Chapter 10

HUMAN RESPIRATORY SYSTEM

STUDENTS'LEARNING OUTCOMES

After studying this chapter, 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).

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.

Recalling
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.

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.

Properties of the Respiratory Surface

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. The following properties enable respiratory surfaces for effective 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 minimum distance.
3. It has a blood supply – so that gases can diffuse in and out of 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.

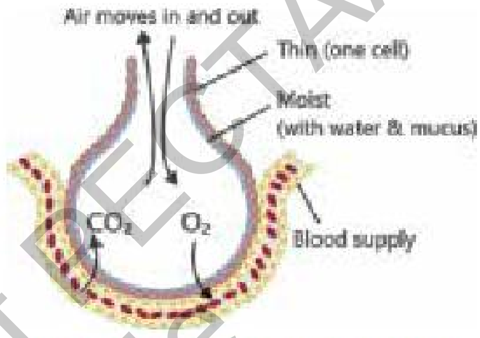


Figure 10.1: Some properties of respiratory surface

7. Air reaches to it after passing a branched tubular way – so that air becomes saturated with water vapour before reaching it.

Components of Human Respiratory System

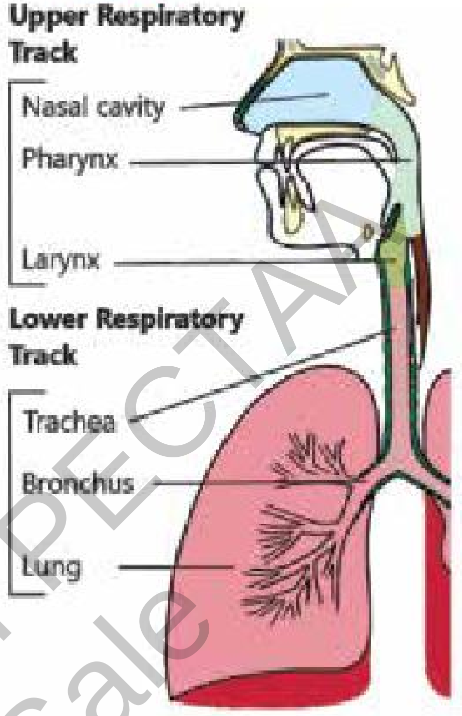
The organs of the respiratory system form a continuous system of passages, called the **respiratory tract**, through which air flows into and out of the body. The respiratory tract has two major divisions: the upper respiratory tract and the lower respiratory tract.

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.

1- Nasal cavity

The external openings of nose, called **nostrils**, lead to a **nasal cavity**. It is a large, air-filled space behind the nose and 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 sense of smell, and contribution to the sense of taste.



2- Pharynx

It is a tube-like structure that connects the nasal cavity and oral cavity to 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 esophagus.

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.

Epiglottis is a cartilaginous flap that extends in front and above the opening of larynx called 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.

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.

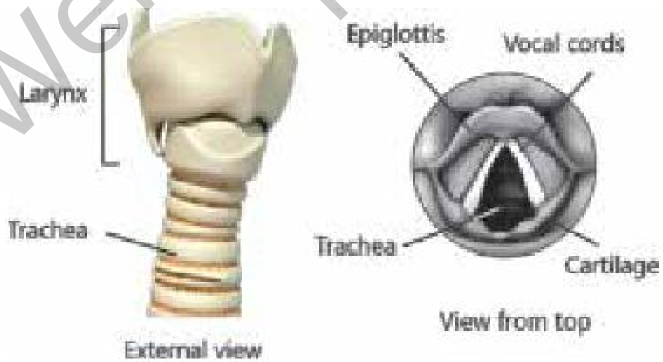


Figure 10.3: Larynx and Trachea

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.

Lower Respiratory Track

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

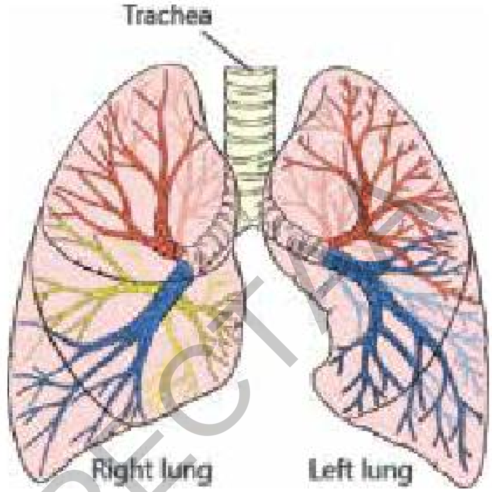


Figure 10.4: Tree-like branching of the lower respiratory tract

1- Trachea

The 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.

2- Bronchi, Bronchioles, and Alveoli

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. 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.

3- Lungs

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. 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 centre of the chest.

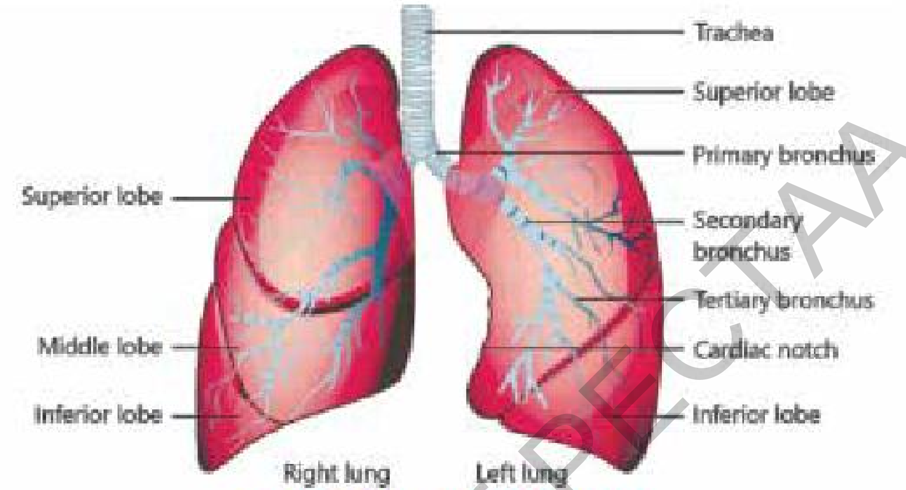


Figure 10.5: Right and left lungs

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.

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

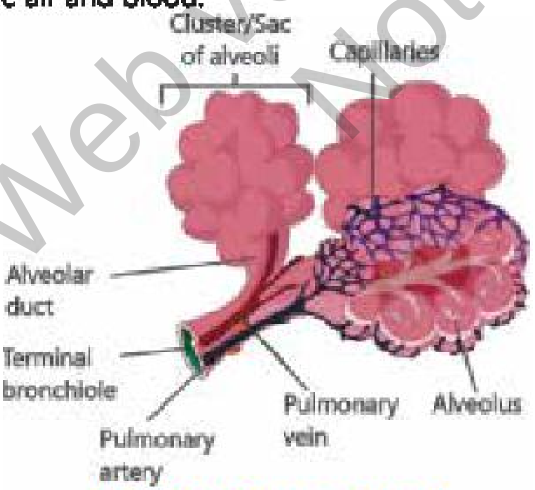


Figure 10.6: Clusters of alveoli

Recalling
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.

The alveoli are the functional units of the lungs where gas exchange takes place. 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.

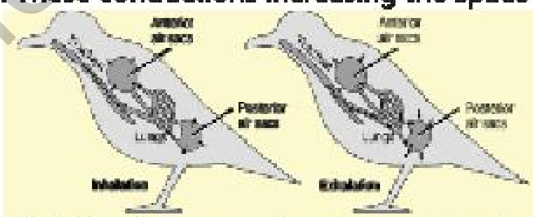
Mechanism of Breathing or Ventilation

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

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.

Inspiration: Taking in of air is called inspiration or inhalation. For this purpose, the diaphragm contracts. It causes the diaphragm to lower and take a more flattened shape. At the same time, the intercostal muscles contract.

It raises the ribs and expands the rib cage. These contractions increasing the space in the thorax. As a result, lungs expand because of the adherence of the visceral and parietal pleural membranes. 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.



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: Moving the air out of lungs is called expiration or exhalation. 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. When diaphragm relaxes, it assumes its dome-like shape. Similarly, when intercostal muscles relax, the ribs lower and rib cage moves inward. These movements decrease the space in thorax and allow the lungs to recoil. So, the pressure inside lungs becomes more than the atmospheric pressure and the air moves out of the lungs.

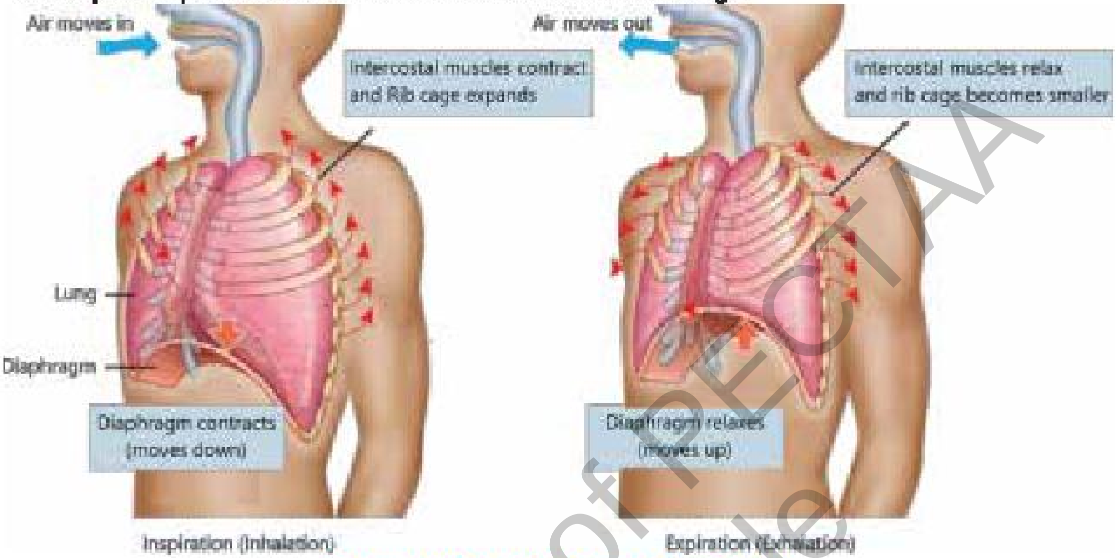


Figure 10.7: Mechanism of breathing

Control of Breathing

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.

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.

Transport of Oxygen

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 plasms but is bound to molecules of haemoglobin inside the RBCs.

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

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**. 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

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.

> 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.

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.

Transport of Carbon dioxide

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. While, the process reverses in lungs where the partial pressure of CO_2 is lower in alveoli than in blood. Blood transports carbon dioxide from tissues to lugs in three ways.

1- As bicarbonate ions

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

> 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.

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

2- As Carboxyhaemoglobin

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.

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.

3- As dissolved CO_2 in Plasma

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

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

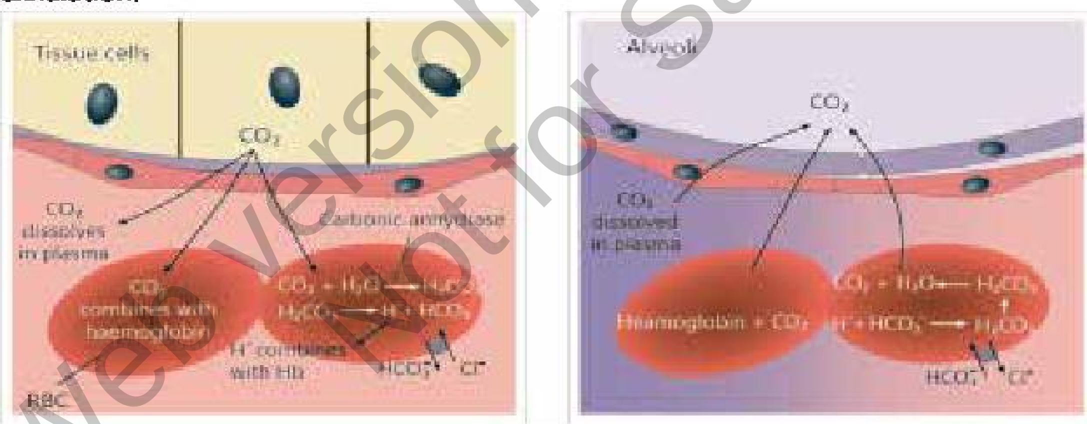


Figure 10.8: Transport of Carbon dioxide by blood

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.

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.

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. 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_2molecules.

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

Myoglobin

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. 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. 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.

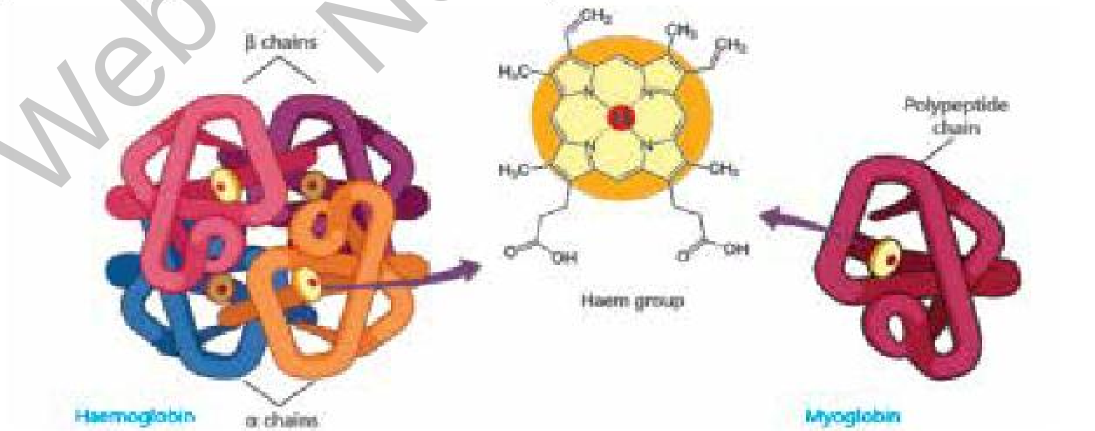


Figure 10.9: Structure of haemoglobin and myoglobin

Table10.1: Differences between Haemoglobin and Myoglobin

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

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.

Upper Respiratory Tract Infections

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

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

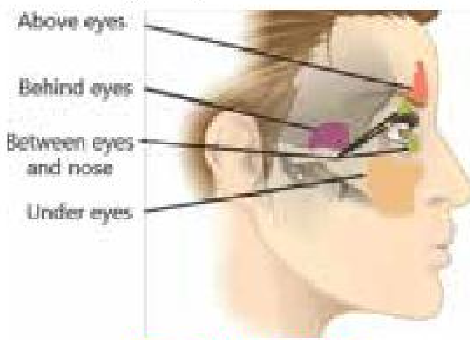


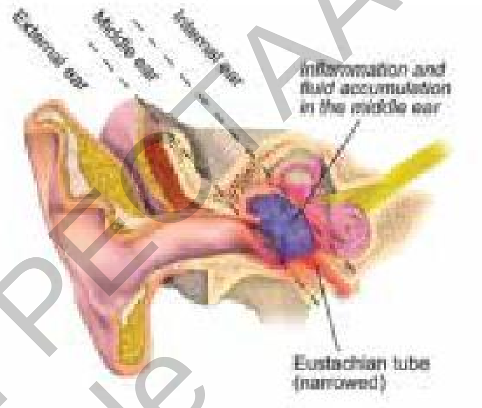
Figure 10.10: Sinuses

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.

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. 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.

2. Otitis media

It is the inflammation of the middle ear. Otitis may be acute (rapid onset) or chronic (lasts more than six weeks). The common cause of otitis media 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, and hearing difficulties.

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

Lower Respiratory Tract Infections

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

1. 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.

Pneumonia killed more than 808000 children under the age of 5 in 2017, accounting for 15% of all deaths of children under 5 years.

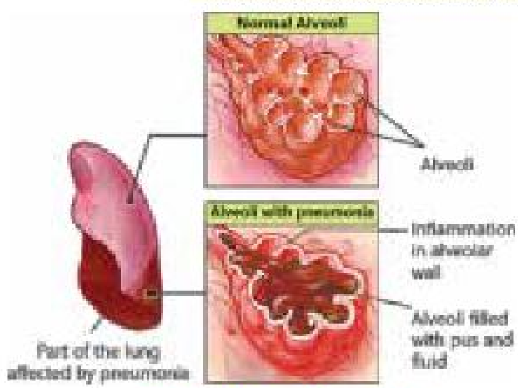


Figure 10.12: Pneumonia

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 heat rate, and fatigue.

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

2. Pulmonary Tuberculosis

Tuberculosis (TB) is a chronic infection caused by bacteria *Mycobacterium tuberculosis*. It can affect many parts of the body but it generally affects the lungs. 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. 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. This can lead to a condition called respiratory failure, which is a medical emergency.

Figure 10.13: A lung affected with TB

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

Treatment: includes the use of multiple antibioticsover a long period of time (for 9 months) regularly.

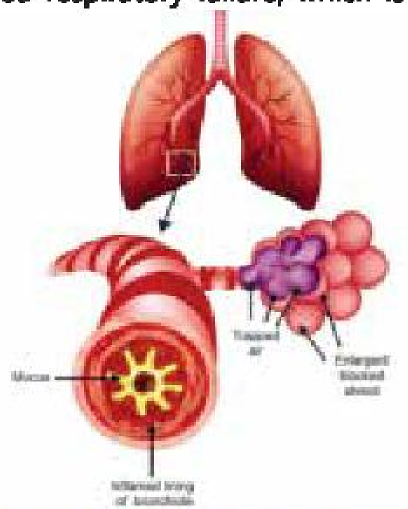


Figure 10.14: A lung affected by COPD

Disorders of the Lungs

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 lungs. The common causes of COPD are tobacco smoking, long terms 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. Others 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.

Emphysema

Emphysema is a type of COPD. 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. The primary cause of emphysema is smoking. It can also be caused by long-term exposure to air pollution, dust, or chemical fumes. Emphysema disease can also be caused by a genetic deficiency of a protein called alpha-1 antitrypsin.

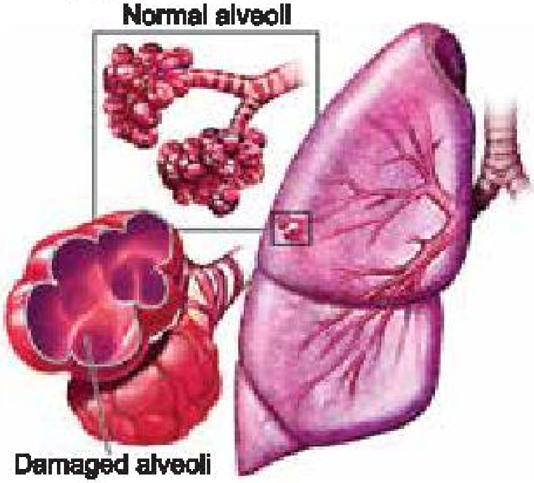


Figure 10.15: Emphysema

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.

EXERCISE

MULTIPLE CHOICE QUESTIONS

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

SECTION 2: SHORT QUESTIONS

1. Define respiratory surface and list its properties.
2. How nasal cavity functions in filtering the inhaled air?
3. Trace the path of air through different parts of the respiratory system.
4. Describe the structure and function of alveoli.
5. What is the role of diaphragm during inhalation and exhalation?
6. What the three ways of the transport of carbon dioxide in blood?
7. What are the advantages of having millions of alveoli rather than a pair of simple balloon-like lungs?
8. Differentiate between:
   - Internal and external respiration
   - Upper and lower respiratory tract
   - Bronchi and bronchioles
   - Haemoglobin and myoglobin

LONG QUESTIONS

1. Describe the mechanism of inhalation and exhalation.
2. Describe the transport of oxygen through blood.
3. Describe the transport of carbon dioxide through blood.
4. Describe the structure and function of haemoglobin.
5. Describe the causes, symptoms and treatment of sinusitis.
6. Describe the causes, symptoms and treatment of pneumonia and pulmonary tuberculosis.
7. Describe causes, symptoms and treatment of emphysema.

INQUISITIVE QUESTIONS

1. How does the structure of the alveoli optimize the exchange of gases like oxygen and carbon dioxide?
2. How do diseases like chronic obstructive pulmonary disease (COPD) affect gaseous exchange efficiency?
3. Can you explain the process of external respiration versus internal respiration in the context of gaseous exchange?
4. How does the transport of like oxygen in the bloodstream support cellular respiration?
5. What are the environmental factors that can influence gaseous exchange in humans?