بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

(In the Name of Allah, the Most Merciful, the Most Compassionate.)

BIOLOGY

(TECH)

10

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PUNJAB EDUCATION, CURRICULUM,
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AUTHOR

- **Dr. Zaheer ud Din,** Prof. Emeritus, Government College University, Lahore
- **Dr. Raheela Nadeem,** Registrar, UBAS, Lahore
- **Dr. Adnan Ahmad,** Senior Research Officer, PCSIR, Lahore

EDITOR

- **Dr. Hafiz Muhammad Usman Tariq,** Demonstrator (Physiology), Akhtar Saeed Medical & Dental College, Lahore

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Layout & Designing — **Hafiz Inam-ul-Haq**

Prepared by: Al-Faisal Nashran, Urdu Bazar, Lahore 04237230777 03349941510

EXPERIMENTAL EDITION

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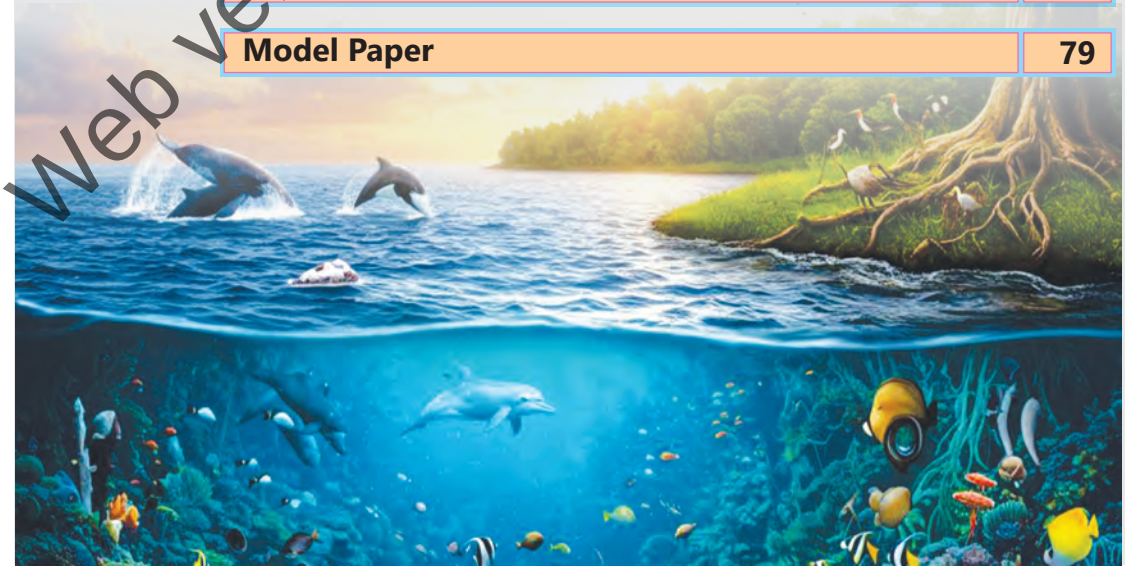


1 HUMAN DIGESTIVE SYSTEM

Students Learning Outcomes

After studying this chapter, students will be able to:

- Describe the needs of ingestion, digestion, absorption, assimilation and egestion.
- Identify and describe the structures of the main regions of the alimentary canal and the associated organs.
- Describe swallowing and peristalsis.
- Sort out the action of enzymes in specific regions of alimentary canal, with respect to their substrates and products.
- State the role of the liver.
- Describe the structure of a villus, including the roles of capillaries and lacteals.

Everything our body does - like moving, growing, and staying healthy - depends on nutrients. In order to get these nutrients, the food must first be broken down into simpler parts so the body cells can absorb them. This process happens inside our digestive system. In this chapter, we will discover how the digestive system works to turn food into usable nutrients.

1.1 NUTRITION AND ITS IMPORTANCE

Nutrition is how organisms get and use nutrients. It helps them to grow, stay healthy, and repair their bodies. Animals, including humans, cannot make their own food. They get it from other organisms. This is called **heterotrophic** nutrition. In animals, nutrition takes place in the following main steps:

1. **Ingestion:** Taking in food and drinks through the mouth.
2. **Digestion:** Breaking food into smaller parts which the body can absorb.
3. **Absorption:** Moving nutrients from the digested food into the blood or lymph.
4. **Assimilation:** Using the absorbed nutrients in cells and tissues.
5. **Egestion:** Removing undigested food and waste from the body.

Autotrophic nutrition is a mode of nutrition in which organisms produce their own food from inorganic substances using light or chemical energy.

Heterotrophic nutrition is a mode of nutrition in which organisms obtain their food by consuming other organisms or organic matter.

The food we eat consists of polymers i.e., large molecules like carbohydrates, proteins, and fats. They cannot pass through cell membranes. These polymers must be broken down into smaller, soluble parts called monomers - like sugars, amino acids, and fatty acids. This process is called **digestion**. These small molecules can enter the cells.

1.2 HUMAN DIGESTIVE SYSTEM

The human digestive system consists of a long tube and some helper (accessory) organs. The tube is called the **alimentary canal**. It starts at the mouth and ends at the anus. The salivary glands, liver, and pancreas send their juices into the alimentary canal and aid in digestion.

1. Oral Cavity

The space behind mouth is called oral cavity or mouth cavity. It contains **taste buds** on the surface of tongue for the taste of food. The **mechanical digestion** of food begins in oral cavity. During mechanical digestion, the teeth cut and grind

During this grinding, tongue keeps the food between the teeth.

food into smaller pieces.

In oral cavity, **partial chemical digestion** of carbohydrates is done by three pairs of **salivary glands**. These glands are attached with oral cavity and secrete **saliva** - a mixture of water, mucus, and a digestive enzyme called **salivary amylase**. Water and mucous moisten the food pieces. Salivary amylase breaks down the starch present in food into maltose.

Starch is a polysaccharide made up of many sugar molecules. Maltose is a disaccharide made of two sugar molecules.

Swallowing: After the physical and partial chemical digestion, the food mass in oral cavity is called **bolus**. It is swallowed by pushing it into the pharynx. For swallowing, the tongue moves the bolus to the back of the oral cavity. The swallowed food enters the pharynx.

During swallowing, the palate (roof of oral cavity) moves upward to close the opening of the nasal cavity.

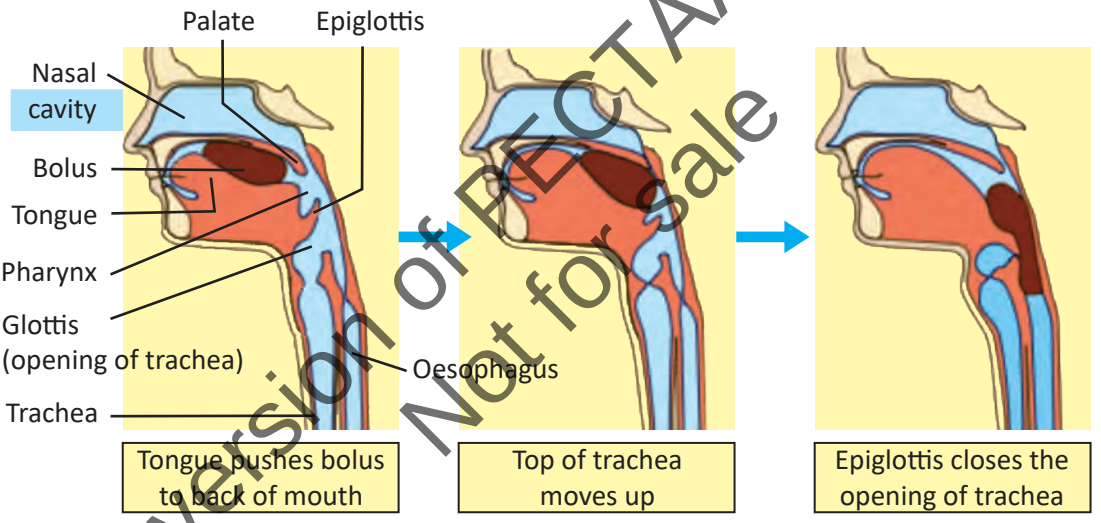


FIGURE 1.1: Oral cavity and steps in swallowing

2. Pharynx and Oesophagus

Pharynx is a short tube-like part after oral cavity. It connects oral cavity to oesophagus and also connects nose to windpipe (trachea). The process of chemical digestion that started in oral cavity continues here. An important function of pharynx is to prevent the entry of food particles into lungs. It is done with the help of an elastic cartilage tissue called **epiglottis**. When swallowed food passes through pharynx, the top of trachea (windpipe) is pushed up against epiglottis. In this way, the opening of trachea (glottis) closes and the swallowed food passes over it.

Oesophagus is a long tube (about 25 cm or 9.84 inches long). It connects the pharynx to the stomach. When food enters oesophagus, successive waves of contraction are generated in its muscular walls. These waves of contractions move food along the oesophagus to the stomach. These waves of muscular contraction are called **peristalsis**.

3. Stomach

J-shaped stomach is located in the upper left side of the abdominal cavity, below the diaphragm. The part of stomach immediately after oesophagus is called **cardiac end** while the part before small intestine is called **pyloric end**. At the junction of the oesophagus and stomach, there is sphincter (ring of muscles) called **cardiac sphincter** (lower oesophageal sphincter). It prevents food from flowing back from stomach into the oesophagus. Similarly, **pyloric sphincter** is present between stomach and small intestine.

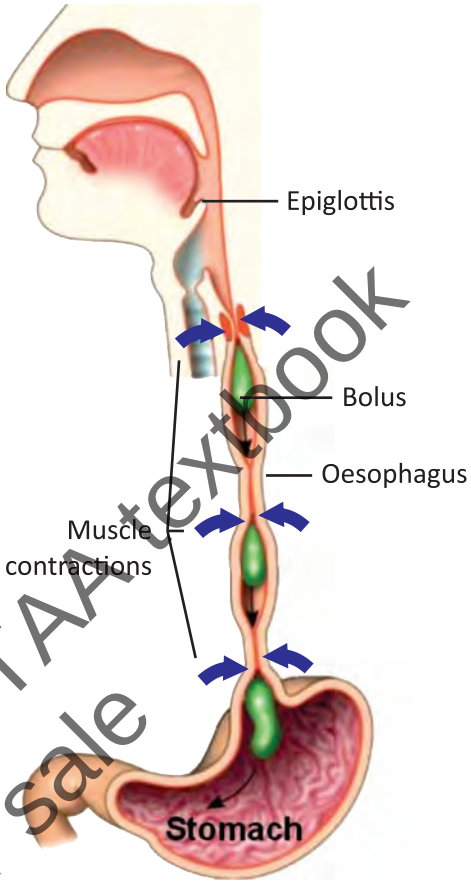


FIGURE 1.2: Peristalsis

Stomach is responsible for the mechanical and partial chemical digestion of food. It also stores food. The walls of stomach are made of thick smooth muscles. When food arrives in stomach, these muscles contract rigorously. Their contractions help in the churning (breaking down) of food into smaller particles. Heat is also produced due to this churning. This heat helps to melt the lipids.

Many small **gastric glands** present in the inner walls of stomach secrete **gastric juice**. It contains hydrochloric acid, an inactive enzyme pepsinogen, and mucus. Hydrochloric acid converts **pepsinogen** into an active enzyme **pepsin**. Pepsin breaks large proteins into shorter chains of amino acids called **peptides**. Hydrochloric acid also kills pathogenic bacteria present in food.

The stomach's HCl is so strong it can dissolve metal! But your stomach is protected by the thick mucus lining that keeps it safe from its own acid.

The **mucus** forms a protective layer on the inner walls of stomach. Here, it neutralizes the HCl. So, pepsinogen cannot be activated here and the walls are

protected from breakdown.

Food usually remains in stomach for three to four hours. Due to the actions in stomach, the food becomes a soup-like mixture called **chyme**. The pyloric sphincter controls the flow of chyme. Each time the pyloric sphincter opens, about 5 to 15 ml of chyme moves into the small intestine.

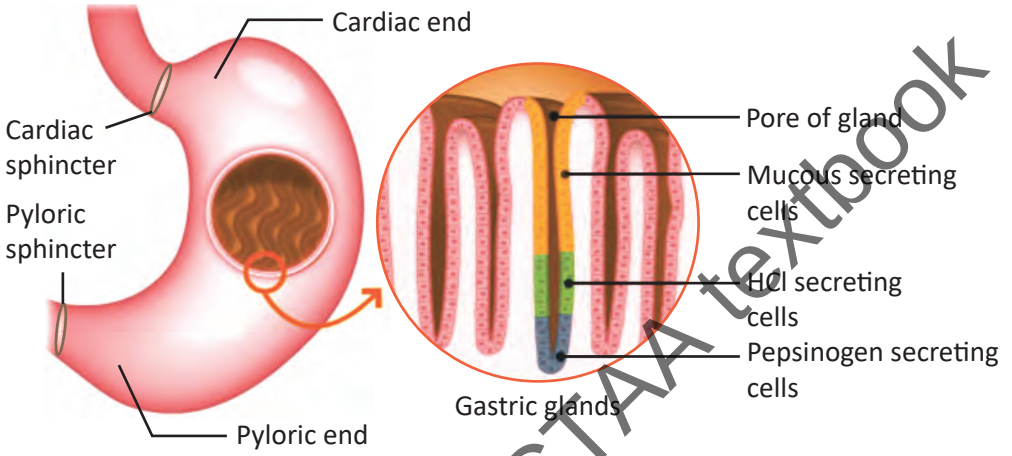


FIGURE 1.3: Structure of stomach

4. Small Intestine

Small intestine is highly coiled tube and is nearly 7 m (about 23 ft) long. It has three parts:

i. **Duodenum** is the first part. It is about 25 cm (about 10 inches) long.
ii. **Jejunum** is the middle part. It is about 2.5 m (about 8 feet) long.
iii. **Ileum** is the last part. It is about 4 m (about 13 feet) long.

In duodenum, secretions of liver and pancreas act on food. The secretion of liver i.e., **bile** enters duodenum through common bile duct. It contains salts which break large fats into small droplets. In this way, a milky fluid is formed in which fat droplets are kept separate. This process is called emulsification. The secretion of pancreas i.e., **pancreatic juice** enters duodenum through pancreatic duct, which joins the common bile duct before entering duodenum.

Bile also contains pigments that are formed when RBCs are broken in liver. These pigments are removed from the body with faeces.

Pancreatic juice contains many enzymes e.g., **trypsin, pancreatic amylase** and **lipase**. These enzymes digest proteins, carbohydrates and lipids respectively. Pancreatic juice also contains sodium bicarbonate that neutralizes the acidity of chyme. The glands present in the walls of small intestine also secrete enzymes for the complete digestion of all types of food.

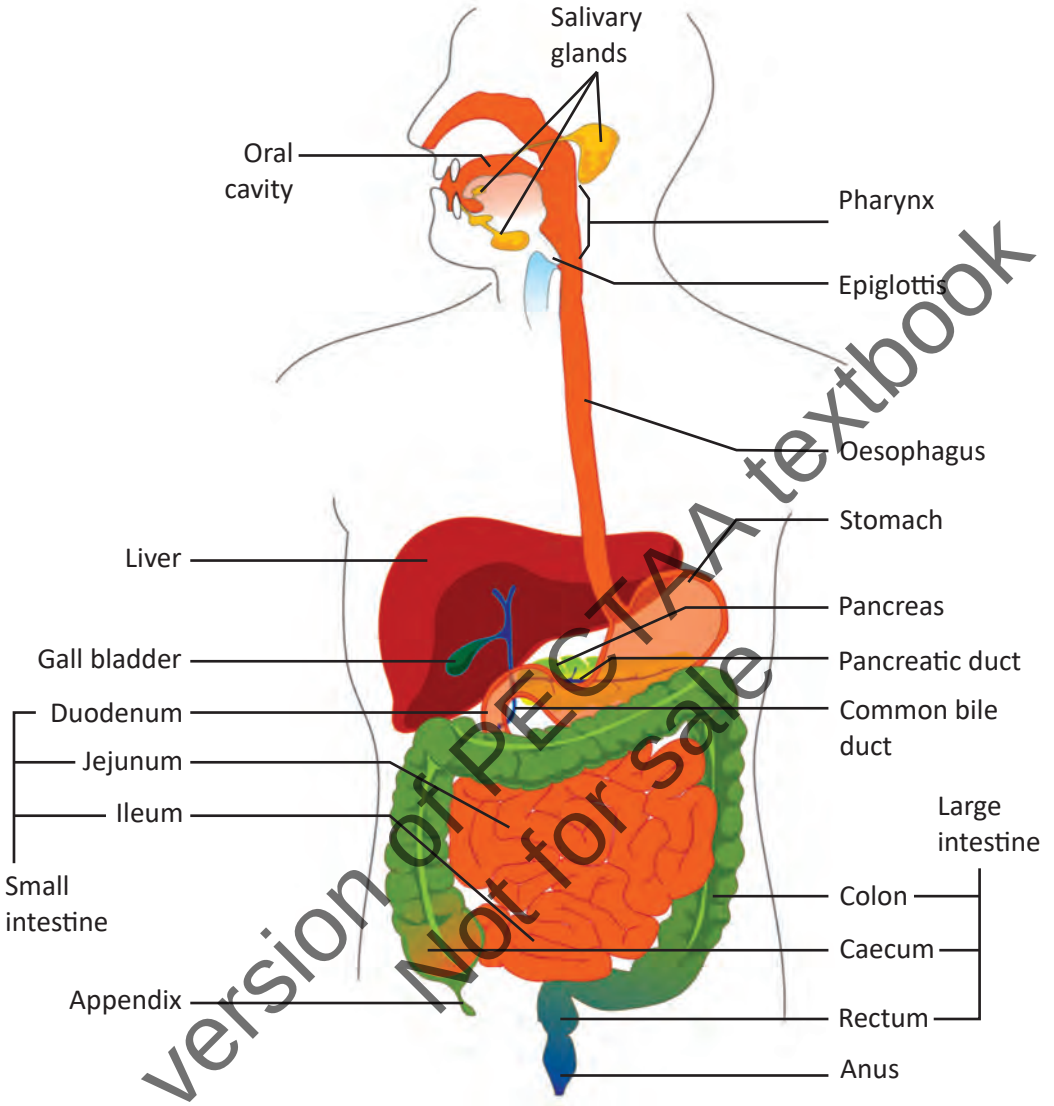


FIGURE 1.4: Human digestive system

Absorption of Food

After the complete digestion of food, the end products i.e., amino acids, simple sugars, glycerol, and fatty acids etc. move from alimentary canal into the circulatory system. The inner walls of small intestine are highly folded. Moreover, these folds have millions of finger-like projections called **villi** (singular; villus). The folds and villi provide a large surface area for the absorption of food. Food molecules are absorbed through this surface through diffusion and active transport. The wall of a villus is made of a single layer of cells. Inside the villus,

there are **blood capillaries** and a lymph vessel called **lacteal**.

The glycerol and fatty acids present in small intestine enter the lacteals of villi. The lacteals carry them to the main lymph vessels, which empty into the blood vessels near the heart. Amino acids and simple sugars enter the blood capillaries of villi. These capillaries join to make **hepatic portal vein** which carries the amino acids and sugars to liver. From liver, the hepatic vein carries these nutrients to heart and then to all parts of the body.

There is a small finger-like **appendix** at the blind end of caecum. It may seem like an unimportant organ, but it actually plays a role in your immune system!

Infection in appendix causes severe pain. If infected appendix is not removed surgically, it can burst and infection may spread in abdomen.

5. Large intestine

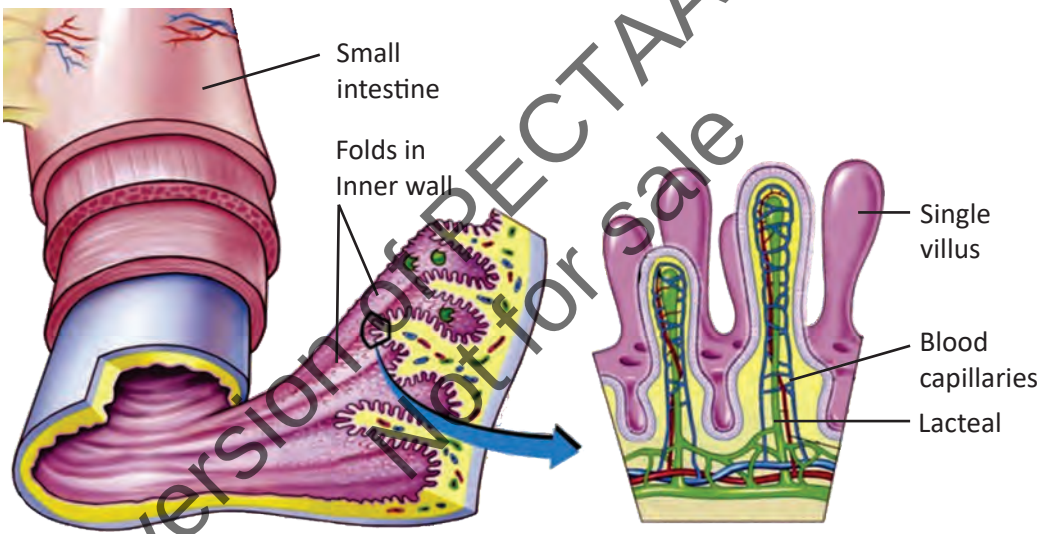


FIGURE 1.5: Small intestine and Villi

Table 1.1: The action of enzymes in the regions of alimentary canal

Region	Enzyme	Substrate	Product
Oral Cavity	Salivary Amylase	Starch	Maltose
Stomach	Pepsin	Proteins	Peptides
Small Intestine	Pancreatic Amylase	Starch	Maltose
	Trypsin	Proteins	Peptides
	Chymotrypsin	Proteins	Peptides
	Peptidase	Peptides	Amino acids and peptides
	Lipase	Fats	Fatty acids glycerol

Nucleases	Nucleic acids	Nucleotides
Maltase	Maltose	Glucose
Sucrase	Sucrose	Glucose and Fructose
Lactase	Lactose	Glucose and Galactose
Dipeptidases	Dipeptides	Amino acids

After the absorption digested food material and some water, the undigested material and water move to the large intestine by peristalsis. Large intestine has 3 parts i.e. **caecum** (a pouch that forms junction with small intestine), the **colon**, and **rectum**. Absorption of more water occurs from large intestine. Due to it, the undigested material solidifies and is now called **faeces**. The faeces contain the undigested material, large number of bacteria, broken cells of alimentary canal, bile pigments and water. Faeces are temporarily stored in the rectum. During egestion, faeces are expelled out through anus.

Role of liver

Liver is a large organ located to the right of the stomach. In an adult human, it weighs about 1.5 kg. There is a sac-like organ, called **gall bladder**, on the ventral side of liver. Liver secretes bile, which is stored in gall bladder. The common bile duct carries bile from gall bladder into duodenum. Bile does not contain enzymes but it has salts which break fats into small droplets. Bile salts also keep fat droplets separate from one another. It helps the enzymes to attack on lipids. Liver also performs many other functions in the body. For example,

- Stores glucose as glycogen and breaks glycogen to glucose when required.
- Stores of fat-soluble vitamins.
- Breaks amino acids. In this process, harmful ammonia is produced.
- Converts ammonia into less toxic urea for excretion through urine.
- Breaks toxic substances e.g., alcohol.
- Breaks the RBCs which have completed their life spans.
- Prepares vitamin A from carotene.
- Produces heat in cold temperatures by speeding up metabolism.

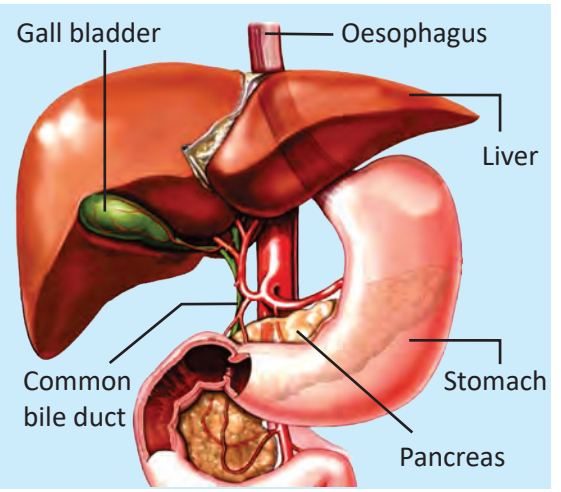


FIGURE 1.6: Liver and associated organs

EXERCISE

A. Select the correct answers for the following questions.

1. The three portions of the small intestine, in the correct order, are;

   a) Duodenum, jejunum, ileum
   b) Ileum, duodenum, jejunum
   c) Colon, caecum, rectum
   d) Caecum, colon, rectum

2. The wavelike movement of muscles that pushes food through the digestive system is called;

   a) Chemical digestion
   b) Mechanical digestion
   c) Peristalsis
   d) Absorption

3. The part of the digestive system where no digestion takes place is;

   a) Oral cavity b) Oesophagus c) Stomach d) Duodenum

4. Which group of enzymes breaks up starches and other carbohydrates?

   a) Proteases b) Lipases c) Amylases d) Pepsin

5. The pancreas produces digestive enzymes and releases them into;

   a) Colon b) Gall bladder c) Liver d) Duodenum

6. In stomach, pepsinogen is converted into pepsin by the action of;

   a) Bile salts d) Hormones c) HCl d) Bicarbonate

7. In which part are the carbohydrates, lipids and proteins digested?

   a) Oral cavity
   b) Stomach
   c) Small intestine
   d) Large intestine

8. The enzyme trypsin is found in;

   a) Pancreatic juice b) Bile c) Gastric juice d) Saliva

9. The common bile duct carries bile from gall bladder to;

   a) Stomach b) Duodenum c) Colon d) Pancreas

10. Why the small intestine has many folds and contains villi and microvilli?

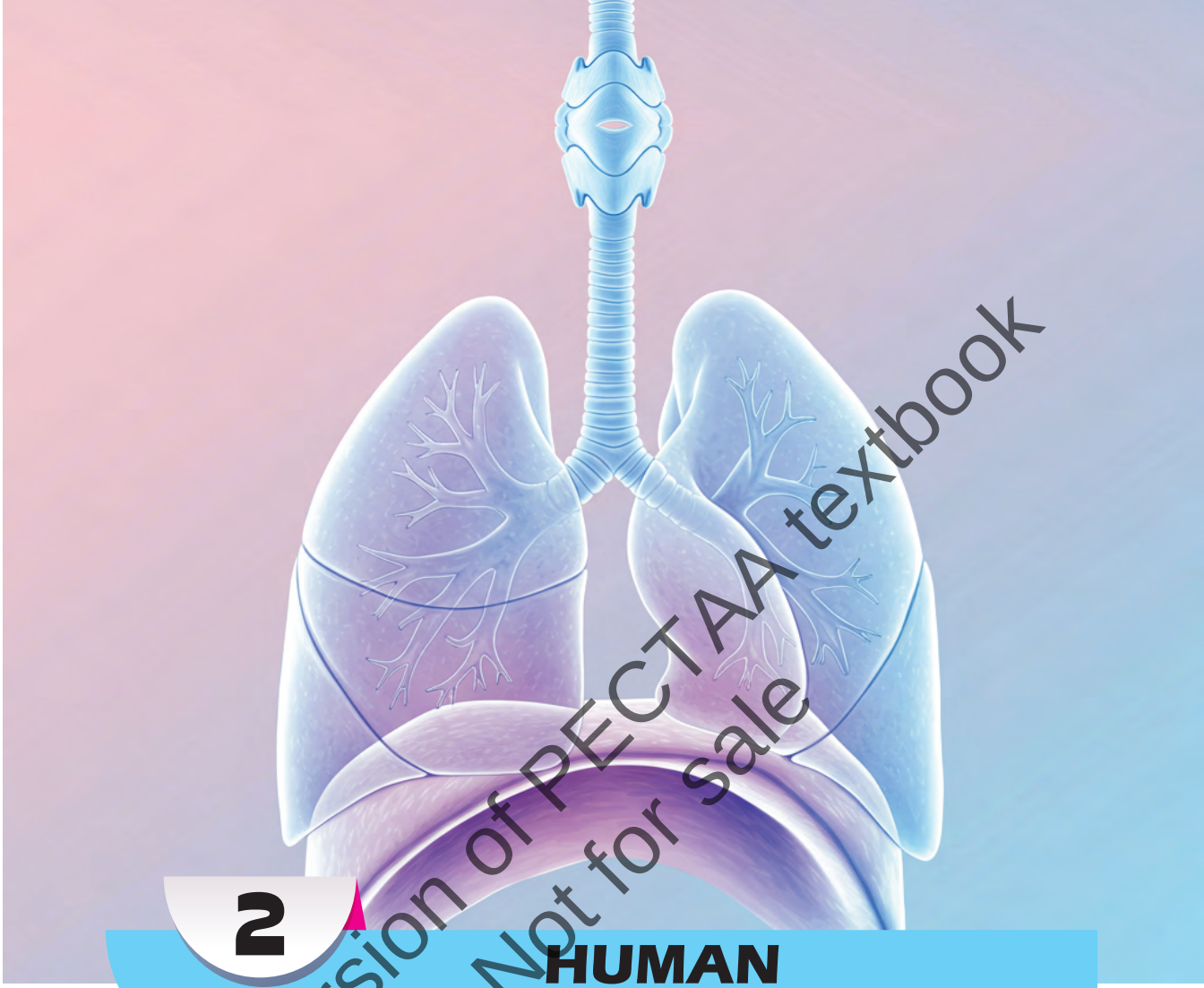
    a) To slow down the passage of food.
    b) To promote food absorption.
    c) To prevent the backflow of chyme.
    d) To produce enzymes.

B. Write short answers.

1. State the role of salivary glands in digestion.
2. What do the terms swallowing and peristalsis mean?
3. What are the functions of HCl in gastric juice?
4. State the role of pancreatic juice contribute in food.
5. Write a brief note on the structure of villi.

C. Write answers in detail.

1. Describe the absorption of food in small intestine.
2. Explain the role of oral cavity in the digestive system.
3. Explain the structure and functions of stomach.
4. Justify the importance of liver and pancreas in digestion.



2 HUMAN RESPIRATORY SYSTEM

Students Learning Outcomes

After studying this chapter, students will be able to:

- Describe the roles of the parts of the air passageway and lungs.
- Describe the mechanism of breathing in terms of movements ribs and diaphragm.
- Differentiate between the composition of inspired and expired air.

Organisms get energy by doing **cellular respiration**. It is the process in which cells oxidize food (glucose) and get energy. For this purpose, organisms need to carry oxygen to their cells and to remove carbon dioxide from cells. **Gaseous exchange** is the process in which oxygen present in the inhaled air (in lungs) moves into blood, and carbon dioxide from the blood moves into the air to be exhaled. For gaseous exchange, animals do breathing.

In aerobic respiration, oxygen is utilized while carbon dioxide and water are produced.

Breathing

Breathing is the process in which animals move air into and out of their body. It is done to get oxygen from air and to release carbon dioxide in it. Breathing and respiration are not the same processes. Respiration is a chemical process while breathing is a physical process. Breathing helps in gaseous exchange. Gaseous exchange, in turn, helps in respiration.

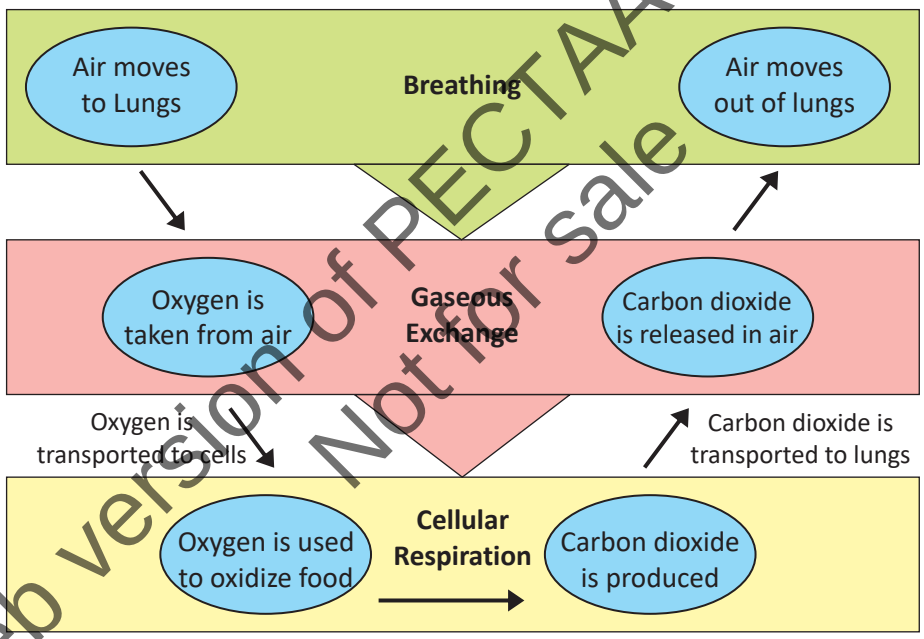


FIGURE 2.1: Relationship between respiration, gaseous exchange and breathing

2.1 HUMAN RESPIRATORY SYSTEM

Respiratory system is responsible for breathing and gaseous exchange. The human respiratory system consists of two major parts i.e., air passageway and lungs.

A. The Air Passageway

When air enters the body, it passes through connected tubes to reach the

lungs. After gaseous exchange, air moves from the lungs to outside through the same connected tubes. These connected tubes are collectively called air passageway. It consists of the following parts.

1. Nostrils and Nasal cavity

The nasal cavity is made up of two narrow cavities between nostrils and pharynx. Air enters the nasal cavity through nostrils. **Fine hairs** in nasal cavity filter the incoming air by trapping large dust particles. **Mucus** on the walls of nasal cavity traps small dust particles. Mucus also warms the air and keeps its temperature nearly equal to the temperature of body.

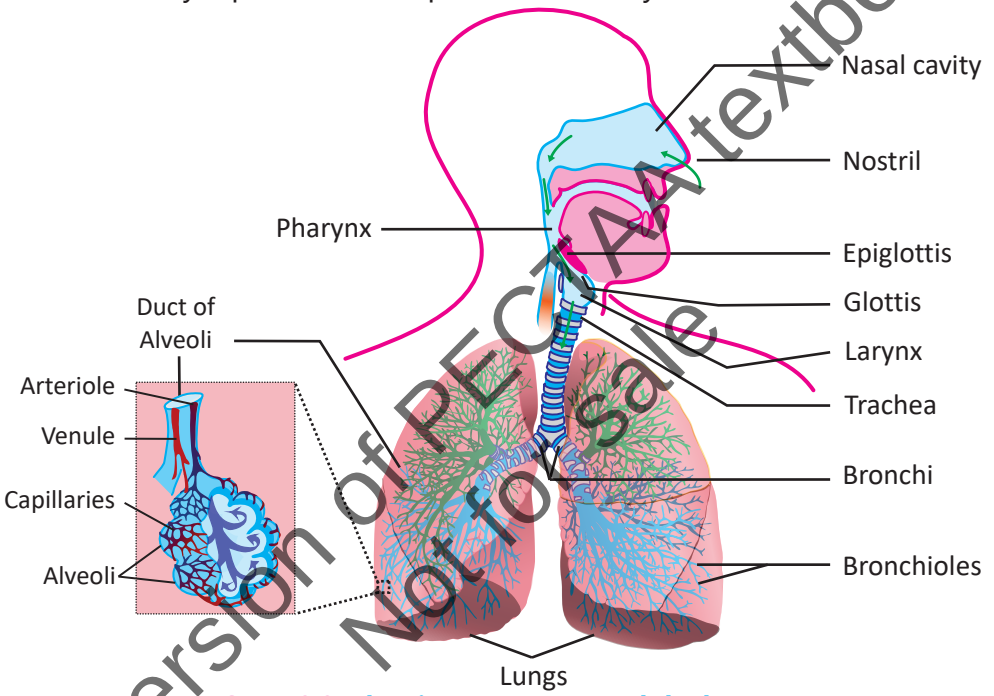


FIGURE 2.2: The air passageway and the lungs

2. Pharynx

Nasal cavity opens into pharynx. At the floor of pharynx there is an opening called **glottis**. It opens in larynx. The glottis is guarded by a flap called **epiglottis**. It prevents food and liquid from entering the windpipe and lungs.

Recalling:

Pharynx is a common passage for food to oesophagus and for air to larynx.

3. Larynx

It is a box present between pharynx and trachea. Larynx is also called the **voice box**. Two fibrous bands called vocal cords are

The vibrations of vocal cords and the movements of lips, cheeks, tongue and jaws produce specific sounds which result in speech.

attached to the inner walls of larynx. The vibrations of vocal cords produce sounds.

4. Trachea and Bronchi

Trachea (windpipe) is a 12 cm (4.72 inches) long tube attached with larynx. It ends in two branches called **bronchi** (*singular*: bronchus). Each bronchus enters into the lung of its side.

The inner walls of trachea and bronchi are lined with mucus and cilia. Mucus traps fine dust particles and bacteria. Cilia move these particles and mucus upwards to the pharynx. In the walls of trachea, **C-shaped cartilages** are present. While the walls of bronchi have plate-like cartilages. These cartilages prevent trachea and bronchi from collapsing even when there is no air in them.

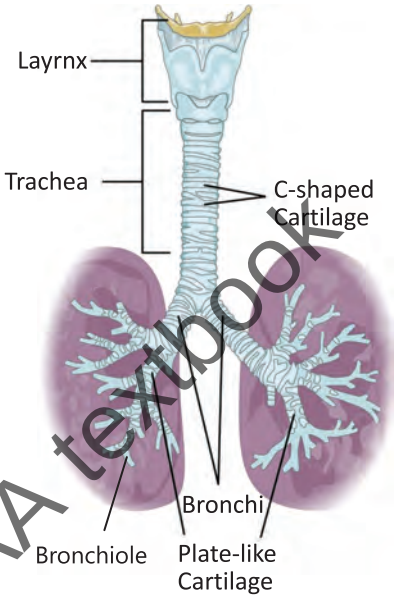


FIGURE 2.3: Cartilage in Trachea and Bronchi

5. Bronchioles and Alveoli

Inside lungs, both bronchi continue to divide into very small tubes called bronchioles. As the branching continues, the amount of cartilage in the walls decreases. Cartilage is absent in the smallest bronchioles. Each bronchiole ends at an alveolar duct. This duct opens into a cluster of pouches. These thin-walled pouches are called alveoli (*singular:* alveolus). Each alveolus is surrounded by blood capillaries. When air reaches alveoli, oxygen moves from the air into blood, and carbon dioxide passes out of blood into the air in the alveoli.

The chest wall is made up of 12 pairs of ribs and the rib muscles called **inter-coastal muscles**.

B. The Lungs

There is a pair of lungs in the thoracic cavity. From above and sides, lungs are enclosed by the chest wall. While, there is a thick muscular structure, called **diaphragm** below lungs. Lungs are spongy and elastic organs. The left lung is slightly smaller than the right lung. There are two lobes in the left lung while right lung has three lobes. Lungs are

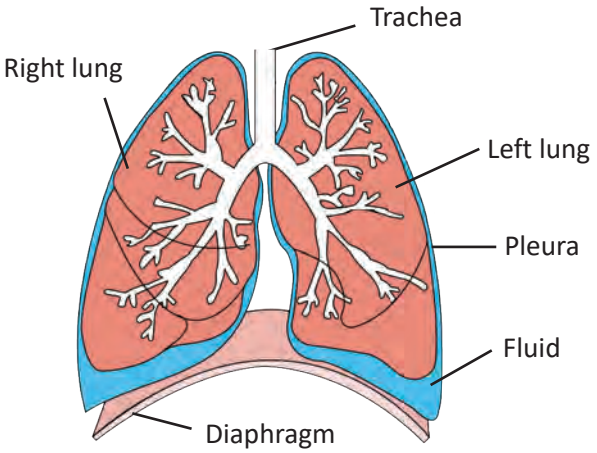


Figure 2.4: Lungs

enclosed in a double membrane called **pleura**. Its inner layer is attached to the surface of the lungs while the outer layer lines the inner surface of the chest wall and the diaphragm. It contains a **pleural fluid** for reducing friction between lungs and the chest wall.

Blood Circulation in Lungs

Pulmonary artery carries deoxygenated blood from heart to lungs. Inside each lung, the pulmonary artery divides into smaller arterioles. The arterioles divide further and make capillaries around the alveoli. After surrounding the alveoli, the capillaries join to form venules. The venules join to form pulmonary vein which carries oxygenated blood back to heart.

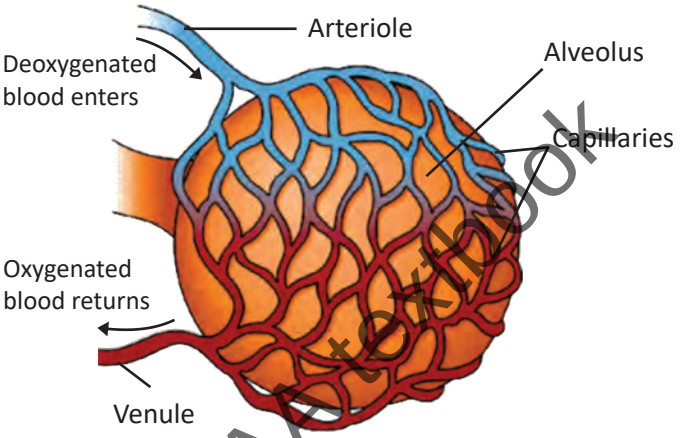


Figure 2.5: Blood circulation in lungs (around an alveolus)

2.2 THE MECHANISM OF BREATHING

The physical movements for taking air to lungs and then removing air from lungs are called as **breathing**. There are two phases of breathing i.e., inhalation and exhalation.

1. Inhalation (inspiration)

Inhalation means intake of air to the lungs. The following events occur

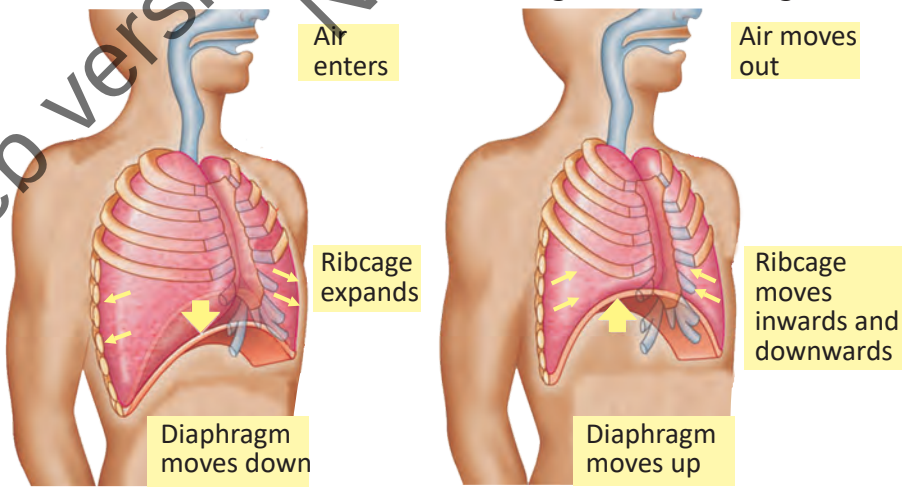


Figure 2.6: Breathing; (a)- Inhalation (b)- Exhalation

during inhalation;

The **intercostal muscles** (muscles located between the ribs) contract to expand the ribcage. At the same time, **diaphragm** also contracts and moves down. These two contractions increase the volume of the chest. So, pressure inside the chest is reduced and air is moved into lungs.

2. Exhalation (expiration)

Exhalation means moving the air out of the lungs. The following events occur during exhalation;

The **intercostal muscles** relax to move ribcage inwards. At the same time **diaphragm** also relaxes and moves up. These two movements decrease the volume of the chest. So, pressure inside the chest increases and air is forced out.

We lose half a litre of water a day through breathing. This is the water vapour we see when we breathe onto glass.

The Rate of Breathing

Humans breathe **16 -20 times per minute** in normal conditions i.e., at rest. During exercise or hard job, muscles carry out cellular respiration at greater rate. So, more carbon dioxide is produced. The respiratory centre in brain detects greater concentration of carbon dioxide in blood. It sends messages to the muscles of ribs and diaphragm at greater speed. The speed of contraction and relaxation of these muscles increases. So, the breathing rate increases up to **30-40 times per minute**.

Composition of the Inhaled and the Exhaled Air

Feature	Inspired Air	Expired Air
Oxygen %age	21	16
Carbon dioxide %age	0.04	4
Nitrogen %age	79	79
Water vapours	Variable	Saturated
Temperature	Variable	Almost equal to body temperature
Dust particles	Variable	Almost none

EXERCISE

A. Select the correct answers for the following questions.

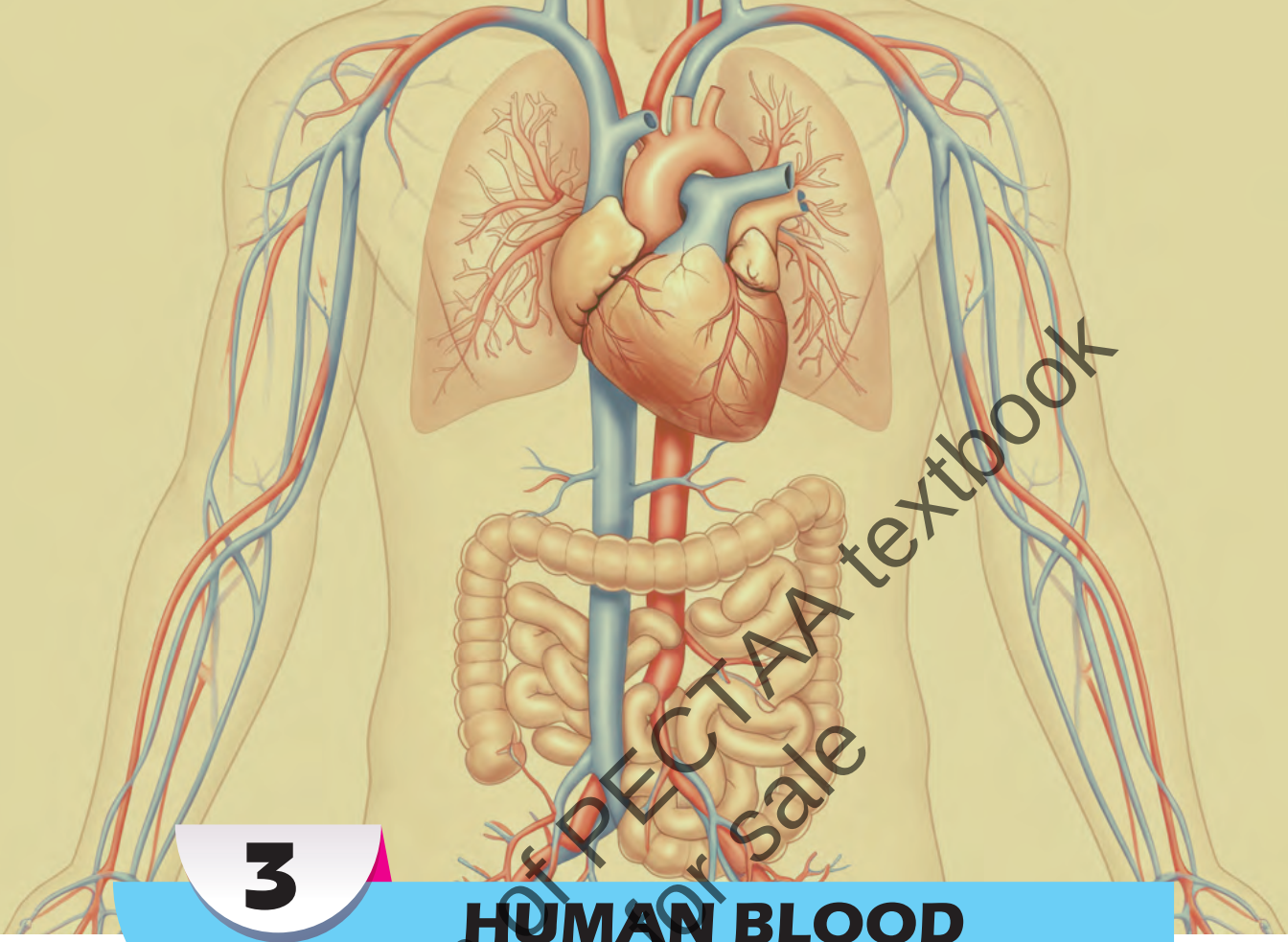
1. Breathing means;
   a) Breakdown of C-H bonds to produce energy
   b) Movements that take air in and out of body
   c) Getting oxygen from the air and removing carbon dioxide
   d) Transport of oxygen through blood to different parts of the body
2. Which path does air take immediately after passing through the larynx?
   a) Pharynx b) Bronchi c) Trachea d) Alveoli
3. Why are alveoli surrounded by capillaries?
   a) To absorb water b) To exchange gases
   c) To produce mucus d) To trap dust particles
4. Which feature of alveoli helps in rapid gas exchange?
   a) Thick walls b) Large diameter
   c) Moist surface d) Strong muscles
5. Which action increases lung volume during breathing?
   a) Relaxing the diaphragm b) Contracting intercostal muscles
   c) Closing the trachea d) Stiffening alveolar walls
6. Which factor controls the breathing rate?
   a) Carbon dioxide in blood b) Oxygen in blood
   c) Carbon dioxide in muscles d) Oxygen in muscles

B. Write short answers.

1. Differentiate between gaseous exchange and breathing.
2. Differentiate between breathing and cellular respiration.
3. What is the function of cartilages present in the walls of trachea and bronchi?
4. What is the average breathing rate in human at rest and during exercise?
5. How does the structure of alveoli maximize gas exchange?

C. Write answers in detail.

1. Explain the process of inhalation and exhalation step by step.
2. Write a short note on the major parts of the human air passageway.
3. Describe the functions and locations of the bronchus, trachea, and alveoli.



3 HUMAN BLOOD CIRCULATORY SYSTEM

Students Learning Outcomes

After studying this chapter, students will be able to:

- Describe how the blood is circulated inside the human body.
- Explain how blood is used to transport materials throughout the human body.
- Identify the different types of organs connected to the blood system and their roles.
- Identify the different components that make up the blood.
- Name the cell types found in blood and their roles.
- Explain the structure of the heart with a diagram.

The transport system consists of two key parts i.e., (i) blood circulatory system, and (ii) lymphatic system. In this chapter, you will study the details of the blood circulatory system. The main components of human blood circulatory system are blood, heart, and blood vessels.

3.1 BLOOD AND ITS COMPONENTS

Blood is a type of connective tissue. Its main function is to transport materials through the body. It carries important materials to where they are needed. It transports oxygen from the lungs to all body cells and carries carbon dioxide back to the lungs for removal. Blood also delivers nutrients from the digestive system to the cells, hormones from glands to target organs, and waste products from the cells to kidneys for excretion.

About 55% of blood is composed of a fluid portion called **plasma** while 45% of blood is made up of cells or cell-like bodies. The adult human has about 5 litres blood in the body.

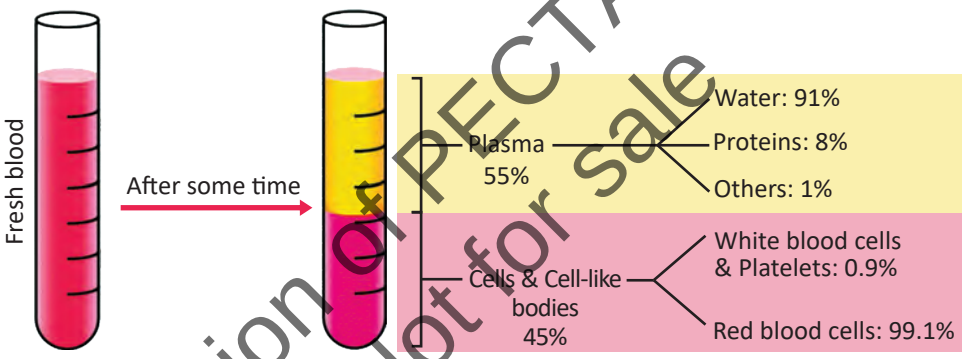


FIGURE 3.1: Percentage composition of blood

1. Blood Plasma

It is the liquid portion of blood. Plasma is composed 90-92% of water, 7-9% of proteins and 1% of other substances.

If fibrinogen is removed from blood plasma, the rest is called **serum**.

- **Proteins:** Antibodies are important plasma proteins. Antibodies defend the body against pathogens. Fibrinogen is also a plasma protein. It is responsible for blood clotting. Albumin is a plasma protein which maintains the osmotic pressure of blood.
- **Salts:** The important plasma salts are made of sodium, chloride, and bicarbonate ions. In addition, there are little amounts of calcium, magnesium, copper, potassium, and zinc.
- **Nutrients, wastes and hormones:** Plasma contains nutrients like

glucose, lipids, and amino acids etc. They enter blood from the digestive system. The wastes produced by cells are also present in plasma. Hormones secreted by endocrine glands are also carried by plasma.

- **Respiratory gases:**
  Small amounts of carbon dioxide and oxygen are dissolved in plasma. Oxygen is mainly carried by RBCs but about 1.5% of oxygen is also present in plasma in dissolved form. Similarly, about 5-7% of carbon dioxide is carried as dissolved in plasma.

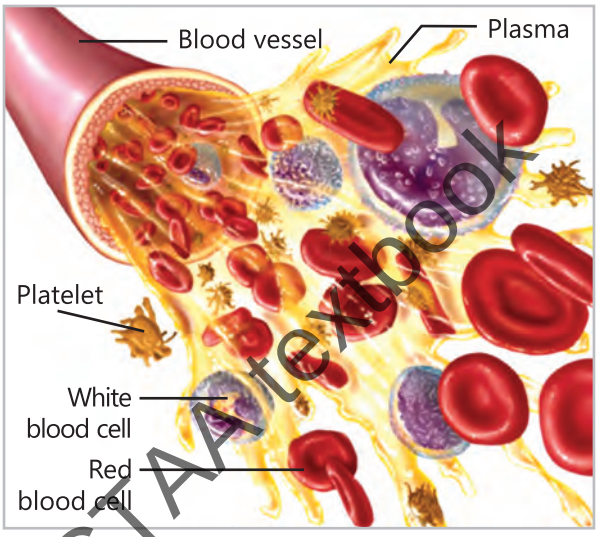


FIGURE 3.2: Blood composition

2. Blood Cells (and Cell-like Bodies)

Red Blood Cells (Erythrocytes)

Red blood cells (RBCs) are disc-shaped cells with a depression at the centre. They contain a red protein, **haemoglobin**. It transports oxygen and little amount of carbon dioxide. There are 4 to 5.5 million RBCs per mm^3 of blood. Before and immediately after birth, RBCs are formed in **liver and spleen**. In adults, they are formed in the **red bone marrow** of short bones (sternum, ribs and vertebrae). During the formation of an RBC, its nucleus and organelles are broken down. The average life span of an RBC is about 120 days. When RBCs complete their age, they are removed by spleen, bone marrow, and liver.

There are more than 30 trillion RBCs throughout the body. About 2 million RBCs die and are replaced every second.

White Blood Cells (Leukocytes)

White blood cells (WBCs) are colourless and have irregular shapes. They are formed in the red bone marrow. Some WBCs mature in lymph nodes, tonsils, thymus, or spleen. WBCs are larger in size and less in number than RBCs. Each mm^3 of blood normally contains about 7,000 WBCs. They defend the body against diseases. Their life span depends upon the needs. There are several types of WBCs.

1. **Granulocytes:** These WBCs have granules in cytoplasm. They include **neutrophils, eosinophils,** and **basophils.** Their names tell the staining properties of their cytoplasm. Neutrophils destroy bacteria and clean up dead cells at infection sites. Eosinophils fight with parasites and cause allergic reactions. Basophils release histamine to cause inflammation and produce allergic responses.
2. **Agranulocytes:** They have clear cytoplasm. There are two types of agranulocytes i.e., monocytes and lymphocytes. **Monocytes** make **macrophages** which engulf the germs and dead cells. **Lymphocytes** make antibodies against pathogens.

Cell-like bodies i.e., Platelets (Thrombocytes)

Platelets are not whole cells. They are small fragments of large cells of bone marrow. Platelets lack a nucleus. Their life span is 7 to 12 days. A mm^3 of blood contains 250,000 platelets.

When a blood vessel is damaged, platelets gather at the damaged site. Here, they convert plasma protein, fibrinogen into **fibrin**. The fibrin molecules form a net that traps RBCs. The mass of fibrin and RBCs hardens. This hard mass is called a **clot**. The clot prevents bleeding until the damaged vessel is repaired.

Macrophages die in the process of killing the germs. The dead cells accumulate and make the white substance called **pus**, seen at infection sites.

FIGURE 3.3: A macrophage engulfing the bacteria

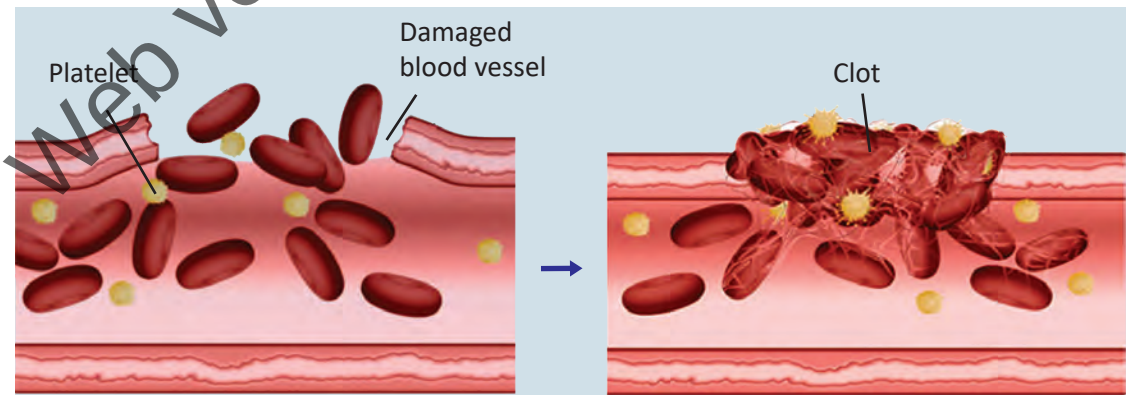


FIGURE 3.4: Formation of clot by platelets

3.2 HUMAN HEART

The heart is a muscular organ that pumps blood through a network of blood vessels. The heart lies within the chest cavity, behind the breast bone (sternum), between the two lungs.

Structure of the Heart

There is a tough, sac-like membrane around the heart. It is called **pericardium**. It secretes a fluid around heart. This fluid reduces friction between the pericardium and heart. Like birds and other mammals, human heart has two sides. The wall between the left and right sides is called **septum**. Each side is divided into two chambers. The upper chambers are called **atria** (singular: atrium), and lower chambers are called **ventricles**. The atria have thinner walls as compared to ventricles.

The left ventricle is the largest and strongest chamber in the heart.

Special flaps called **valves** are present between the chambers of both sides. The valves open in only one direction. The valve between right atrium and right ventricle is called **tricuspid valve** (made of 3 flaps). The valve between left atrium and left ventricle is called **bicuspid valve** (made of 2 flaps). As the ventricles contract, tricuspid and bicuspid valves close. So, the blood cannot flow back into atria. In this way, blood is pumped from the ventricles into large vessels. A **semilunar valve** is present between each ventricles and large vessels. These valves prevent blood from flowing back into the ventricles.

The Circulation of Blood

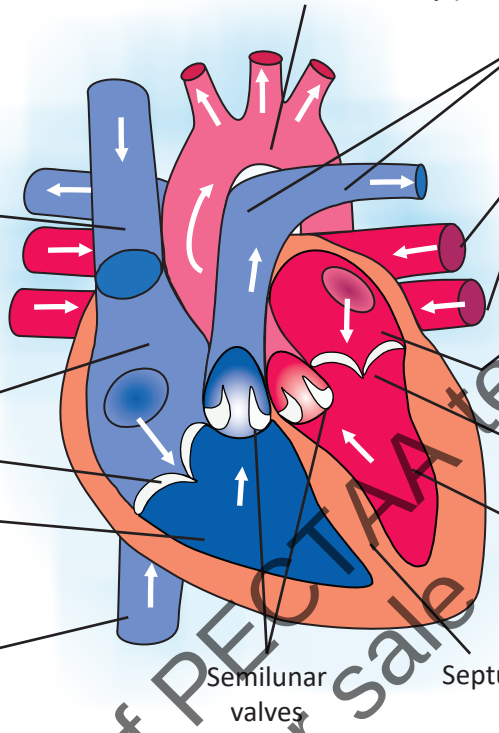
The right side of the heart collects blood from body and sends it to the lungs while the left side collects blood from the lungs and sends it to the body. It means that human heart works as a **double pump**. It is done in the following way.

Oxygenated blood is bright red. Deoxygenated blood is dark red.

Two veins i.e., superior and inferior vena cavae bring **deoxygenated blood** (with high concentration of CO_2 and low concentration of O_2) from parts of the body (other than lungs). These veins open in the right atrium. The right atrium contracts and sends this blood into the right ventricle. The right ventricle contracts and pumps this blood into pulmonary arteries. The pulmonary arteries take this blood to lungs. In lungs, CO_2 diffuses out of the blood, and O_2 diffuses into the blood.

From lungs, pulmonary veins carry the **oxygenated blood** back. These veins open in the left atrium of heart. This blood is pumped into left ventricle.

FIGURE 3.5:
Human heart; structure and blood circulation



Due to high pressure in systemic circulation, blood can reach to all body parts. On the other hand, due to low pressure in pulmonary circulation, blood flows in lungs in slow speed. It gives sufficient time for gaseous exchange in lungs.

When left ventricle contracts it pumps the blood into a large blood vessel called **aorta.** From aorta, this blood is transported to all parts of the body.

Pulmonary and systemic circulations: The flow of blood from heart to lungs and then from lungs to heart is called **pulmonary**

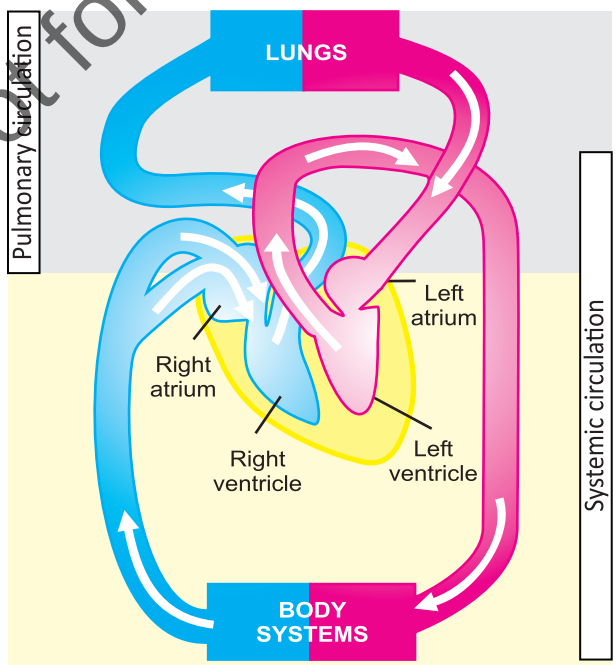


FIGURE 3.6: Pulmonary and systemic circulations

circulation. Similarly, the flow of blood from heart to the body tissues and then from body tissues to heart is called **systemic circulation**.

Heartbeat

The alternating contraction (systole) and relaxation (diastole) of heart chambers makes one heartbeat. The average human heart beats 70 times per minute. This is also called the heart rate. A heartbeat has two phases.

- **Systole** occurs when both ventricles contract to pump the blood into pulmonary arteries and aorta.
- **Diastole** occurs immediately after systole when both atria relax so that blood enters the atria. Contraction of the atria fills the ventricles.

During systole **"lubb"** sound is produced due to the closing of tricuspid and bicuspid valves.

During diastole **"dubb"** sound is produced due to the closing of semilunar valves.

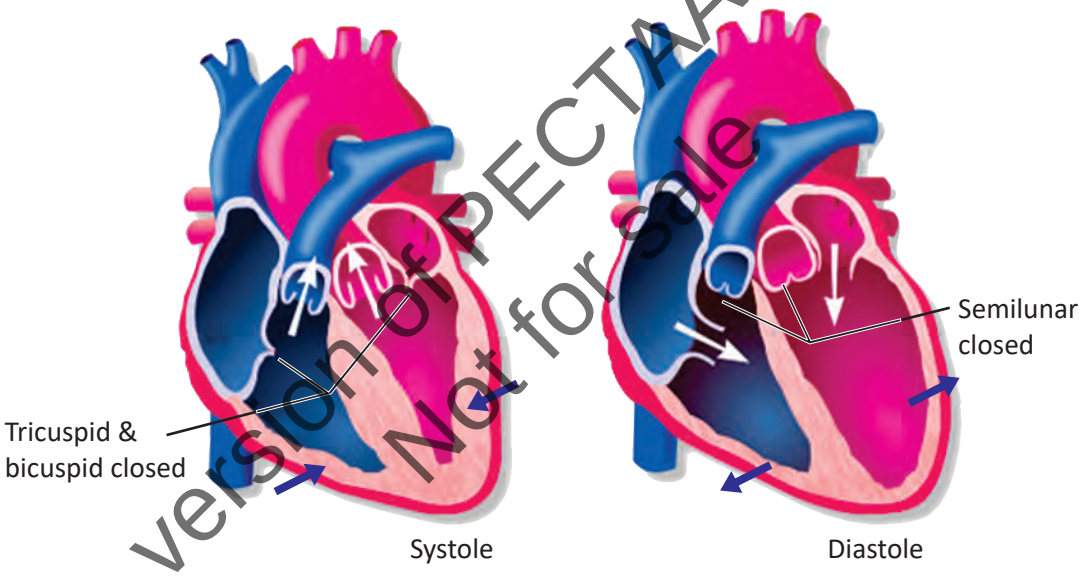


FIGURE 3.7: One Heartbeat

3.3 BLOOD VESSELS

1. Arteries

Arteries carry blood away from the heart. In adults, all arteries carry oxygenated blood, with the exception of pulmonary arteries. The thick walls of arteries are made of: an inner layer of **endothelium**, a middle layer of **smooth muscles** and elastic tissues, and an outer layer of **connective tissue**. Arteries are strong and elastic. The hollow internal cavity of arteries in which the blood flows is called **lumen**. When arteries enter body organs, they divide into smaller vessels

known as arterioles. The arterioles enter tissues and divide into capillaries.

2. Capillaries

Capillaries are the smallest blood vessels. The walls of capillaries are composed of only a single layer of cells i.e., **endothelium**. This layer is so thin that water, nutrients and oxygen can pass through it to enter the tissue fluid. Similarly, carbon dioxide and other wastes present in tissue fluid can pass through it to enter blood. In tissues, capillaries unite to form small veins, called **venules**. The venules unite to form veins.

3. Veins

Veins carry blood towards the heart. In adults, all veins carry deoxygenated blood, with the exception of pulmonary veins. The walls of vein are composed of the same three layers as are present in the artery wall i.e., an inner layer of **endothelium**, a middle layer of **smooth muscle** and elastic tissues, and an outer layer of **connective tissue**. In veins, the middle layer is comparatively thin as compared to arteries. It has lesser smooth muscles and elastic tissues. The lumen of the veins is broader than that of arteries. Most veins have **valves** that prevent the back flow of blood.

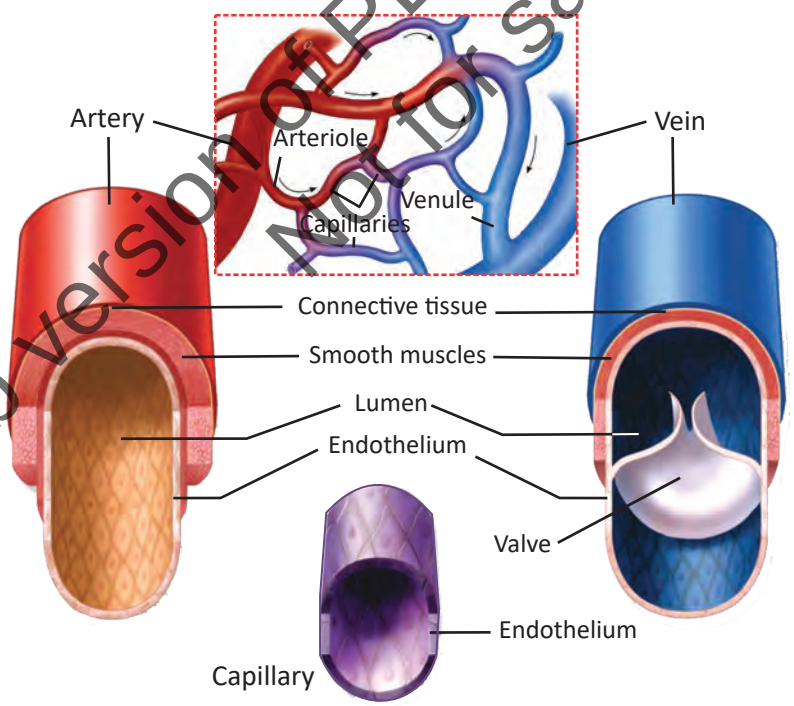
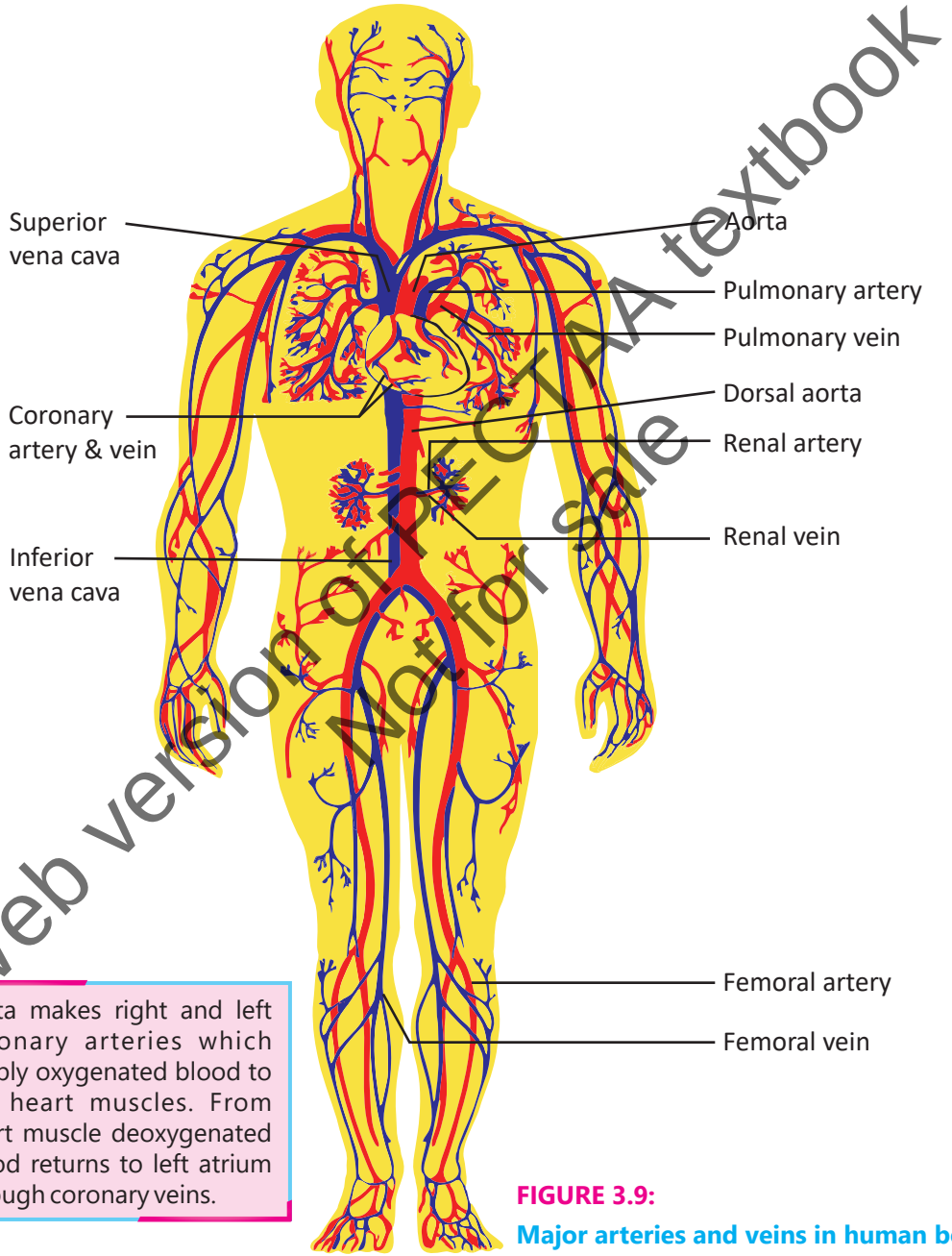


FIGURE 3.8: Blood vessels

3.4 ARTERIAL AND VENOUS SYSTEMS

Arterial System

- **Arteries of Pulmonary circulation:** A large artery called **pulmonary trunk** carries deoxygenated blood from right ventricle. It branches into two smaller pulmonary arteries, with one artery going to each lung.



Aorta makes right and left coronary arteries which supply oxygenated blood to the heart muscles. From heart muscle deoxygenated blood returns to left atrium through coronary veins.

FIGURE 3.9:
Major arteries and veins in human body

- **Arteries of Systemic circulation:** Oxygenated blood is pumped from left ventricle into **aorta**. It forms arteries which supply blood to head, shoulders and arms. Aorta passes through the thorax and becomes **dorsal aorta**. It makes many arteries that supply blood to all parts of the lower region. For example, **hepatic artery** supplies blood to the liver and **renal arteries** supply blood to kidneys. Aorta divides and makes two **femoral arteries** which supply blood to legs.

Venous System

- **Veins of Pulmonary circulation:** Two **pulmonary veins** carry oxygenated blood from lungs to the left atrium of heart.

Veins are blue-looking, but the blood inside is actually dark red.

- **Veins of Systemic circulation:** Two major veins i.e., superior vena cava and the inferior vena cava carry deoxygenated blood from body to right atrium. The **superior vena cava** is made by joining of veins from head, shoulders and arms. The **inferior vena cava** is made of many veins from parts of the lower region. For example, two **femoral veins** from legs empty into inferior vena cava. **Renal** veins carry blood from the kidneys. The **hepatic portal vein** carries blood from alimentary canal to the liver. From liver, a **hepatic vein** carries blood to the inferior vena cava.

EXERCISE

A. Select the correct answers for the following questions.

1. Which component of blood is mainly responsible for carrying oxygen?
   a) White blood cells b) Platelets
   c) Red blood cells d) Plasma
2. A person with low platelet count is likely to face difficulty in:
   a) Fighting infections b) Breathing
   c) Clotting blood d) Transporting oxygen
3. Which of the following layer is found in all blood vessels?
   a) Smooth muscle b) Endothelium
   c) Skeletal muscle d) Connective tissue
4. Which of the following contains deoxygenated blood in an adult human?
   a) Left atrium b) Pulmonary artery
   c) Pulmonary vein d) Aorta

5. When fibrinogen makes blood clot it separates from blood and the rest is;

a) Plasma b) Lymph c) Serum d) Pus

6. Which heart chamber has the thickest walls?

a) Right atrium b) Left atrium c) Left ventricle d) Right ventricle

7. The exchange of materials between the blood and tissues occurs in;

a) Arteries b) Veins

c) Capillaries d) Arteries and veins

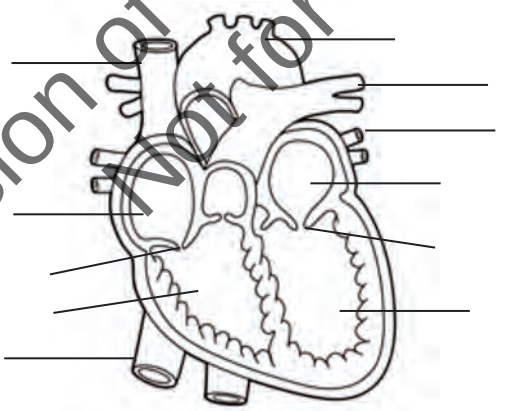
8. All veins carry deoxygenated blood except the _____ vein.

a) Vena cava b) Hepatic portal

c) Pulmonary d) Renal

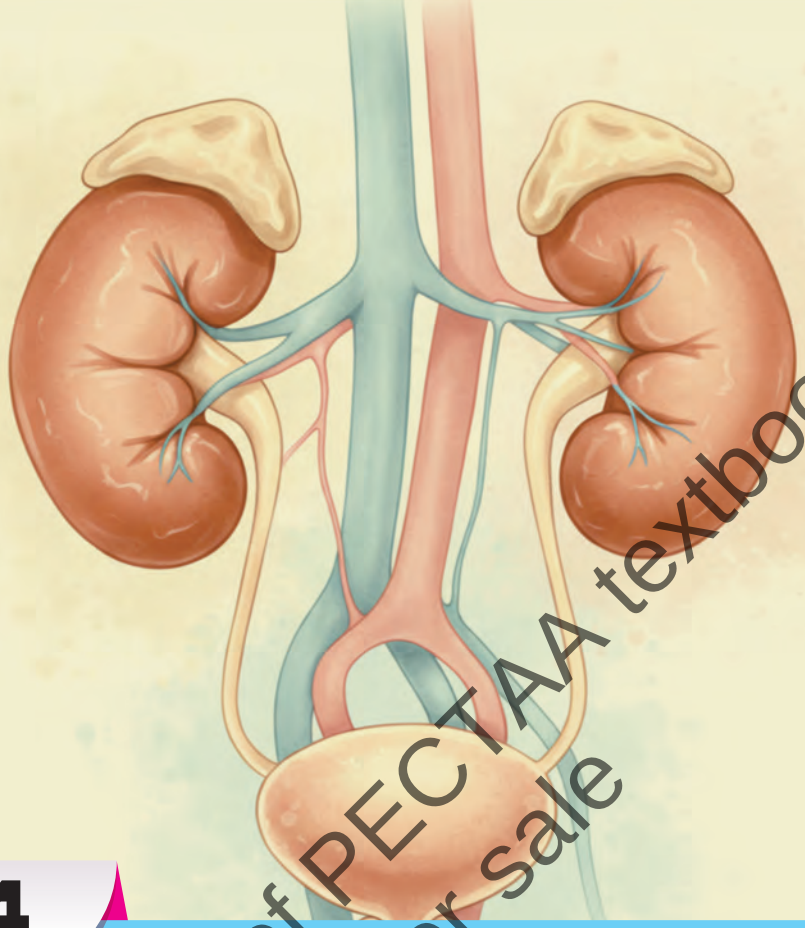
B. Write short answers.

1. List the types of cells present in blood along with their functions.
2. Differentiate between atria and ventricles.
3. Trace the flow of blood from the vena cava to various body parts.
4. Identify the causes and treatments of myocardial infarction.
5. Colour the following diagram of heart to show oxygenated and deoxygenated blood. Label the different structures as marked.



C. Write answers in detail.

1. Describe the functions of the components of blood.
2. Explain how blood transports materials throughout the human body.
3. Explain the structure of the heart with a diagram.
4. Compare the structure and function of an artery, a vein and a capillary.



4 HUMAN URINARY SYSTEM

Students Learning Outcomes

After studying this chapter, students will be able to:

- Identify the different organs of urinary system.
- Relate the structure of the kidney with its function.
- State that nephron is the excretory unit of kidney.
- Locate the different parts of nephrons and relate them with their function.
- State that main role of the kidney is urine formation.
- Describe that urine formation involves three processes i.e., filtration, reabsorption and secretion.
- Explain that the kidney plays an important role in osmoregulation.

The urinary system regulates the internal environment of body. It ensures that waste products and excess substances are removed from body. In this chapter, we will study the structure and functions of the human urinary system and the related kidney disorders.

4.1 HUMAN URINARY SYSTEM

The human **urinary system** (excretory system) consists of a pair of kidneys, a pair of ureters, a urinary bladder and a urethra. Kidneys remove extra water, salts and nitrogenous wastes from blood and make urine. From each kidney, a tube called **ureter** carries urine to the urinary bladder. The **urinary bladder** temporarily stores urine. The **urethra** is the tube that carries urine from the urinary bladder to the outside.

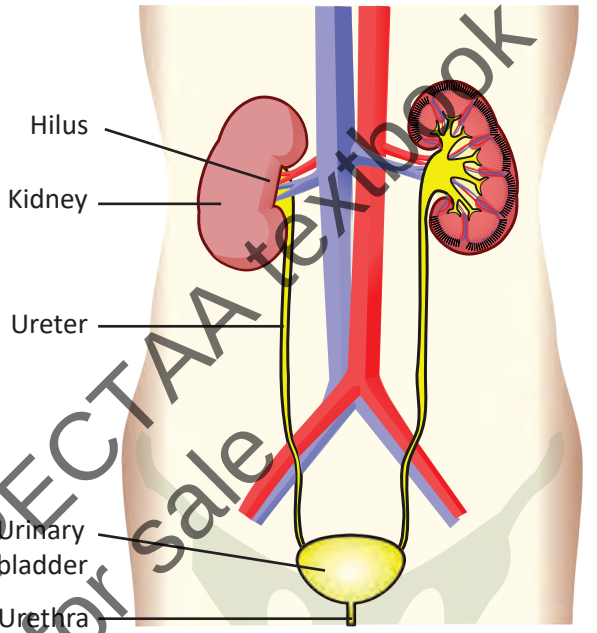


FIGURE 4.1: The Urinary System

The Kidneys

Kidneys are the main organs of urinary system. Renal arteries supply them blood with metabolic wastes (e.g., urea, extra water and salts). Kidneys filter these wastes from blood and then excrete them in the form of urine.

Kidneys are bean-shaped organs having a concave and a convex side. They are present in the abdominal cavity, below the diaphragm, on the sides of vertebral column. The concave side of each kidney is towards vertebral column. The left kidney is a little higher than the right. Kidneys are dark-red in colour. Each kidney is about 10 cm long, 5 cm wide and 4 cm thick.

Structure of the Kidney

External structure: Kidney is surrounded by a tough tissue called **renal capsule**. On the concave side of kidney, there is a depression called **hilus**. It is the point from where renal artery enters in kidney and renal vein and ureter leave kidney.

Internal structure: Internally, a kidney is divided into two regions. The outer region is called **renal cortex** while the inner one is called **renal medulla**. There are many cone-shaped areas in renal medulla, called **renal pyramids**. The base of each pyramid faces the renal cortex while its tip is in a cavity called **renal pelvis**. It extends to outside of kidneys and forms a ureter.

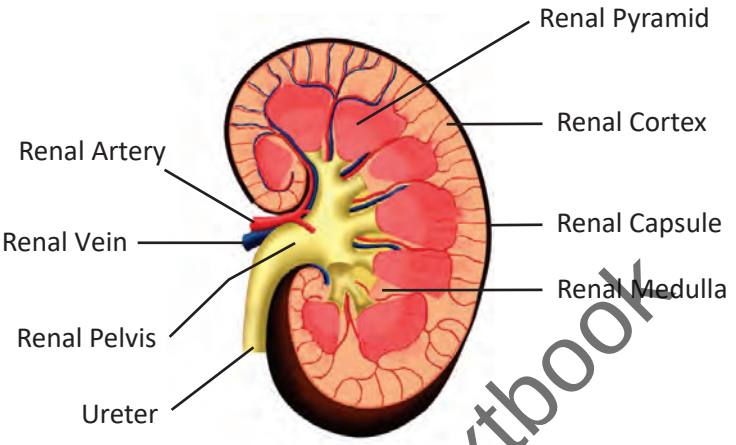


FIGURE 4.2: Structure of kidney

Nephron

The functional unit of kidney are called **nephrons**. There are more than one

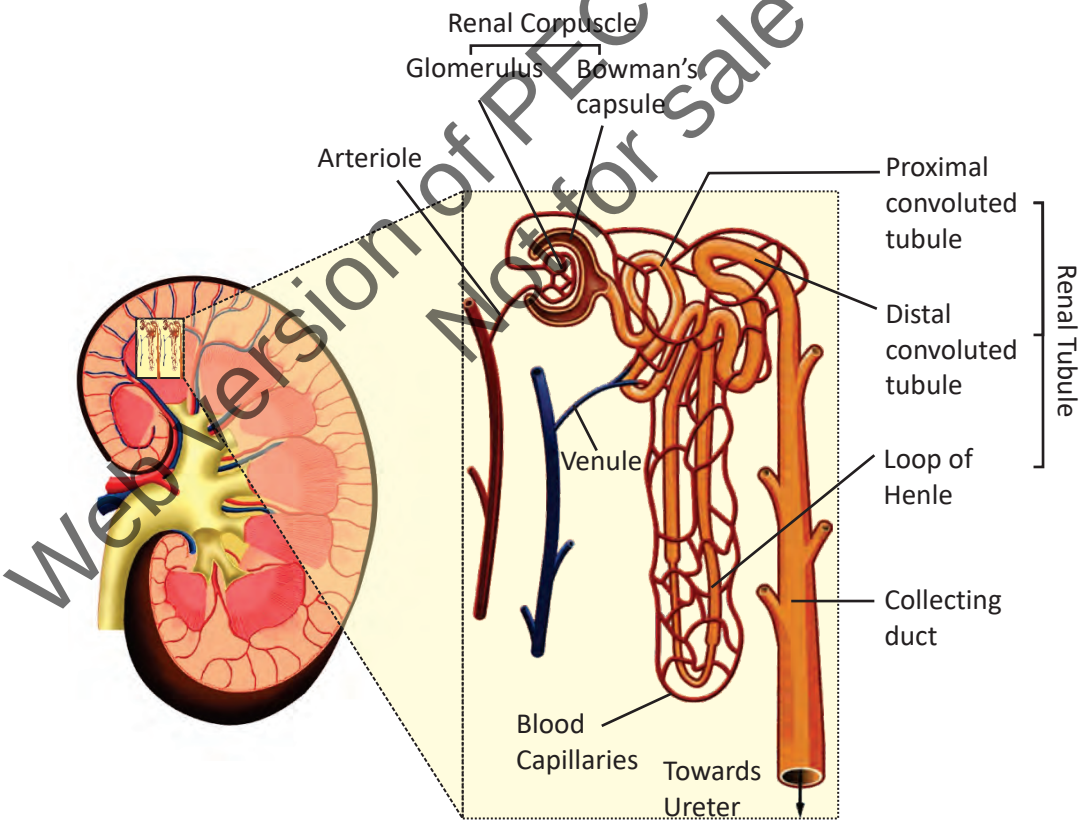


FIGURE 4.3: The Structure of Nephron

million nephrons in each kidney. A nephron consists of two parts i.e., renal corpuscle and renal tubule.

1. **Renal corpuscle:** It is the first part of nephron and is composed of glomerulus and the Bowman's capsule. The **glomerulus** is a network of capillaries while the **Bowman's capsule** is the cup-shaped structure around the glomerulus.
2. **Renal tubule:** It is a long tube attached with the Bowman's capsule. It has three parts. The first part is convoluted and is called the **proximal convoluted tubule**. The middle part is U-shaped and is called the **Loop of Henle**. The last part is again convoluted and is called the **distal convoluted tubule**.

The distal convoluted tubules of many nephrons open in a single **collecting duct**. Many collecting ducts join together and open into the renal pelvis.

4.2 FUNCTIONING OF THE KIDNEY

Kidneys control the chemical composition of blood. They take waste materials from blood and convert them to urine. It occurs in three steps.

1. Pressure Filtration

Blood enters kidney through a renal artery. The artery divides into many arterioles. Each arteriole divides into the capillaries of glomerulus. When blood reaches glomerulus, its pressure is very high. So, many small molecules (water, salts, glucose and urea etc.) move out of glomerulus. These materials enter Bowman's capsule. This step is called pressure filtration. The filtered material in Bowman's capsule is called **glomerular filtrate**. It is about 20% of the blood plasma that enters the glomerulus.

Blood cells and proteins are not filtered through the glomerular capillaries because they are relatively larger in size.

2. Reabsorption

The glomerular filtrate moves to the next part of nephron i.e., renal tubule. Many useful materials are reabsorbed from glomerular filtrate into the blood capillaries surrounding the renal tubule.

- Large amount of water, nearly 100% of glucose and amino acids, and most of the salts are reabsorbed from proximal convoluted tube.
- Some water is reabsorbed from descending limb of the loop of Henle. Large amounts of salts are reabsorbed from ascending limb of the loop of Henle.

- Some water is also reabsorbed from distal convoluted tubule and collecting duct.

3. Tubular Secretion

When useful materials are reabsorbed into blood, some of the remaining wastes present in blood are secreted from blood capillaries to renal tubule. It is an active transport process and is called tubular secretion.

After reabsorption and tubular secretion, the filtrate in the renal tubules is known as **urine**. Urine from all nephrons moves to the renal pelvis. From renal pelvis, urine moves to the urinary bladder via ureters. Here it is stored. When the urinary bladder is filled, urine is passed out through urethra.

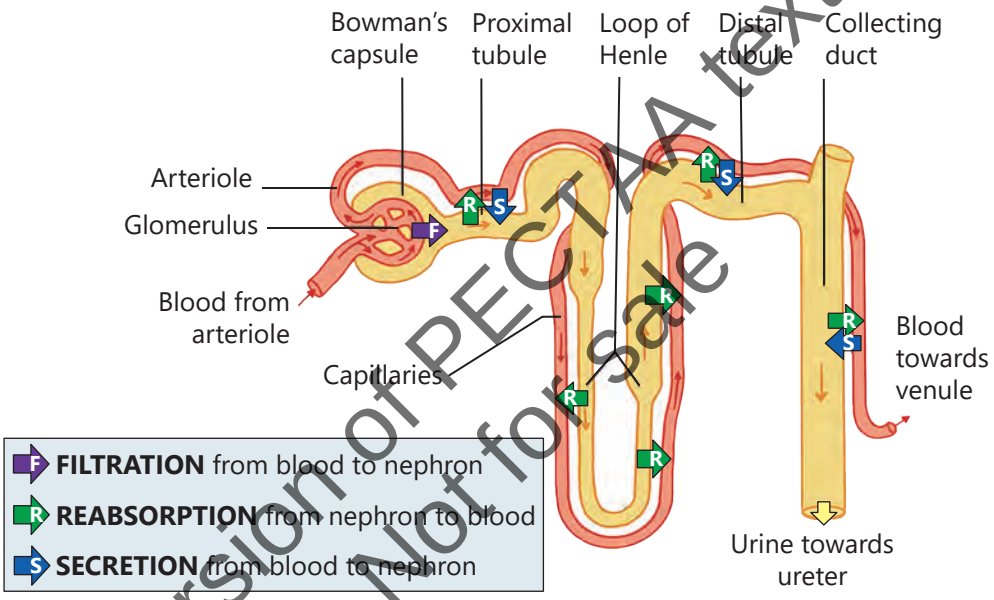


FIGURE 4.4: Functioning of Kidney

Role of Kidneys in Osmoregulation

Osmoregulation means the control of the amount of water according to body's needs. Kidneys are the main organs which work for osmoregulation. They control the amount of water in blood. So, the amount of water in other body fluids is also controlled.

- **Diluted Urine:** If there is excess water in blood, more water is filtered from the glomerulus to Bowman's capsule. There is less reabsorption of water from renal tubule to capillaries. In this way, abundant dilute urine is produced and the amount of water in blood is brought to normal.
- **Concentrated Urine:** If the amount of water in blood is less than normal,

less water is filtered from the glomerulus to Bowman's capsule. There is more reabsorption of water from renal tubule to capillaries. In this way, concentrated urine is produced and the water is preserved in blood.

EXERCISE

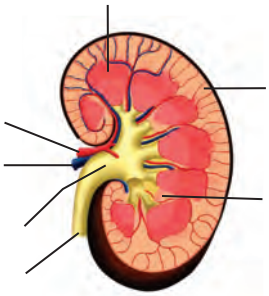
A. Select the correct answers for the following questions.

1. The process of regulating the amount of water in body fluid is called
   a) Filtration b) Reabsorption
   c) Tubular secretion d) Osmoregulation
2. What happens in the proximal convoluted tubule of nephron?
   a) Blood is filtered by glomerulus
   b) Reabsorption of water and nutrients occurs
   c) Urine is stored
   d) Water is secreted into the bloodstream
3. Which structure is responsible for filtering blood to produce urine?
   a) Nephron b) Renal pelvis c) Ureter d) Renal capsule
4. Which structure in nephron is responsible for filtering blood?
   a) Loop of Henle b) Glomerulus
   c) Proximal convoluted tubule d) Distal convoluted tubule
5. In which part of nephron, the reabsorption of nutrients occurs?
   a) Glomerulus b) Proximal convoluted tubule
   c) Loop of Henle d) Distal convoluted tubule
6. Which process in nephron involves the active transport of materials from blood into nephron?
   a) Filtration b) Reabsorption
   c) Secretion d) Excretion
7. Which is NOT present in the filtrate entering the Bowman's capsule of nephron?
   a) Water b) Calcium ions
   c) Blood cells d) Urea

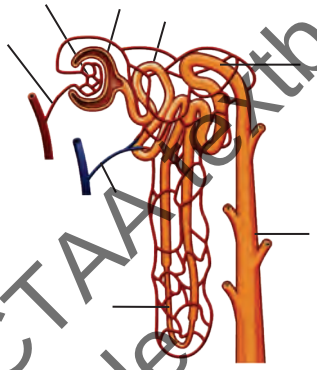
B. Write short answers.

1. Enlist the main parts of the human urinary system.
2. Briefly describe how kidneys control the composition of blood.

3. Name the major parts of a nephron.
4. Differentiate between:
   i. Excretion and osmoregulation
   ii. Renal cortex and renal medulla
   iii. Renal corpuscle and renal tubule
   iv. Pressure filtration and tubular secretion
5. Label the parts of the diagrams (A) and (B):



(A)



(B)

C. Write answers in detail.

1. Write a note on the structure of kidney.
2. Describe the structure of a nephron and draw a labelled diagram.
3. Describe the process of pressure filtration and re-absorption in kidneys.
4. What is tubular secretion? How it helps in removing wastes from blood?

5 COORDINATION

Students Learning Outcomes

After studying this chapter, students will be able to:

- Describe the nervous system and its role.
- Discuss the central nervous system and peripheral nervous system.
- Outline the types of neurons with diagrams.
- Define a stimulus with examples.
- State that nerve impulses are electrical signals that travel across neuron.
- Define and sketch synapses.
- Introduce neurotransmitters.
- Explain through sketching a diagram the involvement of the nervous system when a person accidentally touches something painfully hot and withdraws their hands as a reflex.
- Explain the endocrine system.
- Identify the major endocrine glands and hormones with their functions.

BACKGROUND INFORMATION

Coordinated Action: A coordinated action has five components;

1. Stimulus

Any factor in external or internal environment, which can initiate a response in the body, is called a stimulus. For example, touch, light, sound, heat, cold, pressure, infection etc. are the stimuli.

2. Receptor

The organ, tissue or cell which receives stimuli is called the receptor. For example, ears are the receptors for the stimulus of sound. Receptors send the messages of stimulus to coordinators.

The junction between two neurons and between a neuron and another cell is called **synapse**.

3. Coordinator

A coordinator receives information from receptors and sends messages to particular organs for proper action. In nervous coordination, **brain** and **spinal cord** are coordinators. In chemical coordination, **endocrine glands** are the coordinators.

4. Effector

These are the parts of the body which receive coordinator's message and perform specific actions. In nervous coordination, **muscles** and **glands** are the effectors. While in chemical coordination, different tissues of the body act as effectors.

5. Response

A response is the action performed by effectors, on receiving the message from coordinator. For example, pulling our hand away from something very hot.

Coordination means integration among different parts of the body and their response to stimuli in order to keep harmony with the environment. Coordination occurs in all multicellular organisms. Animals possess two systems for this function i.e., nervous system and endocrine system.

5.1 NEURONS – THE UNITS OF NERVOUS SYSTEM

Neurons or nerve cells are the cells that transmit messages in the body in the form of nerve impulses.

Nerve Impulse: It is a wave of electrochemical changes that travels across the membranes of neurons.

Structure of Neuron

A neuron consists of three major parts i.e., cell body, dendrites and axon. The **cell body** contains the nucleus, other organelles and most of the cytoplasm. Small branches which project from the cell body are called **dendrites**. They transmit nerve impulses towards cell body. **Axon** is a long branch from cell body. Its terminal end is further branched. Axon transmits nerve impulses from cell body to other neurons, muscles, or glands.

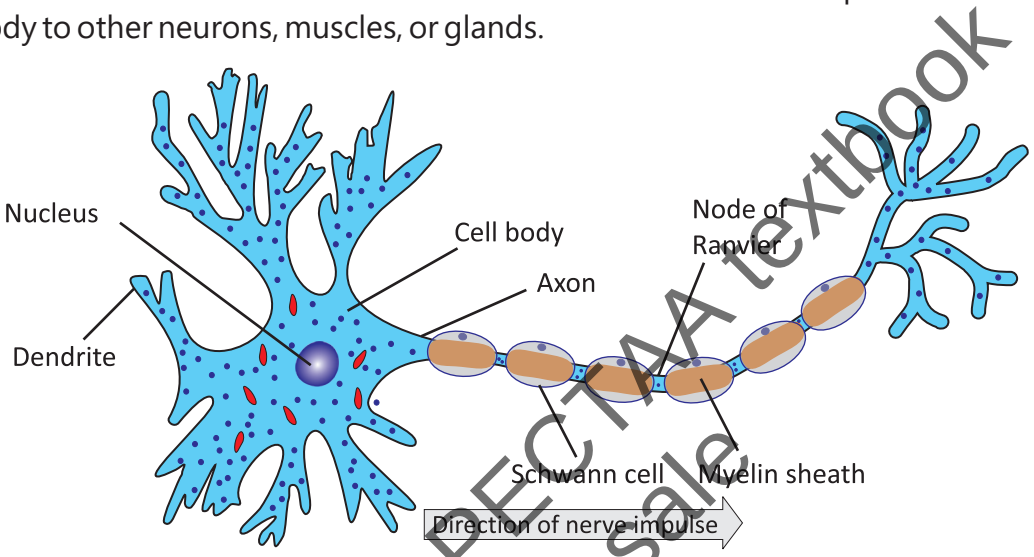


FIGURE 5.1: A Model Neuron (Motor Neuron)

Neurons are supported by specialized cells, called **neuroglia. Schwann cells** are a type of neuroglia. In many neurons, Schwann cells produce insulating covering called **myelin sheaths** over the membrane of axons. Axons which are covered by myelin sheath are called myelinated. The axons which are not covered with myelin sheath are called non-myelinated. The myelin sheath is interrupted at intervals by small gaps called **nodes of Ranvier**. In myelinated neurons, nerve impulses 'jump' from node to node. This increases the speed of nerve impulse.

In the Central Nervous System (CNS), myelinated axons form the **white matter**, and the non-myelinated axons, dendrites and cell bodies form the **grey matter**

Synapse and Neurotransmitters

A synapse is a small gap between two neurons or between a neuron and an effector cell. When nerve impulse reaches the end of a neuron, it cannot jump directly to the next neuron or effector. Neurotransmitters are special chemicals that help to carry messages across a synapse.

When a nerve impulse reaches the end of a neuron, it releases

neurotransmitters. They travel across the synapse and attach to the next neuron or effector cell. It helps the nerve impulse to continue its journey. Examples of neurotransmitters include dopamine and serotonin.

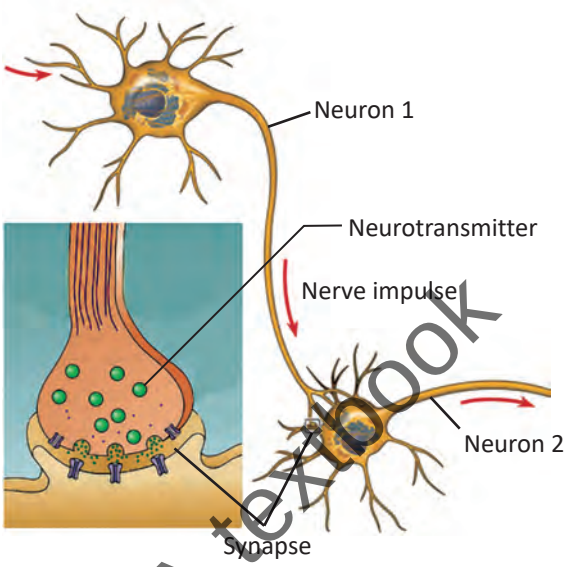


FIGURE 5.2: Synapse

Types of Neurons

1. **Sensory neurons** transmit nerve impulses from receptors to the CNS.
2. **Inter-neurons** are present in brain and spinal cord. They receive impulses from sensory neurons and transmit them to motor neurons.
3. **Motor neurons** transmit nerve impulses from inter-neurons to effectors (muscle or glands).

In certain parts of body, the cell bodies of neurons form groups enveloped by membranes. The groups of cell bodies are called **ganglia** (*Singular:* **ganglion**).

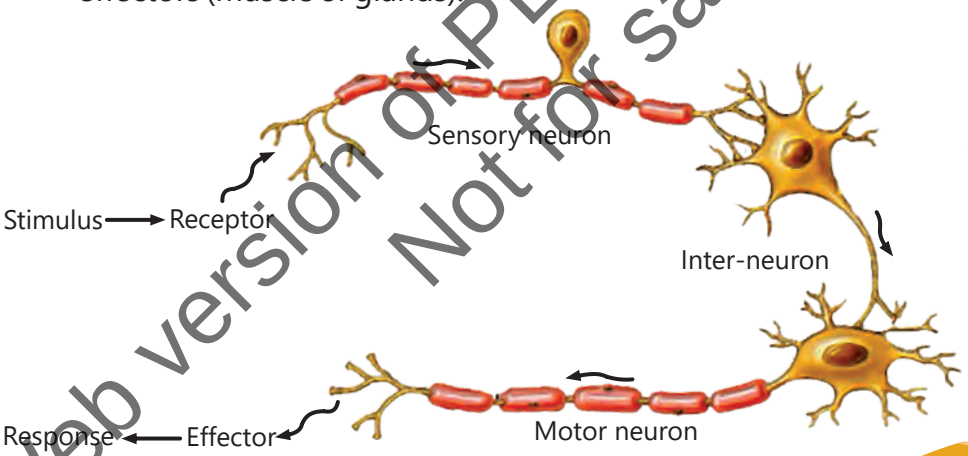


FIGURE 5.3: Types of Neuron

Nerve

A nerve is collection of axons that are enveloped by a covering of connective tissue. Nerves arise from brain and spinal cord and make the **Peripheral Nervous System (PNS)**. There are three types of nerves, on the basis of axons present in them. **Sensory nerves** contain the axons of

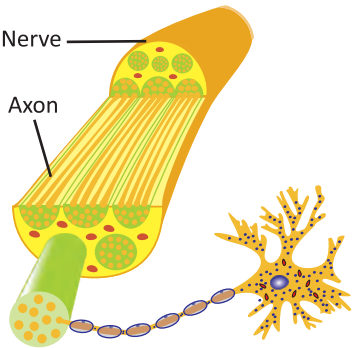


FIGURE 5.4: Nerve

sensory neurons only. **Motor nerves** contain the axons of motor neurons only. **Mixed nerves** contain the axons of sensory and motor neurons.

5.2 DIVISIONS OF THE NERVOUS SYSTEM

There are two major components of nervous system i.e., **central nervous system (CNS)** and **peripheral nervous system (PNS)**. The CNS comprises of brain and spinal cord. The PNS consists of nerves that arise from brain and spinal cord and spread in different parts of body.

All these components are made of neurons and supporting (neuroglial) cells.

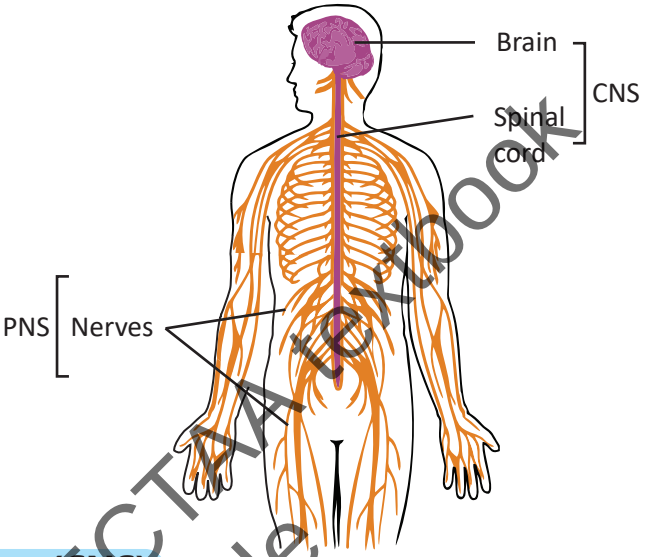


FIGURE 5.5: CNS and PNS

1. Central Nervous System (CNS)

The central nervous system consists of brain and spinal cord.

A. Brain

All life activities are under the control of brain. Brain is present inside **cranium** (part of skull). Inside cranium, brain is covered by three layers of membranes, collectively called **meninges**. Meninges protect the brain from harmful substances. Brain contains fluid-filled cavities called **ventricles**. The ventricles of brain are continuous with the central canal of spinal cord. Fluid within ventricles and central canal is called **cerebrospinal fluid** (CSF). The brain can be divided into three major parts: forebrain, midbrain and hindbrain.

The average adult human brain weighs 1.4 kg, or about 2% of total body weight. It contains about 100 billion neurons.

1. Forebrain

It is the largest area of brain. Following are the major parts of this region.

(i)- Cerebrum is the largest part of forebrain. A deep groove (longitudinal fissure) divides the cerebrum into right and left **cerebral hemispheres**.

The upper layer of both hemispheres is highly folded and is called cerebral cortex. It is made of

Each hemisphere receives information from the opposite side of the body and sends message to that side. For example, the sensation of a touch on the right hand is received by the left hemisphere.

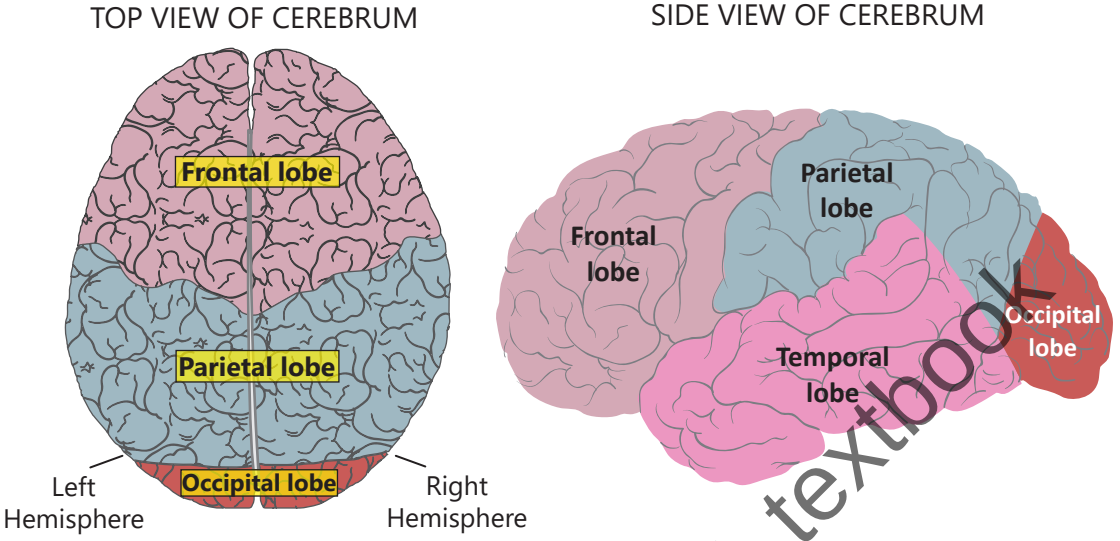


FIGURE 5.6: Cerebral hemispheres and the 4 lobes

grey matter (containing cell bodies and non-myelinated axons). The material beneath cortex is **white matter** (containing myelinated axons).

Each hemisphere is further divided into four lobes. The **frontal lobe** contains regions for problem solving, judgment, speaking, and movements. The **parietal lobe** has regions for language and touch. The **temporal lobe** contains regions which deal with memory, learning, feelings, and hearing. The **occipital lobe** has regions for vision and color perception.

(ii)- Thalamus is a structure wrapped by the cerebrum. It conveys information coming from receptors to the cerebrum. Thalamus is also involved in pain perception and consciousness.

(iii)- Hypothalamus lies above midbrain and just below thalamus. In humans, it is about the size of an almond. It regulates body temperature, hunger, thirst, sleep, and emotional states. It also controls the secretions of the major endocrine gland i.e., **pituitary gland**.

2. Midbrain

The midbrain is located between forebrain and hindbrain. So, it is a bridge between these two parts. It conveys information between them. It also enables the body to make adjustments to movements. It is also responsible for sleep/wake, alertness and temperature regulation.

Medulla oblongata, pons, and midbrain connect the rest of brain to spinal cord. They are collectively called **brain stem**.

3. Hindbrain

Hindbrain controls all automatic body functions. It consists of three parts.

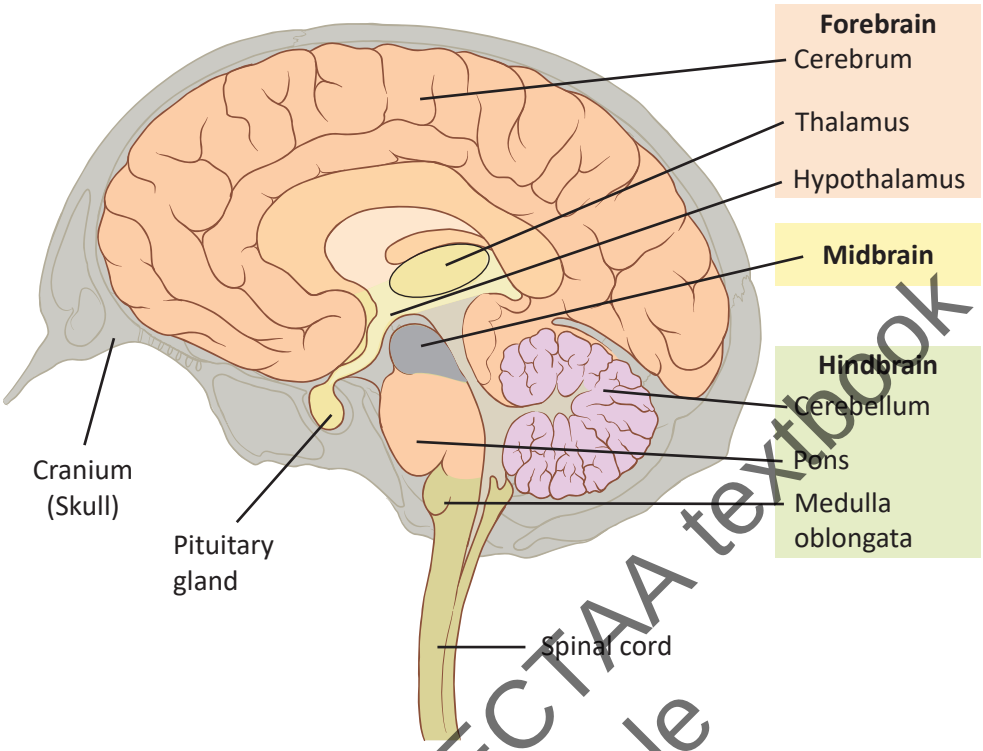


FIGURE 5.7: Structure of brain

(i)- Medulla oblongata is on the top of the spinal cord. It transmits impulses between spinal cord and the higher parts of brain. It controls autonomic functions such as heartbeat, heart rate, breathing and blood pressure. It also controls reflexes such as vomiting, coughing, sneezing.

(ii)- Cerebellum is behind medulla oblongata. It is the second largest part. Its surface is highly folded. It coordinates balance and muscle movements.

(iii)- Pons is present on top of the medulla. It makes connections between the spinal cord and cerebellum, and between cerebrum and cerebellum. It also regulates alertness, sleep, and wakefulness.

B. Spinal Cord

It is a tubular bundle of nerves that starts from brain and extends to lower back. It is located in vertebral column. It is also covered by **meninges**. Spinal cord transmits impulses between brain and body parts. It also acts as a coordinating centre for some simple reflexes.

The outer region of spinal cord is made of **white matter**. The central region is made of **grey matter**. It is butterfly shaped and surrounds the central canal. Thirty-one pairs of spinal nerves arise from spinal cord. All the spinal nerves are **"mixed"** nerves because each contains axons of both sensory and

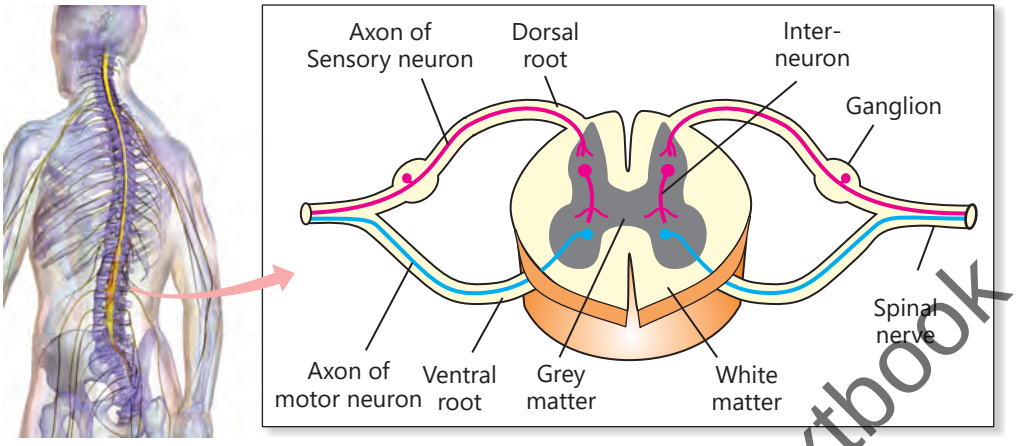


FIGURE 5.8: Spinal Cord and Spinal Nerves

motor neurons. The **dorsal root** contains sensory axons and a ganglion where cell bodies are located. The **ventral root** contains axons of motor neurons.

2. Peripheral Nervous System (PNS)

It is composed of nerves and their ganglia. Humans have 12 pairs of **cranial nerves** and 31 pairs of **spinal nerves**. Some cranial nerves are sensory,

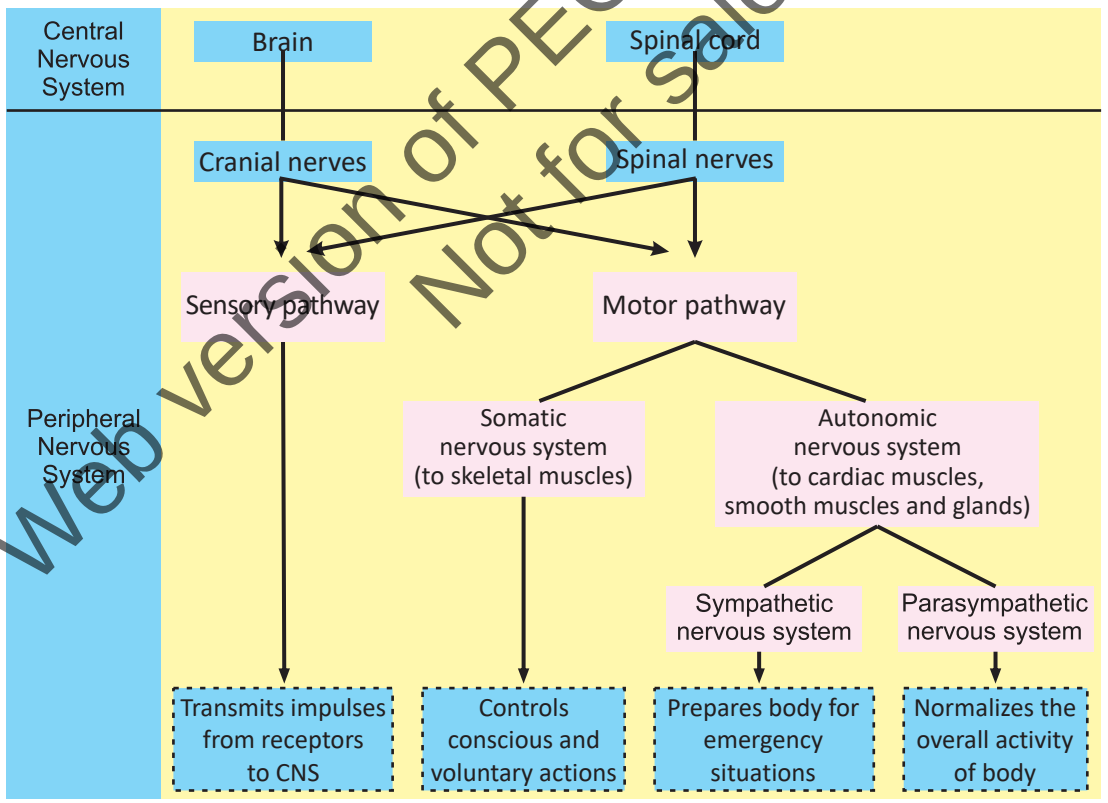


FIGURE 5.9: The Divisions of Nervous System

some are motor and some are mixed. On the other hand, all spinal nerves are mixed. The cranial and spinal nerves make two pathways i.e. sensory pathway (conducting impulses from receptors to CNS) and motor pathway (conducting impulses from CNS to effectors). Motor pathway makes two systems.

(i) Somatic Nervous System: It controls conscious and voluntary actions. It includes all of the motor neurons that are connected to skeletal muscles.

(ii) Autonomic Nervous System: It consists of motor neurons that are connected to cardiac muscles, smooth muscle and glands. It is generally without conscious control. Autonomic nervous system consists of sympathetic and parasympathetic systems. **Sympathetic** nervous system prepares body in emergency situations. This is often called the **"fight or flight"** response. This system dilates pupils, speeds up heartbeat, increases breathing rate and inhibits digestion. When there is no stress, **parasympathetic** nervous system normalizes the activity of body. It is called **"rest and digest"** response. It causes pupils to contract, promotes digestion, and normalizes the rate of heartbeat.

Reflex Action

Reflex actions are the **quick involuntary response** in which brain is not involved. Reflex actions are controlled by a reflex

When a receptor is stimulated, it sends information to the brain. The higher centres of brain (regions of cerebrum) analyse the information and send messages for appropriate actions. Such actions are under our conscious control and are called **voluntary actions**. Some regions of brain control actions without any conscious control. Such actions are called **involuntary actions**

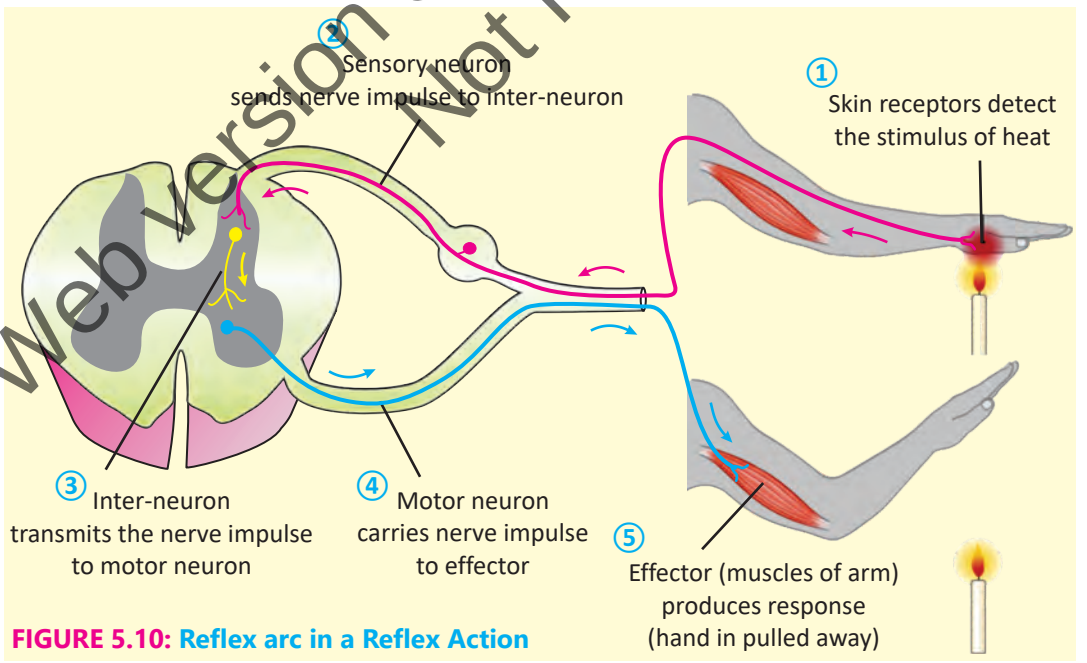


FIGURE 5.10: Reflex arc in a Reflex Action

arc. A **reflex arc** is the pathway of neurons over which the nerve impulses travel during a reflex action.

Example:

We pull our hand away from a hot flame without thinking about it. It is a reflex action and happens in the following way;

1. Skin receptors detect the stimulus of heat.
2. Sensory neuron sends nerve impulse to inter-neuron of spinal cord.
3. The inter-neuron transmits the nerve impulse to motor neuron.
4. The motor neuron carries the nerve impulse to effector (muscles of arm).
5. The effector produces a response by contracting. So, our hand is pulled.

5.3 ENDOCRINE SYSTEM

It is the other system responsible for coordination in animals. The **endocrine system** consists of special endocrine glands which produce and secrete hormones. **Hormones** are the chemicals, released from endocrine gland, which regulate different body functions like growth, reproduction, and glucose level in blood etc.

The secretion of saliva from salivary glands is an involuntary action. When we start chewing food in mouth, brain sends message to salivary glands to secrete saliva. It can also happen when we smell, see or even imagine food.

The endocrine glands do not have ducts to pour their hormones. That is why; they are also called **ductless glands**. They secrete hormones into blood which carries them to different parts of the body. The following are the major endocrine glands and their important hormones.

1. Pituitary Gland

It is a small gland present in the brain. It is suspended from the hypothalamus by a short stalk. There are two lobes of pituitary gland i.e., anterior lobe and posterior lobe.

a. Hormones of Anterior Lobe of Pituitary

1. Growth hormone (GH) stimulates the growth of muscle, bone, and other tissues. If growth hormone is produced more than normal, it results in extra growth in body. This condition is called **gigantism**. On the

Naseer Soomro was once the tallest man in Pakistan. He was born normal size, but developed pituitary gland problem at the age of 10. His pituitary gland produced excess amounts of the **Growth Hormone**.

other hand, if growth hormone is produced less than normal, it results in less growth in body. This condition is known as **dwarfism**.

2. Adreno-cortico-tropic hormone (ACTH) stimulates the adrenal cortex gland to produce its hormones.

3. Thyroid-stimulating hormone (TSH) stimulates the thyroid gland to produce its hormone (thyroxine).

4. Luteinizing hormone (LH) is needed for the release of egg cells from ovary (ovulation) in females. In males, it stimulates the testes to produce sex hormones. Anterior lobe also produces follicle stimulating hormone (FSH) that is involved in the reproductive system.

b. Hormones of Posterior Lobe of Pituitary

The hypothalamus produces two hormones that are stored in the posterior lobe of pituitary gland.

1. Antidiuretic hormone (ADH), also called **vasopressin**, increases the reabsorption of water from nephrons in kidneys.

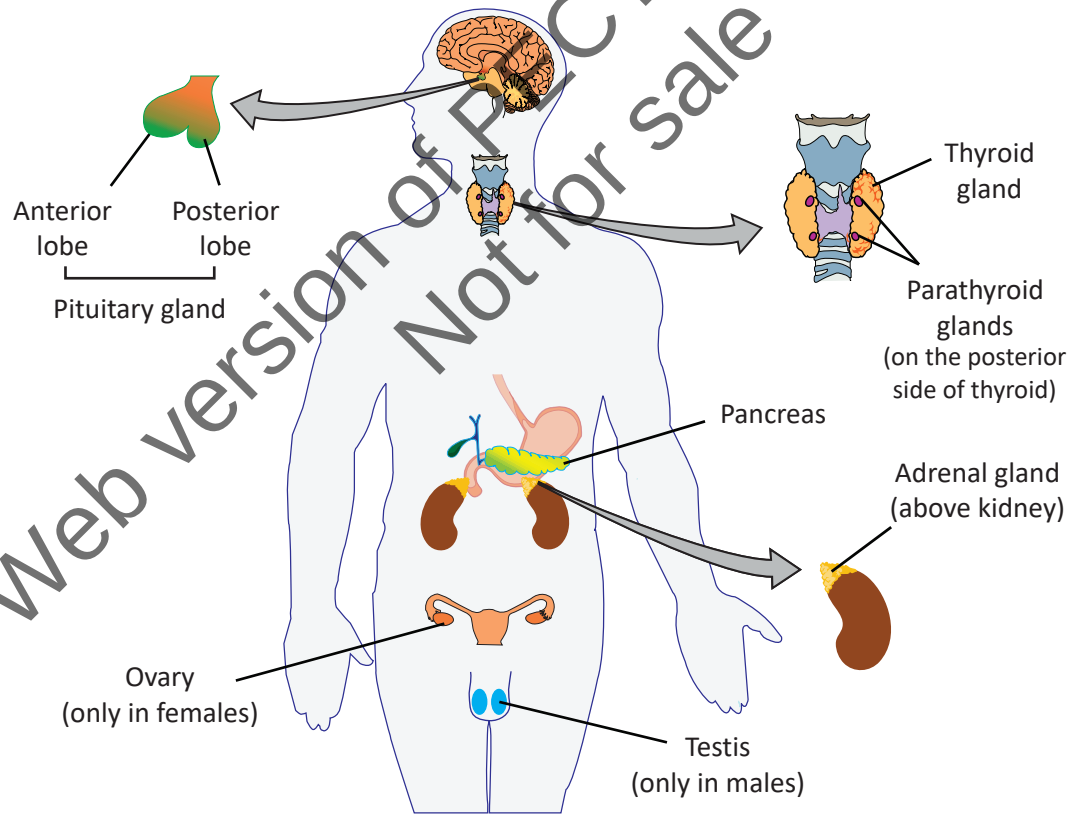


FIGURE 5.11: Important endocrine glands in human body

2. Oxytocin initiates contractions in uterus during childbirth. It also stimulates the flow of milk during breastfeeding.

2. Thyroid gland

It is located near the lower part of the larynx. It secretes two hormones.

i. Thyroxin stimulates enzymes of cellular metabolism (glucose oxidation) for energy production. It increases basal metabolic rate and so produces heat.

If thyroxine is produced less than the required amount, cellular metabolism slows down. It results in lethargy, weight gain, and low heart rate and low body temperature.

If thyroxine is produced more than required, cellular metabolism becomes faster. It results in weight loss; and high blood pressure, high heart rate, and high body temperature.

Iodine is required for the production of thyroxine. If a person lacks iodine in diet, thyroid gland cannot make hormone. In this condition, thyroid gland enlarges. This disorder is called **goitre**. Goiter is now rare in Pakistan because iodine is added to commercially available table salt.

ii. Calcitonin stimulates the transfer of calcium ions from blood to bone, where the calcium ions can be used to generate bone tissue. In this way, calcitonin acts to decrease blood calcium levels.

When there is more parathormone, more calcium is transferred from bones to blood. So the bones become weak. The deficiency of parathormone results in decreased blood calcium level. It leads to tetany (muscle twitching, cramps and convulsions).

3 Parathyroid glands

The four parathyroid glands are embedded in the back of the thyroid gland. They secrete a hormone called **parathormone**. It stimulates the transfer of calcium ions from the bones to the blood. Thus, it has the opposite effect of calcitonin.

4. Adrenal glands

An adrenal gland is located above each kidney. Each adrenal gland has an inner core, the **medulla**, and an outer layer, the **cortex**.

The **adrenal medulla** produces two hormones: **epinephrine** (adrenaline) and **nor-epinephrine** (nor-adrenaline). These hormones take part in the emergency response of the sympathetic nervous system. When a person is in emergency, the medulla releases its hormones to prepare the body for **"fight-or-flight"** response. These hormones increase heart rate, blood

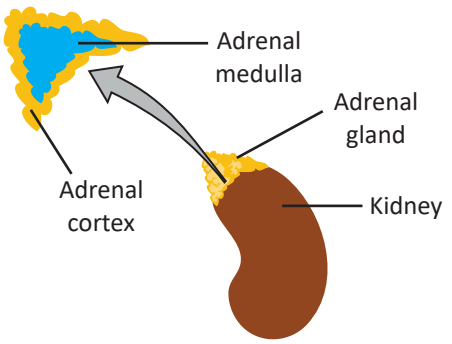


FIGURE 5.12: Parts of adrenal gland

pressure, blood glucose level, and blood flow to the heart and lungs. They also stimulate enlargement of the bronchioles and dilation of the pupils.

The **adrenal cortex** secretes hormones cortisol and aldosterone. **Cortisol** promotes the production of glucose from proteins. **Aldosterone** raises blood pressure and volume by stimulating salt and water retention by the kidneys.

v. Pancreas

Pancreas has two functions. It is a part of digestive system, where it plays the role of a ducted (exocrine) gland and secretes digestive enzymes. It also has special cells called the **islets of Langerhans** (discovered in 1869 by a German student, Paul Langerhans). These cells function as an endocrine gland. They secrete two hormones i.e., **insulin** and **glucagon**. They regulate the level of glucose in the blood. **Insulin** lowers the blood glucose level by stimulating body cells to store glucose or use it for energy. In contrast, **glucagon** stimulates release of glucose from liver into the bloodstream.

In **diabetes mellitus**, the cells are unable to obtain glucose resulting in high blood glucose concentrations. In type-1 diabetes mellitus, the pancreas does not produce required insulin. Such patients are treated with daily injections of insulin. In type-2 diabetes, insulin is produced but the target cells do not respond to it. This type of diabetes can be controlled through exercise and diet.

In diabetes, excess glucose inhibits water reabsorption by the kidneys, producing large amounts of urine. It results in dehydration and can cause kidney damage. Excess glucose may also lead to imbalance in water and salt concentration in body. The patients also experience loss of body weight, weakening of muscles and tiredness.

Blood Glucose Concentration (BGC) Test: The amount of glucose in blood is measured by this test. It is used to diagnose diabetes. Blood glucose may be measured on a fasting basis (collected after an 8 to 10 hour fasting), randomly (anytime) and after a meal. The results of some BGC tests are given here.

Blood Glucose After 8 – 10 hours Fast	
BGC	**Diagnosis**
From 70 to 99 mg/100ml	Normal
From 100 to 125 mg/100ml	Pre-diabetes
126 mg/100ml and above	Diabetes

Blood Glucose 2 hours after a 75-gram Glucose intake	
BGC	**Diagnosis**
Less than 140 mg/100ml	Normal
From 140 to 200 mg/100ml	Pre-diabetes
Over 200 mg/100ml	Diabetes

Table 5.1: Summary of Major Endocrine Glands and Their Functions		
Gland	**Hormone**	**Functions**
Anterior lobe of Pituitary	Growth hormone	Regulates development of muscles and bones
	Adrenocorticotropic hormone	Stimulates secretion of cortisol and aldosterone by the adrenal cortex
	Thyroid stimulating hormone	Stimulates the thyroid gland to produce its hormone
	Luteinizing hormone	Stimulates the ovary to release egg Stimulates the testes to produce sex hormones
Posterior lobe of Pituitary	Antidiuretic hormone	Increases the reabsorption of water from nephrons
	Oxytocin	Initiates contractions in uterus during childbirth Stimulates flow of milk from breasts
Thyroid	Thyroxine	Stimulates enzymes of cellular metabolism
	Calcitonin	Decreases blood calcium concentration
Parathyroid	Parathormone	Increases blood calcium concentration
Adrenal medulla	Epinephrine, Norepinephrine	Initiate body's response to stress and the "fight-or-flight" response to danger
Adrenal cortex	Cortisol	Promotes production of glucose from proteins
	Aldosterone	Promotes salt and water retention by the kidneys
Pancreas	Insulin	Lowers the blood glucose level by stimulating body cells to store glucose or use it
	Glucagon	Stimulates release of glucose from liver into blood
Ovaries	Oestrogen and Progesterone	Cause the release of egg from the ovary and regulate female secondary sex characteristics
Testes	Androgens (Testosterone)	Regulate male secondary sex characteristics

6. Gonads

Gonads (ovaries in females and testes in males) are gamete-producing organs. They also produce sex hormones.

In females, the ovaries secrete hormones called **estrogen** and **progesterone**. These hormones cause the release of egg from the ovary and regulate female secondary sex characteristics (e.g., development of breast).

In males, the testes secrete a group of sex hormones called **androgens (e.g., testosterone)**. It regulates male secondary sex characteristics (e.g., growth of hair on face and coarseness of voice etc.)

EXERCISE

A. Select the correct answers for the following questions.

1. Schwann cells are the supporting cells for neurons. They make:
   a) Cell body b) Axon c) Myelin sheath d) Dendrites
2. Which part of the brain controls balance while riding a bicycle?
   a) Cerebrum b) Medulla c) Cerebellum d) Spinal cord
3. Which part is responsible for sensations of temperature, hunger, thirst, and sleep?
   a) Hypothalamus b) Thalamus c) Pons d) Cerebellum
4. If a patient cannot remember things, which part of their brain may be affected?
   a) Cerebrum b) Cerebellum c) Medulla d) Spinal cord
5. During danger, which system activates quickly?
   a) Parasympathetic b) Skeletal c) Endocrine d) Sympathetic
6. Why are reflex actions faster than normal actions?
   a) Brain processes them quickly b) Brain is not involved
   c) Signals move slower d) They need thinking
7. Which of these acts as exocrine as well as endocrine gland?
   a) Pituitary b) Thyroid c) Adrenal d) Pancreas
8. The chemical messengers of the endocrine system are called;
   a) Transmitters b) Hormones c) Neurons d) Enzymes
9. What could happen if hormone of parathyroid gland were missing?
   a) Low calcium levels b) High blood sugar
   c) Weak muscles d) Poor digestion
10. Which endocrine gland prepares the body for "fight or flight" response?
    a) Thyroid b) Pituitary c) Adrenal d) Pancreas

B. Write short answers.

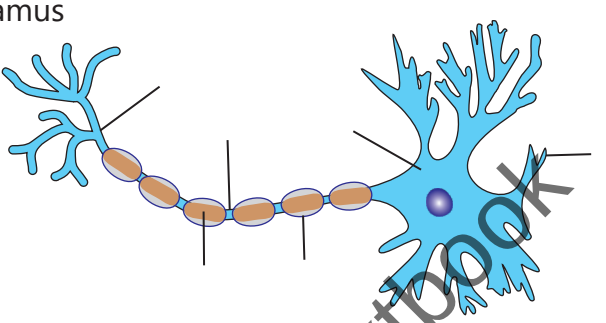
1. Define stimulus with examples.
2. Differentiate between sensory, motor, and inter-neurons.
3. Define reflex action and the reflex arc.
4. Differentiate between the following:

(a) Dendrite and axon

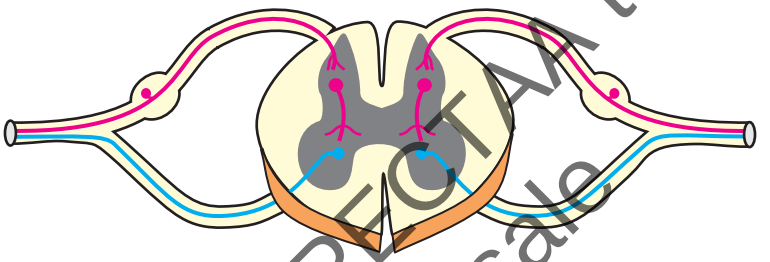
(b) Cerebrum and Cerebellum

(c) Thalamus and Hypothalamus

5. Identify the diagram and label the different parts.

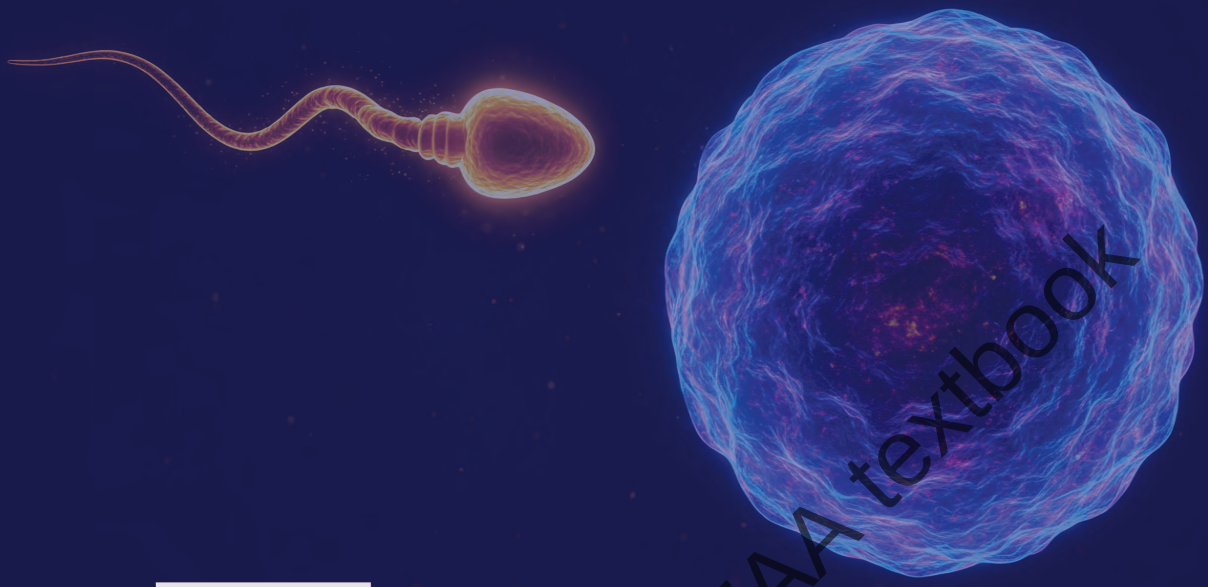


6. Identify the following diagram, and locate the white matter, grey matter, three types of neuron, and ganglia.



C. Write answers in detail.

1. Describe the structure of a neuron and support your answer with a labelled diagram.
2. What are the differences and similarities among the three types of neurons?
3. Write the major functions of the forebrain, midbrain, and hindbrain.
4. What is meant by reflex action? Describe an example of reflex action and identify the reflex arc in this example.
5. State the hormones of the pituitary gland and write their functions.
6. Write notes on adrenal glands, pancreas, ovaries and testes.



6 REPRODUCTIVE SYSTEM

Students Learning Outcomes

After studying this chapter, students will be able to:

- Describe the process of gametogenesis and fertilization.
- Identify, on diagrams of the parts of male reproductive system and describe their functions.
- Identify, on diagrams of the parts of female reproductive system and describe their functions.

All organisms have the ability to produce new individual or their kind. **Sexual reproduction** involves the joining (fusion) of male and female gametes.

6.1 FORMATION OF GAMETES AND FERTILIZATION

Animals have special organs i.e., gonads where special cells called gametes are made. The gonads in male animals are called testes (Singular: testis) where male gametes i.e., sperms are produced. The gonads in female animals are

called ovaries where female gametes i.e., egg cells or ova produced.

Formation of Gametes

This process of formation of gametes is called **gametogenesis**. It involves the cell division meiosis. Meiosis results in a reduction of the number of chromosomes in gametes to haploid (1n) as compared to the diploid (2n) number in other body cells.

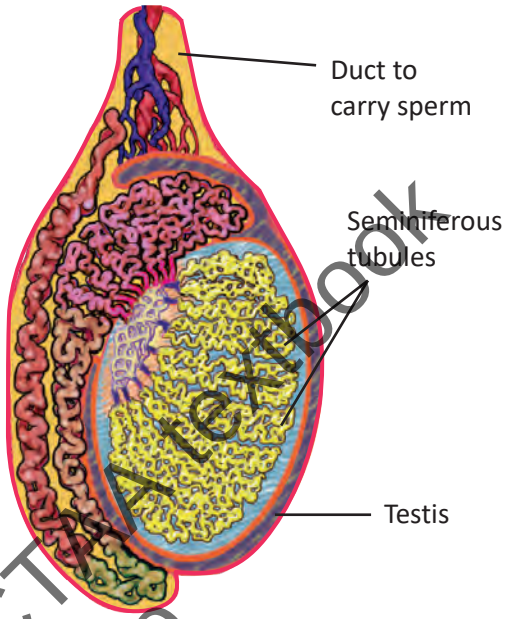


FIGURE 6.1: A testis

(a) Formation of Male Gametes

The formation of male gametes (sperms) is called **spermatogenesis**. This process occurs in **seminiferous tubules** of testes. Follicle stimulating hormone (FSH) along with the male sex hormone i.e., testosterone stimulate sperm production. FSH is produced by the anterior pituitary gland while testosterone is produced by testes.

In seminiferous tubules, the diploid gamete mother cells, called **primary spermatocytes** are present. Each primary spermatocyte divides by meiosis-I and forms two haploid secondary spermatocytes. Each secondary spermatocyte divides by meiosis-II. In this way, four haploid **spermatids** are formed. These are immature sperms. Changes occur in spermatids and they mature into motile **sperms**.

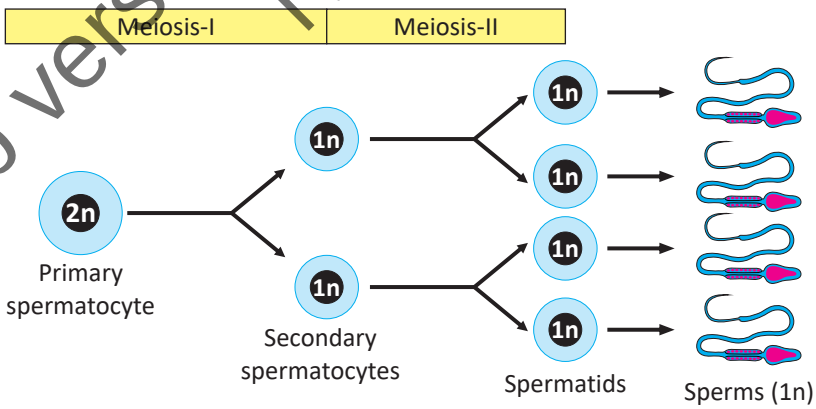


Figure 6.2: Spermatogenesis

(b) Formation of Female Gametes

The formation of female gametes (egg or ovum) is called **oogenesis**. It

occurs in ovary in a small, fluid-filled sac called **follicle**. Follicle stimulating hormone released by the anterior lobe of pituitary gland stimulates the formation of ovum in follicle.

In follicle, there is a diploid gamete mother cell called **primary oocyte**. It divides by meiosis. As a result of first meiotic division, two haploid cells are produced. The larger cell is called **secondary oocyte** while the smaller cell is called **first polar body**. In meiosis II, secondary oocyte produces two haploid cells i.e., a **second polar body** and an **egg**.

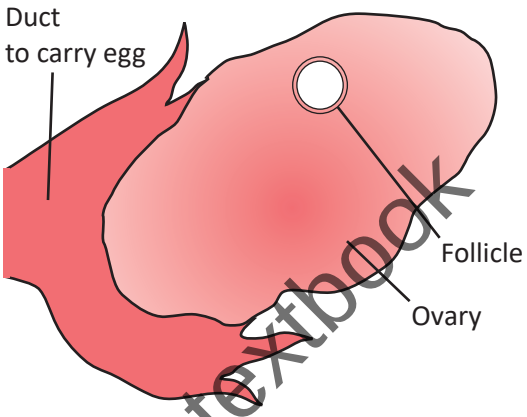


FIGURE 6.3: An ovary

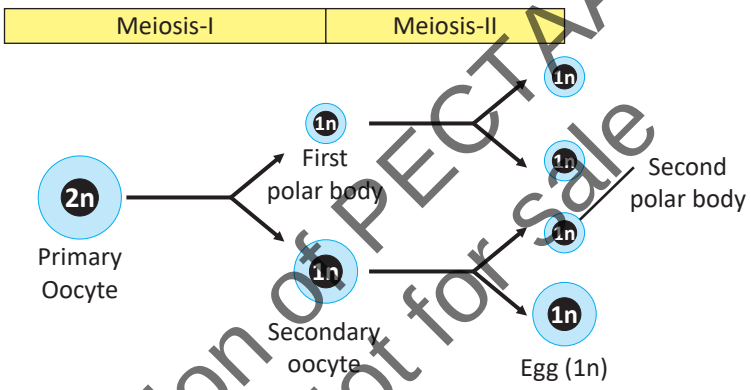


FIGURE 6.4: Oogenesis

Fertilization

Fertilization means the fusion of male and female gametes to form a new cell, called zygote. In humans, fertilization occurs inside the body of female after the release of egg cell from ovary i.e., **ovulation**. Fertilization occurs in the following steps:

1. Sperms move towards the egg due to the chemical signals released by the egg or surrounding cells.
2. The acrosome, a cap-like structure on the head of the sperm, releases enzymes which digest the egg's outer layers, allowing the sperm to reach the egg cell membrane.
3. The sperm and egg cell membranes fuse. This fusion triggers reactions in egg. So, the egg's outer layers become impermeable for more sperms.

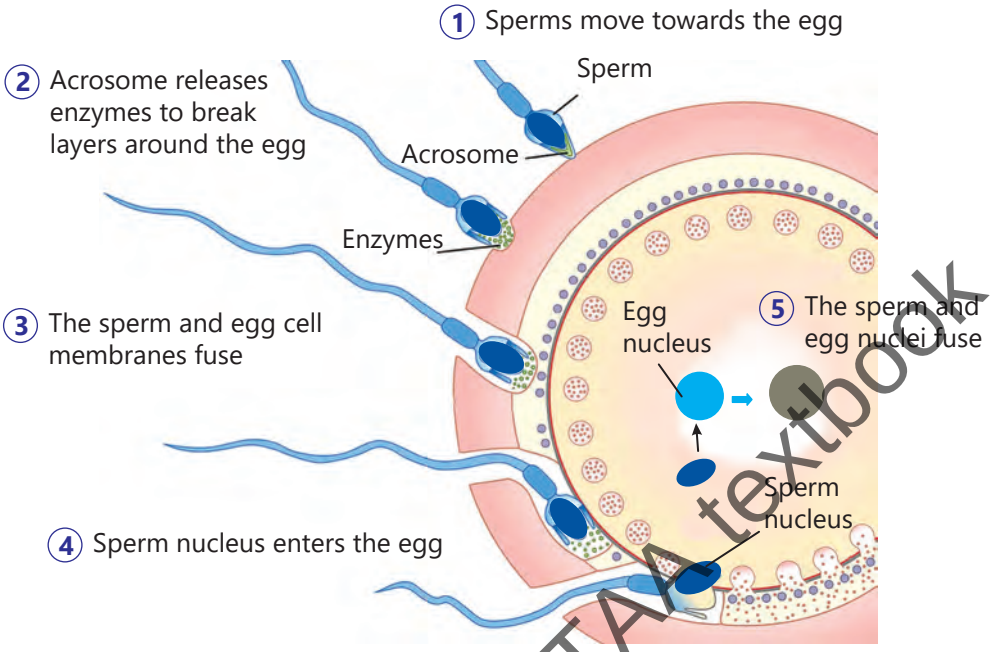


FIGURE 6.5: Steps of fertilization

4. After fusion of membranes, the sperm nucleus enters the egg.
5. Both nuclei fuse to form a diploid zygote.

6.2 REPRODUCTIVE SYSTEMS

Male Reproductive System

It consists of the following parts:

> The average male produces around 1,500 sperm per second — that's over 100 million per day!

Testes: Pair of oval-shaped glands that produce sperm and the male hormone testosterone.

Epididymis: A long, coiled tube attached to each testis where sperm are stored and matured.

Vas deferens: A muscular tube that transports mature sperm from the epididymis to the urethra.

Seminal vesicles: Two small glands behind the bladder that produce a sugary fluid to nourish sperm.

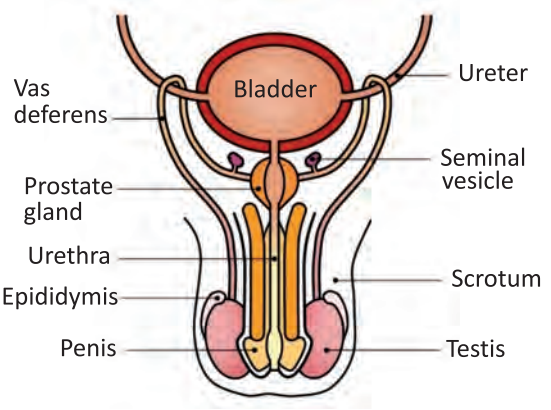


FIGURE 6.6: Male reproductive system

Prostate gland: A walnut-sized gland below the bladder that adds protective fluid to the semen.

Urethra: A tube inside the penis that carries semen and urine to the outside of the body

Penis: An external organ that transfers sperm into female reproductive tract.

Female Reproductive System

It consists of the following main parts:

Ovaries: Pair of almond-shaped glands that produce eggs (ova) and hormones like oestrogen and progesterone.

Fallopian Tubes: Two tubes that transport eggs from the ovaries to the uterus. Fertilization occurs here.

Uterus: A hollow, muscular organ where a fertilized egg implants and develops into a foetus during pregnancy.

Cervix: The lower, narrow part of the uterus.

Vagina: A muscular canal that connects the cervix to the outside.

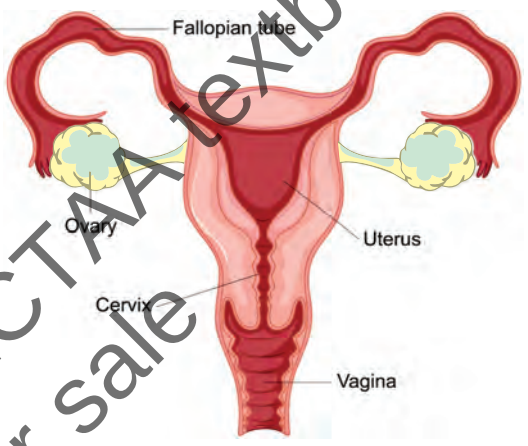


FIGURE 6.7: Female reproductive system

EXERCISE

A. Select the correct answers for the following questions.

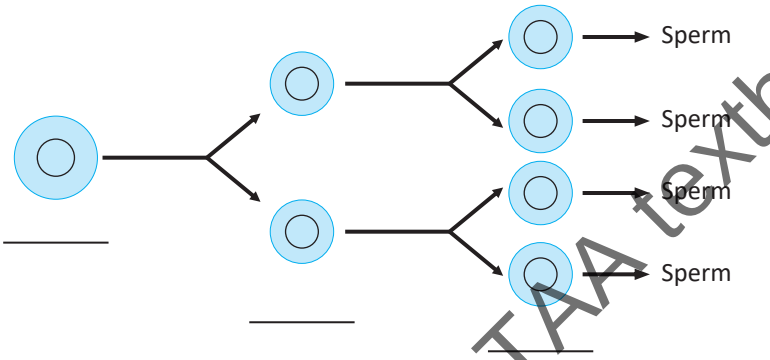
1. In which part of the body oogenesis takes place?
   a) Oviduct b) Ovary c) Uterus d) Fallopian tube
2. Which of the following is NOT a part of the male reproductive system?
   a) Testes b) Uterus c) Epididymis d) Prostate gland
3. What is the function of acrosome?
   a) Guides the sperm towards egg cell
   b) Releases enzymes that help sperm penetrate the egg's outer layers
   c.) Activates the egg for fertilization
   d) Helps in the fusion of sperm and egg nuclei

4. What is the function of the Fallopian tubes?

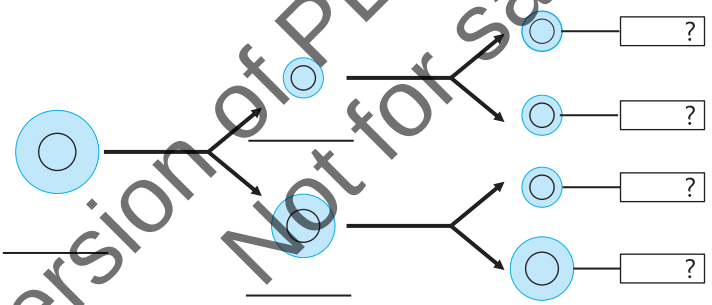
a) Site of fertilization
b) Storage of eggs
c) Secretion of oestrogen
d) Transport of sperm to testes

B. Write short answers.

1. Complete the chart of spermatogenesis by mentioning the names of cells and number of chromosomes (2n or 1n).



2. Complete the chart of oogenesis by mentioning the names of cells and number of chromosomes (2n or 1n).



3. Name the parts of the testis and ovary where gamete formation takes place.
4. What happens to the egg after it is released from the ovary?
5. Compare spermatogenesis and oogenesis in terms of the number of gametes produced.

C. Write answers in detail.

1. Describe the process of spermatogenesis.
2. Describe the functions of the major parts of male reproductive system.
3. Describe the functions the parts of female reproductive system.

7 INHERITANCE

Students Learning Outcomes

After studying this chapter, students will be able to:

- Sketch the structure of chromosomes.
- Define genotype and phenotype, allele, homozygous, heterozygous, dominant, recessive.
- Illustrate Mendelian inheritance laws through monohybrid and dihybrid cross.
- Outline function of DNA as carrier of hereditary information.

An organism is made of a lot of structural and behavioural characteristics. Organisms are able to pass these characteristics to their offspring. Offspring get some characteristics from each parent. They also get characteristics which are not present in their parents. The process by which characteristics are transferred from parents to offspring is called **inheritance** or **heredity**.

Every cell in the body contains the instructions for making characteristics. Inside the cells, this information is present in long molecules of Deoxyribonucleic acid (DNA). The cells use the information in their DNA to produce particular proteins. The proteins made by a cell determine its characteristics.

7.1 STRUCTURE OF CHROMOSOME

Chromosome is made up of **chromatin** material. In eukaryotes, chromatin consists of **DNA** and special proteins called **histones**. Chromatin is a thread-like material. In chromatin, a long molecule of DNA is wrapped around the bundles

Recalling:

- All the cells of the organisms of a species have a constant number of chromosomes.
- The body cells are diploid (2n). It means that the chromosomes are in pairs (homologous chromosomes).
- Before cell division, the DNA makes a copy of itself. In this way, chromatids are formed. When the cell divides, each daughter cell receives one chromatid from each chromosome.

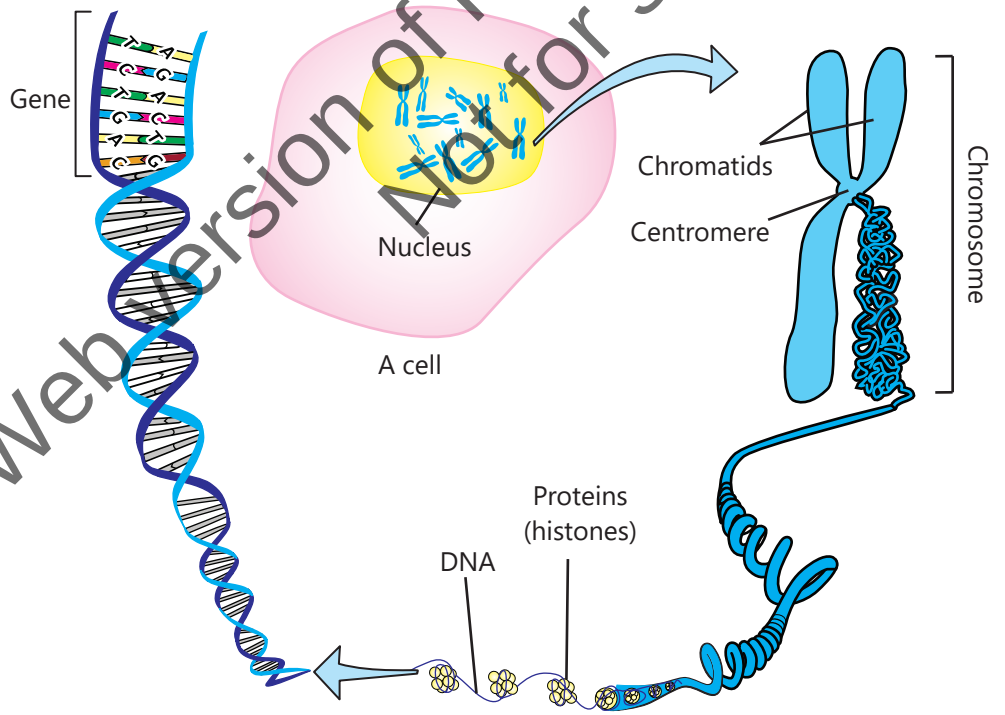


FIGURE 7.1: Chemical composition of chromosome

of **histones**. When a cell is not dividing its chromatin is in the form of fine thread, scattered in the nucleus. During cell division, chromatin coils and makes compact structures of chromosomes.

A **chromosome** is rod-shaped and consists of two identical halves. Each half of chromosome is called a **chromatid.** The two chromatids of a chromosome are attached at a point called **centromere.** The centromere holds the two chromatids together until they separate during cell division.

The prokaryotes have only one chromosome which is made of a circular DNA molecule. It is not bound by a nuclear envelop and is present in cytoplasm.

7.2 DNA AND RNA

DNA (Deoxyribonucleic Acid): DNA is a double-stranded, helical molecule. It is made of nucleotides. Each nucleotide of DNA is made of a deoxyribose sugar, a phosphate group, and a nitrogenous base (adenine, thymine, cytosine, or guanine). The two strands are held together by base pairing (A with T, and C with G).

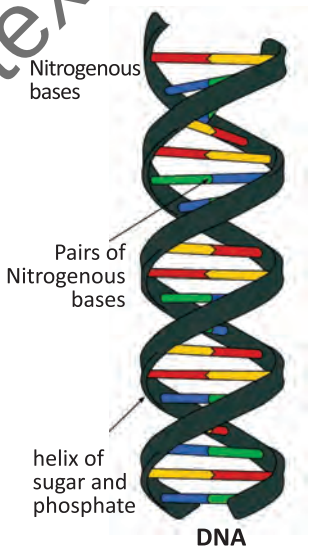


FIGURE 7.2: DNA

Gene and Allele

A **gene** is a segment of DNA that contains the information for a hereditary character. For example, the gene for eye colour, gene for earlobe shape, and gene for the hair texture. Genes are located on chromosomes. The locations or positions of genes on chromosomes are known as **loci** (singular locus). Like chromosomes, genes are also in pairs.

The pair of genes on homologous chromosomes may not contain identical genes. The homologous chromosomes may have different forms of the same gene. These alternate (different) forms of a gene are called its **alleles**. For example, the gene of hair colour can have two alleles. One allele makes hair pigments while the other does not make pigments.

Genotype

The combination of the alleles is called **genotype**. When both alleles are the same, the genotype is **homozygous**. The genotype, in which both alleles are different, is called **heterozygous**. For example, in Fig. 7.4, a cell has genes for eye colour, hair shape and ear shape. All genes are in pairs.

- Both alleles of the eye colour gene are similar. It means that the genotype for eye colour is homozygous. Similarly, both alleles of the hair shape

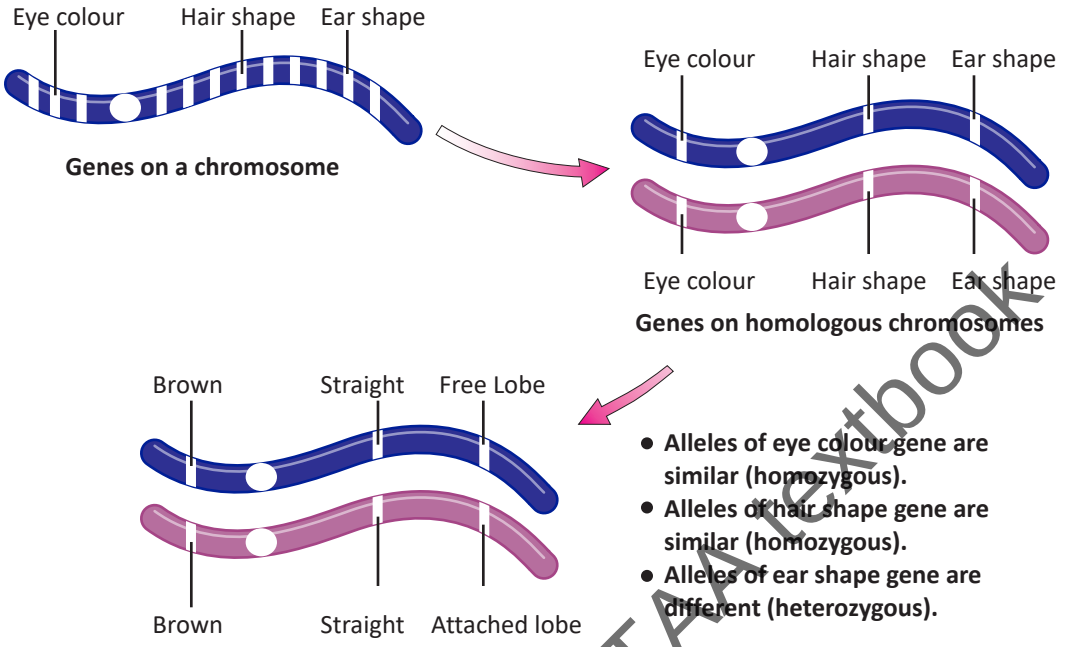


FIGURE 7.4: Alleles and genotypes

gene are similar. It means that its genotype is also homozygous.

- The alleles of the ear shape gene make different characteristics. One allele makes free earlobe while the other allele makes attached earlobe. It means that the genotype for ear shape is heterozygous.

In the heterozygous genotype one allele may mask the working of the other allele. Such an allele is called the **dominant allele**. The allele which is masked (not expressed) is called **recessive allele**. Dominant alleles are expressed by capital letters while the recessive alleles are expressed by lowercase letters. For example, in the pair Tt, the dominant alleles T is responsible for tall plant while the recessive allele t is for dwarf plant. So, if a plant has genotype Tt, it will be a tall plant. The observable outcome of genotype, in the form of characteristic, is called **phenotype**.

7.3 MENDEL'S LAWS OF INHERITANCE

Gregor Mendel was an Austrian monk, working in a monastery. From 1856 to 1863, he performed experiments on garden pea. The results of these experiments cleared the views of heredity.

FIGURE 7.5: Gregor Mendel

Selection of garden pea for experiments

Mendel selected the garden pea for his

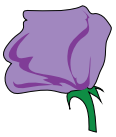
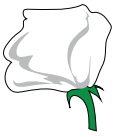
	Flower colour	Seed colour	Seed shape	Pod colour	Pod shape	Flower position	Plant height
Character 1	 Purple	 Yellow	 Round	 Green	 Flat	 Axial	 Tall
Character 2	 White	 Green	 Wrinkled	 Yellow	 Constricted	 Terminal	 Short (dwarf)

FIGURE 7.6: Distinguishing characters in plant studied by Mendel

experiments. His choice was a good one for several reasons.

1. Pea plants have a relatively short generation time.
2. Pea plant has seven easily distinguishable characteristics, such as round versus wrinkled seeds and purple versus white flowers.
3. Normally, self-pollination occurs in pea flowers. But cross-pollination can also be performed. For this purpose, the stamens of a flower are removed and its pollen grains are transferred to the flower of another plant.

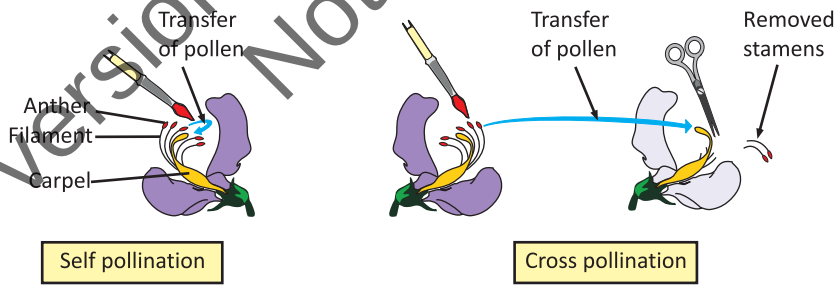


FIGURE 7.7: Self and Cross-pollination in pea plants

Mendel's Experiments

Mendel got the true-breeding plants for each characteristic. If a plant with a characteristic produces offspring with the same characteristic on self-pollination; it means that the plant is **true-breeding** for that characteristic. For example, when a true-breeding tall plant self-pollinates, it will always produce tall plants. After choosing the true-breeding varieties, Mendel performed

monohybrid crosses. It is a cross in which only one characteristic is studied.

Experiment 1

Mendel crossed a true-breeding tall plant with a true-breeding short plant. He called these true-breeding parents as **P generation.** The offspring of this cross were called the first filial generation, or **F1 generation**. All offspring of F1 were all tall.

During Mendel's time, most people believed that characteristics of both parents are mixed together and are passed to offspring. For example, if a short plant is crossed with a tall plant, the offspring will be medium sized.

Next, Mendel allowed the tall plants of F1 generation to self-pollinate. He called the next generation as F2 generation. He found that 75% of F2 offspring were tall, while 25% were short.

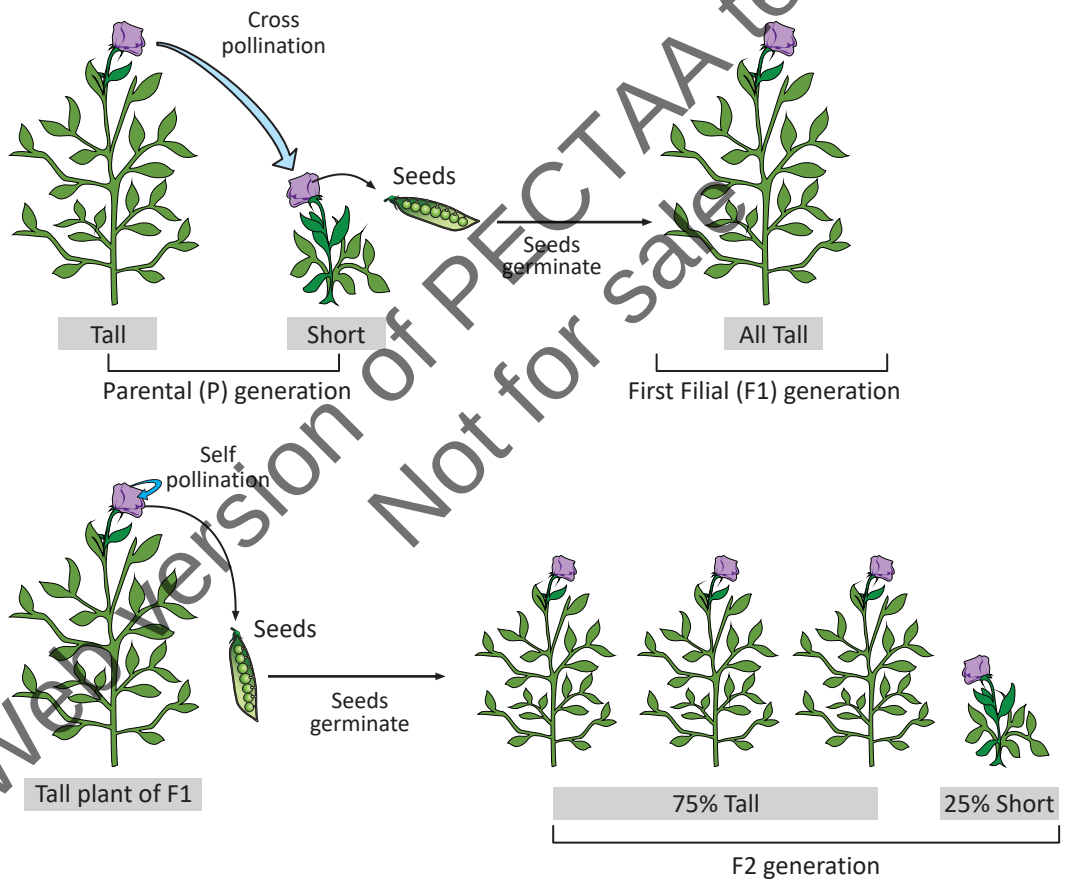


FIGURE 7.8: Mendel's experiment

Mendel found the same results over and over again with all the characteristics.

Conclusions

Concept of Dominance: Mendel explained his results and proposed that there were two forms (alleles) of the gene of plant height. When two different alleles are together in an organism, one allele may mask the expression of the other. The allele that shows its effect is called dominant, while the one that is hidden is called recessive. This is called as the concept of **dominance**.

Law of Segregation: Mendel explained that each parent has two alleles of a gene. But a parent can only pass one allele to the offspring. During gamete formation, the alleles separate and there is only one allele in each gamete. When fertilization occurs, the offspring has the two alleles again. It is called the **law of segregation**. It states that "the alleles are separated during gamete formation and each gamete receives one or the other allele, but not both".

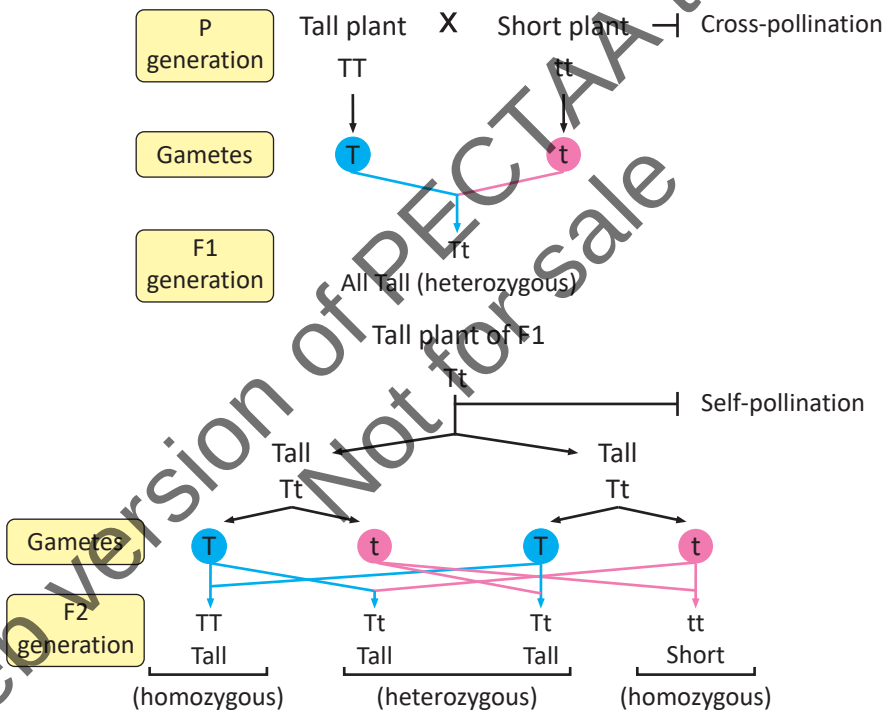


FIGURE 7.9: Segregation of alleles

In pea plant, the allele for tallness is dominant. In P generation, one parent had alleles TT. Each of its gametes received a single T allele. The second parent had alleles tt. Each of its gametes had a single t allele. When these gametes (T and t) joined, the new plants in F1 plant received the pair as Tt. So, all F1 plants were tall. When self-pollination was allowed in F1 tall plant, the results were:

- 25% of the F2 generation received both alleles of shortness i.e., tt. So, they

were short.

- 50% plants of F2 received one T allele and one t. So, they were tall (Tt).
- 25% plants of F2 received both alleles of tallness i.e., TT. So, they were also tall.

Experiment 2

In his next experiments, Mendel did **dihybrid crosses**. In a dihybrid cross, the inheritance of two characteristics is studied at the same time. In such experiments, studied the characteristics of seed shape (round or wrinkled) and

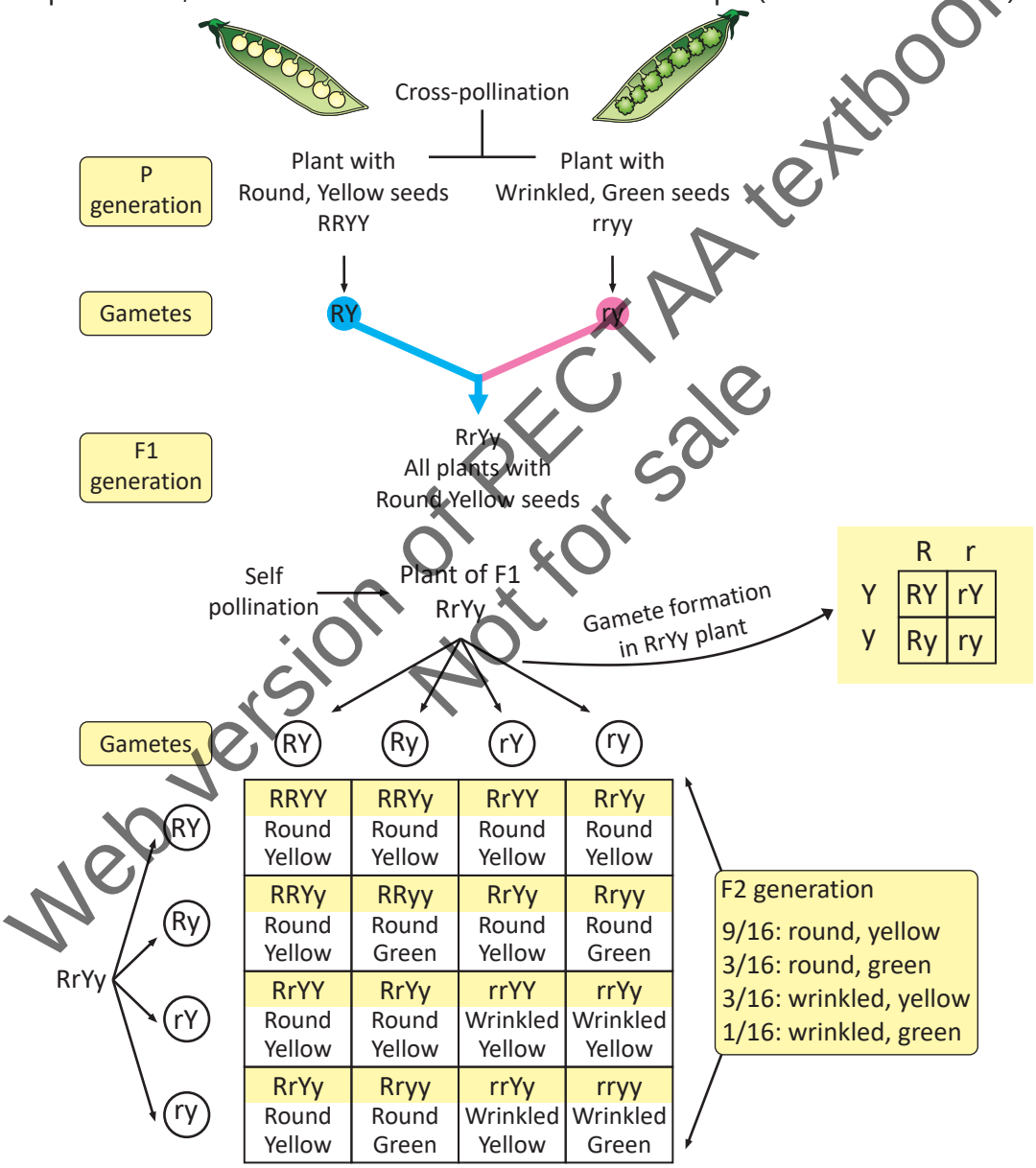


FIGURE 7.10: Independent assortment of alleles

seed colour (yellow or green). He first grew true-breeding varieties of pea plants. One plant had round yellow seeds and the other had wrinkled green seeds.

Mendel crossed these true-breeding plants. All F1 plants produced round yellow seeds. It proved that the allele for round seeds (R) is dominant over the allele for wrinkled seeds ®. Similarly, the allele for yellow seeds (Y) is dominant over the allele for green seeds (y). All the F1 plants were heterozygous for both seed shape and seed colour (genotype: RrYy).

He allowed self-pollination in the F1 plants and got the F2 generation. The F2 generation had the following four phenotypes:

- 9/16 that have round, yellow seeds (genotypes: RRYY, RRYy, RrYY, and RrYy)
- 3/16 that have round, green seeds (genotypes: RRyy and Rryy)
- 3/16 that have wrinkled, yellow seeds (genotypes: rrYY and rrYy)
- 1/16 that have wrinkled, green seeds (genotype: rryy)

Conclusions:

Law of Independent Assortment

The F1 plants (RrYy), produced four types of gametes i.e., RY, Ry, rY, and ry. When these plants were allowed to self-pollinate, there were 16 combinations of alleles in F2 generation. It means that alleles R and r segregated independently of the alleles Y and y. Mendel's discovery is referred to as the **law of independent assortment**. It states that "alleles separate independently of one another during the formation of gametes".

EXERCISE

A. Select the correct answers for the following questions.

1. Chromosomes of eukaryotes are made of;

   a) Lipids and proteins b) Lipids and DNA

   c) RNA and proteins d) DNA and proteins

2. What is the relationship between a gene and an allele?

   a) Alleles are alternative forms of a gene

   b) Genes are alternative forms of an allele

   c) Genes mask the effects of genes

   d) Alleles and genes are unrelated

3. The allele that is expressed, when two separate alleles are inherited;
   a) Dominant b) Recessive c) Homozygous d) Heterozygous
4. Which of these is a reason why pea plants were suitable for Mendel's experiments?
   a) Long life cycle b) Easy to cross-pollinate
   c) Few seeds produced per plant d) No variation in traits
5. What does Mendel's Law of Segregation state?
   a) Genes are linked together
   b) Each allele separates during gamete formation
   c) Dominant traits appear in all generations
   d) Alleles blend together
6. In peas, allele for purple flower (P) is dominant over the allele for white flower (p). If a white flower is crossed with a heterozygous purple flower (Pp), what will be the ratio of offspring?
   a) 100% purple b) 75% purple & 25% white
   c) 50% purple & 50% white d) 100% white

B. Write short answers.

1. Write down the combination of alleles in the gametes of a plant, which has genotype Rryy.
2. State Mendel's law of segregation.
3. State Mendel's law of independent assortment.
4. Define monohybrid cross and a dihybrid cross and give an example of each.
5. Draw a cross between two pea plants. One of them has round green seeds (RRyy) while the other has wrinkled yellow seeds (rrYY).
6. Differentiate between:
   - Gene and allele
   - F1 and F2 generations
   - Dominant and recessive
   - Homozygous and heterozygous

C. Write answers in detail.

1. Write a note on the structure and composition of chromosome.
2. Why did Mendel choose pea plants for his genetic experiments?
3. Describe Mendel's experiment on two-character inheritance and state the law he proposed.
4. Describe Mendel's Law of Segregation? Give an example.

8

BIOTECHNOLOGY

Students Learning Outcomes

After studying this chapter, students will be able to:

- Introduce biotechnology.
- Explain the role of yeast in the production of bread and ethanol.
- Understand that bacteria are useful in biotechnology and genetic modification.
- Describe the basic method of genetic engineering/genetic modification.
- Discuss potential advantages and risks of genetic modification.

Biotechnology is a new branch of biology that involves manipulation of organisms at molecular and cellular level to get services and products for human welfare. This field provides benefits in the areas of human health, agriculture, industries, and environment. In this chapter, we will study the basics of biotechnology and its applications.

8.1 INTRODUCTION OF BIOTECHNOLOGY

In 1919, Hungarian engineer **Karl Ereky** first proposed the term "biotechnology". It may be defined as the use of living cells or organisms to create products or processes for specific purposes. Through this technology;

- The hereditary characteristics of organisms are modified.
- New organisms with desired characters are developed from a cell or a part of an organism.
- Any required substance is produced from the modified organism.

Modern biotechnology emerged after the invention of the structure and function of DNA in 1953. The techniques being used in modern biotechnology include fermentation, recombinant DNA technology, cell culture, gene editing, genetic engineering, and tissue culturing etc.

Sir Ian Wilmut is a British embryologist. He was the leader of the research group that in 1997 first produced a mammal (a lamb named Dolly) from an adult body cell.

Importance of Yeast in Fermentation

Yeast is a microscopic fungus that plays a crucial role in both bread making and ethanol production through a process called fermentation.

Fermentation is the oldest form of biotechnology. It is used for making bread, beer, and yogurt thousands of years ago.

Role in Bread Making

Yeast ferments the sugars present in the dough and produces carbon dioxide (CO_2) gas. This gas forms bubbles in the dough, causing it to rise and become soft and airy. The alcohol produced during this process evaporates during baking.

Role in Ethanol Production

Yeast ferments sugars from crops like sugarcane or corn to produce ethanol (alcohol) and carbon dioxide. The ethanol is then purified and used as a biofuel or in alcoholic beverages.

Importance of Bacteria in Biotechnology

Bacteria are essential tools in biotechnology because they are simple, fast-growing, and can easily accept new genetic material. Scientists use them for producing medicines, studying genes, and creating genetically modified organisms (GMOs).

Role in Biotechnology

Certain bacteria produce important substances like antibiotics (e.g., *Streptomyces* produces streptomycin). Many bacteria produce enzymes which scientists use in making cheese and detergents. Similarly, many bacteria produce vitamins (like vitamin B12). Scientists also use bacteria to clean up oil spills and waste through a process called **bioremediation**. In the food industry, bacteria like *Lactobacillus* help in making yogurt and cheese by fermenting milk.

Role in Genetic Modification

Scientists use special structures called plasmids (small loops of DNA found in bacteria) as carriers to introduce new genes into bacterial cells. In this way, the modified bacteria start producing proteins from that foreign gene. This method is used to produce:

- Human insulin for treating diabetes
- Human growth hormone for growth disorders
- Vaccines against diseases

Some bacteria are also used to introduce new genes into plant cells during the creation of genetically modified crops.

8.2 GENETIC ENGINEERING

Genetic engineering is defined as the process of altering (editing) the genes of organisms or transferring the genes from one organism into other organisms. In genetic engineering, special enzymes are used to cut and attach DNA at specific locations. As a result of genetic engineering, **Genetically Modified Organisms** are produced. The following are the two main examples of genetic engineering.

1. Gene Editing

Gene editing is a technique where scientists make changes in the DNA (genes) of an organism. These can involve adding, removing, or replacing specific parts of DNA. It allows scientists to add, delete, or change parts of the DNA. It is done to correct genetic abnormalities and to improve characteristics.

Examples of Gene Editing

1. **Curing Genetic Diseases:** Scientists are researching how gene editing can cure diseases caused by abnormal genes, such as sickle cell anaemia (a blood disorder), cystic fibrosis (a lung disease).
2. **Improving Crops:** Gene editing can create crops that grow faster, resist

Gene editing is done very carefully because changes made to DNA can have unexpected effects.

pests and diseases, and survive droughts better. For example, virus resistant varieties of tomato and tobacco have been developed. Modified varieties of soybeans, corn, tomato, and cotton have been produced which show resistance against herbicides.

3. **Producing Better Medicines:** Gene editing helps create bacteria that produce important medicines, like insulin for diabetes.

2- Gene Transfer

Genetic engineers use special **vectors** to transfer genes into an organism.

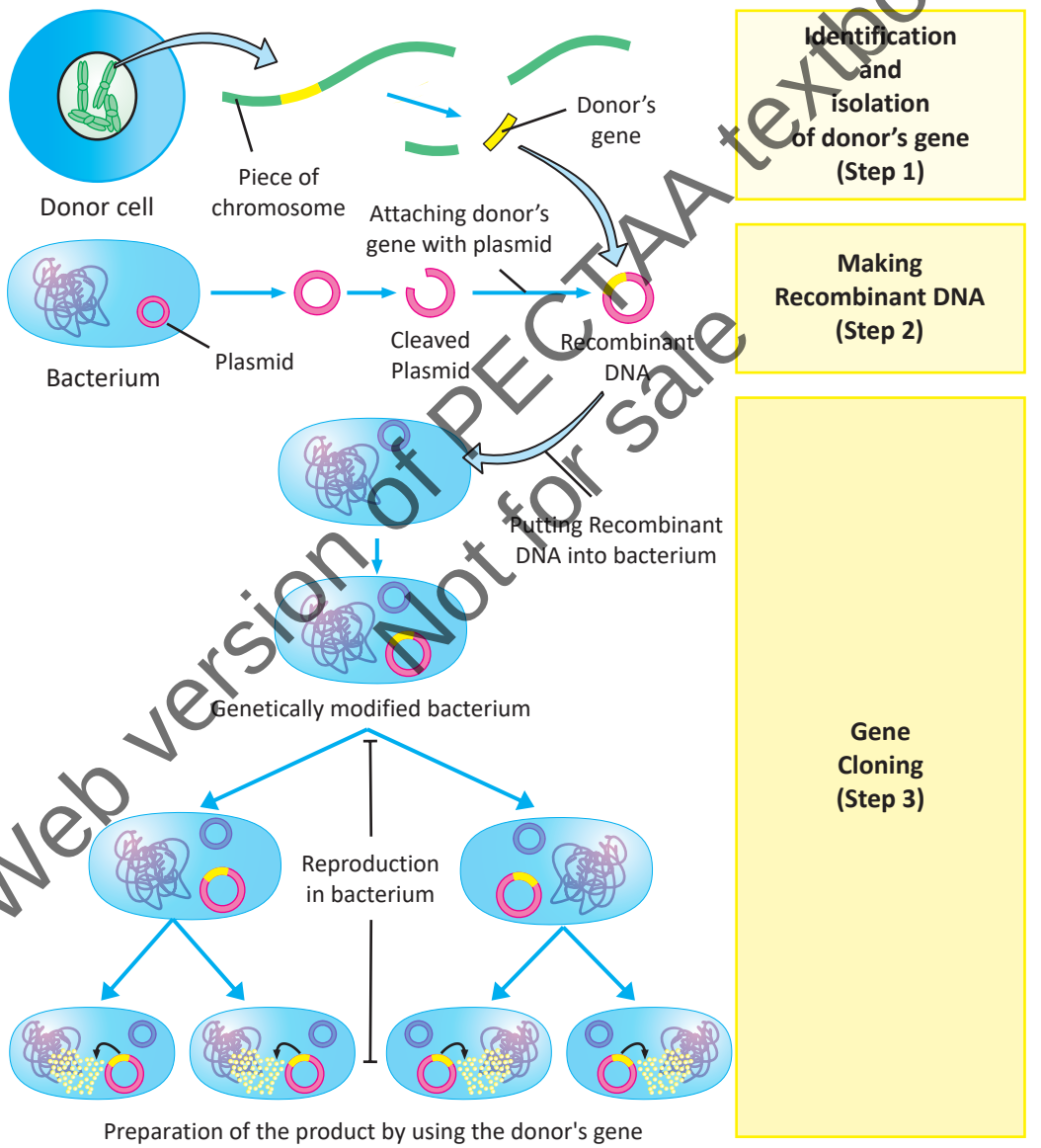


FIGURE 8.1: Transfer of gene to an organism and its cloning

The most commonly used vectors to transfer genes into bacteria are plasmids and bacteriophages. **Plasmids** are small, circular DNA molecules present in some bacteria. **Bacteriophages** are the viruses that can enter bacteria. The following are the steps for transferring a gene into organism e.g. bacteria.

1. The gene of donor organism is **identified** and **isolated** from its chromosome.
2. A plasmid is removed from a bacterial cell. The plasmid DNA is cut. Donor's gene is attached at the cut ends of the plasmid. The plasmid is now a combination of its original DNA and the new DNA (donor's gene). Now it is called **recombinant DNA**.
3. The recombinant DNA is put back into a bacterial cell. When bacterial cell reproduces to form a colony of cells, all genetically modified bacteria contain the recombinant DNA. In this way, the bacterial colony contains many copies of the donor's gene. This step is also called **gene cloning**.

Examples of Gene Transfer

1. The human insulin gene is transferred into a bacterium. The modified bacteria produce insulin, which is collected for treating diabetic patients.
2. Human growth hormone is produced in genetically modified bacteria. It is used to treat dwarfism.
3. Interferon (anti-virus protein) is made in modified bacteria.
4. In gene therapy, genetic engineers introduce genes into a patient's cells. It is used to treat genetic disorders of blood (e.g., thalassaemia).
5. Vaccine against Hepatitis B virus has been produced from yeast through genetic modification.
6. A gene from a bacterium is transferred into cotton and corn crops. The genetically modified crops then produce a natural toxin that kills insects but is safe for humans.
7. Gene from a bacterium is transferred into rice plants. The rice produces beta-carotene, which the body converts into vitamin A. Such genetically modified rice help prevent blindness caused by vitamin A deficiency.

Some COVID-19 vaccines are made by using mRNA. This mRNA carries instructions to make a harmless proteins of the corona virus, which trains the immune system to fight the real virus.

FIGURE 8.2: Golden rice & White rice

Table 8.1: Products made by using Gene Transfer			
Product	**Genetic Material Transferred**	**Organism or Technology Used**	**Purpose**
Insulin	Human insulin gene	Bacteria	Treat diabetes
Growth Hormone	Human growth hormone gene	Bacteria	Treat growth disorders
Interferon	Human interferon gene	Bacteria	Treat viral infections and boost immunity
Hepatitis B Vaccine	Surface protein gene of Hepatitis B virus	Yeast cells	Protect against Hepatitis B
Bt Crops	Bt toxin gene	Cotton, Corn plants	Insect resistance
Golden Rice	Beta-carotene producing genes	Rice plants	Prevent vitamin A deficiency

8.3 APPLICATIONS OF BIOTECHNOLOGY

The following are the applications of biotechnology.

1. Food Biotechnology

- Biotechnologists have developed virus resistant, pest resistant, and drought resistant varieties of many crop plants.
- Enzymes extracted from certain microbes are used in different industries for the production of alcohol.

Research in Pakistan has led to the development of rice varieties that are resistant to certain diseases and pests.

Pakistan has also advanced in using tissue culture technology for the mass propagation of high-yielding fruit crops such as mangoes and citrus.

2. Medical Biotechnology

In medical field, biotechnology is helping in the following:

- Making proteins like hormones and enzymes used for treating various diseases.
- Developing vaccines to prevent viral and bacterial infections.
- Correcting defective genes responsible for genetic disorders.
- Production of targeted antibodies for disease diagnosis and treatment.
- Identifying inherited diseases and genetic conditions early.

In humans, more than 3500 disorders are due to errors in genes. Biotechnologists are trying to remove such disorders through biotechnology.

In **Human Genome Project**, biologists discovered the locations of all genes in human body. They also found the characteristics controlled by each gene.

3. Environmental Biotechnology

- **Bioremediation** is defined as the use of organisms such as bacteria, plants, or fungi to remove or neutralize pollutants from the environment. Genetically modified bacteria are used to break down the harmful chemicals present in waste matters and industrial discharge.

FIGURE 8.3: Saplings to grow forest

- Large number of saplings of different plants are produced through tissue culture. These saplings are planted to grow new forests in limited time.
- Modified bacteria are also used for extracting different minerals e.g., copper and uranium.
- Microbes such as bacteria, blue green algae and fungi are used to produce manure.

4. Marine Biotechnology

It involves the use of marine organisms to develop new products, treatments, and technologies. For example:

- Genetic modifications in many fishes have led to faster growth rates.
- Compounds extracted from marine organisms (sponges, corals, and marine bacteria) are used to develop new cancer drugs, antibiotics and antiviral medicines.
- Certain marine bacteria are used to degrade oil spills, helping to clean up marine environments.
- Marine algae are cultivated in large quantities and processed into biodiesel, ethanol, and other types of renewable energy.
- Enzymes extracted from marine organisms are used in various industries. For example, an enzyme extracted from marine bacteria is used to produce high-fructose corn syrup (common sweetener in the food industry).

5. Industrial Biotechnology

The following are the main applications of industrial biotechnology.

- Biofuels like ethanol, biodiesel, and biogas are produced. For example, yeast is used to ferment sugars from crops (corn, sugarcane) into ethanol. This ethanol can be blended with petrol to produce a cleaner fuel.
- Biodegradable plastic (bioplastic) is produced from fermented plant starch (usually corn or sugarcane).

- Pharmaceutical products are made through microbial fermentation and genetic engineering. For example, the production of antibiotics, such as penicillin, involves the fermentation of specific molds like *"Penicillium"*. Similarly, human insulin is produced through bacteria.

8.4 POTENTIAL RISKS OF BIOTECHNOLOGY

Health Concerns: Some people worry that consuming genetically modified foods could cause allergic reactions or long-term health problems. There is also concern that new genes might interact with human cells in unexpected ways.

Environmental Impact: GM plants can sometimes cross-pollinate with wild plants. So, the modified genes can be spread in natural ecosystems. It can lead to create such species that may harm the environment.

Loss of Biodiversity: If farmers mostly grow GM crops, traditional and naturally diverse varieties might become rare or extinct. This can reduce biodiversity.

Development of Resistant Pests and Weeds: Pests exposed repeatedly to GM crops may evolve into "powerful pests" that are no longer affected by the crop's built-in defences.

Ethical Issues: Many people feel that it is morally wrong to alter the natural genes of living organisms.

EXERCISE

A. Select the correct answers for the following questions.

1. Why are bacteria commonly used in genetic engineering for producing products?
   a) They naturally produces the required products
   b) They grow quickly and accept human genes
   c) They resist all infections
   d) They have a human-like immune system
2. In genetic engineering, the first step is:
   a) Inserting DNA into the organism
   b) Cutting the desired gene from DNA
   c) Growing the modified organism
   d) Making proteins from the gene

3. Which of these is often used as a vector in genetic engineering?
a) Virus b) Fungi c) Yeast d) Blood cell

4. In genetic engineering, the desired gene is usually inserted into a bacterium by using:
a) Protein b) Another bacterium c) Vector d) Enzyme

5. In genetic engineering, after inserting the gene, the host cell is allowed to:
a) Mutate randomly b) Die naturally
c) Multiply and express the gene d) Produce waste

6. In genetic engineering, "recombinant DNA" means:
a) Natural DNA b) DNA copied by mistake
c) DNA joined from two sources d) DNA destroyed by enzymes

7. A gene for toxin production is inserted into a plant for:
a) Reducing water need b) Increasing vitamin content
c) Resisting insect attacks d) Speeding up flowering

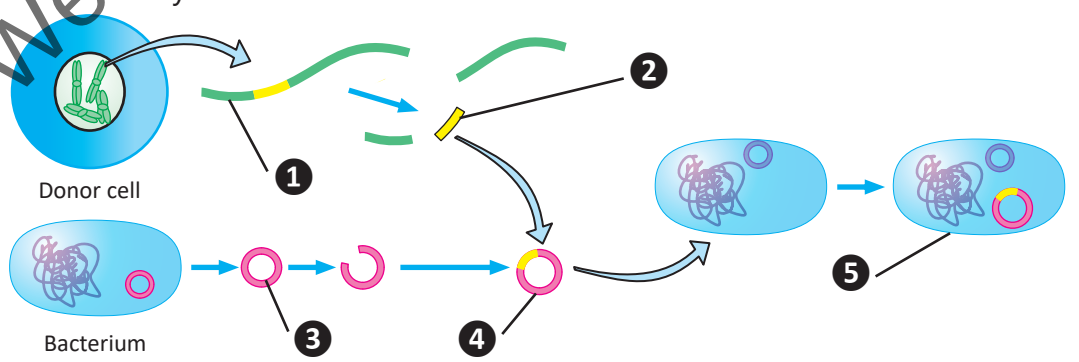
8. Genetically modified bacteria produce the following products, except;
a) Hepatitis B vaccine b) Growth hormone
c) Insulin d) Interferon

9. Which biotechnology products help against viral infections?
a) Antibiotics b) Vaccines
c) Clotting factors d) Growth hormone

10. Golden rice is a genetically modified plant to increase:
a) Protein b) Vitamin A c) Iron d) Calcium

B. Write short answers.

1. What is the relation between biotechnology and genetic engineering?
2. What is a plasmid? Where biologists use plasmids in genetic engineering?
3. The following diagram shows how a gene is transferred to bacterial cell. Identify the structures labelled as 1 to 5.



4. What do you mean by genecally modified organism?
5. List two types of medical products that can be produced using genetic engineering.
6. List two ways by which genetic engineering may improve crops.

C. Write answers in detail.

1. Explain with examples that food biotechnology has advanced agriculture.
2. Explain with examples that medical biotechnology has advanced healthcare in diabetes and cancer.
3. Explain the role of yeast in the production of bread and ethanol.
4. Enlist the steps for transferring a human gene into a bacterial cell.
5. Describe the advantages of gene editing.
6. Discuss the potential risks of genetic modification.

Pairing Scheme / Instructions for Preparation of Exam Paper of Biology Matric Tech for Class-10

The paper of Matric Tech Biology for class 10 will consist of 40 marks. Timing of the paper will be two hours. The paper will be made as per following details:

Part-I: Objective:

Q-1:

10 Multiple Choice Questions. The detail is as follows: 1 × 10 = 10

Chapter	1	2	3	4	5	6	7	8
MCQS	1	1	1	2	1	1	1	2

Part-II: Subjective:

Q-2:

4 short answer questions have to be answered out of 6. The detail is as follows: 2 × 4 = 8

Chapter	1	2	3	5
No. of Short Questions	1	1	2	2

Q-3:

4 short answer questions have to be answered out of 6. The detail is as follows: 2 × 4 = 8

Chapter	4	6	7	8
No. of Short Questions	1	1	2	2

Part-III: Subjective:

This section will contain three questions bifurcated in two-part **a & b** (carrying 4 & 3 marks each) and students have to attempt 2 questions The detail is as follows: 2 × 7 = 14

Q-4:

Chapter	1	3
Part	a	b

Q-5:

Chapter	6	5
Part	a	b

Q-6:

Chapter	8	7
Part	a	b

MODEL PAPER OF BIOLOGY FOR CLASS-10

Objective Type

نوٹ: ہر سوال کے چار ممکنہ جوابات A، B، C اور D دیے گئے ہیں۔ جو انتخاب آپ کے خیال میں درست ہے، اس سوال کے سامنے والے دائرے کو مار کر یا پین کی سیاہی سے بھریں۔ دو یا دو سے زیادہ دائروں کو کاٹنے یا بھرنے کی صورت میں جواب غلط تصوّر ہو گا۔

Note: Four possible answers A, B, C and D to each question are given. The choice which you think is correct, fill that circle with marker or pen ink in the answer-book. Cutting or filling two or more circles will result in zero mark in that question.

(i) خوراک کی نالی سے فوراً بعد معدے کا حصہ کہلاتا ہے۔

(i) The part of the stomach just after the oesophagus is called:

(a) Fundus فنڈس (b) Pyloric end پائلورک حصہ
(c) Cardiac end کارڈیک حصہ (d) Body جسم

(ii) ان میں سے کون سا ترتیب اُس راستے کو درست طور پر ظاہر کرتا ہے جس سے ہوا سانس لینے (Inhalation) کے دوران گزرتی ہے؟

(ii) Which of these correctly orders the structures through which air passes during inhalation?

(a) Pharynx → trachea → larynx → bronchi فیرنکس ← ٹریکیا ← لیرنکس ← برونکائی
(b) Pharynx → larynx → trachea → bronchi فیرنکس ← لیرنکس ← ٹریکیا ← برونکائی
(c) Larynx → pharynx → bronchi → trachea لیرنکس ← فیرنکس ← برونکائی ← ٹریکیا
(d) Larynx → pharynx → trachea → bronchi لیرنکس ← فیرنکس ← ٹریکیا ← برونکائی

(iii) ٹانگوں سے ڈی آکسی جنیٹڈ (deoxygenated) خون کے دل تک واپس آنے کا درست راستہ بتائیں:

(iii) Trace the correct pathway for deoxygenated blood from legs back to the heart:

(a) Femoral veins → Inferior vena cava → Right atrium فیمورل وریدیں ← انفیریئر وینا کیوا ← دایاں ایٹریئم
(b) Femoral arteries → Inferior vena cava → Right atrium فیمورل شریانیں ← انفیریئر وینا کیوا ← دایاں ایٹریئم
(c) Femoral veins → Superior vena cava → Right atrium فیمورل وریدیں ← سپیریئر وینا کیوا ← دایاں ایٹریئم
(d) Femoral arteries → Superior vena cava → Right atrium فیمورل شریانیں ← سپیریئر وینا کیوا ← دایاں ایٹریئم

(iv) Ureter leaves the kidney through: (iv) یوریٹر گردے سے کس راستے کے ذریعے نکلتا ہے؟

(a) pelvis پیلوِس (b) hilus ہائیلس
(c) papillary duct پیپی لیری ڈکٹ (d) collecting duct کلیکٹنگ ڈکٹ

(v) Tubular secretion is a/an: (v) ٹیوبولر سیکریشن کس قسم کا عمل ہے؟

(a) active transport ایکٹوٹرانسپورٹ (b) diffusion ڈیفیوژن
(c) osmosis اوسموسس (d) passive transport پیسوٹرانسپورٹ

(vi) The function of glucagon is to: (vi) گلوکاگون کا کام ہے:

(a) accelerates protein synthesis within cells — خلیوں کے اندر پروٹین کی ترکیب کو تیز کرنا
(b) stimulates release of glucose from liver — جگر سے گلوکوز کے اخراج کو بڑھانا
(c) decrease release of glucose from liver — جگر سے گلوکوز کے اخراج کو کم کرنا
(d) slow down glucose formation from lactic acid — لیکٹک ایسڈ سے گلوکوز کی تشکیل کو سست کرنا

(vii) Fertilization usually occurs in the: (vii) عام طور پر فرٹیلائزیشن کہاں ہوتی ہے؟

(a) uterus یوٹرس (b) vagina ویجائنا
(c) fallopian tube فیلوپین ٹیوب (d) cervix سروکس

(viii) When two different alleles are present then the allele which appears is called: (viii) جب دو مختلف ایلیل موجود ہوں تو ظاہر ہونے والا ایلیل کہلاتا ہے؛

(a) dominant ڈومینینٹ (b) recessive ریسیسو
(c) homozygous ہوموزائیگس (d) hetrozygous ہیٹروزائیگس

(ix) If a gene from bacteria is transferred into corn, the advantage is: (ix) اگر بیکٹیریا کا جین مکئی میں منتقل کیا جائے تو فائدہ کیا ہوگا؟

(a) larger corn size مکئی کے سائز میں اضافہ (b) production of natural toxin قدرتی زہر (ٹاکسن) کی پیداوار
(c) more vitamins زیادہ وٹامنز (d) faster growth تیزی سے نشوونما

(x) Which of it is used as a vector in genetic engineering: (x) ان میں سے کون جینیٹک انجینئرنگ میں ویکٹر کے طور پر اکثر استعمال ہوتا ہے؟

(a) virus وائرس (b) fungi فنجائی
(c) yeast یسٹ (d) blood cell خون کا (بلڈ) سیل

Subjective Type (Part I)

Q. 2: Write short answers to any four(04) questions: کوئی سے چار(4)سوالات کے مختصر جوابات لکھیے:

(i) State two functions of the liver other than digestion. (i) ہاضمے کے علاوہ جگر کے دو افعال بیان کریں۔

(ii) What is pleura? Write its function. (ii) پلیورا کیا ہے؟ اس کا فعل لکھیں۔

(iii) Give the names and functions of any two proteins present in blood plasma. (iii) خون کے پلازما میں موجود کسی دو پروٹینوں کے نام اور افعال لکھیں۔

(iv) What are agranulocytes? Write its types. (iv) ایگرینولوسائٹس (Agranulocytes) کیا ہیں؟ اس کی اقسام لکھیں۔

(v) Compare the functions of thalamus and hypothalamus. (v) تھیلس اور ہائپو تھیلس کے افعال کا موازنہ کریں۔

(vi) Name any four hormones secreted by anterior lobe of pituitary gland. (vi) پیچوٹری گلینڈ کے اینٹیریئر لوب سے خارج ہونے والے کسی چار ہارمونز کے نام لکھیں۔

کوئی سے چار(4)سوالات کے مختصر جوابات لکھیے:

Q.3 : Write short answers to any four(04) questions:

(i) پریشر فلٹریشن اور ٹیوبیولر سیکریشن میں فرق بیان کریں۔

(i) Differentiate between pressure filtration and tubular secretion.

(ii) ایسٹروجن اور پروجیسٹرون کے افعال کا تقابل کریں۔

(ii) Compare the functions of estrogen and progesterone.

(iii) What is the composition of eukaryotic chromatin? یوکریاٹک کروميٹن کی ترکیب کیا ہے؟ (iii)

(iv) مینڈل نے مٹر کے پودے کو تجرباتی مواد کے طور پر کیوں منتخب کیا؟ دو وجوہات لکھیں۔

(iv) Why did Mendel choose pea plant as an experimental material? Give two reasons.

(v) جینیاتی تبدیلی (Genetic Modification) میں بیکٹیریا کا کردار بیان کریں۔

(v) Mention the role of bacteria in Genetic Modification.

(vi) Write any two potential risks of biotechnology. بائیوٹیکنالوجی کے دو ممکنہ خدشات لکھیں۔ (vi)

Subjective Type (Part II)

Note: Attempt any two questions. نوٹ: کوئی سے دو سوالات کے جوابات لکھیے۔

Q.4. (a) Justify the importance of liver and pancreas in digestion.

(الف) ہاضمے میں جگر اور لبلبہ کی اہمیت کو ثابت کریں۔

(b) Compare the structure and function of an artery, a vein and a capillary.

(ب) شریان، ورید اور کیپیلری کی ساخت اور افعال کا تقابل کریں۔

Q.5. (a) Explain that organs of testis and ovary where the gametes are formed.

(الف) ٹیسٹس اور اووری کے اُن حصوں کی وضاحت کریں جہاں گیمیٹ بنتے ہیں؟

(b) What are the differences and similarities among the three types of neurons?

(ب) تینوں اقسام کے نیورونز میں فرق اور مماثلتیں بیان کریں۔

Q.6. (a) Enlist the steps for transferring a human gene into a bacterial cell.

(الف) انسانی جین کو بیکٹیریا کے خلیے میں منتقل کرنے کے مراحل درج کریں

(b) Describe Mendel Law of Segregation.

(ب) مینڈل کا لاء آف سیگریگیشن بیان کریں۔