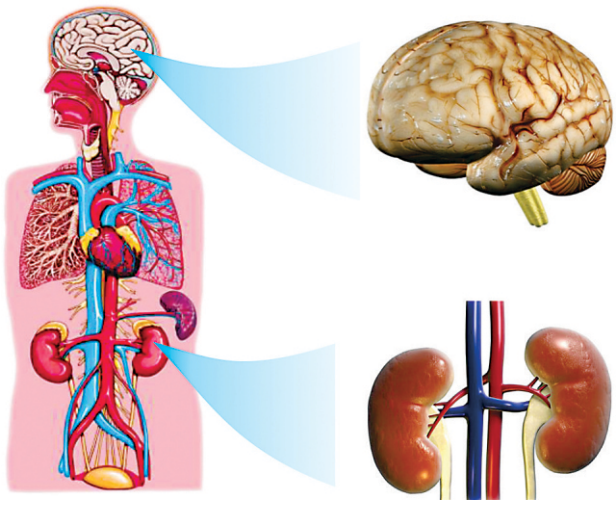
Chapter 1

HUMAN ORGAN SYSTEMS



STUDENTS' LEARNING OUTCOMES

After studying this chapter, students will be able to:

- ☑ Describe the structure and functions of the nervous system.
- ☑ Describe the working of the nervous system.
- ☑ Explain reflex action with an example.
- ☑ Differentiate between voluntary and involuntary actions.
- ☑ Define excretion.
- ☑ Draw and label human excretory system.
- ☑ Describe the role of kidney in excretion of nitrogenous wastes.
- ☑ Investigate the possible causes of malfunctioning of kidneys.
- ☑ Suggest techniques to cure problems of kidneys.

In previous classes, we have learnt about various organs and their functions in human body. In this chapter we will study the functions of human brain, spinal cord and nerves which constitutes **nervous system**. Kidneys, their role in excretion, kidney problems and their treatment will also be discussed.

1.1 Nervous System

Whenever a person gets injury on his foot while walking, he feels pain and his hand immediately reaches the injured site. Who asked the hand to reach the site? In fact, there is an organ system in our body which carries messages form one part of the body to another and coordinates body functions. This system is called nervous system.

Human nervous system consists of central nervous system (CNS) and peripheral nervous system (PNS) (Figure 1.1). The central nervous system is composed of brain and spinal cord. Peripheral nervous system consists of a network of nerves which connect the central nervous system to all parts of the body.

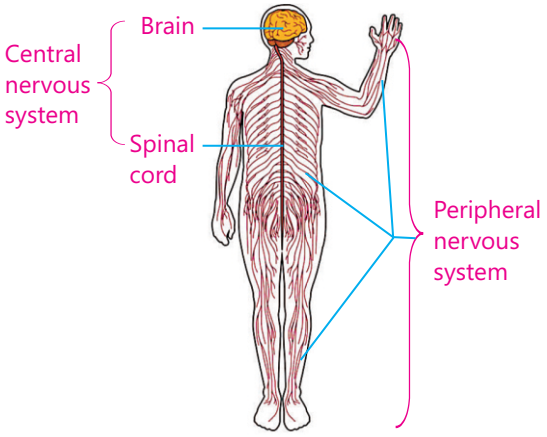


Figure 1.1: Human nervous system

Neuron or Nerve Cell

Neuron or nerve cell is the basic structural and functional unit of the nervous system. All parts of the nervous system, i.e., brain, spinal cord and nerves are made up of neurons. Neurons transmit messages in the form of electrochemical waves called **nerve impulses**.

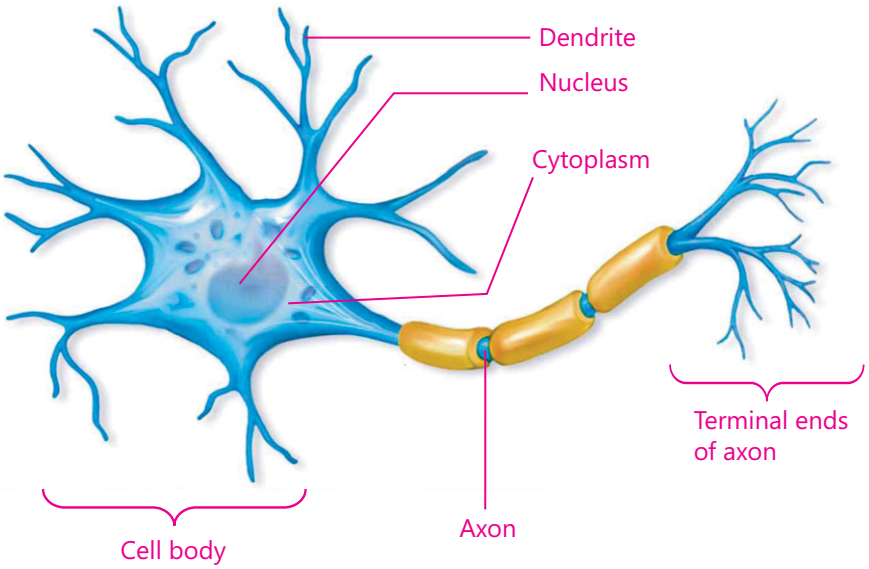


Figure 1.2: Nerve cell or neuron

The part of a neuron which contains nucleus and most of the cytoplasm is called cell body. The fine projections of the cell body which receive messages are called dendrites. A long projection of the cell body which conducts messages away from the cell body is called axon (Figure 1.2). Terminal ends of the axons transmit the messages to the next cells.

Interesting information

Impulses may travel as fast as 150 metre per second or as slow as 0.2 metre per second.

Nerve

A nerve is cable-like bundle of axons enclosed in a common sheath. Nerve transmits messages from one part of body to another.

Types of Neurons

On the basis of their functions, neurons are of three types, i.e. sensory neurons, motor neurons and inter-neurons. **Sensory neurons** carry nerve impulses from sense organs (ears, eyes, skin, tongue, nose, etc.) to the central nervous system. **Motor neurons** carry nerve impulses from central nervous system to **effectors** (muscles and glands), i.e., the parts which respond. **Inter-neurons** are present in central nervous system (brain and spinal cord). They form a link between sensory and motor neurons (Figure 1.3).

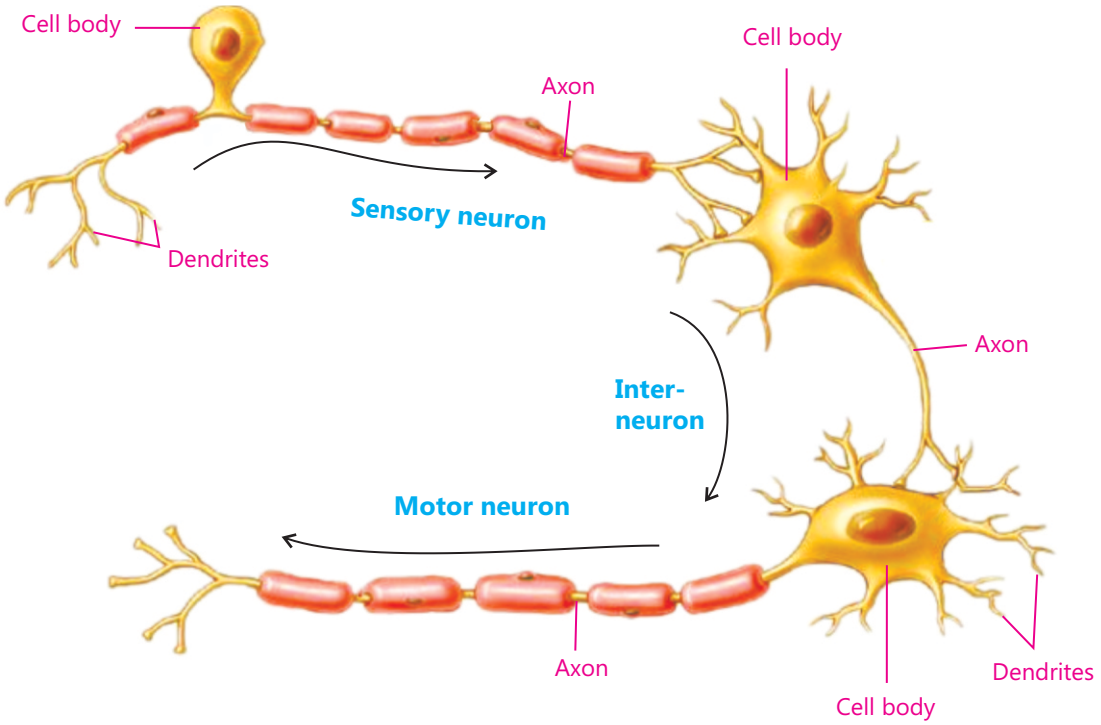
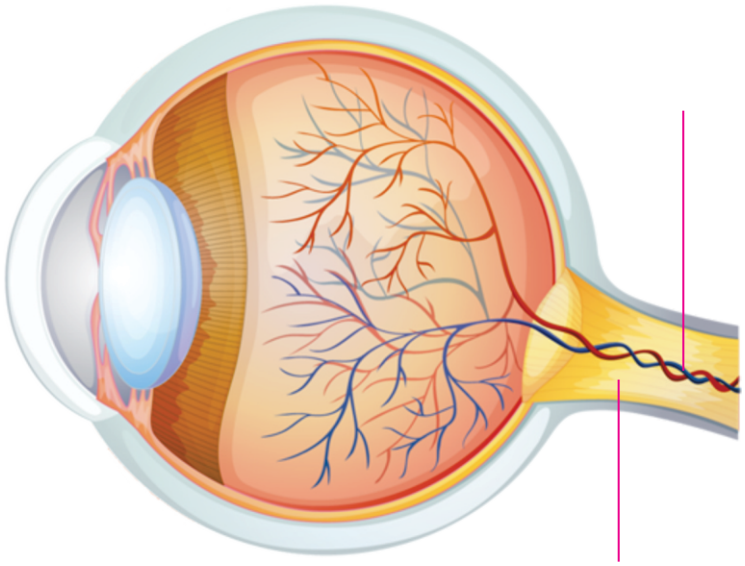


Figure 1.3: Sensory neuron, Inter-neuron and Motor neuron

Activity 1.1 - Identification and Labelling

Identify the following diagram and label the parts which are indicated.



Mini Exercise

Make the diagram of a neuron or nerve cell and label its different parts.

1.1.1 Central Nervous System(CNS)

Central nervous system acts as a control centre of the whole nervous system. It comprises brain and spinal cord.

Brain

Human brain (Figure 1.4) is enclosed in a bony skull called **cranium**, and consists of billions of inter-neurons. It is divided into the following parts.

1. Forebrain

Forebrain is the largest part of the brain. It consists of three main parts, i.e., cerebrum, thalamus and hypothalamus. **Cerebrum** is the topmost and the largest part of the brain. It is divided into right and left cerebral hemispheres. Cerebrum controls many actions like thinking, feelings, emotions, seeing, hearing, perceptions, memory, speech, decision making, etc.

Inside cerebrum there is small structure called **thalamus**. It controls many sensory functions. **Hypothalamus** lies at the base of thalamus. It controls body temperature, hunger and thirst.

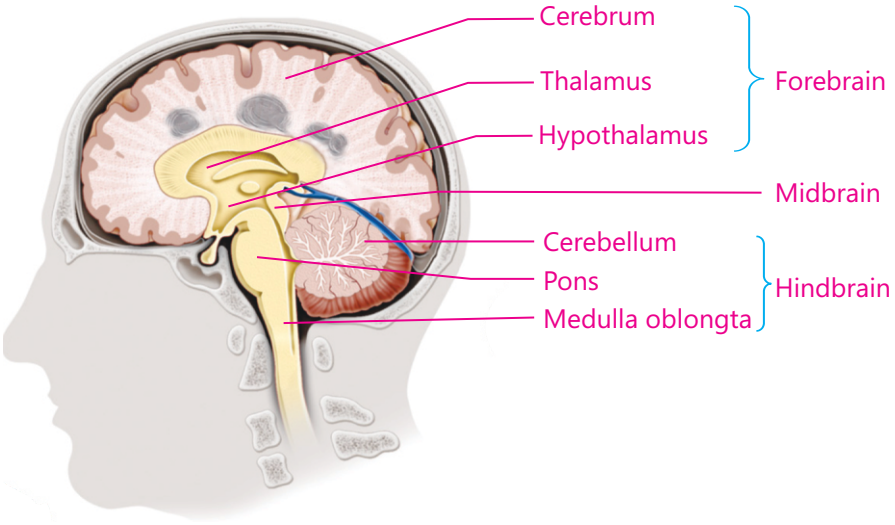


Figure 1.4: Section of skull showing different parts of human brain

2 Midbrain

Midbrain is a small part of the brain which is present below the cerebrum. It receives information from sense organs which is then passed on appropriate part of the forebrain.

3. Hindbrain

Hindbrain consists of three parts, i.e., cerebellum, pons and medulla oblongata. **Cerebellum** lies under the back part of the cerebrum. It acts as a controller for maintaining the body balance and making precise and accurate movements. **Pons** is an oval structure present beneath midbrain. It controls many functions like sleep, swallowing, equilibrium and taste, etc.

Medulla oblongata forms the posterior part of the brain where it is connected with the spinal cord. Medulla oblongata controls heartbeat, breathing and digestion, etc. Medulla oblongata keeps on working when rest of the brain goes to sleep.

? Do you know?

Brain of an adult man weighs about 1.5 kg and consists of about 100,000,000,000 neurons.

Spinal Cord

Spinal cord is an extension of medulla oblongata (Figure 1.5). It runs backwards inside the backbone up to its lower end. It is also made up of inter-neurons.

Spinal cord creates a link between brain and different body parts. It also controls some reflex actions (immediate and involuntary actions) and some other involuntary actions.

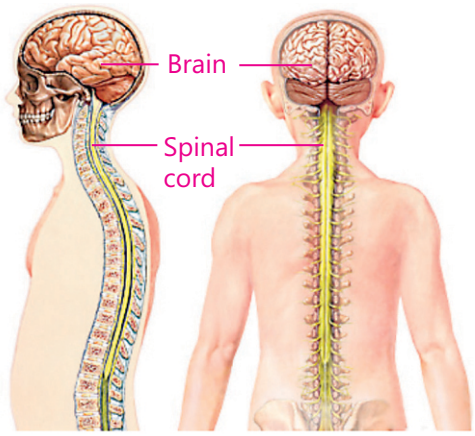


Figure 1.5: Spinal cord

1.1.2 Peripheral Nervous System

Peripheral nervous system (PNS) consists of a network of nerves which are spread in the body to connect all the body parts to the central nervous system (brain and spinal cord) (Figure 1.1). The nerves which arise from brain are called **cranial nerves**. The nerves which arise from spinal cord are called **spinal nerves**. There are 12 pairs of cranial nerves and 31 pairs of spinal nerves in human body.

1.1.3 Working Model of the Nervous System

Nervous system coordinates all body functions. It also detects the changes in environment and produces response to the changes. The working of the nervous system has been depicted in Figure 1.6.

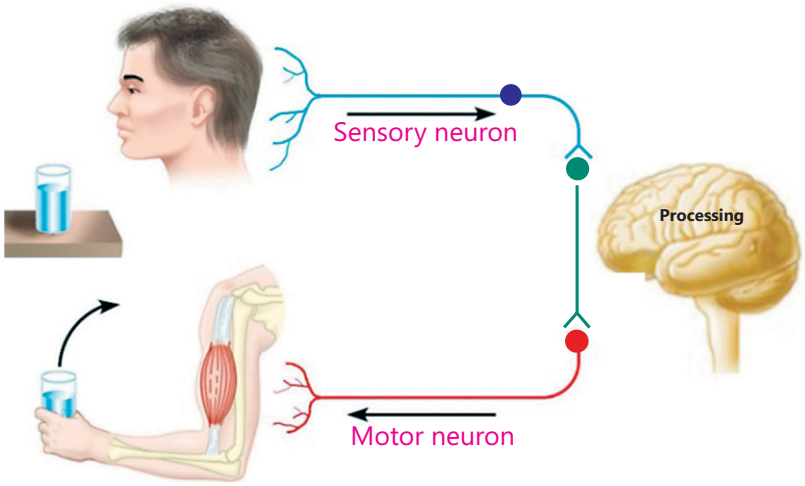


Figure 1.6: Function of nervous system

- Any change in the environment (external or internal) that can be detected by a receptor to initiate a nerve impulse is called stimulus (Plural: stimuli). Heat, cold, pressure, sound waves, etc. are the examples of stimuli. The special organs, tissues or cells which detect stimuli are called **receptors**.
- The sensory neurons carry the messages regarding stimuli in the form of nerve impulses from receptors to central nervous system.
- The central nervous system processes the messages and transmits the nerve impulses to motor neurons.
- The motor neurons carry the nerve impulses to the parts of the body which produce responses. Such parts are called **effectors**. Muscles and glands in the body act as effectors.

Activity 1.2

Make a flow diagram showing the pathway of a nerve impulse when you pat at the shoulder of your friend.

1.1.4 Actions Controlled by the Nervous System

Voluntary Actions

The body actions which are performed under conscious control, i.e., which are done after thinking over them are called **voluntary actions**. For example; speaking, eating, reading, walking, running, clapping, etc., are voluntary actions.

Involuntary Actions

The body actions which are performed without involvement of thinking process are called involuntary actions. **Involuntary actions** are not performed under conscious control. Heartbeat, breathing, blinking of eyes, movement of small intestine, etc., are the examples of involuntary actions.

1.2 Reflex Action

An immediate and involuntary response to a stimulus is called **reflex action**. Quick pulling of hand just after touching the hot object is a common example of reflex action.

In this example of reflex action shown in Figure 1.7, temperature of hot object is a

stimulus which is received by the cells (receptors) of the skin. A nerve impulse is created in the sensory neuron present in skin. The nerve impulse is carried by the sensory neuron to the spinal cord. The inter-neuron of the spinal cord transmits the impulse to the motor neuron. The motor neuron carries the impulse to the arm muscles (effectors). The arm muscles contract and the hand is pulled back. The pathway of nerve impulses which complete a reflex action is called **reflex arc**. It consists of receptor, a sensory neuron, an inter-neuron, a motor neuron and effectors.

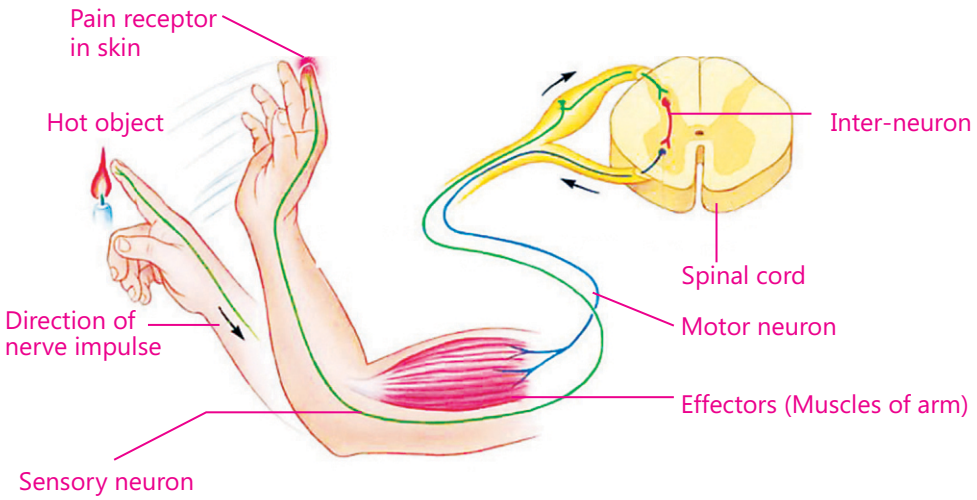


Figure 1.7: Reflex arc representing reflex action. Touching a hot object (flame in this example) results in immediate withdrawal of hand through contraction of muscles of arm.

1.3 Excretory System

As a result of breakdown of various food items and other chemical components of the body, nitrogenous waste matter is produced, which must be immediately removed from the body. Waste products in the body also include nitrogenous materials and other salts. Accumulation of waste materials in the body is dangerous and therefore must be removed from the body. The removal of nitrogenous waste materials from the body is called **excretion**.

Nitrogenous materials, extra water and salts are removed by the **excretory system**. Some extra salts are also removed through skin during perspiration. Human excretory system consists of one pair of kidneys and associated structures, i.e. two ureters, a urinary bladder and a urethra (Figure 1.8).

1.3.1 Kidneys and Associated Structures

Human body has two dark brown, bean-shaped kidneys in the abdominal region, one on either side of the vertebral column. The right kidney is a little lower than the left one. The outer surface of kidney is convex while the inner surface is concave. The following structures are attached with kidneys.

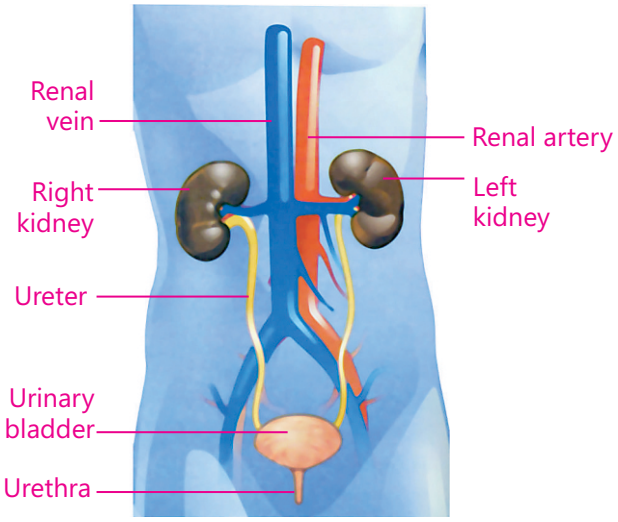


Figure 1.8: Human excretory system

A tube which arises from each kidney and enters the urinary bladder is called ureter. It transports urine from kidneys to urinary bladder. Urinary bladder is a muscular sac which collects urine from both ureters. A fine tube through which urine is released from urinary bladder to the outside is called Urethra.

Internal Structure of Kidney

Internally, each kidney is divided into three regions, i.e., renal cortex, renal medulla and renal pelvis (Figure 1.9). **Renal cortex** is the outermost region. **Renal medulla** is the middle region which is divided into conical masses called **renal pyramids**. **Renal pelvis** is the inner area where urine is drained. The urine from renal pelvis moves into ureter.

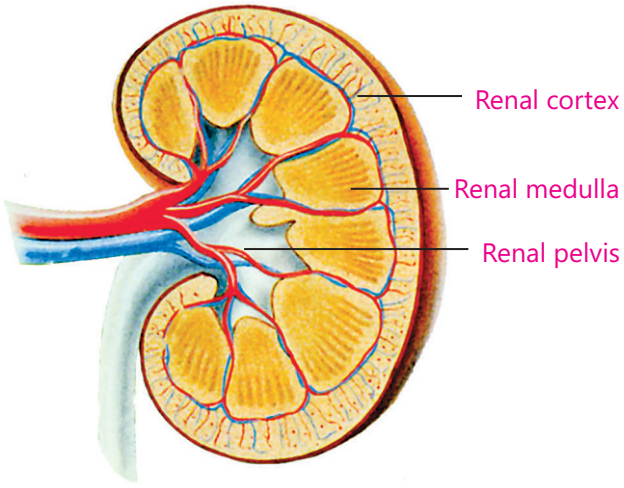


Figure 1.9: Internal structure of kidney

Nephron

Nephrons are the functional units of the kidney. They are the tubules where urine is formed. There are over one million nephrons in each kidney. Each nephron has two parts, i.e., renal corpuscle and renal tubule (Figure 1.10).

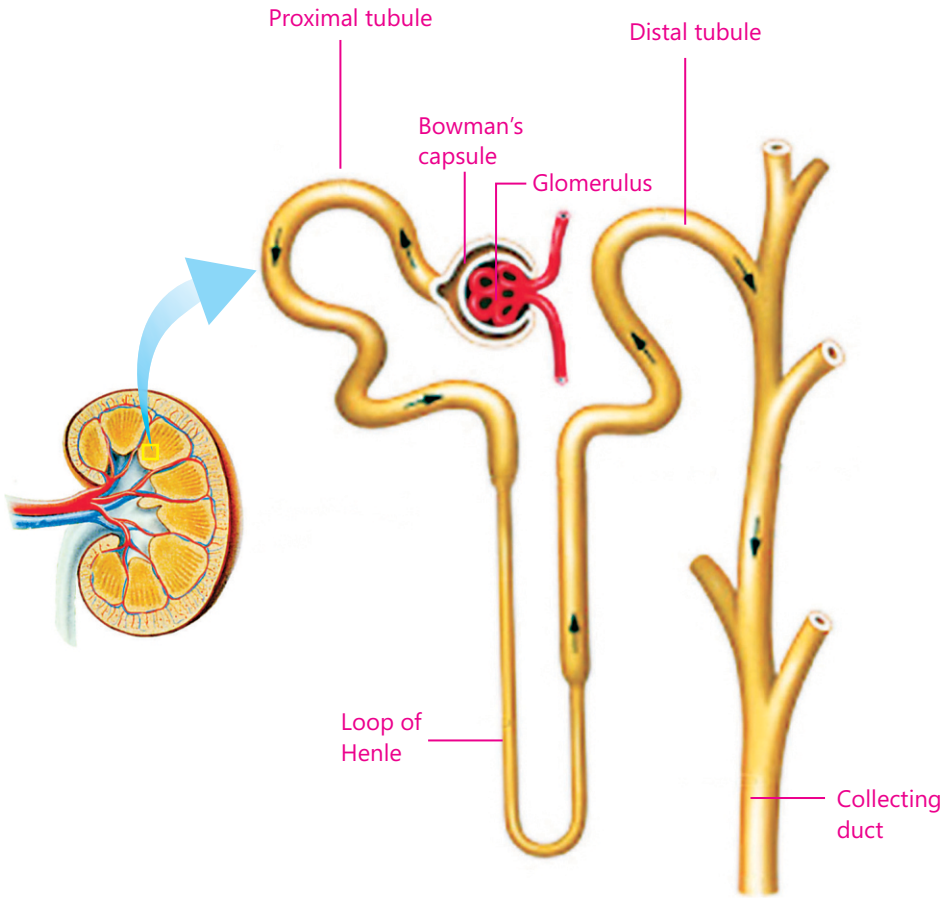


Figure 1.10: Structure of a nephron

Renal Corpuscle

It is the first part of nephron. It consists of two structures, i.e., glomerulus and Bowman's capsule (Figure 1.10). **Glomerulus** is a tuft of blood capillaries formed by the division and sub-division of small arteries and veins. **Bowman's capsule** is a cup-shaped structure enclosing glomerulus.

Renal Tubule

This part of nephron starts after Bowman's capsule. The first coiled part of renal tubule is called **proximal tubule**. The next part is U-shaped and is called **Loop of Henle**. The last part of the renal tubule is again coiled and is called **distal tubule**.

The distal tubules of many nephrons open in a **collecting duct** (Figure 1.10). Many collecting ducts join and drain into renal pelvis.

1.3.2 Function of Kidneys

Blood carries nitrogenous waste materials from the body to the kidneys. Inside the kidneys, blood containing nitrogenous waste reaches the glomerulus. Here, most of the water and waste materials are filtered from the blood into the Bowman's capsule (Figure 1.11). The blood after losing waste material is collected in arterioles, which ultimately form renal artery. The "clean" blood is brought back to the main circulatory system. This filtrate which moves into the renal tubule of nephron also contains some useful substances. During its passage towards the collecting duct, 99% of the filtrate (containing useful substances) is reabsorbed into the blood in capillaries around renal

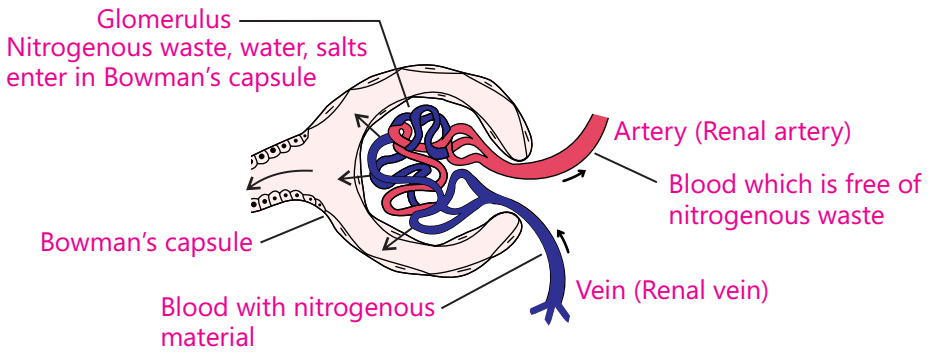


Figure 1.11: Structure of a Bowman's capsule

tubule. During this reabsorption, more waste materials are absorbed from blood capillaries into the renal tubule filtrate. Now, the filtrate in renal tubule is called **urine** which moves into the collecting ducts and then into the renal pelvis.

For your information

The average composition of normal human urine in grams per 100 cm^3 is approximately as follows:

Water	= 96.0 g
Urea	= 2.0 g
Mineral salts (mainly sodium chloride)	= 1.8 g
Other nitrogenous substances	= 0.2 g

Activity 1.3

- Get or purchase a kidney of a sheep or a goat from butcher's shop.
- Observe its outer structure and make its diagram on your workbook.
- Cut the kidney lengthwise into two halves.
- Observe the cut surfaces of two halves of the kidney with the help of a magnifying glass and draw the internal structure of the kidney on your workbook.

1.4 Malfunctioning of Kidneys

1.4.1 Formation of Stones in Kidneys

Sometimes kidneys cannot work efficiently, i.e. to remove nitrogenous waste or salts from the blood. In such situation, the salts accumulate in kidneys and form stones (Figure 1.12). Formation of stones disturbs the normal functioning of kidneys and causes severe pain. Kidney stones may travel to ureter or urinary bladder (Figure 1.12). The common causes of stones in kidneys are excessive calcium salts in the food and uric acid etc.

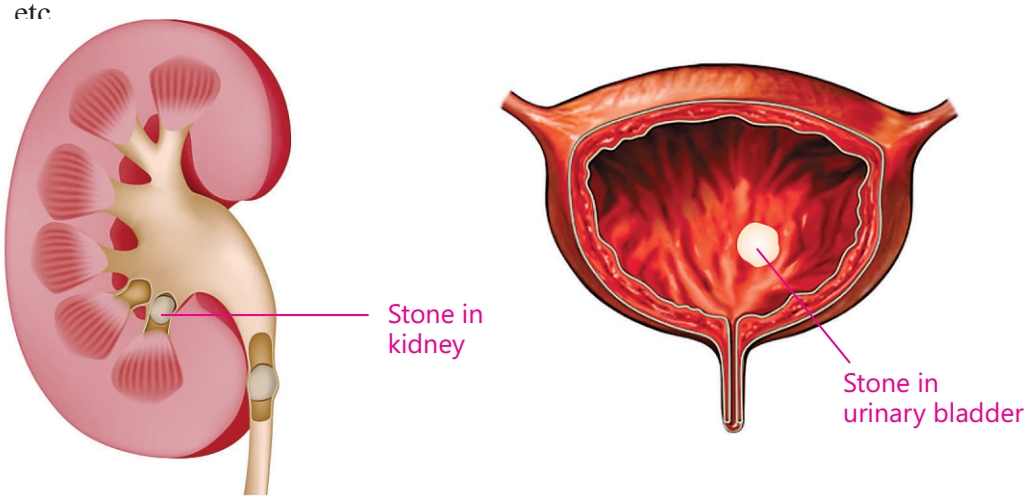


Figure 1.12: Stones in kidney and urinary bladder

Small sized stones can be removed through urinary system by drinking more water. Medium sized stones are removed by **lithotripsy**. Lithotripsy involves bombardment of shockwaves on the stones from outside. Shockwaves break the stones into small pieces which are passed out of the body through urine. Still larger stones need surgery for their removal.

1.4.2 Renal Failure

Renal failure is the complete or partial failure of kidneys to work. The main causes of renal failure are long-term **infections, diabetes mellitus** and **hypertension.** Diabetes mellitus is a disease in which sugar level increases in the blood. Hypertension is a state of high blood pressure in the body. Sudden blockage of blood supply to the kidneys may also result in renal failure. Dialysis and kidney transplant are the treatments of renal failure.

1.4.3 Treatment of Malfunctional Kidneys

1.4.3.1 Dialysis

Cleaning of blood by artificial methods is called dialysis. It is done by a machine called dialyzer. The blood of the patient is passed through the dialyzer which contains dialysis fluid. Blood flows through the tubes of the dialyzer and dialysis fluid flows around these tubes (Figure 1.13). The waste materials move from blood to the dialysis fluid. The cleansed blood is returned to the body.

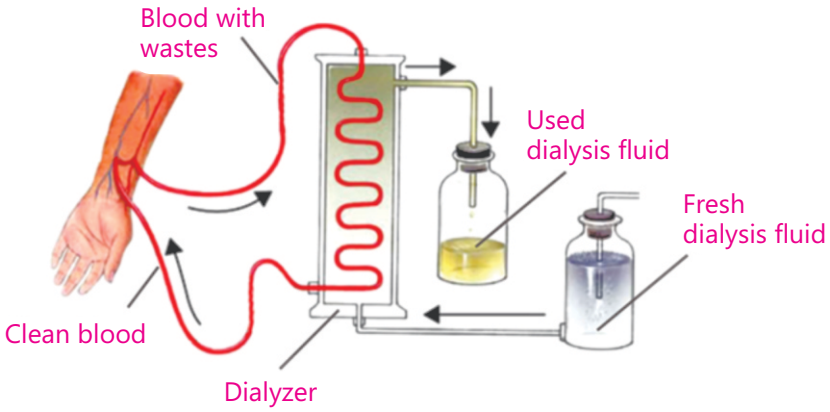


Figure 1.13: Dialysis

1.4.3.2 Kidney Transplant

This method is used at the last stage of kidney failure. In this method, a kidney donated by some healthy person is grafted in the body of the patient (Figure 1.14). The donor of kidney may be blood relative or any other close relative.

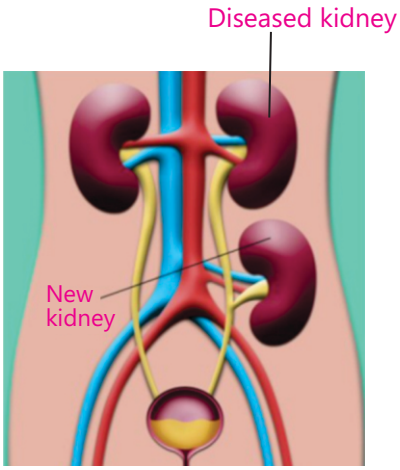


Figure 1.14: Kidney transplant

Science, Technology, Society and Environment

Lithotripsy and kidney transplant are the well-known technologies used in medical science to cure kidney problems.

KEY POINTS

- Nervous system carries messages from one part of the body to another and coordinates body's functions.
- Central nervous system consists of brain and spinal cord.
- Peripheral nervous system consists of a network of nerves which connect the central nervous system to all the body parts.
- Sensory neurons carry messages from sense organs to central nervous system.
- Motor neurons carry messages from central nervous system to muscles and glands.
- Inter-neurons are present in brain and spinal cord. They form a link between sensory neurons and motor neurons.
- The actions which are performed under conscious control are called voluntary actions.
- The actions which are performed without involvement of thinking process are called involuntary actions.
- An immediate and involuntary response to a stimulus is called reflex action.
- Human excretory system consists of a pair of kidneys, two ureters, a urinary bladder and a urethra.
- Nephrons are the functional units of kidneys. These are the tubules where urine is formed.
- Accumulation of salts in kidneys results into kidney stones.
- Kidney stones can be removed by using more water, by lithotripsy or by surgery.
- Dialysis and kidney transplant are the treatments of renal failure.

QUESTIONS

1.1 Encircle the correct option.

(i) The neurons which decide about the action for a certain stimulus:

a. sensory neuron b. motor neuron
c. inter-neuron d. all of a, b, c

(ii) The parts of a neuron which receive messages are:

a. cell bodies b. dendrites
c. axons d. nuclei

(iii) Heartbeat is controlled by:

a. cerebrum b. cerebellum
c. medulla oblongata d. hypothalamus

(iv) Many axons present side by side and enclosed in a common sheath:

a. nerve cell b. nerve
c. dendrite d. spinal cord

(v) Sensory neurons carry messages towards:

a. muscles b. muscles and glands
c. sense organs d. brain and spinal cord

(vi) If body movements are NOT precise and accurate, the part of brain which may be affected:

a. cerebellum b. cerebrum
c. thalamus d. midbrain

(vii) When you have a toothache, you feel pain because:

a. there is a cavity in your tooth
b. tiny bits of food are left between your teeth
c. bacteria digest the food left between your teeth and produce an acid
d. the cavity reaches the nerves and the nerves send a message to the brain

(viii) The part of body which filters nitrogenous wastes from blood:

a. liver b. kidney
c. intestine d. stomach

(ix) The part of the nephron where reabsorption of useful materials occurs from filtrate to blood:

a. glomerulus b. renal tubule

c. collecting duct d. Bowman's capsule

(x) The function of nephron is to:

a. store urine

b. form urine

c. push out urine from urinary bladder

d. break stones in kidneys

1.2 Write names of the main parts of the following.

(i) Forebrain (ii) Hindbrain

(iii) Neuron (iv) Nephron

1.3 Write the functions of the following.

(i) Forebrain (ii) Hindbrain

(iii) Neuron (iv) Nephron

1.4 Give short answers.

(i) Give at least three examples of voluntary actions.

(ii) Give at least three examples of involuntary actions.

(iii) Define:

(a) sensory neurons (b) motor neuron

(c) inter-neuron

(iv) Skin is also considered as excretory organ. Why?

1.5 Differentiate between:

(i) Receptors and effectors

(ii) Neuron and nerve

(iii) Voluntary actions and involuntary actions

(iv) Kidneys and lungs

(v) Lithotripsy and dialysis

1.6 Explain the central nervous system.

1.7 Describe peripheral nervous system.

1.8 Describe the main parts of excretory system in humans.

1.9 Write a note on the internal structure of kidney.

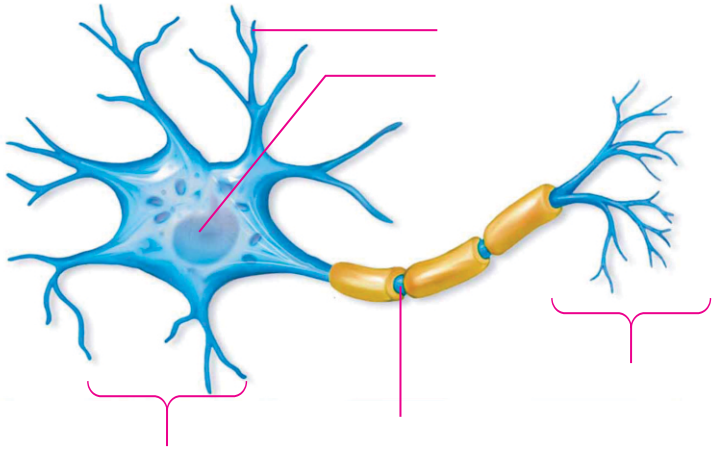
1.10 Describe structure of nephron.

1.11 Write notes on:

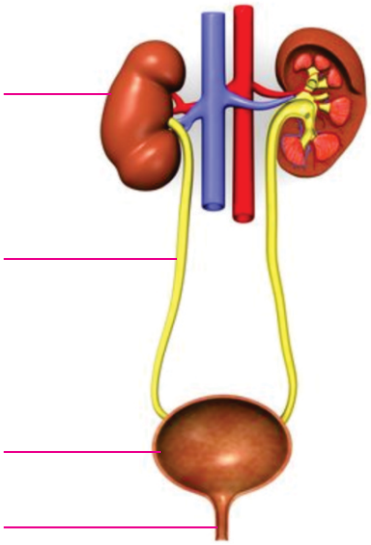
(a) Reflex action (b) Renal failure (c) Dialyzer

1.12 Identify and label the following diagrams.

(a) ----------



(b) ----------



Critical Thinking

1. Why a motor cyclist is advised to wear the helmet?
2. A person met an accident in a car. When he was brought to the hospital he did not know even his name. What would have happened to him? Relate your answer with reference to your nervous system.
3. The table below shows the list of your daily activities. Write the name of that part of brain (forebrain, midbrain or hindbrain) which is controlling this activity.

No.	Activity	Part of brain controlling activity
1.	Sleeping	
2.	Brushing your teeth	
3.	Taking the breakfast	
4.	Balancing your body	
5.	Taking deep breath	

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