can cause mild to life-threatening illness. In pneumonia, the alveoli of one or both lungs are inflamed and filled with pus and fluid. This makes breathing painful and limits oxygen intake.

3. **What are the common causes of pneumonia?**

Ans. Pneumonia is most commonly caused by viruses or bacteria. A variety of organisms, primarily bacteria (particularly ***Streptococcus pneumoniae***) or viruses (e.g., human rhinovirus), and less commonly fungi, can cause pneumonia.

4. **What are the symptoms of pneumonia?**

Ans. Symptoms of pneumonia include cough with phlegm, shortness of breath, chest pain, fever, blueness of skin, loss of appetite, high heart rate, and fatigue.

5. **How is pneumonia treated?**

Ans. Specific antibiotics are used to treat bacterial pneumonia. Analgesics are also used to reduce fever and pain. Vaccination prevents against certain bacterial and viral pneumonias both in children and adults.

6. **What is pulmonary tuberculosis and what causes it?**

Ans. Tuberculosis (TB) is a chronic infection caused by bacteria *Mycobacterium tuberculosis*. It can affect many parts of the body but generally affects the lungs. Pulmonary tuberculosis is highly contagious and spreads through cough or sneezes.

7. **How does tuberculosis affect lung tissue?**

Ans. The bacteria enter the lungs, multiply, and cause inflammation and damage to the lung tissue, including the alveoli. The damage can lead to the formation of small cavities or holes in the lung tissue, which can make it difficult for the lungs to function properly.

8. **What complications occur in advanced pulmonary tuberculosis?**

Ans. In advanced stages, the alveoli are so damaged that the lungs may become unable to supply the body with enough oxygen. This can lead to a condition called respiratory failure, which is a medical emergency.

9. **What are the major symptoms of pulmonary tuberculosis?**

Ans. Major symptoms of pulmonary tuberculosis are cough with blood, intermittent fever usually in the evening, night sweats, weight loss, anorexia, depression, weakness, dry cough, and chest pain due to inflammation of the pleura of the lungs.

10. **How is pulmonary tuberculosis treated?**

Ans. Treatment includes the use of multiple antibiotics over a long period of time (for 9 months regularly).

Q 10. Write a detailed note on the disorders of the lungs?

Ans. Chronic obstructive pulmonary disease (COPD) is an important disorder of the lungs.

1. **Chronic Obstructive Pulmonary Disease (COPD)**

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory disease of the lungs. The common causes of COPD are tobacco smoking, long-term exposure to harmful pollutants and chemical fumes, etc. A small percentage of genetic predisposition (protein alpha-1 antitrypsin deficiency) can also develop COPD, even without smoking or significant exposure to pollutants.

Symptoms

The symptoms of COPD are persistent cough with mucus (sputum), shortness of breath, wheezing, chest fatigue, and frequent respiratory tract infections.

Treatment

COPD is incurable, but by minimizing exposure to smoke, pollutants, and chemicals, this disease can slow its progression. Other therapies include bronchodilators, inhaled corticosteroids, pulmonary rehabilitation, and oxygen therapy. In some severe cases, surgery such as lung transplantation may be considered.

> Chronic bronchitis is a type of COPD. It involves inflammation and narrowing of the bronchial tubes in the lungs. It leads to increased mucus production, which can further block the airways and make breathing difficult. This disease lasts for three months to two years. It is caused by long-term exposure to irritants such as cigarette smoke, air pollution, or industrial dusts. Symptoms of chronic bronchitis are almost same as of COPD such as wheezing, shortness of breath, chest tightness, and frequent respiratory infections. Chronic bronchitis can be managed by quitting smoking. Other treatments are bronchodilators, pulmonary rehabilitation, and in some cases oxygen therapy.

2. Emphysema

Emphysema is a type of COPD.

Cause and Mechanism

In **emphysema**, the inner walls of alveoli are damaged, causing them to eventually rupture. This creates one larger air space instead of many small ones and reduces the surface area available for gas exchange.

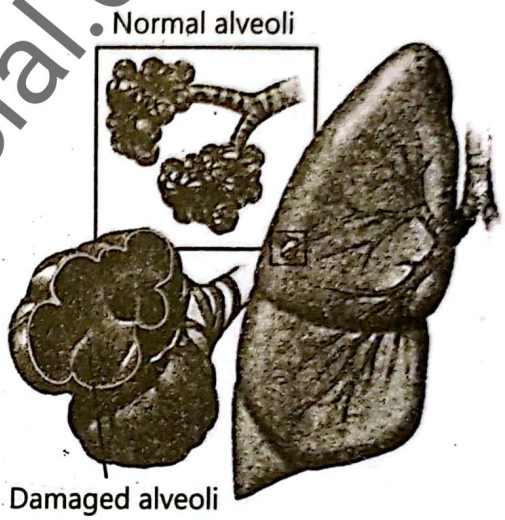


Fig. 10.15 - Emphysema

Primary Causes

The primary cause of emphysema is smoking. It can also be caused by long-term exposure to air pollution, dust, or chemical fumes.

Genetic Factor

Emphysema disease can also be caused by a genetic deficiency of a protein called **alpha-1 antitrypsin.**

Symptoms

The symptoms of emphysema include shortness of breath, coughing, wheezing, fatigue, and chest tightness.

Treatment

Quitting smoking is the most important step in managing emphysema, as continued smoking can speed up the progression of disease. Other treatments include bronchodilators, inhaled steroids, oxygen therapy, and pulmonary rehabilitation.

For Board Exam & MDCAT MCQs

1. **What type of disease is COPD?**
   a) Acute infectious disease
   b) Chronic inflammatory disease ✓
   c) Autoimmune disease
   d) Genetic disease
2. **What is the most common cause of COPD?**
   a) Viral infection
   b) Tobacco smoking ✓
   c) Bacterial infection
   d) Allergies
3. **Which protein deficiency is linked to genetic predisposition for COPD?**
   a) Hemoglobin
   b) Albumin
   c) Alpha-1 antitrypsin ✓
   d) Myoglobin
4. **Which symptom is NOT commonly associated with COPD?**
   a) Persistent cough with mucus
   b) Chest fatigue
   c) Frequent respiratory infections
   d) Sudden high fever ✓
5. **Is COPD a curable disease?**
   a) Yes, with antibiotics
   b) No, it is incurable ✓
   c) Yes, with surgery with vaccines
   d) No, but it can be cured
6. **Which treatment is used to manage symptoms of COPD?**
   a) Antiviral drugs
   b) Bronchodilators and inhaled corticosteroids ✓
   c) Chemotherapy
   d) Antifungal medication

7. **What surgical treatment might be considered for severe COPD?**
a) Appendectomy
b) Lung transplantation ✓
c) Tonsillectomy
d) Heart bypass surgery

8. **Emphysema is a type of?**
a) Asthma
b) Bronchitis
c) COPD ✓
d) Pneumonia

9. **What happens to alveoli in emphysema?**
a) They multiply rapidly
b) Inner walls are damaged and rupture ✓
c) They fill with fluid
d) They shrink and harden

10. **What is the effect of alveoli damage in emphysema on gas exchange?**
a) It increases oxygen absorption
b) It reduces surface area for gas exchange ✓
c) It has no effect
d) It increases carbon dioxide absorption

11. **Besides smoking, which of the following can cause emphysema?**
a) Bacterial infections
b) Exposure to air pollution, dust, or chemical fumes ✓
c) Viral infections
d) Lack of exercise

12. **Which genetic factor can cause emphysema?**
a) Vitamin D deficiency
b) Alpha-1 antitrypsin deficiency ✓
c) Sickle cell anemia
d) Hemophilia

13. **Which of the following is NOT a symptom of emphysema?**
a) Shortness of breath
b) Chest tightness
c) Frequent urination ✓
d) Wheezing

14. **What is the most important step in managing emphysema?**
a) Taking antibiotics
b) Quitting smoking ✓
c) Increasing physical activity
d) Taking vaccines

15. **Pulmonary rehabilitation in emphysema is used to?**
a) Cure the disease completely
b) Improve lung function and quality of life ✓
c) Increase the size of alveoli
d) Prevent lung infections

SQ

1. **What type of disease is Chronic Obstructive Pulmonary Disease (COPD)?**
Ans. COPD is a chronic inflammatory disease of the lungs.

2. **What are the common causes of COPD?**
Ans. The common causes of COPD are tobacco smoking, long-term exposure to harmful pollutants and chemical fumes.

3. **Can COPD develop in individuals who do not smoke or are not exposed to pollutants?**
Ans. Yes, a small percentage of people with a genetic predisposition (protein alpha-1 antitrypsin deficiency) can develop COPD even without smoking or significant exposure to pollutants.

4. **Which genetic deficiency is linked to the development of COPD?**
Ans. Deficiency of the protein alpha-1 antitrypsin is linked to COPD.

5. **List the symptoms of COPD.**
Ans. Symptoms of COPD include persistent cough with mucus (sputum), shortness of breath, wheezing, chest fatigue, and frequent respiratory tract infections.

6. **Is COPD curable?**
Ans. No, COPD is incurable.

7. **How can the progression of COPD be slowed down?**
Ans. The progression of COPD can be slowed down by minimizing exposure to smoke, pollutants, and chemicals.

8. **Name some therapies used to manage COPD symptoms.**
Ans. Therapies include bronchodilators, inhaled corticosteroids, pulmonary rehabilitation, and oxygen therapy.

9. **What surgical option may be considered in severe cases of COPD?**
Ans. Lung transplantation may be considered in some severe cases.

10. **What is emphysema in relation to COPD?**
Ans. Emphysema is a type of COPD.

11. **What happens to the alveoli in emphysema?**
Ans. The inner walls of the alveoli are damaged and eventually rupture.

12. **How does emphysema affect gas exchange in the lungs?**
Ans. Emphysema creates one larger air space instead of many small ones, reducing the surface area available for gas exchange.

13. What is the primary cause of emphysema?

Ans. The primary cause of emphysema is smoking.

14. Besides smoking, what other exposures can cause emphysema?

Ans. Long-term exposure to air pollution, dust, or chemical fumes can also cause emphysema.

15. What genetic factor can cause emphysema?

Ans. A genetic deficiency of the protein alpha-1 antitrypsin can cause emphysema.

16. List the symptoms of emphysema.

Ans. Symptoms include shortness of breath, coughing, wheezing, fatigue, and chest tightness.

17. What is the most important step in managing emphysema?

Ans. Quitting smoking is the most important step in managing emphysema.

18. How does quitting smoking affect emphysema?

Ans. Quitting smoking can slow down the progression of emphysema.

19. Besides quitting smoking, what other treatments are used for emphysema?

Ans. Other treatments include bronchodilators, inhaled steroids, oxygen therapy, and pulmonary rehabilitation.

20. What is pulmonary rehabilitation in the context of COPD and emphysema?

Ans. Pulmonary rehabilitation is a therapy that helps improve lung function and quality of life in COPD and emphysema patients.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

1. During inhalation, diaphragm?

(a) Contracts and moves upward
(b) Contracts and moves downward ✓
(c) Relaxes and moves upward
(d) Relaxes and moves downward

2. Which part of the respiratory system acts as the respiratory surface?

(a) Larynx
(b) Trachea ✓
(c) Bronchi
(d) Alveoli

3. How many oxygen molecules can attach with a haemoglobin molecule?

(a) 1
(b) 2
(c) 3
(d) 4 ✓

4. What is TRUE about respiratory pigments?

(a) Transport oxygen from lungs to tissues ✓
(b) Transport oxygen and carbon dioxide in equal amounts
(c) Transport less oxygen and more carbon dioxide
(d) Regulate the pH of blood

5. Which respiratory pigment is found in muscle tissue?

(a) Haemoglobin
(b) Melanin
(c) Myoglobin ✓
(d) Chlorophyll

6. What is the maximum amount of air that can be inhaled or exhaled during a respiratory cycle?

(a) Tidal volume
(b) Vital capacity ✓
(c) Inspiratory reserve volume
(d) Expiratory reserve volume

7. In what form is carbon dioxide primarily transported in the bloodstream?

(a) Dissolved in plasma
(b) Bound to haemoglobin
(c) Converted to bicarbonate ions ✓
(d) None of the above

8. Which of the following treatments is commonly used to manage pulmonary TB?

(a) Antibiotics ✓
(b) Cough syrup
(c) Surgery
(d) Chemotherapy

9. Which of the following is a common cause of pneumonia?

(a) Bacterial infection
(b) Viral infection
(c) Fungal infection
(d) All of these ✓

10. Emphysema is characterized by?

(a) Inflammation of airways
(b) Narrowing of airways
(c) Destruction of the alveoli in lungs ✓
(d) Fluid build-up in lungs

SHORT ANSWER QUESTIONS

1. Define respiratory surface and list its properties.

Ans. A respiratory surface is a site where gas exchange (oxygen and carbon dioxide) occurs between the body and the environment.

Properties:

- Thin for easy diffusion
- Moist for gases to dissolve
- Large surface area
- Rich blood supply

2. How does the nasal cavity function in filtering the inhaled air?

Ans. The nasal cavity filters air using hair and mucus that trap dust, microbes, and other particles. It also moistens and warms the air before it reaches the lungs.

3. Trace the path of air through different parts of the respiratory system.

Ans. Nasal cavity → Pharynx → Larynx → Trachea → Bronchi → Bronchioles → Alveoli

4. Describe the structure and function of alveoli.

Ans. Structure: Alveoli are tiny, balloon-like air sacs with thin walls and surrounded by capillaries.

Function: Site of gas exchange—oxygen enters blood, and carbon dioxide leaves it.

5. What is the role of diaphragm during inhalation and exhalation?

- Inhalation: Diaphragm contracts and moves downward, expanding the chest cavity.
- Exhalation: Diaphragm relaxes and moves upward, reducing chest volume and pushing air out.

6. What are the three ways of the transport of carbon dioxide in blood?

1. As bicarbonate ions (major form)
2. Bound to haemoglobin (as carbaminohaemoglobin)
3. Dissolved in plasma

7. What are the advantages of having millions of alveoli rather than a pair of simple balloon-like lungs?

- Provides very large surface area for gas exchange
- Ensures efficient oxygen uptake and carbon dioxide removal
- Increases contact with capillaries for better diffusion

8. Differentiate between:

Term	Description
Internal respiration	Exchange of gases between **blood and body cells**
External respiration	Exchange of gases between **lungs (alveoli) and blood**
Upper respiratory tract	Includes **nose, nasal cavity, pharynx, and larynx**
Lower respiratory tract	Includes **trachea, bronchi, bronchioles, and lungs**
Bronchi	Larger airways that **branch from trachea** into lungs
Bronchioles	Smaller branches of bronchi ending in alveoli
Haemoglobin	Oxygen-carrying protein in **red blood cells**
Myoglobin	Oxygen-storing pigment in **muscle cells**

LONG QUESTIONS

Q1. Describe the mechanism of inhalation and exhalation.

Ans. See Long Question No. 04

Q2. Describe the transport of oxygen through blood.

Ans. See Long Question No. 05

Q3. Describe the transport of carbon dioxide through blood.

Ans. See Long Question No. 06

Q4. Describe the structure and function of haemoglobin.

Ans. See Long Question No. 07

Q5. Describe the causes, symptoms and treatment of sinusitis.

Ans. See Long Question No. 08

Q6. Describe the causes, symptoms and treatment of pneumonia and pulmonary tuberculosis.

Ans. See Long Question No. 09

Q7. Describe causes, symptoms and treatment of emphysema.

Ans. See Long Question No. 10

INQUISITIVE QUESTIONS

1. How does the structure of the alveoli optimize the exchange of gases like oxygen and carbon dioxide?

Ans. Alveoli have thin walls, large surface area, are moist, and are surrounded by capillaries, which together allow for rapid and efficient gas exchange by diffusion.

2. How do diseases like chronic obstructive pulmonary disease (COPD) affect gaseous exchange efficiency?

Ans. COPD causes narrowing of airways and destruction of alveoli, reducing surface area and airflow, which impairs oxygen intake and carbon dioxide removal.

3. Can you explain the process of external respiration versus internal respiration in the context of gaseous exchange?

Ans.

- External respiration: Exchange of gases between alveoli and blood in the lungs.
- Internal respiration: Exchange of gases between blood and body cells in tissues.

4. How does the transport of oxygen in the bloodstream support cellular respiration?

Ans. Oxygen binds to haemoglobin in red blood cells and is delivered to cells, where it is used in cellular respiration to produce energy (ATP).

5. What are the environmental factors that can influence gaseous exchange in humans?

Ans.

- Air pollution
- High altitude (low oxygen levels)
- Smoking
- Temperature and humidity
- Allergens and dust particles
- These can reduce oxygen availability or damage lung tissue.

Self-Assessment Unit 10

Max. Marks: 28 Time allowed 60 Mins

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. **What happens to the diaphragm during the process of inhalation?**
   (a) It contracts and shifts upward
   (b) It contracts and moves downward
   (c) It relaxes and rises
   (d) It relaxes and moves down
2. **Which structure in the respiratory system serves as the site of gas exchange?**
   (a) Larynx (b) Trachea (c) Bronchi (d) Alveoli
3. **How many oxygen molecules can one molecule of haemoglobin carry at a time?**
   (a) One (b) Two (c) Three (d) Four
4. **Which of the following is correct regarding respiratory pigments?**
   (a) They carry oxygen from the lungs to body tissues
   (b) They transport equal amounts of oxygen and CO_2
   (c) They carry more carbon dioxide than oxygen
   (d) They help maintain blood pressure
5. **Which pigment is responsible for storing oxygen in muscles?**
   (a) Haemoglobin (b) Melanin (c) Myoglobin (d) Chlorophyll
6. **What term refers to the maximum volume of air that can be inhaled and exhaled forcefully?**
   (a) Tidal volume (b) Vital capacity (c) Inspiratory reserve (d) Residual volume
7. **How is most carbon dioxide carried in the blood?**
   (a) As dissolved gas in plasma (b) Attached to haemoglobin
   (c) In the form of bicarbonate ions (d) In protein complexes
8. **What is the primary method for treating pulmonary tuberculosis (TB)?**
   (a) Antibiotics (b) Cough suppressants (c) Surgical removal (d) Cancer drugs
9. **Which of the following can lead to pneumonia?**
   (a) Bacterial infection (b) Viral infection (c) Fungal infection (d) All of the above
10. **Which condition is marked by damage to alveolar walls, reducing respiratory efficiency?**
    (a) Airway inflammation (b) Narrowed air passages
    (c) Alveolar destruction (Emphysema) (d) Lung fluid retention

Q2. Write short answers to the following questions. **(5x2=10)**

1. Define respiratory surface and list its properties.
2. What is the role of diaphragm during inhalation and exhalation?
1. What the three ways of the transport of carbon dioxide in blood?
2. Describe the structure and function of alveoli.
3. Differentiate between Haemoglobin and myoglobin

(4+4=8)

Q3. Write detailed answer to the following question

1. Describe the transport of oxygen through blood.
2. Describe the causes, symptoms and treatment of sinusitis.