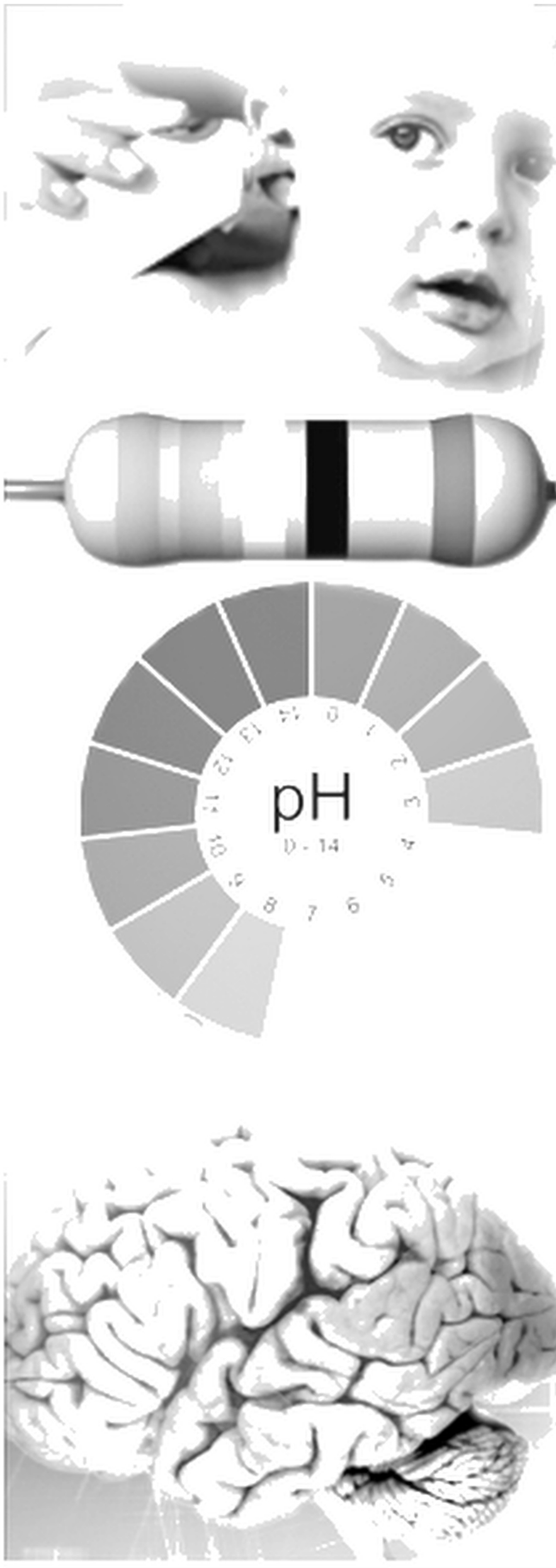

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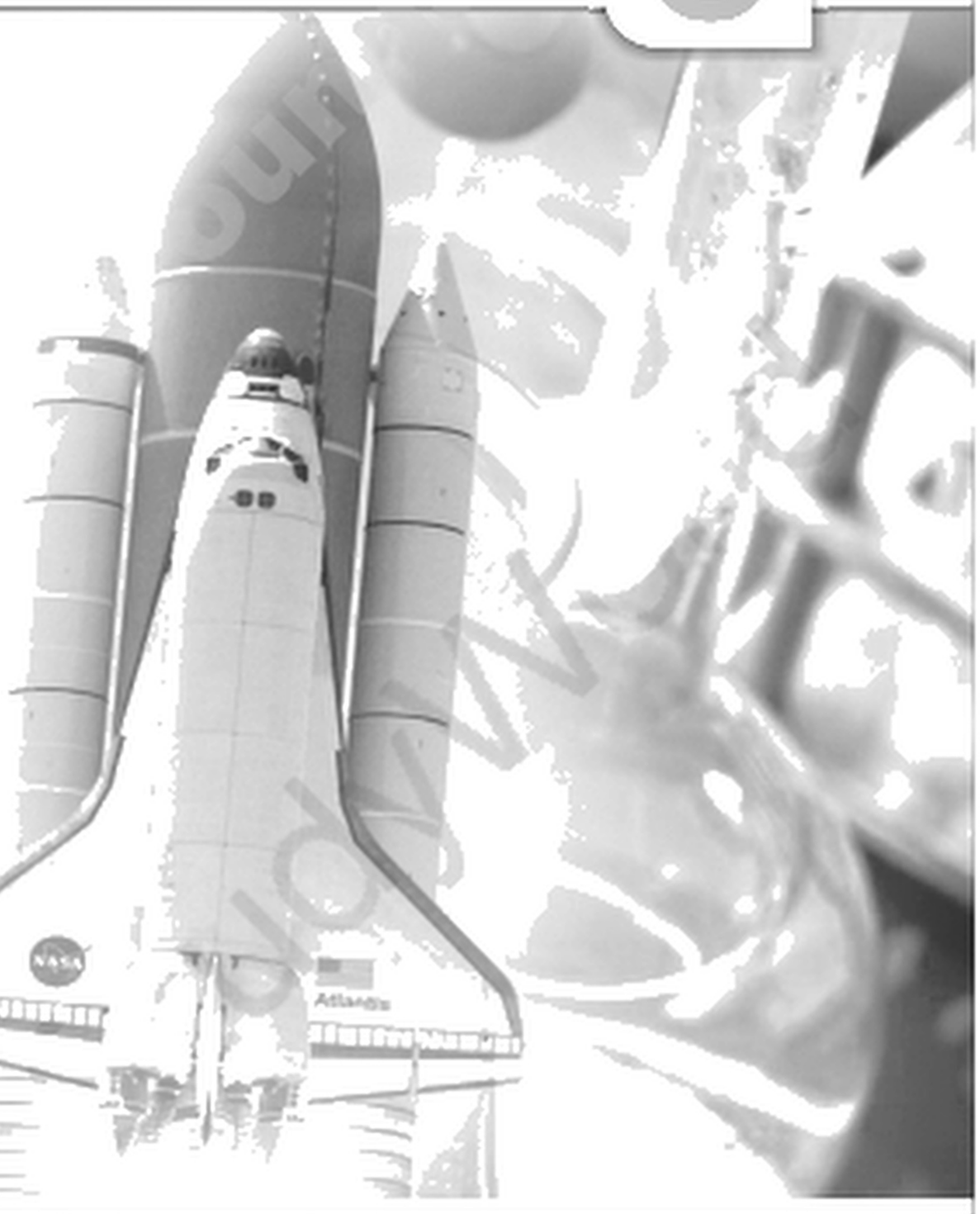

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OUR MOTTO

◎ Standards ◎ Outcomes ◎ Access ◎ Style

Textbook of
General Science Grade - 8

Authors	:	**Jawaid Mohsin Malick, Ms. Sana Zubairi, Ms. Neelofar Shaheen, Mr. Imran Ahmad Khan, Mr. Irfanullah**
Designing	:	**Hafiz Rafiuddin (Late), Shahzad Ahmad**
Composing	:	**Tariq Mehmood**
Desk Officer	:	**Dr. Riaz Hussain Malik, Curriculum Wing**
Management	:	**Ishtiaq Ahmad Malik, Secretary NBF**
Incharge Textbooks	:	**Muhammad Rafique, Assistant Director, NBF**

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Preface

General Science Grade - 8 is developed according to the National Curriculum 2006 and National Style Guide. In 2015 it was Presented under the new management and supervision of textbook development, principles and guidelines with new design and layout.

Science and technology have contributed immensely for the development of human culture. It has, in fact revolutionized various dimensions of our lives. Particularly the need of developing nations is to promote science education for the survival, the prosperity and betterment of their people.

General Science Grade - 8 is designed to promote inquiry based learning. The textbook has been developed to meet the aims and objectives set in the National Curriculum 2006 for General Science.

Our efforts are to make textbooks teachable with quality, i.e., maintaining of standards. It is a continuous effort and we will get feedback of the yearly feasibility reports and redesign the Textbook every year.

Like before, the National Book Foundation has made specific endeavours to publish the text and illustrations in much effective pedagogical form. The meticulous effort of the team is acknowledged. The test items given in the exercises are for learning reinforcement. The examination questions should prepared according to the SLO's and the Bloom's Taxonomy.

Quality of Standards, Pedagogical Outcomes, Taxonomy Access and Actualization of Style is our motto. With these elaborations, this series of new development was presented for use. After educational feedback, research and necessary changes, the book is being published again.

National Book Foundation

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بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ ؕ

شروع اللہ کے نام سے جو بڑا مہربان، نہایت رحم کرنے والا ہے

General Science 8

1

HUMAN ORGAN SYSTEMS

CONTENTS

This is a 14 days lesson
(periods including homework)

After completing this lesson, you will be able to:

- Describe the structure and function of the nervous system.
- Describe the working of the nervous system through a model.
- Explain reflex action with an example.
- Differentiate between voluntary and involuntary action they have experienced.
- Define excretion.
- Draw and label human excretory system.
- Describe the role of kidney in excretion of waste.
- Investigate the possible causes of the malfunctioning of kidneys.
- Suggest techniques to cure problems of kidneys.

Figure 1.1: Each player of a football team has a different role, but together the team works toward a common goal - winning the game.

Reading

Have you ever seen or played a football or hockey match? It is a teamwork game. Teamwork is a wonderful thing. The eleven players of a football team work together to make the winning play.

But the real teamwork of this play involved a much larger number of players – nearly a hundred trillion cells that make up the human body. How does the body get so many individual cells to work together so beautifully?

You can begin to answer this question by studying the organization of the human body. Recall the levels of organization in a muticellular organism that you have studied in previous class. In this chapter, we will study the structure and functions of human nervous system and excretory system.

DID YOU KNOW?

The eleven organ systems of the human body are: Nervous system, Integumentary system, Skeletal system, Muscular system, Circulatory system, Lymphatic system, Respiratory system, Digestive system, Excretory system, Endocrine system, Reproductive system. These systems work together to maintain homeostasis.

1.1 NERVOUS SYSTEM

At this moment you are probably breathing at a rate of about fourteen times a minute. Now let us suppose that you begin a game of badminton or walk upstairs rapidly. Under these conditions your muscle cells become much more active. Much more carbon dioxide is produced. What happens as the rate of carbon dioxide formation increases? Your rate of breathing greatly increases. Carbon dioxide is removed rapidly from the muscle cells. For breathing the activities of the lungs, heart, blood vessels, diaphragm and rib muscles are regulated and interconnected. This is an amazing feat of co-ordination. When all organs of the body work in organized and controlled way it is called **co-ordination.**

The coordination is brought about by your nervous system and yet we do such things all the time often without even noticing them. Now we will discuss to help you understand how your nervous system is able to do these things.

Activity 1.1

NERVOUS SYSTEM

Imagine you have to pick up a pencil from the floor. Write down all the things you think your nervous system would have to do. Discuss your list within a group of your classmates.

Reading

What is **sensitivity**? Responses and stimuli are everyday words but what do we mean when we talk about living things responding to stimuli.

The things that change the activities are called **stimuli** (singular: stimulus) and the reactions to the stimuli are known as **responses**.

Find out what are the stimuli and responses from your daily life? The ability to respond to a stimulus is called **sensitivity** or **irritability**. The response is usually a form of movement beneficial to the organism. For example, plants grow toward the light, single celled organisms such as *Euglena*, swims toward the light.

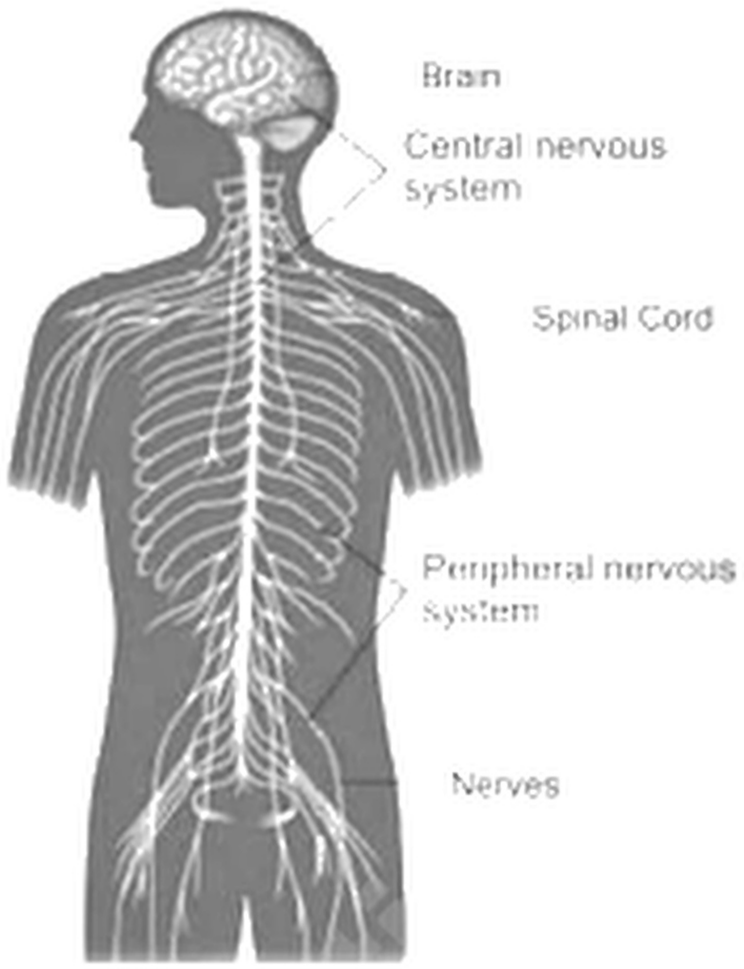


Figure 1.2: Central and peripheral nervous system

Receptors i.e., ears, eyes, nose tongue and skin detect the stimuli. **Effectors** bring about the response. The muscles and glands are the effectors. Muscle responses by contracting and gland responses by secreting.

1.1.1 Human Nervous System

The human nervous system comprises of central nervous system and peripheral nervous system.

Central Nervous System

The **central nervous system** consists of brain and the spinal cord. The **brain** is protected inside the skull and the spinal cord is protected in the backbone. Both the brain and the spinal cord are wrapped in three layers of connective tissue known as **meninges**. A **human brain** can be divided into three parts: forebrain, midbrain and hindbrain.

Forebrain

The **forebrain** consists of cerebrum, thalamus and hypothalamus. The **cerebrum** is the most prominent region of the human brain. A deep groove divides the cerebrum into right and left **cerebral hemisphere**.

The cerebrum is the main centre of various sensations e.g., hearing, sight, smell, memory, intelligence, reasoning etc. The **thalamus** is below the cerebrum. It receives all the impulses from different sensory areas of the body before passing them to the cerebrum. On the ventral side of the thalamus, is the **hypothalamus**. It regulates body temperature, appetite, water balance, blood pressure etc. It also controls heartbeat, thirst, and hunger. It secretes hormones.

Midbrain

The **midbrain** is just a mass of tract. It lies immediately under the lower part of the cerebrum between the two hemispheres.

DID YOU KNOW?

The hemispheres are connected by a band of tissue called **corpus callosum**. The left hemisphere controls the body's right side and the right hemisphere controls the body's left side.

DID YOU KNOW?

Midbrain, pons and medulla are collectively known as brain stem.

From the dorsal surface of the thalamus arises the **pineal body**. Its function is uncertain.

Just below the hypothalamus is the **pituitary body/gland**, a very small gland about the size of a pea. It secretes a number of hormones.

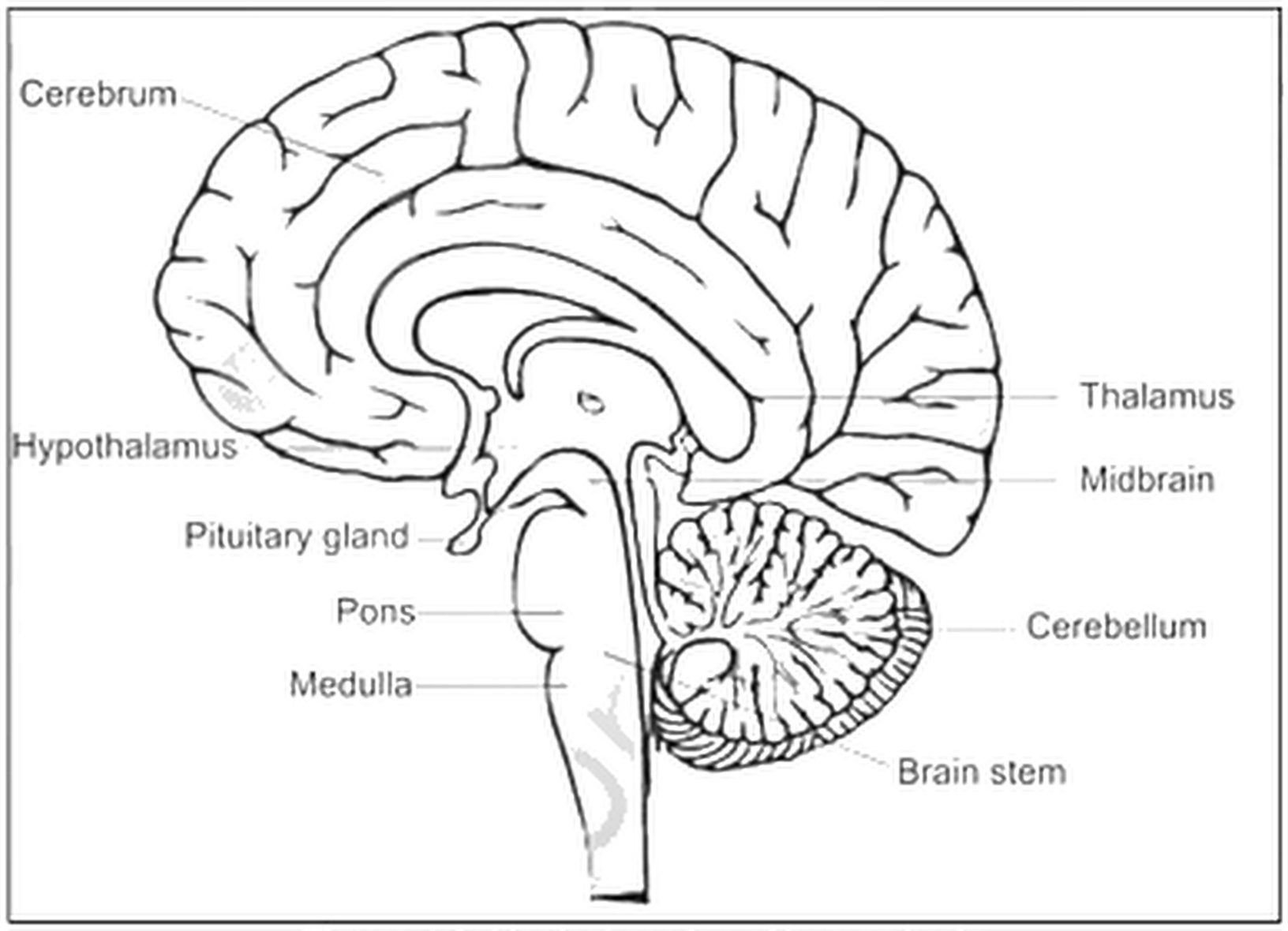


Figure 1.3: Vertical section of human brain

It acts as a relay station for tracts passing between the cerebrum and the spinal cord or cerebellum.

Hindbrain

The **hindbrain** includes cerebellum, pons and medulla. **Cerebellum** is situated under the cerebrum. It controls balance and muscle contraction. **Pons** is a small lobe like structure. It functions with the medulla to regulate breathing rate. **Medulla** or **medulla oblongata** lies below the cerebrum. Its posterior end narrows down gradually into the spinal cord. It controls heartbeat, circulation of blood and respiration etc.

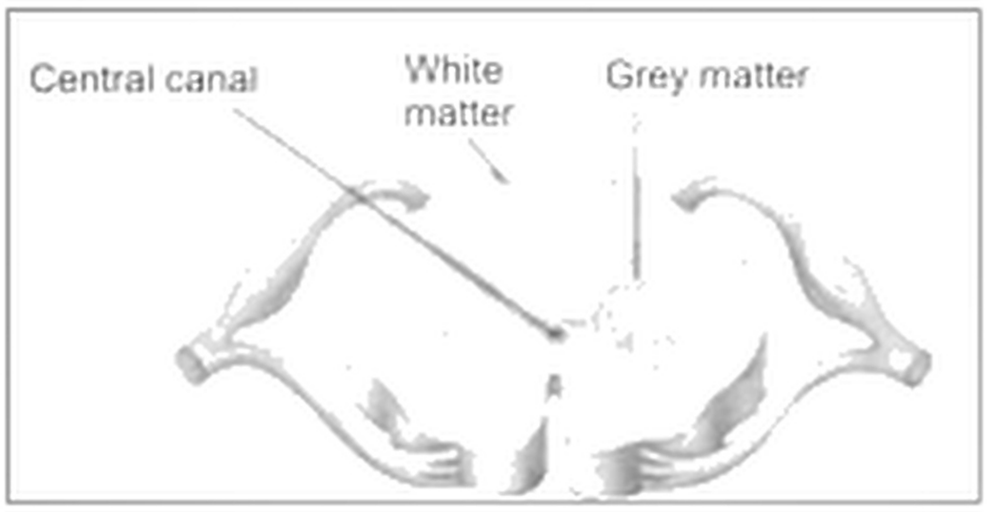


Figure 1.4: Cross section of spinal cord

DID YOU KNOW?

White matter consists of axons of neurons which are covered by myelin sheath. Grey matter consists of cell bodies of neurons and axons without myelin sheath. In brain the white matter is outside surrounded by grey matter.

Spinal Cord

The human spinal cord is an oval shaped hollow cylinder. It extends from the brain to the end of the vertebral column. It passes through the vertebral column which protects it. Like the brain, the spinal cord consists of both **grey** (North American spelling: gray) and **white matter**. The grey matter is surrounded by white matter on the outside. The outer region is light in colour. The inner region is butterfly shaped and darker in colour. There is a narrow **central canal** which contains cerebrospinal fluid. What is the function of this fluid?

Functions of Spinal Cord

The main functions of spinal cord are:

(a) It is the link between brain and different parts of the body.

(b) It serves to transmit impulses from receptor to the brain.

(c) It serves to transmit impulses from brain to effectors.

(d) The spinal cord carries out the reflex actions.

(e) The spinal cord performs some involuntary actions e.g., contraction of urinary bladder.

Activity 1.2

INSIDE THE SPINAL CORD

- Hold a slide of section of spinal cord up the light.
- Can you see the light and dark area?
- Why the one area looks light and the other area looks dark in colour?
- Look the dark area under the microscope. Can you see any nerve cell?

Reading

Peripheral Nervous System

The **peripheral nervous system** includes nerves arising from the brain and spinal cord.

Cranial Nerves

There are twelve pairs of **cranial nerves** arise from the brain. The cranial nerves are sensory nerve, motor nerve or a mixed nerve. Each cranial nerve has a specific function.

Spinal Nerves

These emerge at intervals along the length of the spinal cord. There are thirty-one pairs of spinal nerves in man. These nerves pass between the vertebrae. They all carry both sensory and motor neurons and are described as mixed nerves. They carry impulses to all part of the body and also bring impulses from all parts of the body to the spinal cord (Fig.1.2)

Division of Peripheral Nervous System

There are two divisions of the peripheral nervous system: Somatic nervous system and autonomic nervous system

(a) **Somatic nervous system**: The somatic nervous system consists of the cranial and spinal nerve fibres that connect the central nervous system to the skin and skeletal muscles. It is involved in conscious activities.

(b) **Autonomic nervous system**: The autonomic nervous system includes those fibres that connect the central organs, such as the heart, stomach, intestine and various glands. It is concerned with unconscious activities.

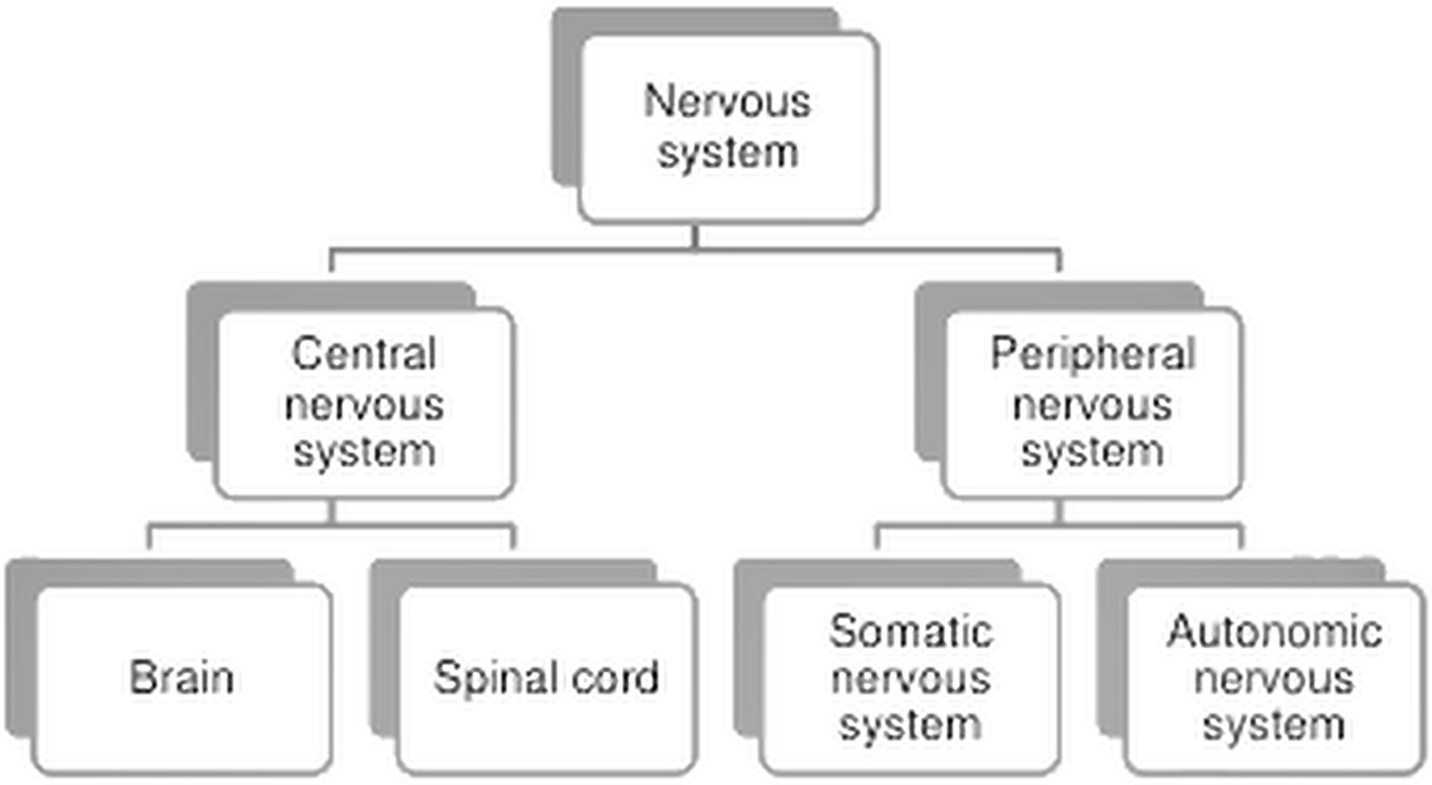


Figure 1.5: Major subdivisions of the human nervous system

1.1.2 How the Nervous System Works?

Nervous system works with the help of nerve cells or neurons, which conduct the signals or impulses between the two components of the nervous system, i.e., central nervous system and peripheral nervous system.

1.1.3 Structure of a Neuron

Like other cells the neurons do have a cell membrane, cytoplasm and a nucleus but they have a different shape. A neuron (neurone) consists of cell body, dendrites and axon.

Cell body: The cell body has a nucleus and most of the organelles of the cell.

Dendrites: The small extensions of the cell body are called dendrites. They receive messages from other cell and conduct them towards the cell body.

Axon: A part of the cell body is stretched out to form axon. The axon can be over a metre long. What is the function of axon? The axon receives messages from the cell body and conducts it away to other cell end. The axon of a neuron may be covered by a myelin sheath (see motor neuron in figure 1.6). What is its function? It is an insulating material and does not allow messages to pass into the neighbouring neuron.

DID YOU KNOW?

The other names of interneuron are: relay neuron and association neuron and associative neuron

There are three types of neurons: sensory, motor neurons and interneuron. The **sensory neurons** carry impulses (messages) from the sense organs like the eye, nose or skin to the central nervous system. The **motor neurons** carry impulses (orders) from the central nervous system to the muscles or glands. The **interneuron** form **synapses** (syn-aspe) i.e., make connections with the sensory neuron and motor neurons. In this way, they enable the impulses to be transmitted from sensory neurons to motor neurons.

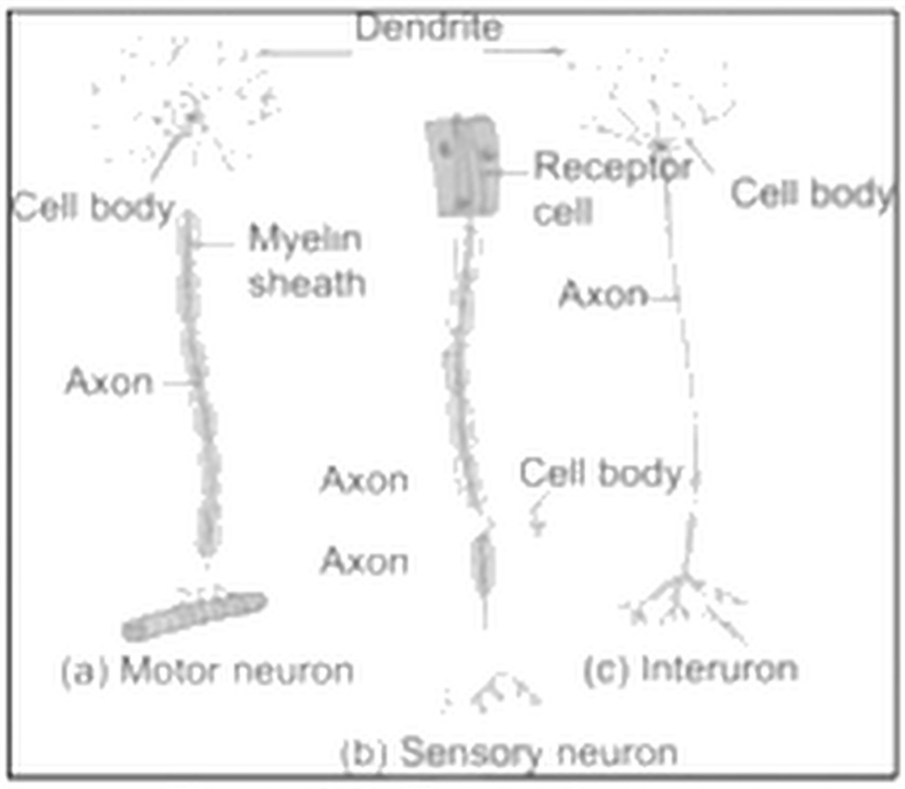


Figure 1.6: Types of neurons

What is a **nerve impulse**? The nerve fibres do not carry sensation like pain or cold. These sensations are felt only when a nerve impulse reaches the brain. The impulse itself is a series of electrical pulses which travel down the fibre. Each

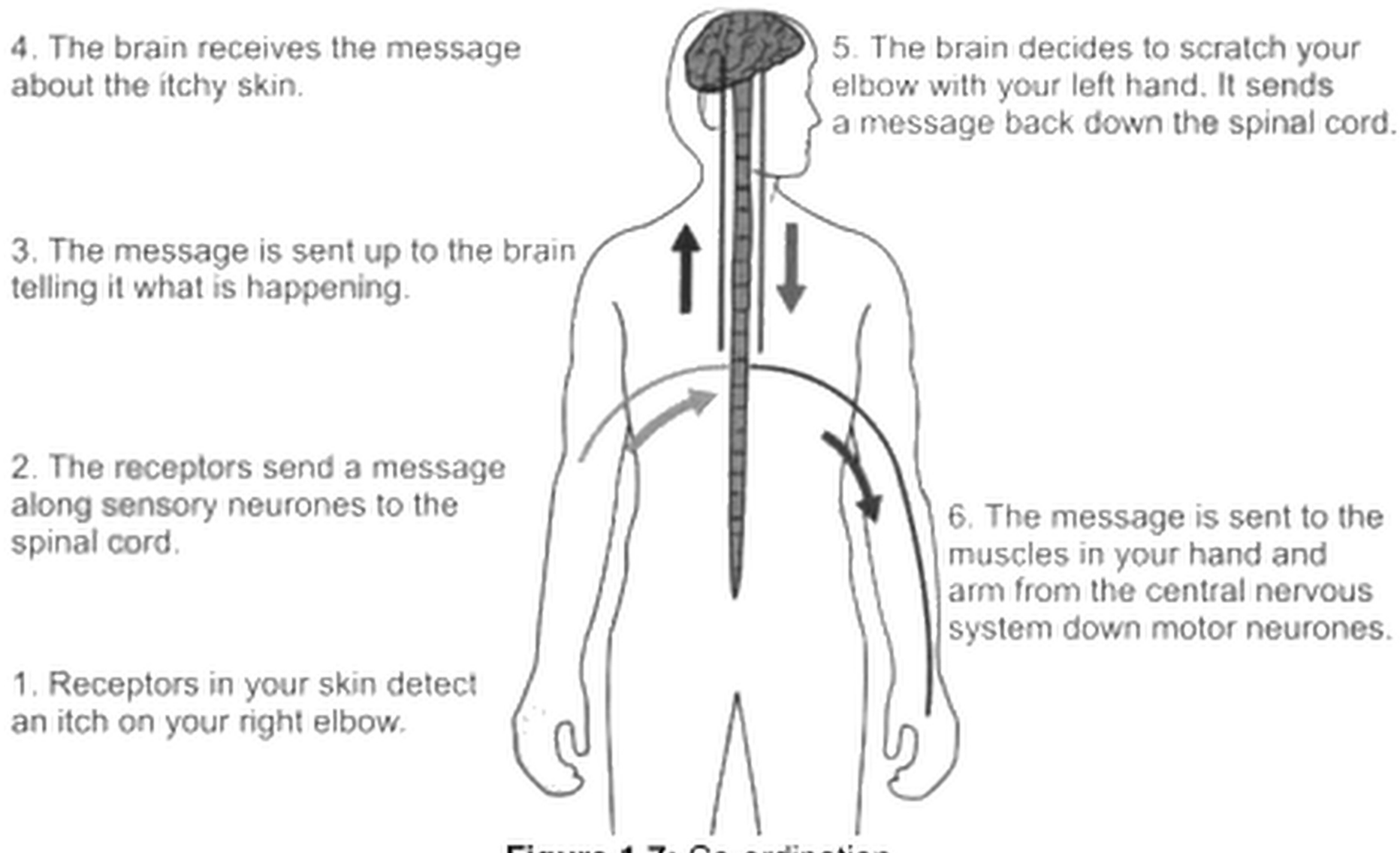


Figure 1.7: Co-ordination

1. What is the stimulus in this reaction?
2. What is the response?
3. Which parts of the body are the receptor, the effector and the coordinator?

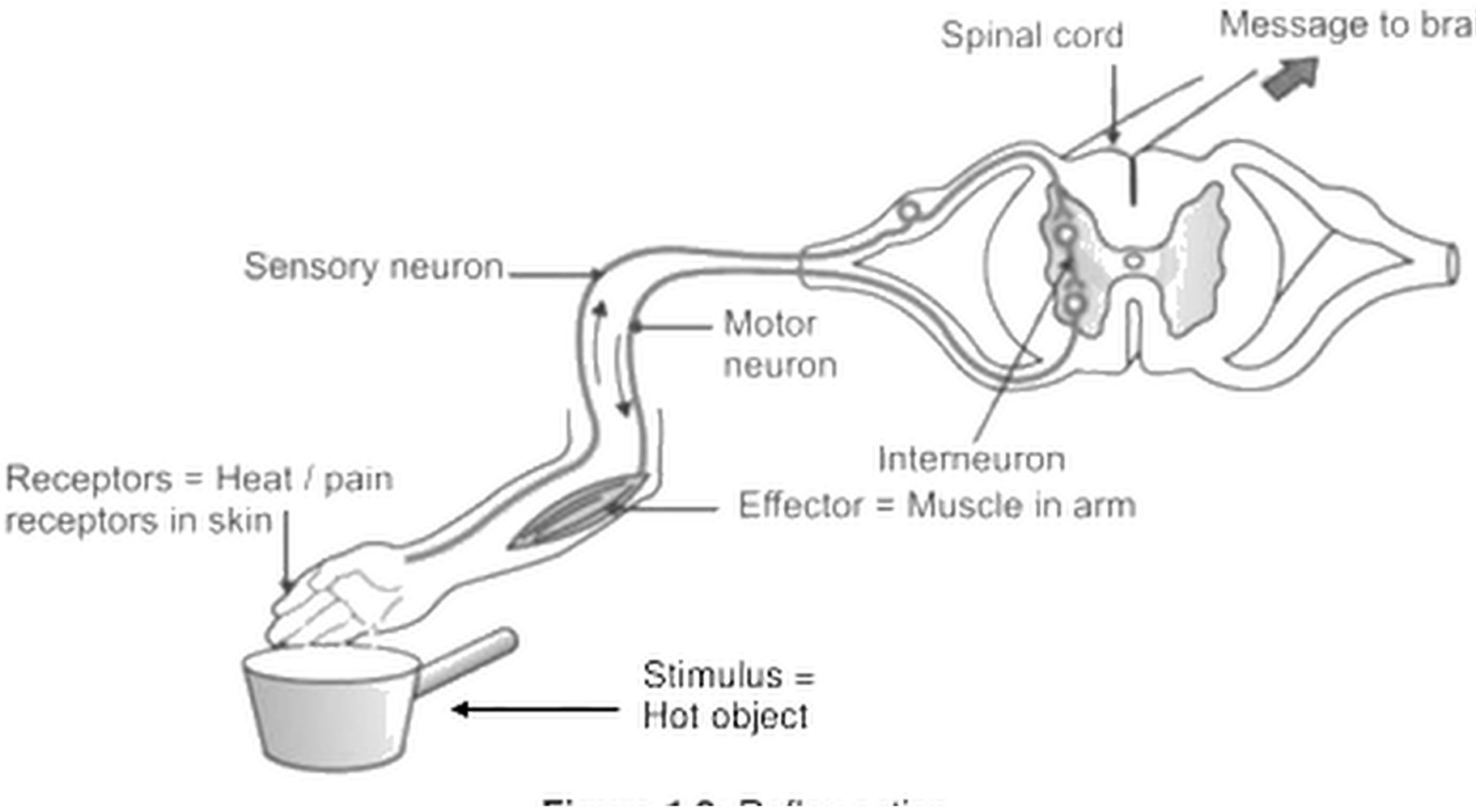
pulse lasts about 0.001 second and travels at speeds of up to 100 metres per second. All nerve impulses are similar; there is no difference between nerve impulses from the eyes, ears or hands. Your nervous system helps you to react to different situations. Let's use an example to see how this happens. What happens when you get an itch on your elbow? Look at the diagram (figure 1.7) and follow the chain of events:

The chain of events is:

stimulus --------- receptor --------- coordinator --------- effector --------- response

1.2 REFLEX ACTION

What happens in reflex actions? 'Reflex' is a word we use very commonly when we talk about some sudden action in response to something in the environment. We say 'I jumped out of the way of the bus reflexly' or 'I pulled my hand back from the flame reflexly', or 'I was so hungry my mouth started watering reflexly'. What exactly do we mean? A common idea in all such examples is that we do something without thinking about it, or without feeling in control of our



reactions. Yet these are situations where we are responding with some action to changes in our environment. How is, control and coordination achieved, in such situations?

Reflex action is also called **reflexes.** These are the responses to external and internal environmental changes. The reflexes are immediate or automatic and without the intervention of will. Certain responses are without the help of the brain. In these cases the **spinal cord** acts as the control centre. Such a response is a **reflex**, which involves no conscious control.

Have you ever touched any hot object? Before you scream in pain, you pulled your hand away. This **reflex action** happens very quickly. Sensory neurons in your skin detect the heat. They send impulses to the spinal cord. In the spinal cord, the impulses pass through the interneuron. The motor neurons carry impulses to the muscles in your arm. The muscles contract and pull your hand away from the hot object.

This reflex action occurs without any input from the brain. But why did you cry out "ouch" after you pulled your hand away? While the reflex action is taking place, the spinal cord is sending messages to the brain. Once the brain receives and interprets the messages, you finally feel the pain and scream.

The stimulus in our example is the hot object. The receptor is the heat sensor in the skin. The impulse (message) travels to the spinal cord along the sensory neuron. In the spinal cord the impulse is passed on to the interneuron. The motor neuron carries the impulse to a muscle in the arm. The muscle is the effector. The muscle contracts to remove the hand from the hot object. This action is the response.

Science Titbits

The simplest reflex arcs in humans involve only two neurons, a sensory neuron and a motor neuron. The knee jerk is an example. Other reflex arcs involve three neurons: a sensory neuron, an interneuron and a motor neuron.

An immediate response to a specific stimulus without conscious control is called a reflex action.

Activity 1.3

REFLEX ACTIONS – THE KNEE JERK

Carry out the following experiment and observe what happens.

1. Sit down and cross your leg in such a way that the shin of the upper leg can swing freely. Ask your friend to give you a sharp tap just below the kneecap with the edge of his hand. What happens? A reflex arc makes the thigh muscle contract and the lower part of the leg swings forward.
2. Try again, this time with your hand rest on the thigh of your upper leg.
3. What feeling do you get in your upper thigh muscle?
4. Is the momentary kicking of your leg an automatic reaction? Can you control it?

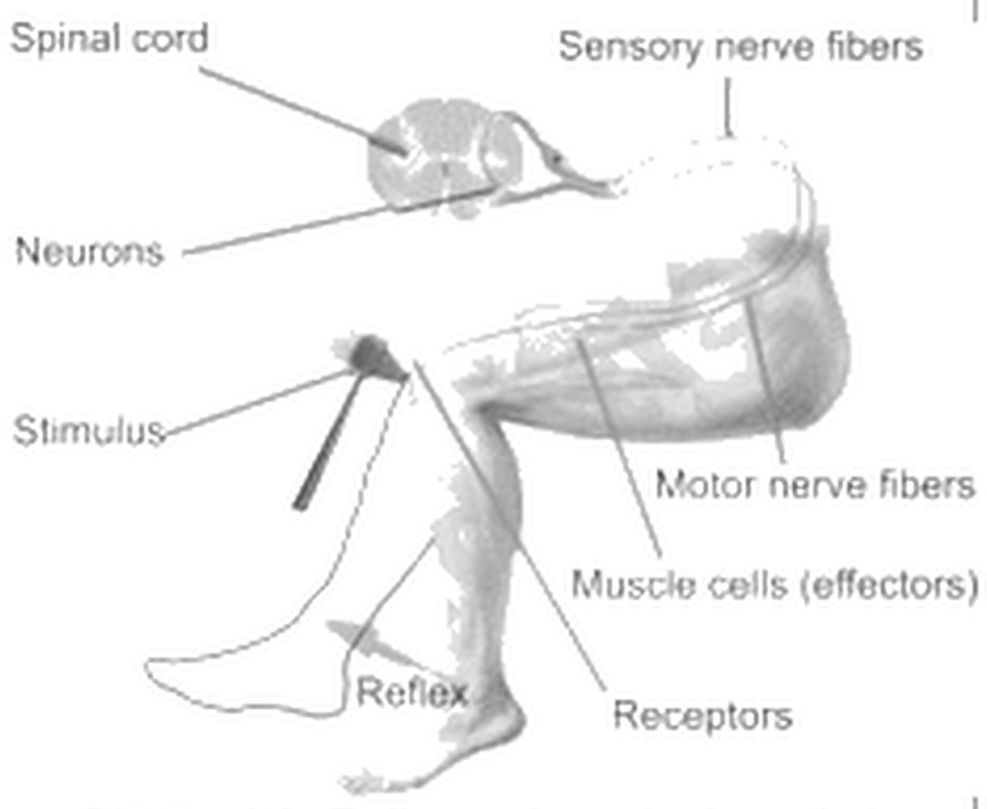


Figure 1.9: Reflex action - the knee jerk

Activity 1.4

STUDYING THE NERVOUS SYSTEM THROUGH A MODEL

1. Examine the model of human brain and identify:
   Cerebral hemisphere
   Cerebrum
   Cerebellum
   Thalamus
   Hypothalamus
   Pituitary gland
   Medulla and spinal cord
2. Examine the model and identify spinal cord and the peripheral (spinal) nerves.

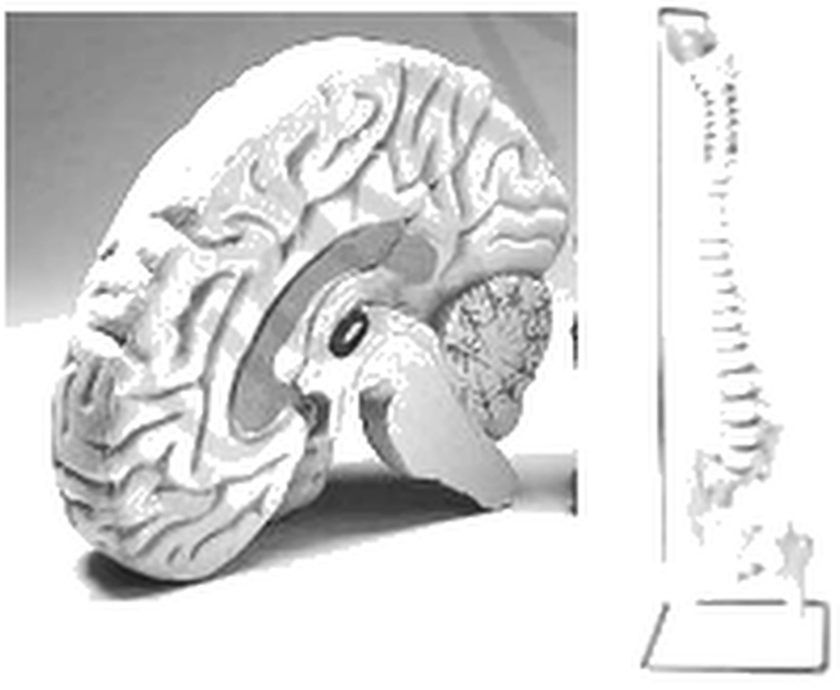


Fig.1.10: Model of Human brain and spinal cord

Activity 1.5

EXAMINATION OF BRAIN OF GOAT

1. Examine the dorsal (upper) surface of goat's brain. Identify the following:
   Cerebral hemisphere, cerebellum, medulla oblongata and spinal cord.
2. Turnover the brain to look at the ventral surface. Name the structures that you can locate.

1.2.1 Voluntary Actions and Involuntary Actions

A **voluntary action** starts in the brain. It may be result of external events, such as seeing a book on the floor, but resulting action, such as picking up the book, is entirely voluntary. Unlike a reflex action it does not happen automatically; you can decide whether or not you carry out the action.

Can you give a few examples of voluntary actions?

Reflexes such as the pupil reflex are quite common. When a bright beam of light hits a person's eye, his pupil automatically becomes smaller, i.e., it contracts. When the light is taken away and his eyes are shaded, the pupils return to their normal size. In this example, the light is the stimulus and the reaction of the pupil is the response. This is an example of **involuntary action**. Involuntary actions are also called **automatic actions**. These are the actions that occur automatically and without our awareness. There are many reflexes or involuntary actions going on inside of our bodies. We are usually unaware of these such as blood pressure, breathing, rate of heartbeat, secretions of gastric glands, peristalsis etc.

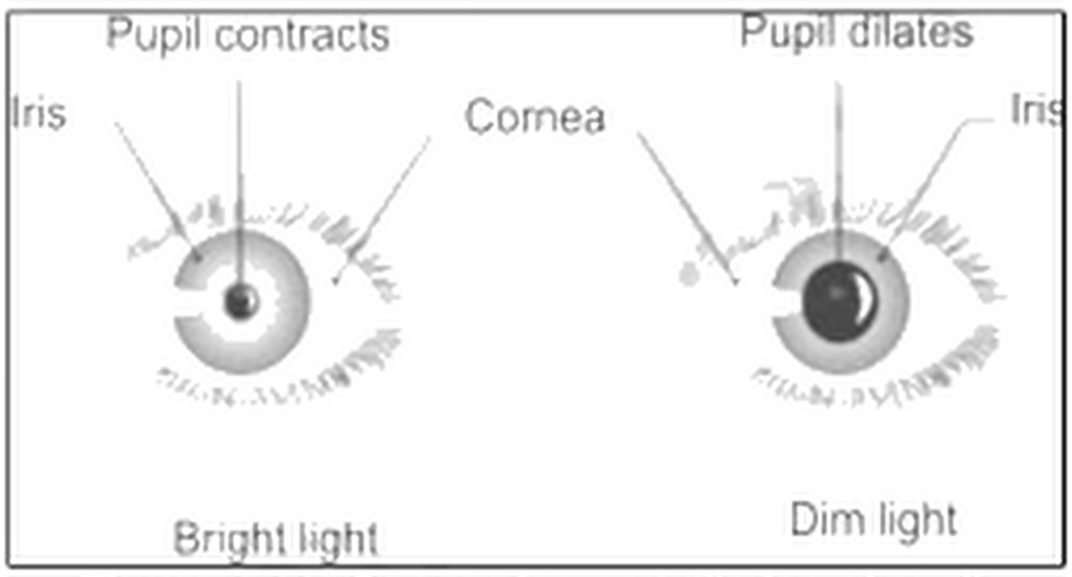


Figure 1.11: Contraction and dilation of pupil

TABLE 1.1 COMPARING VOLUNTARY AND INVOLUNTARY ACTIONS

Voluntary action	Involuntary action
Takes place with will	Takes place without will
Use brain	Use spinal cord
Conscious process	Unconscious process

TABLE 1.2 THE HUMAN BRAIN	
Parts of the brain	**Functions**
1. Cerebrum	Responsible for reasoning, speech, intelligence, memory, voluntary actions and sensation.
2. Hypothalamus	Regulation of body temperature, thermal receptors, appetite blood pressure, heart rate and feelings, thermal receptors etc.
3. Pituitary gland	Secretes a number of hormones.
4. Cerebellum	Controls and co-ordinates muscular action and body balance.
5. Medulla oblongata	Controls involuntary actions e.g., heartbeat, respiratory movement, peristalsis etc.

1.3 EXCRETORY SYSTEM

What is excretion? During respiration in the cell complex substances are broken down into simpler substances with the release of energy. For example the breakdown of glucose during respiration produces carbon dioxide. This is carried away by the blood and removed in the lungs. Excess of amino acids are converted in the liver to form glycogen and **urea.** Breakdown of proteins produce **uric acid**. Urea and uric acid are waste products. They contain nitrogen. Therefore they are called **nitrogenous waste**. They are toxic i.e., poisonous so must be removed. The liver produces urea and then urea is excreted from kidneys as a part of the urine.

> The removal of waste products and poisonous materials produced by chemical reactions, from the body of an organism is called excretion.

TABLE 1.3 EXCRETORY ORGANS AND EXCRETORY PRODUCTS	
Excretory organs	**Excretory products**
1.Lungs	Carbon dioxide, water etc.
2.Liver	Bile pigment (from the breakdown of haemoglobin) etc.
3.Skin	Excess of water, salt, urea, uric acid etc.
4.Kidney	Urea, uric acid, water, salts, toxins, hormones , drugs etc.

1.3.1 Human Excretory System

What is an excretory system? Excretory system is the organ system that disposes of nitrogen containing waste products of reaction taking place in the cells. The excretory system is also known as **urinary system**. The excretory system of man comprises of kidneys, ureters, urinary bladder and urethra.

Kidneys

There are two kidneys in the human body. The kidneys are dark brown in colour and bean shaped. The kidneys are present in the abdomen one on either side of the vertebral column. The kidney is enclosed in a thick transparent membrane called **renal capsule**. The concave surface of each kidney faces the vertebral column. At the centre of this surface is a depression called **hilus**. Here the renal artery, the renal vein and nerves are connected to the kidney.

DID YOU KNOW?

The right kidney is slightly lower than the left one. Why? The right kidney is slightly lower than the left kidney so that it can accommodate the liver which is present on the right side of the body.

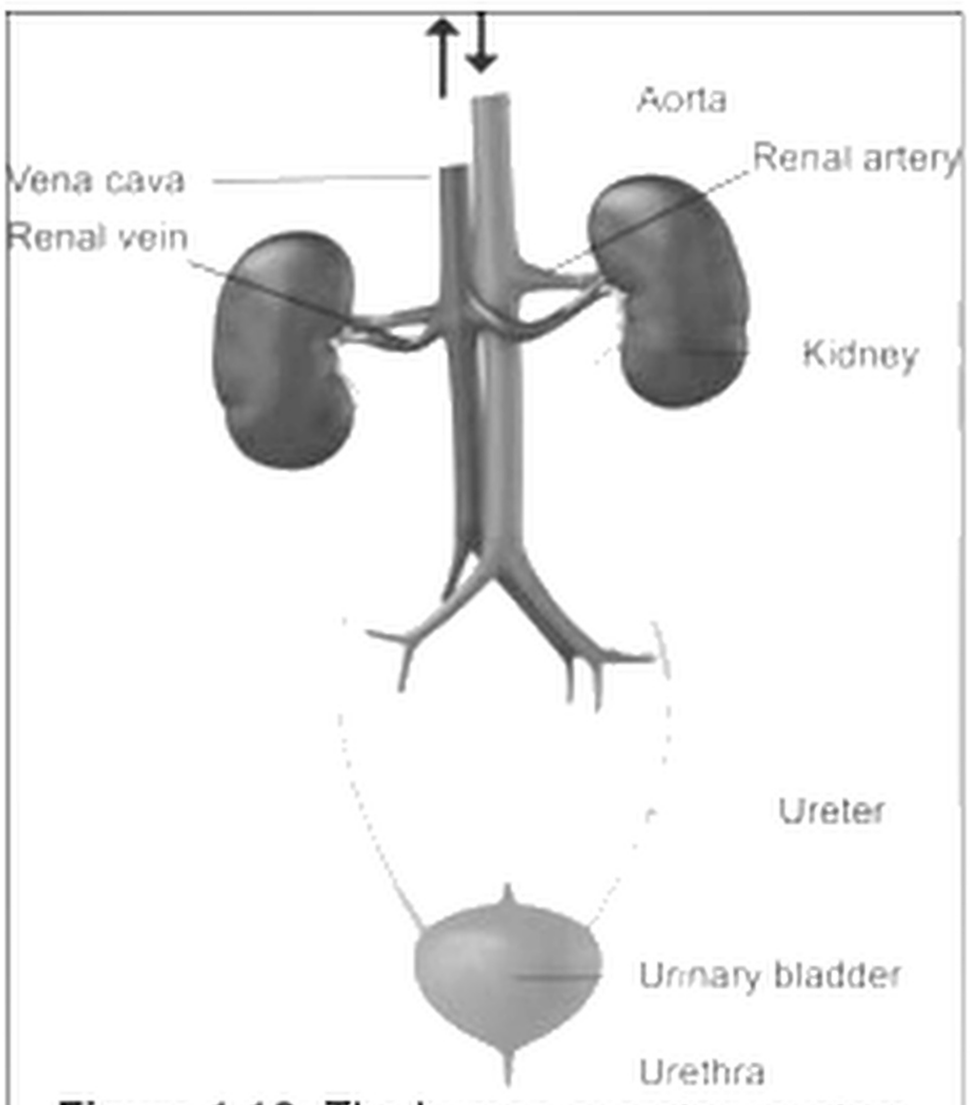


Figure 1.12: The human excretory system

Ureter: From depression of each kidney a tube called **ureter** emerges and runs downwards to open into the **urinary bladder** in the lower part of the abdomen. The ureters carry urine from kidney to the urinary bladder.

Urinary bladder: It is an elastic muscular bag. It stores urine. When the urinary bladder is full it allows the urine to flow into the **urethra**.

Urethra: It is a tube for the passageway of urine out of the body.

Blood vessels: The **renal artery** branches off from the aorta and brings oxygenated blood to the kidney. The **renal vein** takes deoxygenated blood away from the kidneys to vena cava.

TABLE1. 4 STRUCTURE AND FUNCTION OF HUMAN URINARY TRACT

Structure	Function
Kidney	It filters blood. Excretes nitrogenous waste, excess salts and water as urine.
Ureter	It transports urine from kidney to urinary bladder.
Urinary bladder	It temporarily stores urine.
Urethra	It carries urine out of the body

1.3.2 A Longitudinal Section of the Kidney

A longitudinal section of the human kidney shows that it consists of two main regions. The dark-red outer region is called the **cortex**. The inner thicker region is lighter in colour. It is called **medulla**. The medulla consists of 12 to 16 conical structures called **renal pyramids**. They project into the funnel like space the **renal pelvis**. The renal pelvis extends to the ureter or we can say that the renal pelvis is the expanded part of the ureter inside the kidney.

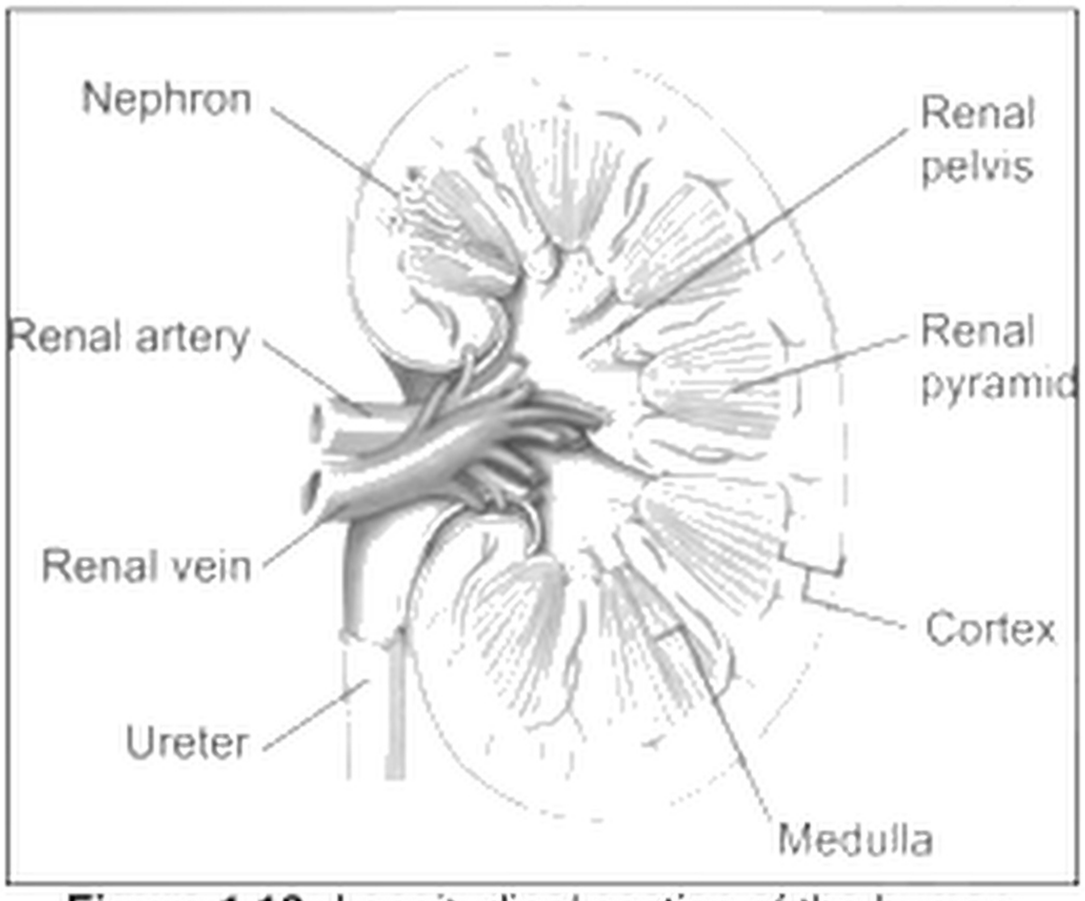


Figure 1.13: Longitudinal section of the human kidney

Science Titbits

The kidneys also carry on a variety of important regulatory activities, including helping control the rate of red blood cell formation by secreting a hormone and helping regulating blood pressure by secreting an enzyme.

TABLE 1.5 STRUCTURE AND FUNCTION OF THE PART OF THE KIDNEY

Structure	Function
Capsule	It surrounds and protects the kidney.
Cortex	It contains Bowman's capsule and glomeruli.
Medulla	It contains loop of Henle and the collecting ducts.
Pyramids	These are the cone shaped areas in the medulla and opens into the renal pelvis.
Renal pelvis	It collects urine.
Ureter	It carries urine to the bladder due to gravity and peristalsis.

1.3.3 The unit of Kidney: Nephron

Can you tell why the blood that enters kidney is red in colour but the urine produced by the kidney is transparent? The structural and functional unit of the kidney is called **nephron**. There are over one million nephrons in each human kidney.

Structure of Nephron

Each nephron consists of three parts: Bowman's capsule, golmerulus and the tubular portion.

Bowman's capsule: Each nephron begins in the cortex as a renal capsule or Bowman's capsule. It is a double walled structure, which surrounds the glomerulus.

Glomerulus: The renal artery divides up into a large number of arterioles and capillaries in the Bowman's capsule. This tuft of blood capillaries is called glomerulus. Blood leaving the glomerulus enters blood capillaries surrounding the tubule. These blood capillaries then unite to from a branch of the renal vein.

Tubular portion: The Bowman's capsule leads into a short coiled tubule called **proximal** (first) **convoluted** (coiled) **tubule**. The U shaped portion of the tubule in the medulla is called **loop of Henle**. The tubule passes back into the cortex. Here it coils again and is called **distal** (last) **convoluted** (coiled) **tubule**.

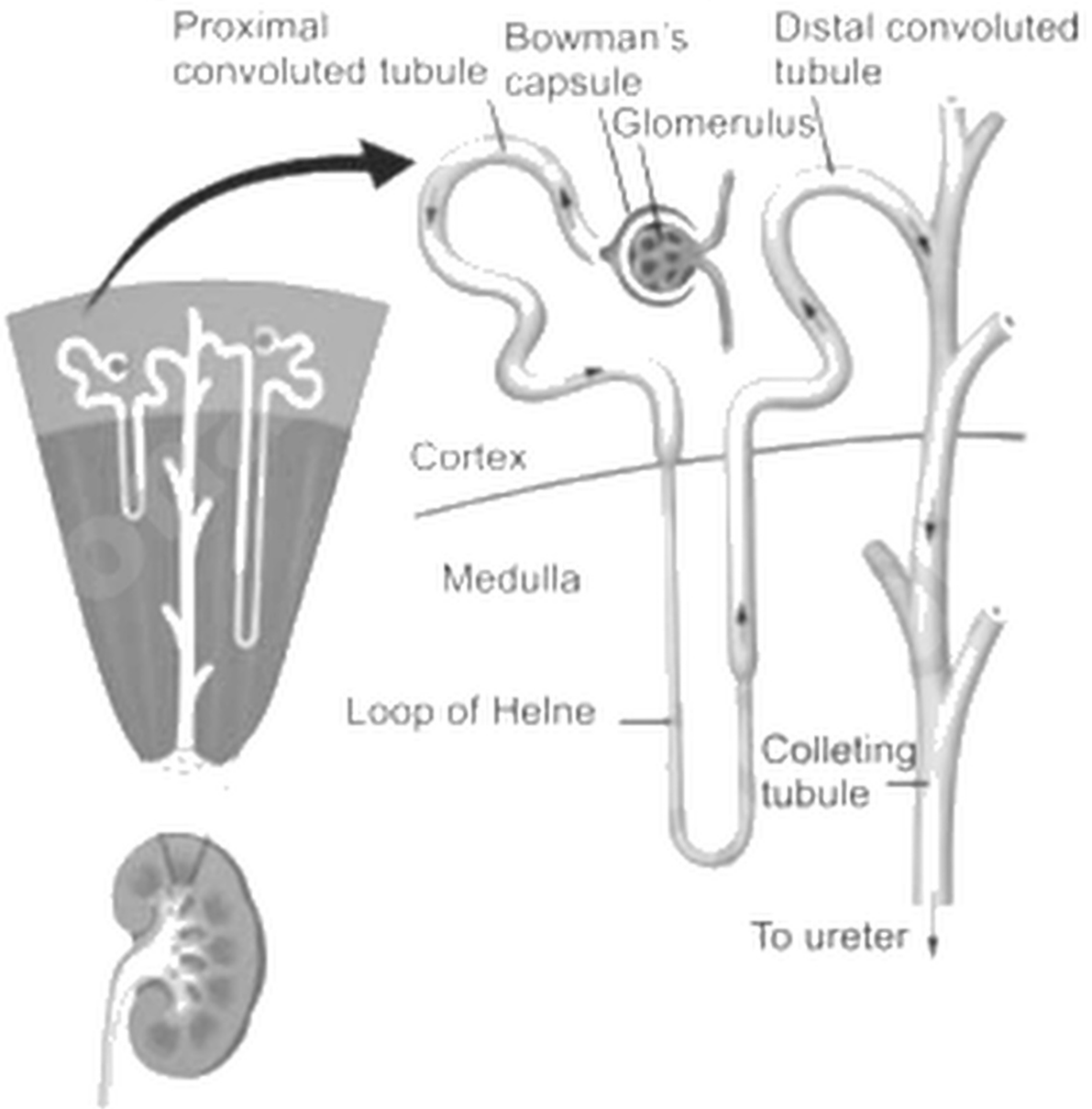


Figure 1.14: Nephron

A nephron is a single glomerulus with its Bowman's capsule, renal tubule and blood capillaries.

The distal tubule then opens into a **collecting tubule** which opens into the renal pelvis.

TABLE 1.6 STRUCTURE AND FUNCTION OF PARTS IN THE NEPHRON

Structure	Function
Glomerulus	Here blood flows under high pressure. Soluble parts of blood are forced out by filtration. Blood cells and proteins are retained in the capillaries.
Bowman's capsule	It collects filtrate from the glomerulus.
Loop of Henle	Here all useful substances are reabsorbed from the filtrate into the surrounding blood capillaries.
Collecting duct	Urine passes down the ducts to the pelvis.

1.3.4 Formation of Urine

As blood travels around the body, it picks up wastes such as carbon dioxide and urea. The wastes are removed from the body in the form of **urine**. Urine formation is divided into three steps: (a) Glomerular filtration (b) Tubular reabsorption (c) Tubular secretion.

(a) Glomerular filtration

During glomerular filtration water, salts, glucose, amino acids, nitrogenous wastes move from glomerulus to Bowman's capsule. The filtered substance is called the glomerular filtrate.

(b) Tubular reabsorption

During tubular reabsorption the glomerular filtrate passes through the tubular portion of the nephron. Here necessary water, glucose, amino acid, some salts from the proximal (at the near) convoluted (coiled) tubule are passed into the peritubular capillaries (the blood capillaries surrounding the loop of nephron/Henle). The substances that are reabsorbed become the tubular fluid, which enters the loop of Helne.

(c) Tubular secretion

During tubular secretion certain molecules are secreted from the peritubular capillaries into distal (farthest) convoluted (coiled) tubule. What is left are urea and waste salts dissolved in water. This is now called **urine**.

Flow Sheet

Renal artery → Blood enters kidney →Bowman's capsule → Glomerulus → (blood pressure is high) →Filtrate blood →Bowman's filtrate →Kidney tubules (coiled part) salt, glucose, water are reabsorbed and given back to blood through renal vein → Collecting duct → (Unnecessary salts, urea, uric acid and water forms urine) → Pelvis →Urinary bladder → Ureter → Urethra –Urine

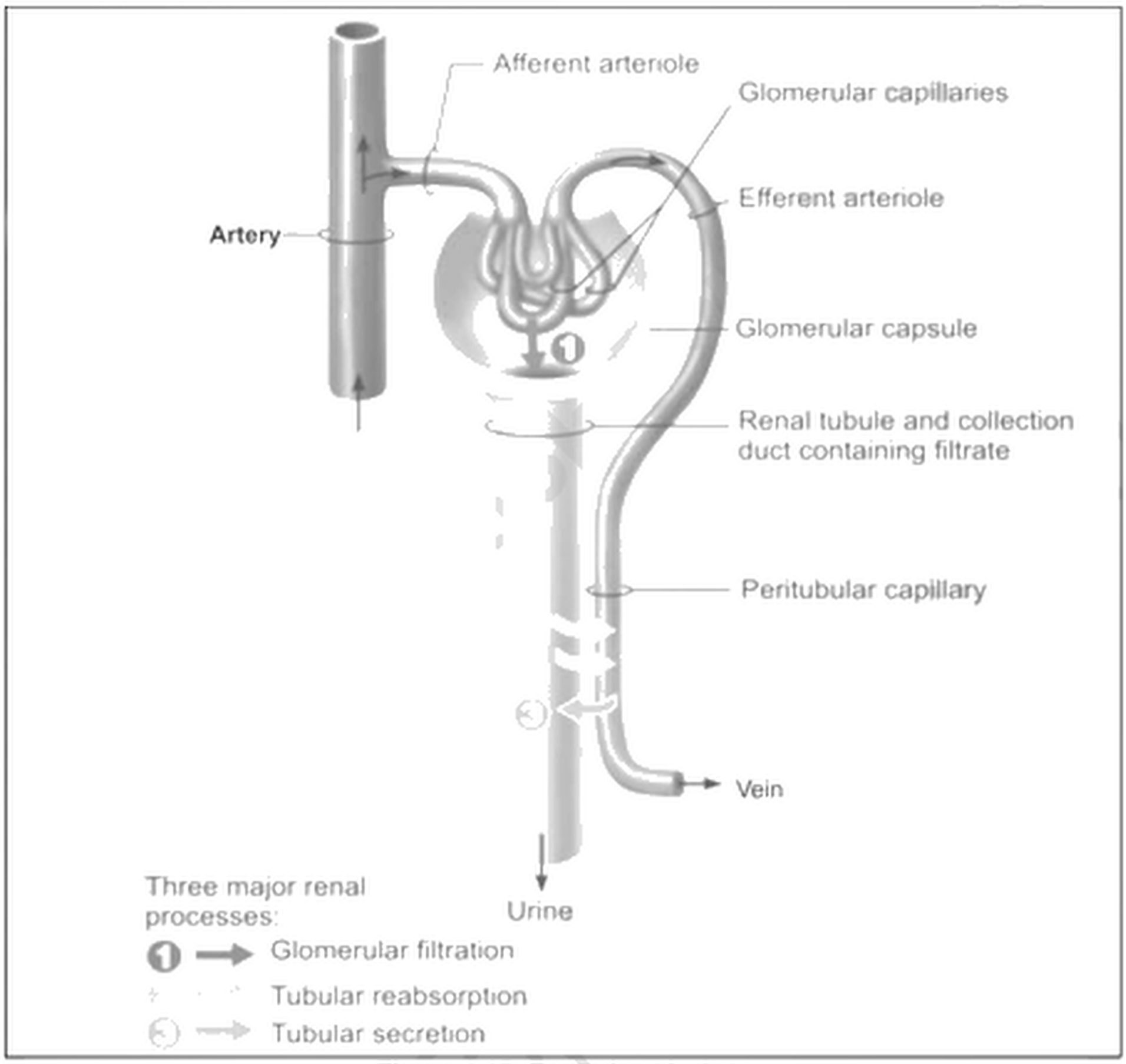


Figure 1.15: Formation of urine

Now you can tell why the blood that enters kidney is red in colour but the urine produced by the kidneys is transparent.

Activity 1.6

EXAMINATION OF THE STRUCTURE OF KIDNEY OF GOAT

1. Obtain a kidney of goat.
   a. Find out the convex surface and concave surface.
   b. Find out the renal capsule.
2. Remove the renal capsule.
   c. What is the colour of the kidney?
3. Cut the kidney into two longitudinal halves.
4. Observe the cut section with a hand lens.
   d. Identify the cortex and medulla?
   e. Why the cortex looks brown in colour?

Figure 1.16 Kidney of goat

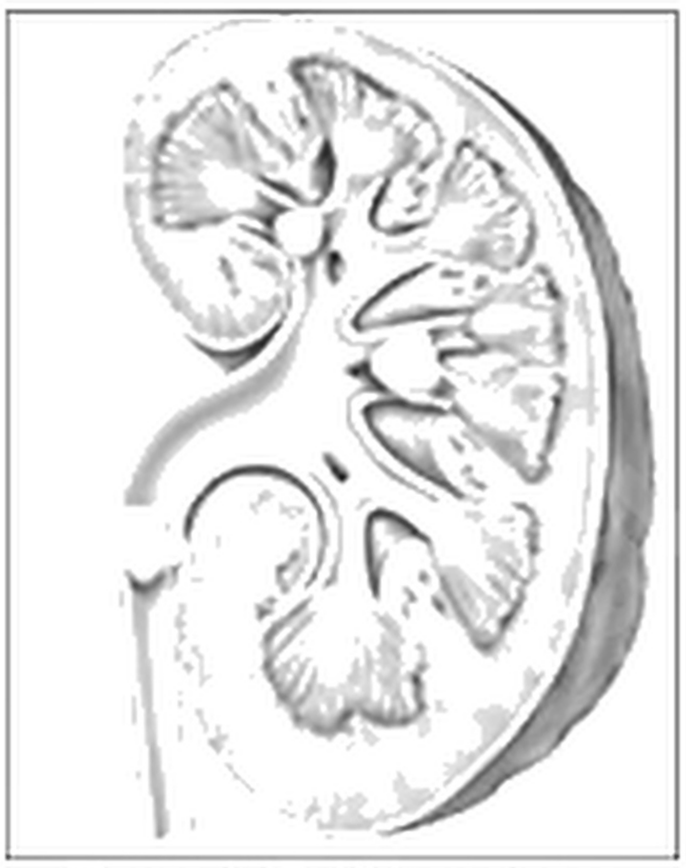


Figure 1.17: Kidney stones

DID YOU KNOW?

The only way to diagnose kidney disease is to see a doctor. Typically, you will be tested by having dye injected into the abdomen in order for the kidneys to be X-rayed.

1.3.5 Malfunctioning of Kidneys and its causes

Malfunction means to work or function imperfectly. The most common causes of kidney diseases include diabetes, high blood pressure and hardening of the arteries, which damage the blood vessels in the kidney. Some kidney diseases are caused by an inflammation of the kidneys.

The kidneys, urinary bladder and urethra may be infected. Glomerulus damage sometimes leads to blockage of the glomeruli so that no fluid moves into the tubule.

Kidney stones may develop in any organ of the urinary system such as collecting ducts and renal pelvis. Kidney stones usually consist of calcium salts and uric acid.

Factors contributing to renal stone formation may include the ingestion of excessive mineral salts, a decrease in water intake and over activity of the parathyroid glands

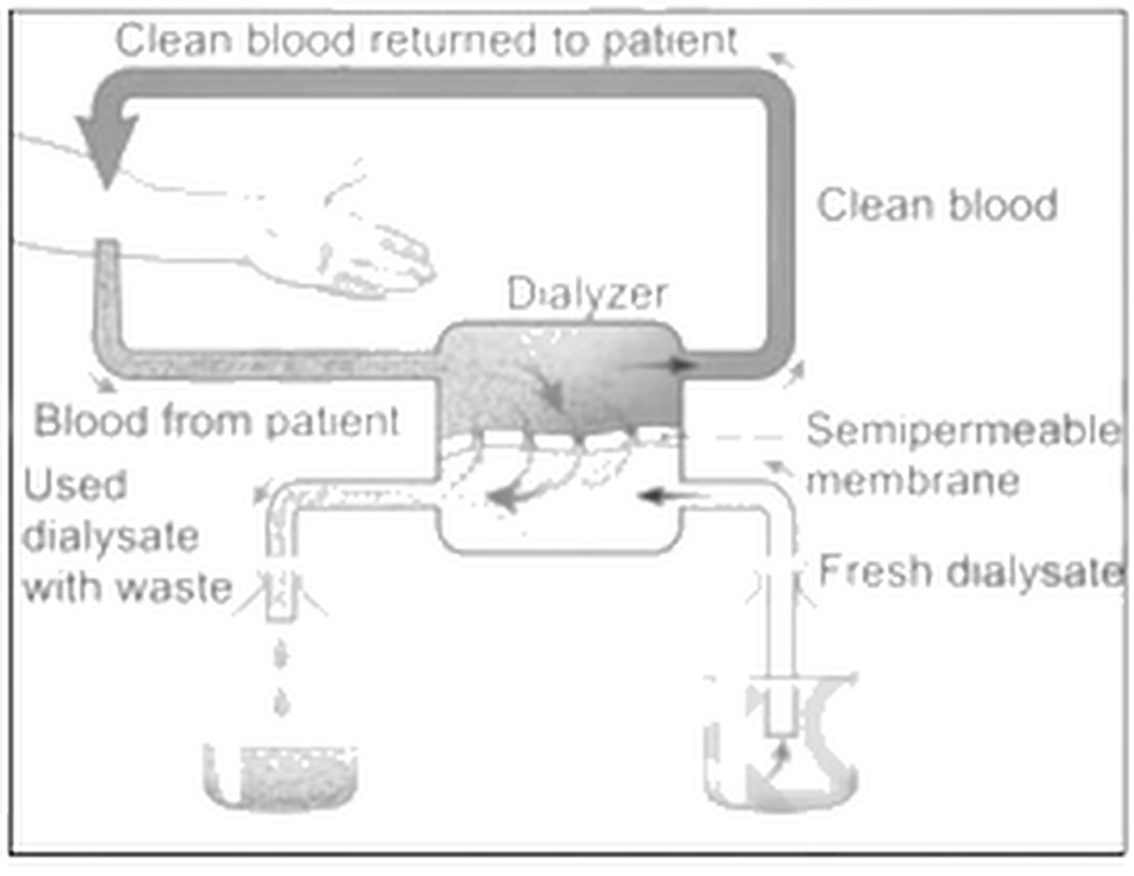
1.3.6 Techniques to Cure Problems of Kidneys

A patient can be treated with a dialysis or kidney machine. The tubing is bathed in a specially controlled **dialysis fluid**. The walls of the tubing are partially permeable. They allow small molecules, like urea and other waste products, to diffuse out of the tubing into the dialysis fluid. Big molecules, like proteins and blood cells, remain in the tubing. The process is called **dialysis.**

The patients with kidney disease can be treated by haemodialysis, peritoneal dialysis and kidney transplant.

Haemodialysis

In this process first a catheter is inserted into the vein, usually in the arm. The blood flows into the tube and then into the machine called dialyzer. Inside the machine the blood is pumped over the surface of a **dialysis membrane** (semi-permeable membrane). This separates the patient's blood from the **dialysis fluid** (dialysate). Urea diffuses out of the blood, across the dialysis membrane and into the dialysis fluid. The dialysis fluid already has sugar and salts in it. So sugars and salts from the blood will not diffuse across into the fluid. Urea and other wastes pass into the dialysis fluid. The patient's 'cleaner' blood passes back into the other vein of the arm through a second catheter. Fresh dialysate enters the machine from one end. The used dialysate with waste leaves the machine from the other end.



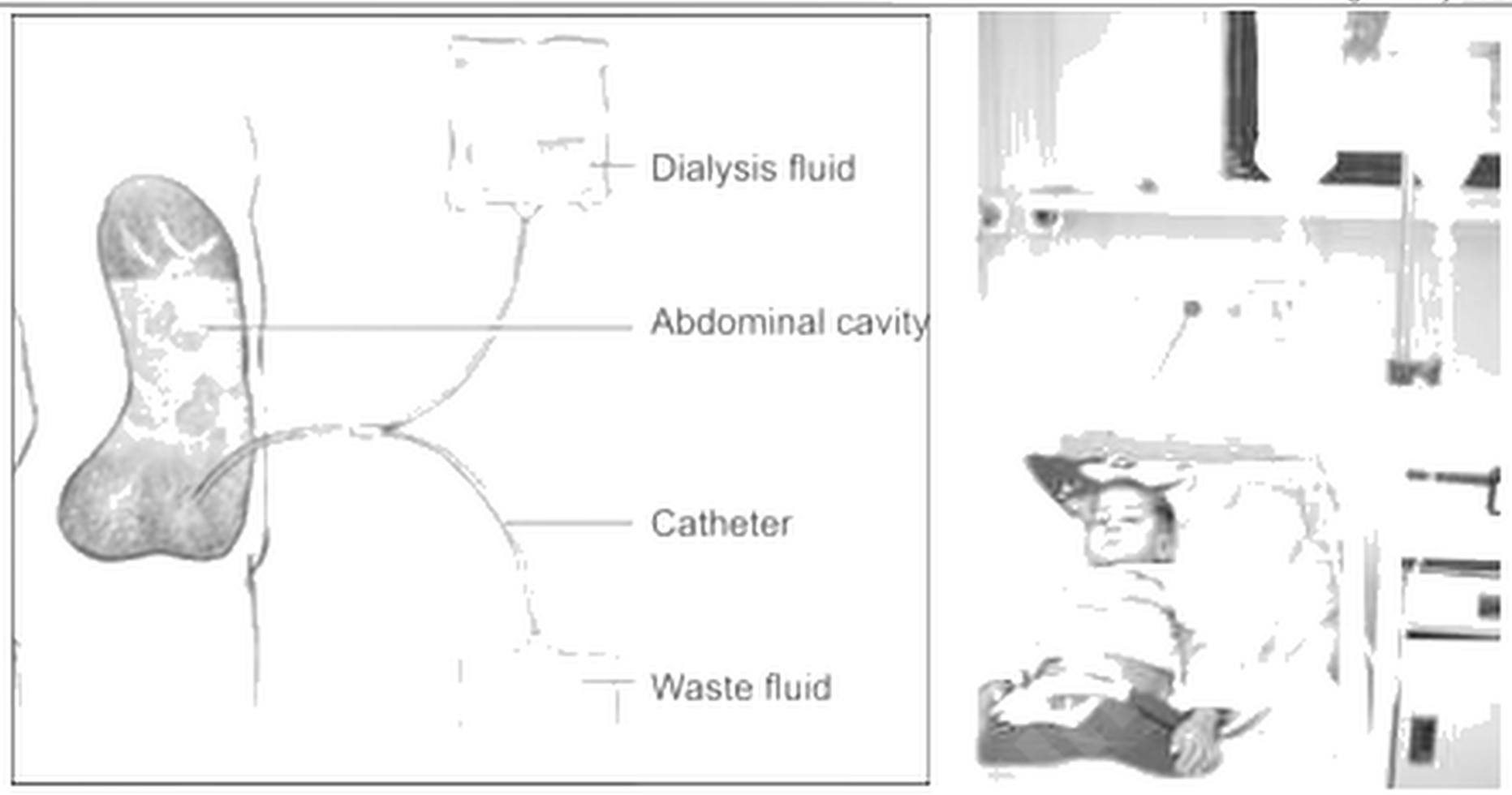


Figure 1.19: Peritoneal dialysis

Peritoneal Dialysis

In this process, a catheter is inserted to the abdomen. The peritoneum (see glossary) which lines the abdominal cavity is the dialyzing membrane. Dialysis fluid is added to the abdominal cavity through the tube. It is left for several hours before removal. Exchange takes place between the dialysis fluid and the tissue fluid in the rest of the abdomen. The fluid can be replaced regularly, 3 or 4 times a day.

Kidney Transplant

Kidney transplant are needed when about 90% of the kidney's function is not taking place. The tissues of both the donor and the patient are tested for matching. The old kidneys are left in their places and they do not harm. The new kidney is placed in the lower abdomen. As soon as the transplanted kidney is connected to the blood vessels, it will begin removing the waste products from the blood. A person can live normally with just one kidney.

Key Points

- Anything that causes activity or change in the activity in an organism is called stimulus. The reaction to the stimulus is known as response. The ability to respond to a stimulus is called sensitivity or irritability.
- The central nervous system consists of brain and the spinal cord. The peripheral nervous system includes nerves arising from the brain and spinal cord.
- The forebrain consists of cerebrum, thalamus and hypothalamus.
- Cerebrum is the main centre of various sensation.
- The pituitary body or gland is a very small gland that secretes a number of hormones.
- The midbrain is just a mass of tract.
- The hindbrain includes cerebellum, pons and medulla oblongata.
- The spinal cord continues with medulla and runs within the backbone. It carries out the reflex actions, conduct impulses to and from the brain.
- Twelve pairs of cranial nerves arise from the brain.
- Thirty-one pairs of spinal nerves emerge at intervals along the length of the spinal cord. They all carry both sensory and motor neurons. A neuron is the structural and function unit of nervous system. The three types of neurons are sensory, motor neurons and interneuron.
- The electric impulse passing along a nerve fibre when it has been stimulated is called nerve impulse. An immediate response to a specific stimulus without conscious control is called reflex action.
- An action that is controlled by the will is called voluntary action. An action that is not controlled by the will and takes place automatically is called involuntary action.
- The removal of waste products and poisonous materials produced by chemical reactions is called excretion. The excretory organs are lungs, liver, skin and kidney.

- Human excretory system consists of kidney, ureter, urinary bladder and urethra.
- A human kidney consists of capsule, cortex, medulla, pyramids, renal pelvis and ureter.
- The structural and functional unit of the kidney is called nephron. A nephron consists of glomerulus, Bowman's capsule, loop of Henle and collecting duct.
- The three steps of urine formation are glomerular filtration, tubular reabsorption and tubular secretion.
- The most common causes of kidney disease include diabetes, high blood pressure and hardening of the arteries.
- In haemodialysis (North American spelling: hemodialysis) a machine is used to remove wastes from the blood of patient.
- In peritoneal dialysis, a fluid is passed into the abdomen of patient. This fluid takes the nitrogenous wastes from the blood capillaries of abdominal walls.

Review Questions

1. Encircle the correct answer from the following choices.

(i) Which system controls co-ordination?

(A) circulatory system (B) respiratory system
(C) excretory system (D) nervous system

(ii) The reaction of any stimulus is called

(A) receptor (B) impulse
(C) response (D) effector

(iii) The nervous system comprises of:

(A) brain, spinal cord, nerves (B) nerves, heart, spleen
(C) brain, liver, spinal cord (D) brain, spinal cord, arteries

(iv) The largest part of the brain is called:

(A) medulla oblongata (B) pons
(C) cerebrum (D) cerebellum

(v) Which part of the brain maintains the balance of the body?

(A) pons (B) pituitary gland
(C) pineal gland (D) cerebellum

(vi) The nucleus in a neuron is located in

(A) axon (B) dendrite

(C) cell body (D) myelin sheath

(vii) Which part of the human brain detects temperature changes in the blood?

(A) cerebrum (B) hypothalamus

(C) cerebellum (D) medulla oblongata

(viii) A child is frightened by a loud noise and shouts for help. In which order are the different types of response involved in this response?

	Involved first----------		involved last
A	sensory neuron	interneuron	sensory neuron
B	motor neuron	sensory neuron	interneuron
C	sensory neuron	motor neuron	interneuron
D	sensory neuron	interneuron	motor neuron

(ix) Where urea is made in the human body?

(A) urinary bladder (B) kidneys

(C) liver (D) gall bladder

(x) The four structures listed are part of the human excretory system: 1. urinary bladder 2. kidney 3. ureter 4. urethra. In which order does a molecule of urea pass through these structures.

	First ----------			Last
A	1	2	3	4
B	1	4	3	2
C	2	1	3	4
D	2	3	1	4

(xi) Which one of the following is an example of excretion?

(A) release of hormones from pancreas

(B) release of carbon dioxide from the lungs

(C) removal of faeces from the alimentary canal

(D) release of saliva from the salivary glands.

(xii) Urea is produced in one organ, filtered from the blood by a second organ and stored inside a third organ before being expelled from the

	production	filtration	storage
A	kidney	urinary bladder	liver
B	kidney	liver	urinary bladder
C	liver	urinary bladder	kidney
D	liver	kidney	urinary bladder

(xiii) A tube present between the kidney and urinary bladder is called
(A) urethra (B) ureter
(C) u tube (D) u turn

(xiv) The organ that collects and stores urine is called:
(A) urinary bladder (B) ureter
(C) urethra (D) kidney

(xv) The structure that consists of tuft of capillaries is called
(A) proximal convoluted tubule (B) distal convoluted tubule
(C) glomerulus (D) loop of Henle

Short Questions

2. What do you understand by?
(a) sensitivity (b) stimulus (c) receptor
(d) response (e) dialysis?
3. What is a nerve impulse?
4. What is the difference between central nervous system and peripheral nervous system?
5. What are the functions of: cerebrum, thalamus, hypothalamus, pituitary gland, cerebellum, pons, medulla oblongata?
6. Name the types of neuron and write their function.
7. Distinguish between:
(i) a motor neuron and a sensory neuron.
(ii) a neuron from a nerve fibre.
(iii) a voluntary action and involuntary action?
(iv) a reflex action and reflex arc?
8. Name the nitrogenous waste products.
9. Identify the shape and location of kidney?

10. i) Name the parts of the excretory system.
    ii) Match each part with one of these functions:
        a. Carries blood with a high concentration of urea.
        b. Filters urea and other wastes chemicals out of the blood.
        c. Carries urine down to the bladder.
        d. Stores urine.
        e. Urine is passed out of the body

Extensive Questions

11. Describe the different parts of the human brain and write their functions.
12. Describe the central nervous system.
13. Describe the peripheral nervous system.
14. What is a reflex action? Describe a simple spinal reflex.
15. Draw a labelled diagram of a spinal reflex arc.
16. Describe human excretory system.
17. Describe the longitudinal section of a human kidney.
18. Describe the structure of a nephron.
19. How urine is formed?
20. What are the causes of malfunctioning of human kidney?
21. What are the techniques to cure problems of kidneys?

Science, Technology and Society Connections

- The two ways to develop the images of human brain are Computed Tomography (CT) Scanning and Magnetic Resonance Imaging. What are the differences between these two techniques?
- How to minimize the risk of the formation of kidney stones?

Answers of MCQs

(i)	D	(ii)	C	(iii)	A	(iv)	C	(v)	D
(vi)	C	(vii)	B	(viii)	D	(ix)	B	(x)	D
(xi)	B	(xii)	D	(xiii)	B	(xiv)	A	(xv)	C

2

HEREDITY IN ORGANISMS

CONTENTS

This is a 14 days lesson (periods including homework)

After completing this lesson, you will be able to:

- Differentiate between mitosis and meiosis.
- Identify DNA and chromosomes in the cell diagram
- Define heredity and recognize its importance in transferring of characteristics from parents to offspring.
- Identify the characteristics that can be transferred from parents to offspring.
- Compare characteristics related to ear and eye colour.

Captains of women cricket team of the world.

Reading

Look at the picture. Can you note the similar and different characteristic among the women cricket players of various countries?

All the students present in your class room have many characteristics in common. Can you name them? However, no two students are exactly alike. Can you note the differences among the students? In this chapter you will learn how characteristics are passed from one to the next generation?

Life for you began in a single cell. All the cells of your body have come from this cell. One cell divides and becomes two cells. How do they divide? In this chapter you will also learn how a cell divides and produces new cells. Reproduction in one organism is due to the reproduction in cells.

2.1 CELL DIVISION

The cells of your body are constantly dividing; as you grow and develop. A cell grows to certain size then it divides. If a cell did not divide it would not get enough oxygen and food. The cell would also not be able to get rid of wastes.

Did you know that your body cells only live for a certain period of time? Your body keeps on making new blood cells to replace the cells that have died. Why the cells divide? Cells divide to replace dead or injured cells. When there is a cut on the body, new skin cells grow over the cut. They replace the damaged skin cells. For the growth of an organism cells division is necessary. How does cell division work?

A cell divides to form two new cells. The cell which divides is called the **parent cell** and the two new cells are called **daughter cells.** For a cell to divide two processes take place:

(a) The nucleus divides (b) The cytoplasm divides

There are two types of cell divisions: mitosis and meiosis. **Mitosis** takes place in the somatic cell i.e., body cells of an organism. **Meiosis** occurs in the special cells of sex organs. Where do you think meiosis occurs in human being? Where do you think meiosis occurs in plants?

2.1.1 Chromosomes

Before learning about cell division we should learn about chromosomes.

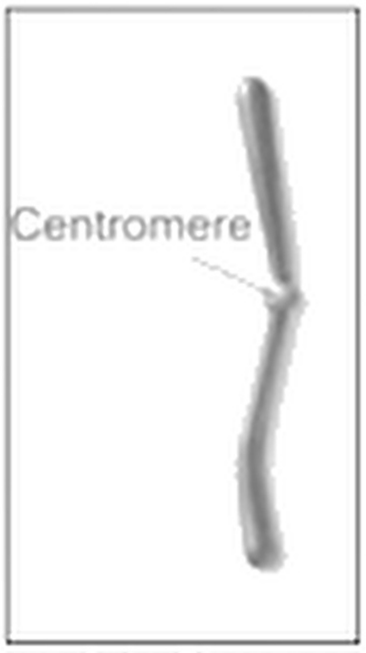


Figure 2.1: Chromosome

Chroma mean colour and *soma* means body. Chromosome means coloured body. It is so named because chromosomes have the ability to be stained with dyes. Well before cell division, each chromosome is replicated or copied. Because of this each chromosome consists of two identical 'sister' **chromatids** (see figure no. 3.1 at page 53). Each pair of chromatids is attached at an area called the **centromere**. Centromere is usually located near the middle of the chromatids. All the body cells of an organism have the same number of chromosome. The number of chromosomes varies in different organisms. The gametes or spores have half number of chromosomes then their body cells.

Science Titbits

Chromosomes are not visible in most cells except during cell division. This is because the DNA and protein molecules that make up the chromosomes are spread throughout the nucleus. At the beginning of cell division, however, the chromosomes condense into compact visible structures that can be seen through a light microscope.

2.1.2 Mitosis

Biologists have divided the events of mitosis into four phases: prophase, metaphase, anaphase and telophase. Here we will see mitosis in an animal cell.

Prophase

The chromosomes shorten, flatten and become visible under light microscope. Each chromosome divides into a pair of identical chromatids joined to one another by the centromere. The **centrioles** are two tiny structures located in the cytoplasm near the nuclear membrane. The centrioles take up the position on opposite sides of the nucleus. A spindle fibre begins to form. The nuclear membrane breaks down.

Metaphase

The chromosomes line up on the middle of the cell. Each chromosome is connected to a different spindle fibre coming from opposite poles at its centromere.

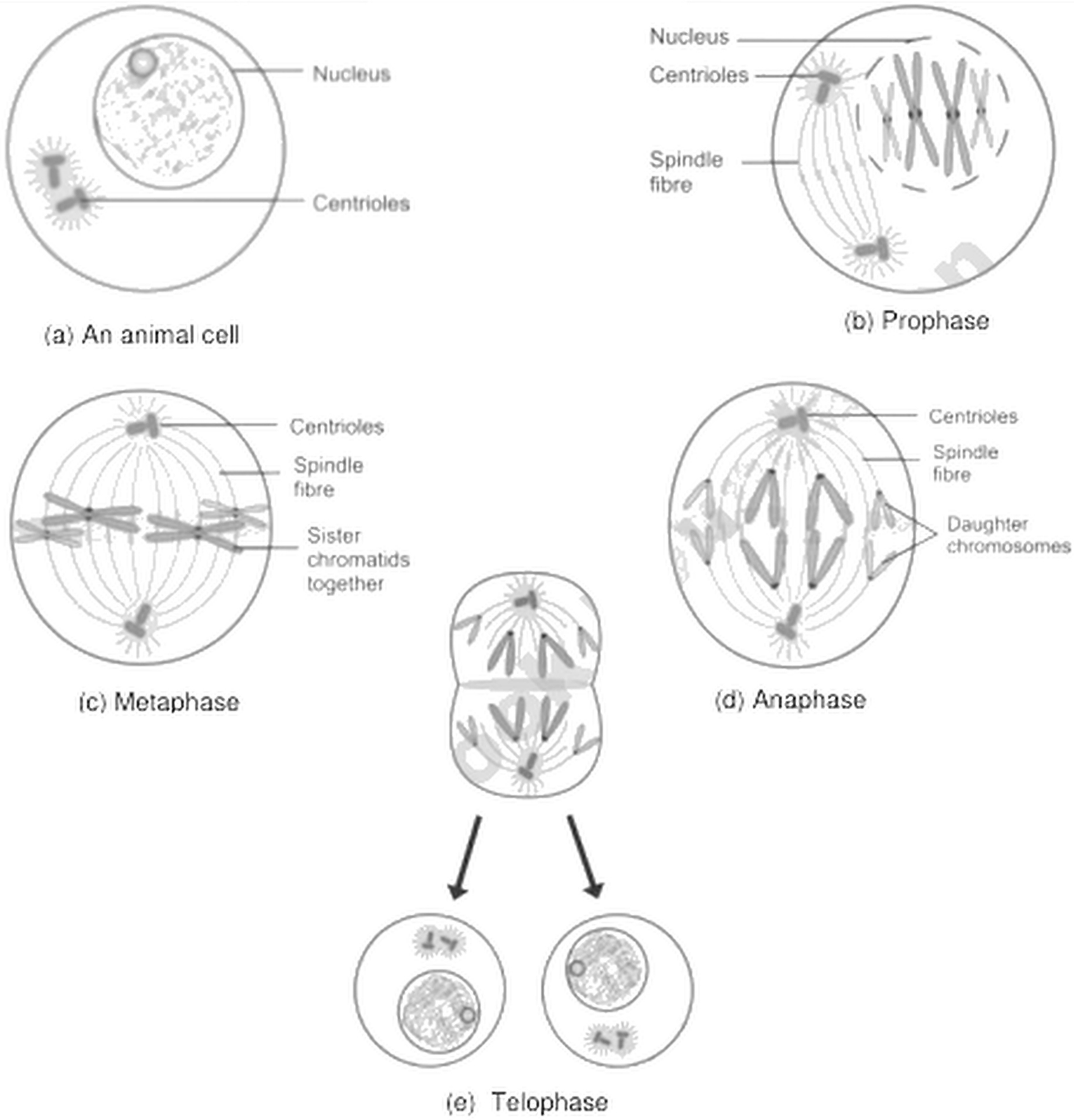


Figure 2.2: Mitosis in an animal cell

Anaphase

The chromatids separate into individual chromosome due to separation of centromere which is separated due to the pull created by the spindle fibres coming from opposite poles and move to the opposite end of the cell.

Telophase

The chromosomes gather at opposite end of the cell. A nuclear membrane forms around each group of chromosomes.

Cytokinesis

Figure 2.3: Cytokinesis

The division of the cell is called cytokinesis. The cytoplasm pinches in half. Each daughter cell has an identical set of chromosomes.

Importance of Mitosis

When living things grow they make new cells. Mitosis makes these new cells, whether it is in the growth of a baby, the healing of a wound, the germination of a seedling, or replacing red blood cells.

> Mitosis the division of a single nucleus into two identical daughter nuclei in which the number of chromosomes remains same.

Mitosis also occurs in asexual reproduction. The cells in the parent plant or or animal divide to make new cells which form new individual.

2.1.3 Meiosis

Meiosis has two clear divisions Meiosis I and Meiosis II.

Meiosis I

This is made up of 4 stages Prophase, Metaphase, Anaphase and Telophase. The cell starts off like as shown in figure 2.4.

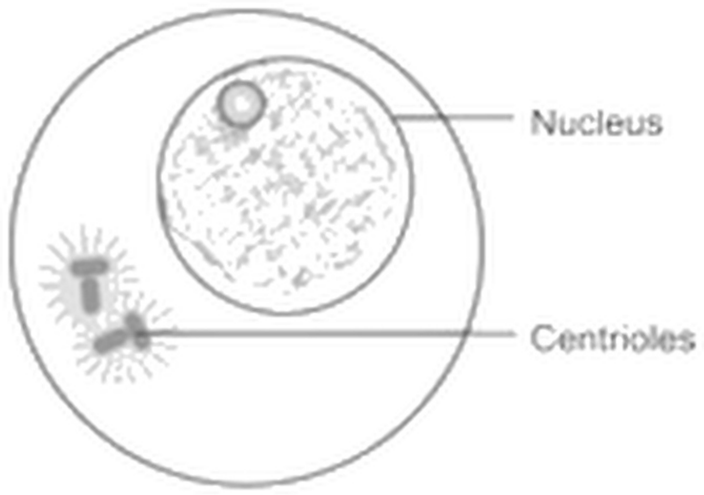
Prophase I

The chromosomes shorten, thicken and become visible under the light microscope. During prophase 1 each chromosome divides into a pair of identical chromatids joined by the centromere. Identical chromosomes called **homologous chromosomes** pair up forming homologous pairs. The nuclear membrane

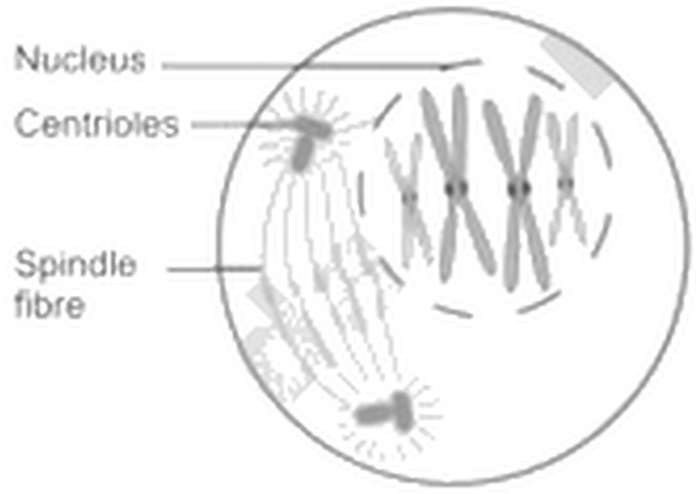
disappears and homologous pairs of chromosomes line up on the middle of the cell. The spindle fibres will start to form.

Metaphase I

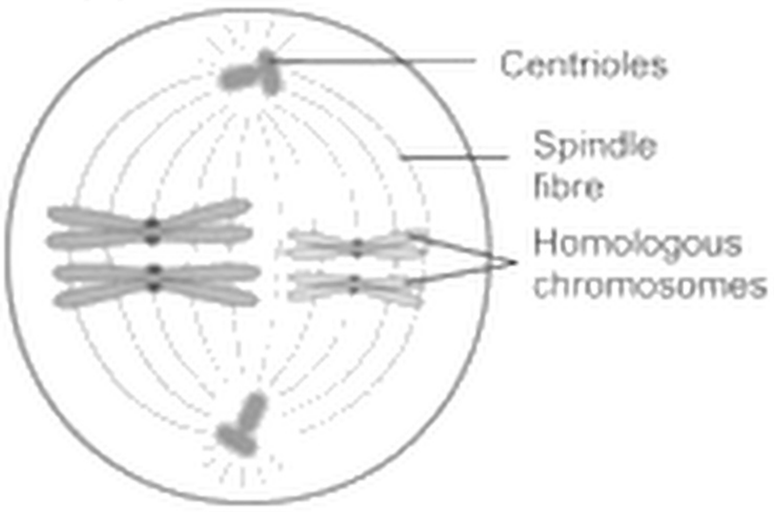
Homologous pairs of chromosomes line up on the middle of the cell. The chromosomes are attached to the spindle fibres by their centromeres.



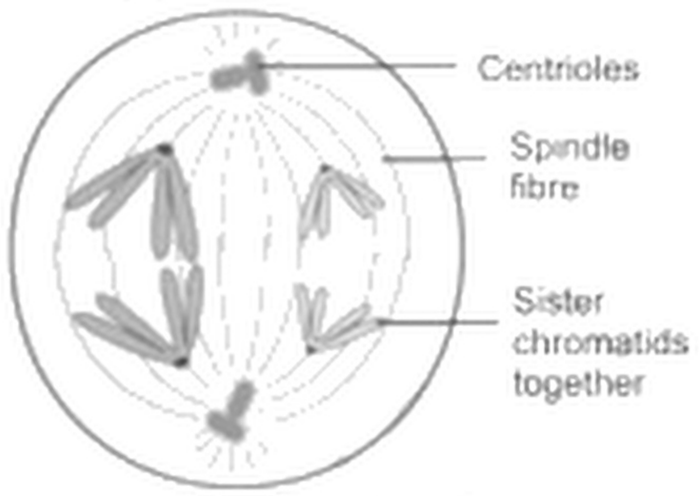
(a) An animal cell



(b) Prophase 1



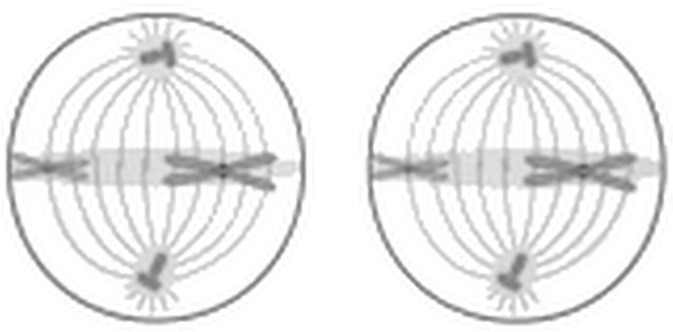
(c) Metaphase I



(d) Anapase 1

(e) Telophase I

(f) Prophase II



(g) Metaphase II

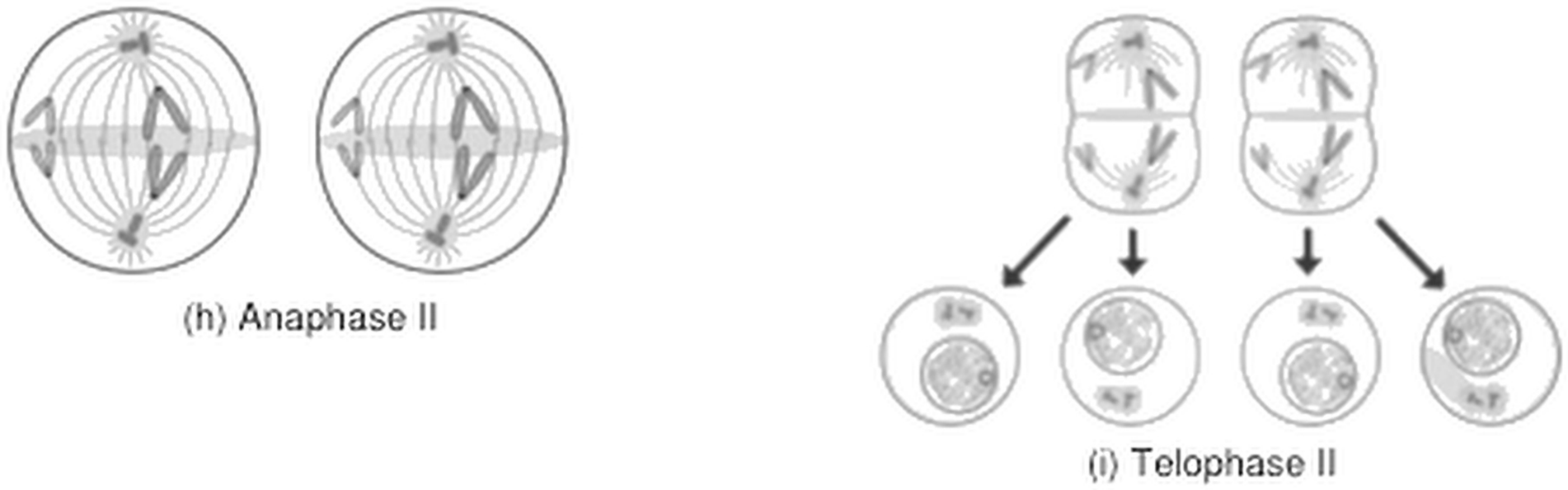


Figure 2.4: Meiosis in an animal cell

Anaphase I

The spindle fibres shorten and the chromosomes separate going to opposite poles of the cell.

Telophase I

The chromosomes gather at opposite end of the cell. Nuclear envelope forms around each set of chromosomes and the chromosomes start to uncoil. Spindle fibres start to breakdown. The cytoplasm pinches in half. Each daughter cell has a half set of chromosomes the parent cell.

The stages of Meiosis II are actually very similar to Mitosis.

Prophase II

Two cells were formed at the end of Meiosis I. During prophase II the nuclear envelope breaks down, spindle fibres form and the chromosomes shorten and thicken.

Metaphase II

The chromosomes align themselves along the equator. They are attached to the spindle fibres by their centromeres.

Anaphase II

Spindle fibres shorten separating the chromatids. This pulls the chromatids to opposite poles of the cell.

Telophase II

The nuclear envelope forms around each set of chromosomes. Chromosomes uncoil. Also as a result of cytokinesis, the cells will split to form 4 daughter cells.

Importance of Meiosis

> In a sexually reproducing organism, it is the division of a single nucleus into four daughter cells in which the number of chromosomes becomes half.

Meiosis is followed by the union of sperm and egg. This provides a mixing of characteristics from each parent in each of their offspring. This mixing produces new combinations of characteristics. Due to meiosis the number of chromosomes remains same from one generation to the next generation. How? Let us see an example. The number of chromosomes in a human body cell is 46. Meiosis halves the number of chromosomes. So the egg cells and sperm cells have only 23 chromosomes. When the gametes i.e., egg cell and sperm cell unite a **zygote** is formed. The fertilized egg or zygote will have 46 chromosomes, 23 from the mother, in the egg and 23 from the father in the sperms.

In humans by meiosis the ovaries produce eggs and the testes produce sperms. In plants by meiosis the anthers produce pollen and the ovaries produce egg cells.

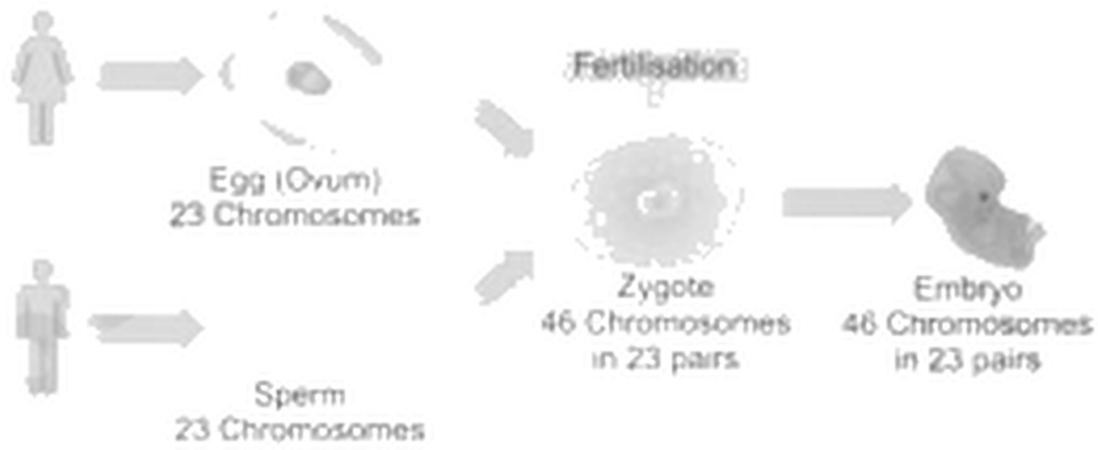


Figure 2.5: Meiosis keeps the constant number of chromosome in each generation.

Activity 2.1

OBSERVING VARIOUS STAGES OF MITOSIS

Observe prepared slide of onion root tip for observing various stages of mitosis.

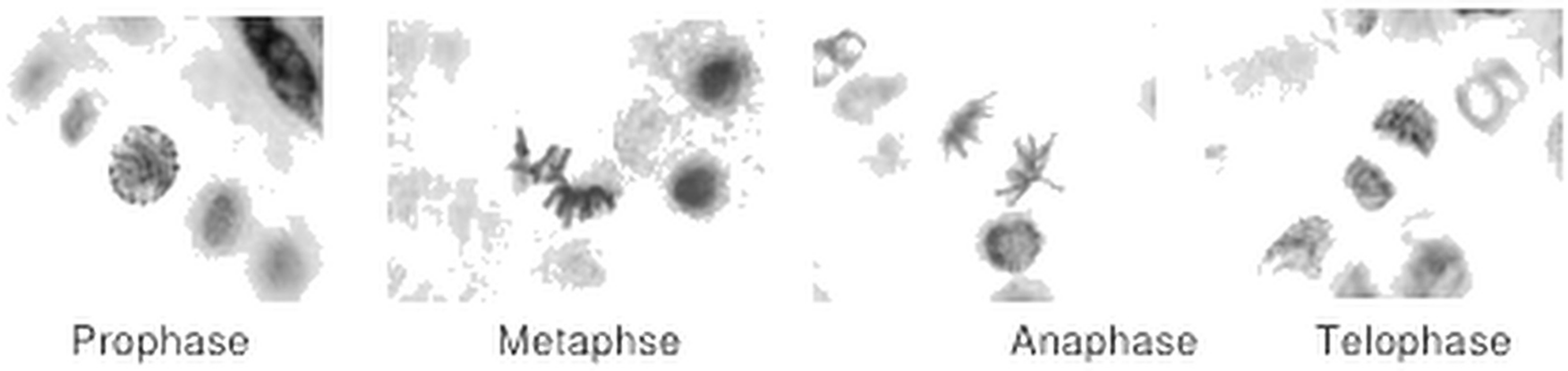


Figure 2.6: Stage of mitosis in onion root tip cells

TABLE 2.1 COMPARING MITOSIS AND MEIOSIS		
	MITOSIS	**MEIOSIS**
1	It takes place in body cells.	It takes place in special cells of sex organs.
2	Two daughter cells are formed.	Four daughter cells are formed
3	The daughter cells are identical to each other and to the parent cells.	The daughter cells are not identical to each other and to the parent cells.
4	The number of chromosomes remains constant.	The number of chromosomes becomes half.
5	The functions include cellular reproduction and general growth and repair of the body.	The functions include producing organisms having different characteristics through sexual reproduction.

2.1.4 Identification of Chromosomes and DNA in the Cell

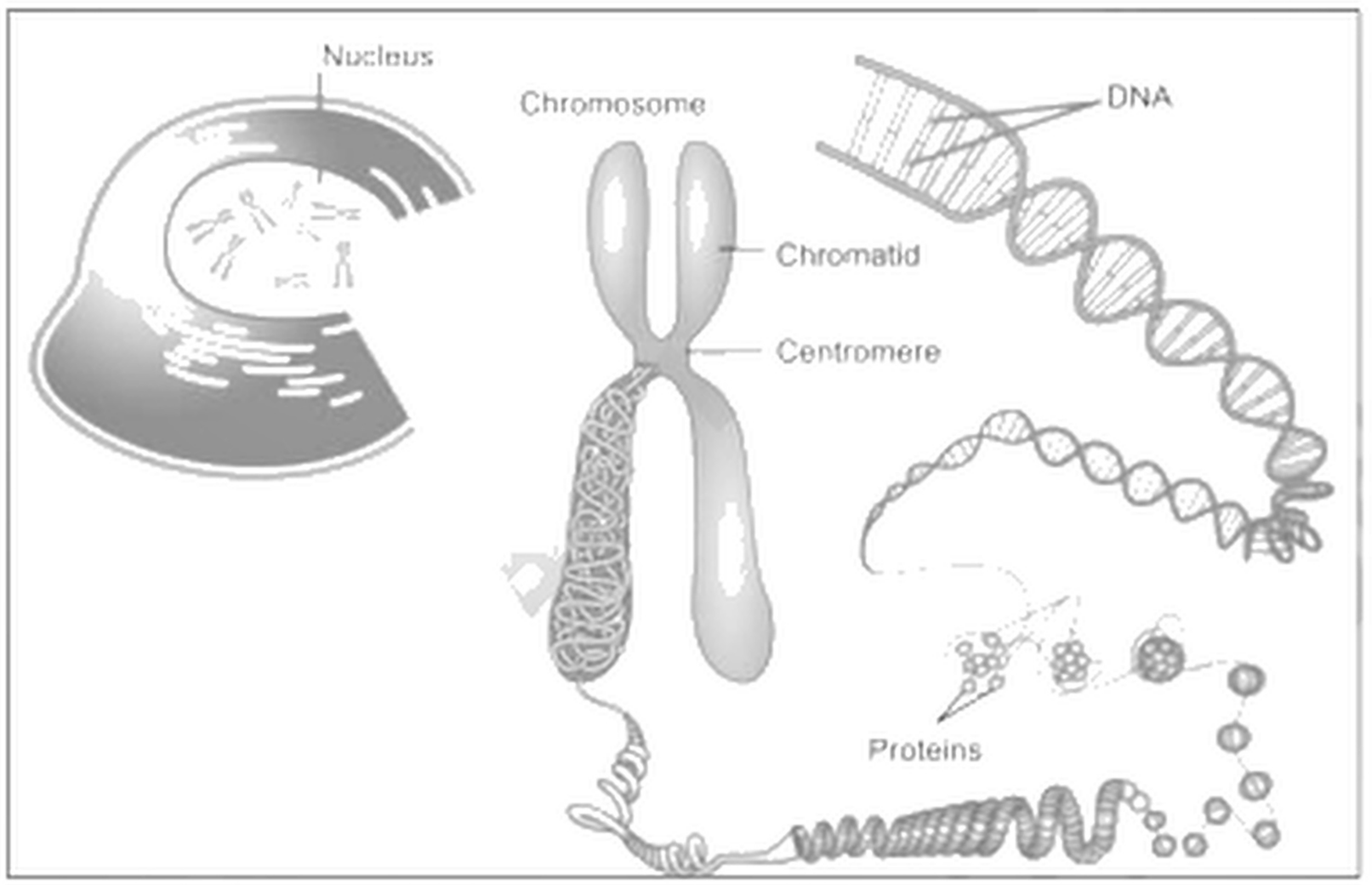
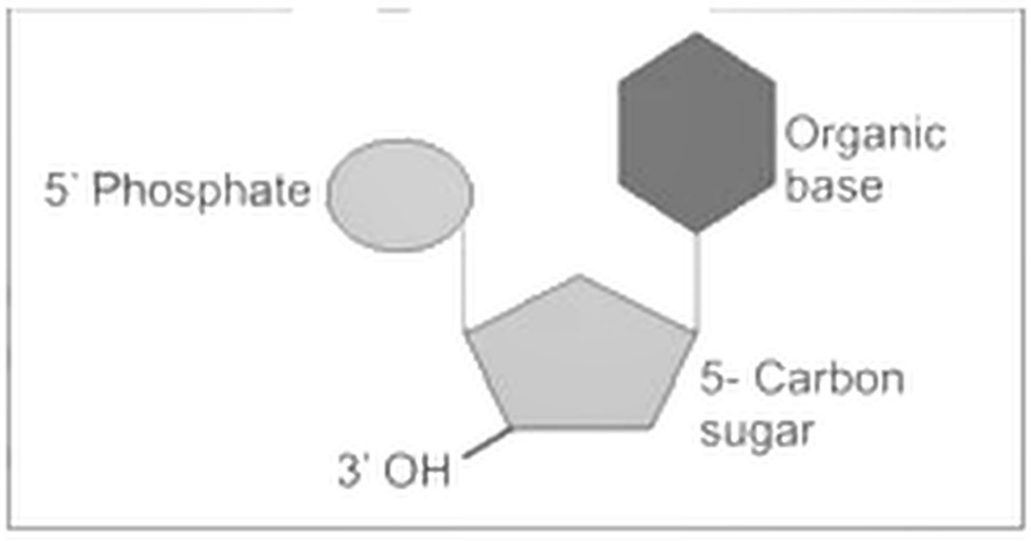


Figure 2.7: Chromosome and DNA in the human cell

A cell has a nucleus. Chromosomes are located in the nucleus. Chemically chromosomes consist of deoxyribonucleic acid (DNA) and protein. DNA is a long molecule is made up of units. Each unit is called a **nucleotide**. A single nucleotide is made up of three



molecules. (1) a 5- carbon sugar called deoxyribose (2) a phosphate group (3) a nitrogenous (nitrogen containing) base. Many nucleotides join to form a polynucleotide.

Structure of DNA

The sugar deoxyribose and phosphate group join up and form the backbone of the DNA strand. The bases are attached to the sugar deoxyribose molecules. Look at the figure 2.11 and 2.12. You will see that DNA strand is made of two strands of nucleotides. It looks like a ladder. The upright part of the ladder is made up of deoxyribose and phosphate group. The "rungs" in the ladder consist of four bases. And then the whole molecule is twisted into a **double helix** – a bit like a spiral staircase.

Activity 2.2

WHAT IS HELIX?

Take a spring made of flexible wire and stretch it. It will become a spiral in shape. It is called a single helix. By twisting two wires together you can make a double helix. In a double helix two strands spiral around one another.

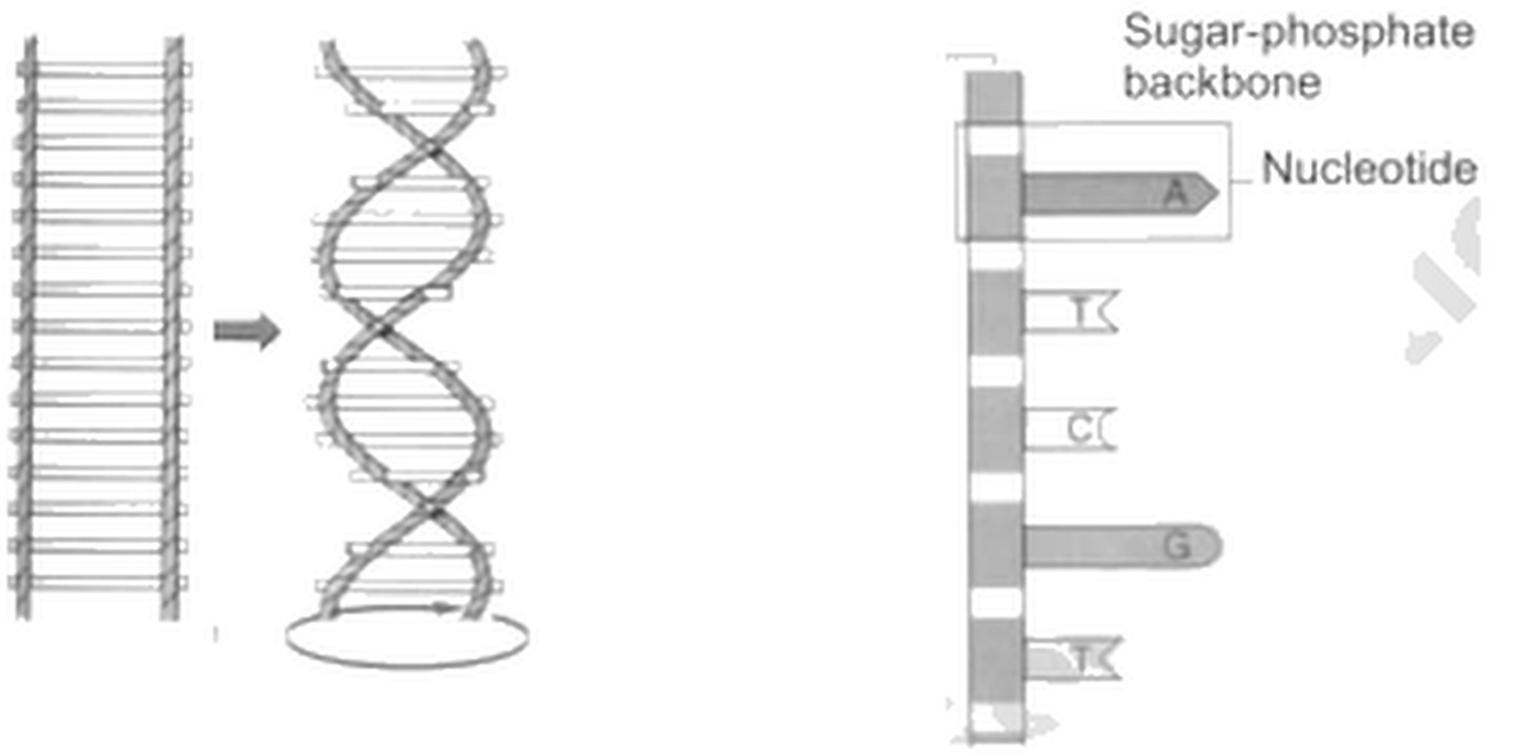
So how is the DNA molecule kept together? If you look at the figure 2.12 you can see that the bases join together. There are four different nitrogenous bases in DNA: adenine (A), cytosine (C), guanine (G) and thymine (T). The nitrogenous bases are always in pairs. Adenine always pairs with thymine and guanine always pairs with cytosine. There are two hydrogen bonds between A and T and three

Science Titbits

The molecular structure of DNA was worked out by James Watson and Francis Crick, working in Cambridge in 1953. They pieced together cut-out models of the molecules involved. They build a 3-D model of the structure of DNA in 1953. It turned out to be a beautiful 'double helix' structure.

Figure 2.9: James Watson and Francis Crick with double helix model of DNA

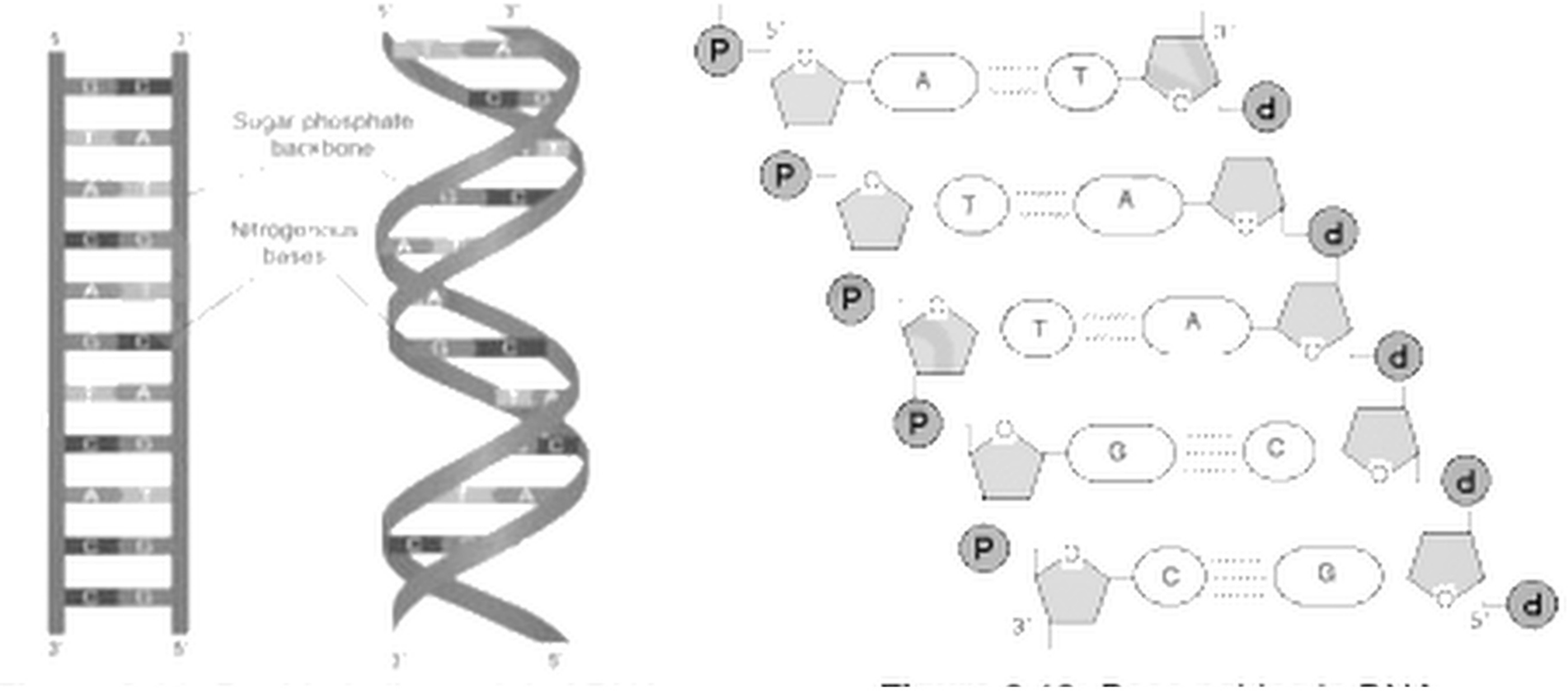
hydrogen bonds between C and G. The nucleotides can be joined together in any order, meaning that any sequence of bases is possible. Although the hydrogen bonds holding the two chains of nucleotides together are weak, they are many in numbers. So altogether they keep the 'double helix' in shape.



(a) (b)

Figure 2.10: (a) Twisting of a ladder (b) Polynculeotide

DNA's sugar-phosphate backbones run in opposite directions. Each strand has a 3′ ("three prime") end and a 5′ end. The primed number refers to the carbon atoms of the nucleotide sugars. At one end of each DNA strand, the sugar's 3′ carbon atom is attached to an –OH group; at the other end, the sugar's 5′ carbon has a phosphate group.



2.2 HEREDITY

Family members often have similar characteristics. You must have some common features with your mother and father. At the same time all members have different appearance. What is responsible for these similarities and differences? What characteristics you have common with your brothers and sisters? What characteristics distinguish you from other members of your family? How do you get the characteristics? The characteristics are passed from parents to their offspring. How? Knowledge of mitosis and meiosis helps us to answer this question. Characteristics from the father are in the nucleus of the sperm. Characteristics from the mother are in the nucleus of the egg. At fertilization the nucleus of the sperm joins with the nucleus of the egg. A new individual grows from the fertilized egg, having characteristics of both the father and the mother. The passing of characteristics from one generation to the next is called **heredity**. The science of heredity is called **genetics**. What is the importance of heredity? Can you tell?

2.3. BASIS OF HEREDITY

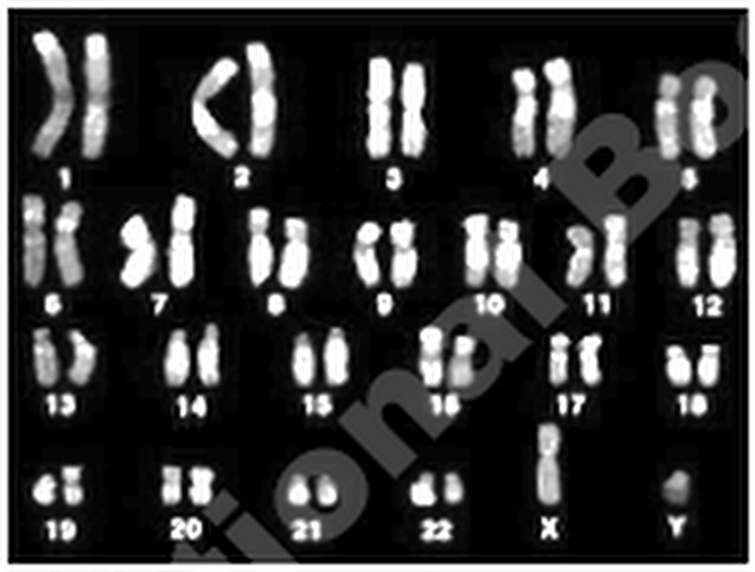


Figure 2.13: The human chromosomes (male)

Figure 2.14: Chromosomes in fruit fly

What is the material of inheritance? A nucleus is present in all cells. The nucleus contains thread-like structure called the **chromosomes**. The chromosomes carry the **genes** that control all your characteristics. Chromosomes occur in pairs. Look at the picture of human chromosomes (figure 2.13). Count them. Is it 46? Are they of same shape and size or of different shapes and sizes? You can separate them into identical pairs. Can you see how many pairs there are? There are different number of chromosomes for different species of animals and plants. Humans have 23 pairs, cats have 19 pairs, fruit flies have 4 pairs, and onions have 9 pairs etc.

2.3.1 What is a gene?

Each chromosome is made up of thousands of **genes** arranged like beads in a string. It is the genes that carry the genetic information that affects how we grow and what we look like. A single gene is made of a short length of DNA. So the long thread of DNA that makes up a chromosome contains hundreds of genes.

- Make a list of characteristic of animals and plants which they share with their offspring.

The list may be like this:

(a) White cat- white offspring.
(b) Black dog- black offspring.
(c) Red rose- red offspring.
(d) Fair colour parents – fair colour offspring and so on.

Activity 2.3

SHARING OF CHARACTERISTICS WITH THE FAMILY MEMBERS

Observe and fill the following table:

Family Members	The characters that I share with
1. FATHER	
2. MOTHER	
3. GRAND FATHER	
4. GRAND MOTHER	
5. BROTHERS	
6. SISTERS	

2.3.2 External Structure of human Ear

The external ear (auricle) is made up essentially of basic four parts: the helix, lobe, concha, and tragus-anti-tragus. A normal human ear has an oval shape that is concave with irregular topography on the inside. The helix is the outer cartilaginous rim of the external ear.

Figure 2.15: Human ear

- One of the most noticeable variations in external ear anatomy is that of free lobes verses attached lobes. This is a genetic trait.

1. **In how many persons the ear lobe is attached or free? Observe and fill the following table:**

Ear lobe	Number of persons
Free ear lobe	
Attached ear lone	

Figure 2.16: Free and attached ear lobes

2. **Make a graph to show the result of your observation.**

- Another variation among ears is the depths of the sunken areas. The concha, scapha, and triangular fossa range from very shallow to very deep. In addition, the intertragical notch (the small notch between the tragus and the antitragus) varies somewhat in width from one individual to the next.

3. **What are the shapes of ear?**

Concavity variations (a) Deep (b) Shallow Intertragical notch width (c) Wide (d) Narrow

Figure 2.17: Various shapes of human ear

Activity 2.4

OBSERVING HUMAN EYE COLOUR

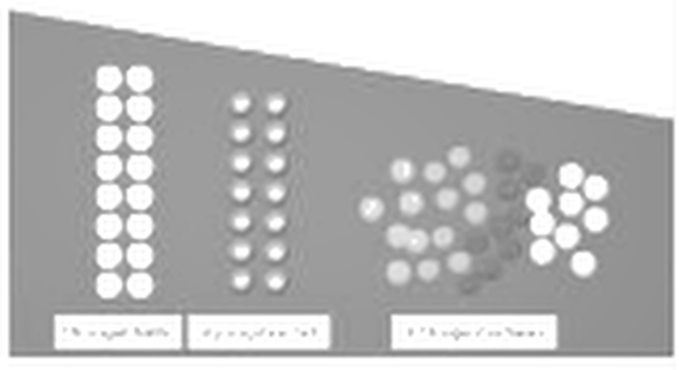
1. The human eye has many colours. Observe the eye colours of your class mates and fill the following:

Eye colour	Eye	Number of Persons
1. Black		
2. Brown		
3. Hazel (light brown)		
4. Green		
5. Blue		

Project 2.1

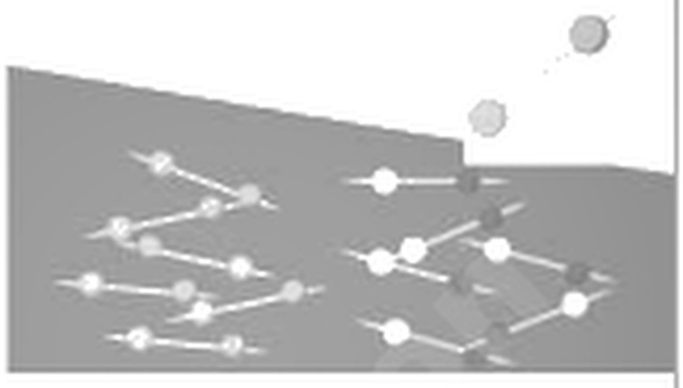
MAKING A MODEL OF DNA USING STYROFOAM BALLS

1. **Materials**: For this project, you will need small styrofoam balls, a needle and thread, paint, and toothpicks.
2. Paint your Styrofoam balls. Choose six different colours to represent the sugar and phosphate groups, and the four nitrogenous bases. They can be any six colours of your choice.
   - You will need to paint 16 sugar balls, 14 phosphate balls, and 4 different colours for each of the nitrogenous bases (cytosine, guanine, thymine, and adenine).

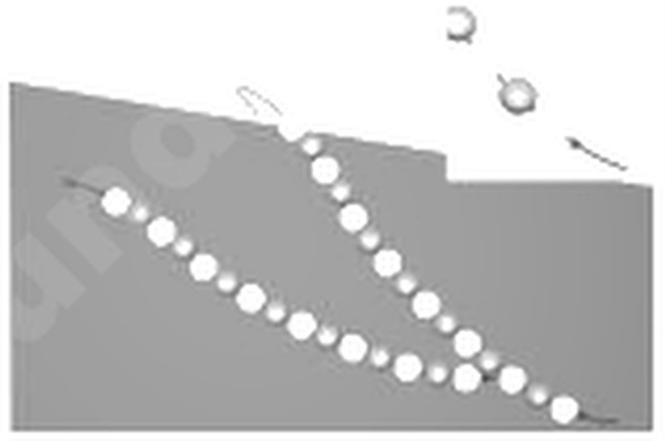


- You could choose to have one of the colours be white, so that you don't have to paint some of the Styrofoam.

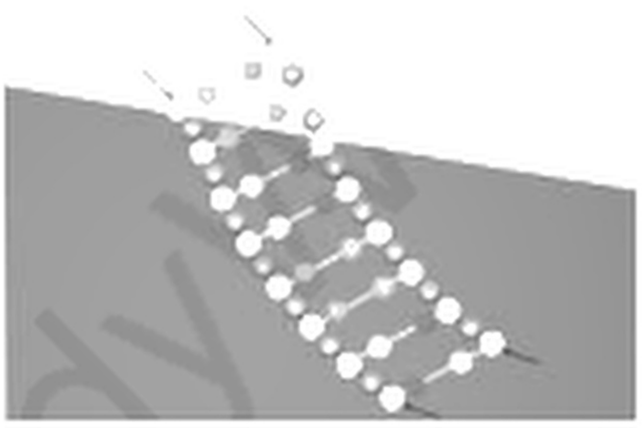
3. Pair off the nitrogenous bases. Once the paint has dried, designate one colour for each of the nitrogenous bases, and then pair them with their matching base. Cytosine always goes with guanine, and thymine always goes with adenine.
   - The order of the colours does not matter, as long as they are in the correct pairs.
   - Stick a toothpick between each of the pairs, leaving a little extra space at the sharp ends of the toothpicks.



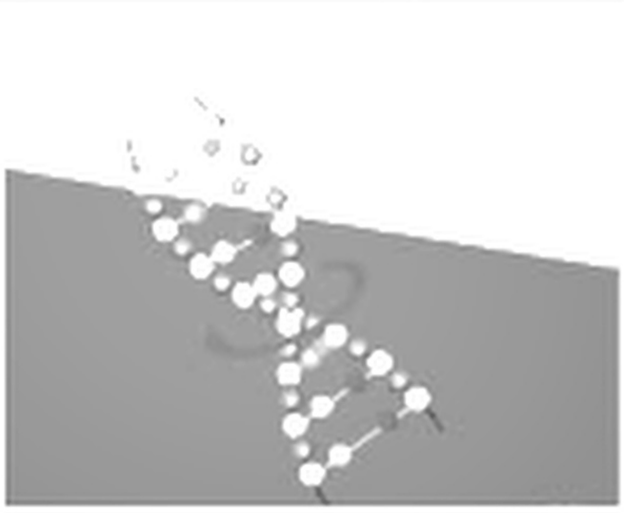
4. Make the double helix. Using the needle and string, cut a piece that is long enough to go the length of 15 Styrofoam balls. Tie a knot at one end of the string, and thread the needle on the other.
   - Line up the Styrofoam sugar and phosphate balls, so that they alternate in sets of 15. There should be more sugar balls than phosphate balls.
   - Make sure that the two strands of sugar and phosphates are in the same order, so that they line up when placed next to each other.
   - Thread through the centres of each alternating string of Styrofoam sugar and phosphate balls. Tie the string off at the end of each strand, to prevent the balls from sliding off.



5. Attach the nitrogenous bases to the double helix strands. Take the toothpicks with your pairs of nitrogenous bases, and stick the sharp end to the matching sugar balls on each long strand.
   - Only attach the pairs to the Styrofoam balls representing sugar, as this is how DNA is attached in real life.
   - Make sure that enough of the toothpick is attached to the strands that the pairs of bases will not fall off easily.



6. Twist the double helix. Once all the pairs of toothpick bases have been attached to the sugar, twist the double strands in a counter-clockwise direction to mimic the appearance of a true double helix. Your model is now complete.



Questions:

4. What part of your DNA model make up the rungs of the ladder?
5. What part of your DNA model make up the sides of the ladder?

Key Points

- A cell divides to form two new cells.
- Mitosis takes place in the somatic cells (body cells) of an organism.
- Meiosis occurs in the special cells of sex organs.
- Mitosis is the division of a single nucleus into two identical daughter nuclei in which the number of chromosomes remains same.
- In a sexually reproducing organism, meiosis is the division of a single nucleus into four daughter cells in which the number of chromosomes becomes half.
- Chromosomes are located in the nucleus. Chemically chromosomes consist of Deoxyribonucleic acid (DNA) and protein.
- A DNA molecule is made up of thousands of units called nucleotide. A single nucleotide is made up of three molecules: phosphate group, deoxyribose (sugar) and nitrogenous base.
- The deoxyribose and phosphate group form the backbone of the DNA strand. The bases are attached to the sugar molecules.
- DNA strand is made up of two strands of nucleotides. The two strands run in opposite directions.
- The upright part of the strand is made up of deoxyribose and phosphate and the "rungs" consist of four bases.
- The passing of characteristics from one generation to the next is called heredity. The science of heredity is called genetics.
- The nucleus contains the chromosomes. The chromosomes carry the genes that control all the characteristics. Chromosomes occur in pairs.
- Each chromosome is made up of thousands of genes arranged like beads on a string.
- Due to heredity there are various human races and varieties of plants and animals.
- A human ear has different shapes. The ear lobe may be free or attached.
- A human eye colour may black, brown, hazel (light brown), green and blue etc.

Review Questions

1. Encircle the correct answer from the following choices.

(i) The cell which divides is called
(A) parent cell (B) daughter cell
(C) original cell (D) all of these

(ii) The cells produced by the division of a cell is called
(A) parent cell (B) daughter cells
(C) original cell (D) all of these

(iii) Which type of cell division takes place in body cells?
(A) mitosis (B) meiosis
(C) asexual reproduction (D) sexual reproduction

(iv) The type of cell division that occurs in the special cells of sex organs is
(A) mitosis (B) meiosis
(C) asexual reproduction (D) sexual reproduction

(v) In humans the number of chromosomes is
(A) 43 (B) 44
(C) 45 (D) 46

(vi) There are eight chromosomes in
(A) fruit fly (B) house fly
(C) dragon fly (D) may fly

(vii) Chromosomes are located in
(A) nucleolus (B) cell membrane
(C) nucleus (D) cytoplasm

(viii) DNA strand is made up of:
(A) two strands of nucleotides that run in opposite direction
(B) one strand of nucleotides that runs spirally
(C) two strands of nucleotides that run in same direction
(D) four strands of nucleotides that run in opposite direction

(ix) The science of heredity is called
(A) biotechnology (B) genetics
(C) bioinformatics (D) biochemistry

(x) What happens to the chromosome number during meiosis?
(A) It halves (B) It doubles
(C) It remains the same (D) It becomes tripple in number

(xi) Sister chromatids are attached to each other at an area called the
(A) centriole (B) centromere
(C) spindle (D) kinetochore

(xii) If a cell has 12 chromosomes, how many chromosomes will each of its daughter cell have after mitosis?
(A) 4 (B) 8
(C) 12 (D) 24

(xiii) At the beginning of cell division, a chromosome consists of two
(A) centromere (B) chromatids
(C) centriole (D) spindle

(xiv) The phase of mitosis during which chromosomes become visible and the centrioles separate from one another is
(A) prophase (B) metaphase
(C) anaphase (D) telophase

(xv) The process of passing characteristics from parents to offspring is
(A) reproduction (B) biotechnology
(C) behaviour (D) heredity

(xvi) The section of DNA that contains sequence of nucleotides for the formation of a protein is called
(A) chromosome (B) centromere
(C) chromatid (D) gene

(xvii) In the cell the DNA is present in
(A) cell membrane (B) cytoplasm
(C) chromosome (D) centriole

Short Questions

2. Define the following: mitosis, meiosis, chromosomes, heredity, gene, and genetics.
3. Where does mitosis occur?
4. State where does meiosis take place in human males and in females?
5. Where does meiosis occur in plants?
6. What are the steps of mitosis?
7. What are the steps of meiosis?
8. The number of chromosomes in fruit fly is 8. What is the number of chromosomes in its sperm or egg?

9. Draw and label a nucleotide?
10. Name the four nitrogenous bases of DNA.
11. What is a gene?

Extensive Questions

12. What is heredity? Explain.
13. What is the importance of (a) heredity (b) mitosis (c) meiosis?
14. Describe the process of mitosis in an animal cell.
15. Describe the process of meiosis in an animal cell.
16. What are the difference between mitosis and meiosis?
17. Describe the structure of DNA.

Science, Technology and Society Connections

- According to heredity genes are responsible for making characteristics of an organism, but environment also plays role in the final appearance of characteristics. Explain with an example.
- How the discovery of DNA has brought revolution in biological and medical science.

Answers of MCQs

(i)	A	(ii)	B	(iii)	A	(iv)	B	(v)	D
(vi)	A	(vii)	C	(viii)	A	(ix)	B	(x)	A
(xi)	B	(xii)	C	(xiii)	B	(xiv)	B	(xv)	D
(xvi)	D	(xvii)	C						

3 BIOTECHNOLOGY

CONTENTS

Making of a biotech food crop

This is a 14 days lesson
(periods including homework)

After completing this lesson, you will be able to:

- Define biotechnology
- Explain how DNA is copied and made.
- Describe the relationship between DNA, genes and chromosomes.
- Define bacterium.
- Explain how genes are introduced into a bacterium.
- List some biotechnological products used in daily life.
- Explain that genetic modification in different foods can increase the amounts of essential nutrients.
- List general applications of biotechnology in various fields.
- Explain how biotechnology allows meeting the nutritional needs of growing populations.

Reading

Look at the above picture. What the girl is doing? Perhaps she is trying to modify a biotech food crop. Did you have yogurt or bread for breakfast today? Has your mother put cheese in sandwiches in your school lunch box? How about the chips in vinegar? If the answer to any of these questions is 'yes' then you have just used a few of the products of biotechnology.

3.1 BIOTECHNOLOGY

What is biotechnology? Biotechnology is not easy to define. The word **biotechnology** describes the way we use plant cells, animal cells and microorganisms to produce substances that are useful to us.

> Biotechnology, is the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life.

The word 'biotechnology' was coined only in 1970. Although the word biotechnology is new, the process of biotechnology has a long history. The use of moulds and bacteria are early examples. For thousands of years, yeast is used to make cheese, bread etc. The ancient civilization of Egypt and China knew that bacteria turn milk into yogurt. Now it will be easy to define biotechnology. Biotechnology is the way that we use living organisms in particular microbes, to produce useful substance.

Science Titbits

Biotechnology in Pakistan: The National Institute of Biotechnology and Genetic Engineering (NIBGE) is the country's major biotech research establishment, concentrating on research in plants, environmental, and medical biotechnology. A Centre of Excellence in Advanced Molecular Biology has been established at Punjab University in 1988. Biotechnology, is being taught at general as well as in agricultural and medical universities.

Before studying details of biotechnology we will see the process of DNA replication (duplication). The process of DNA replication is involved in all biological technique.

3.2 DNA REPLICATION

Before every cell division cell makes copies of chromstids of the chromosomes in the interphase. Now each chromosome consists of two sister chromatids. We have already seen that chromosome consists of DNA and protein.

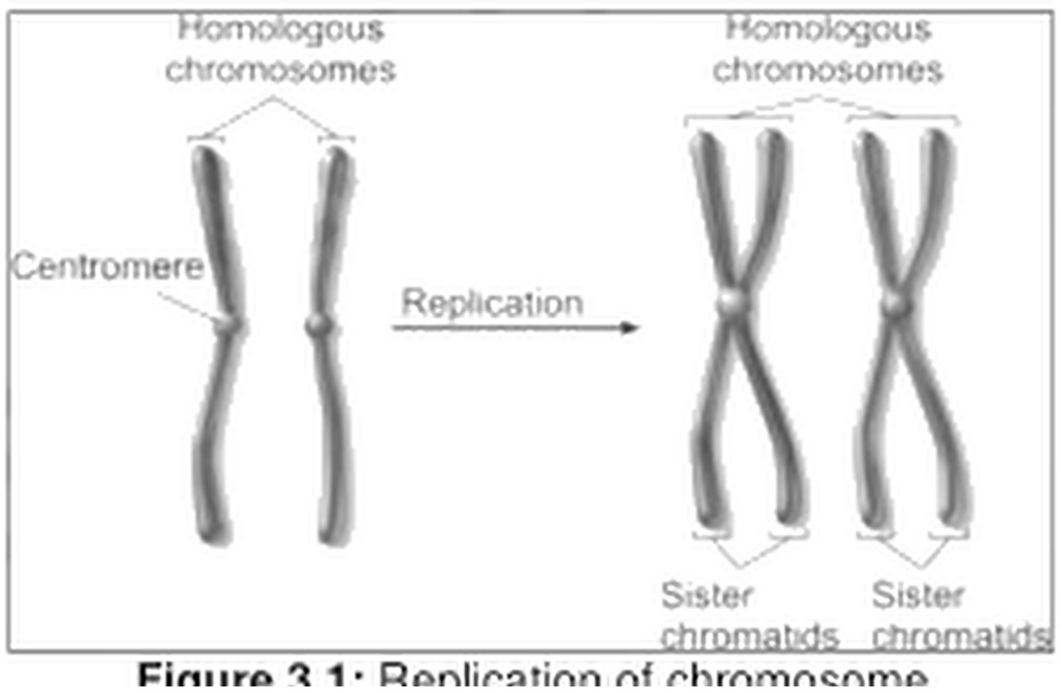


Figure 3.1: Replication of chromosome

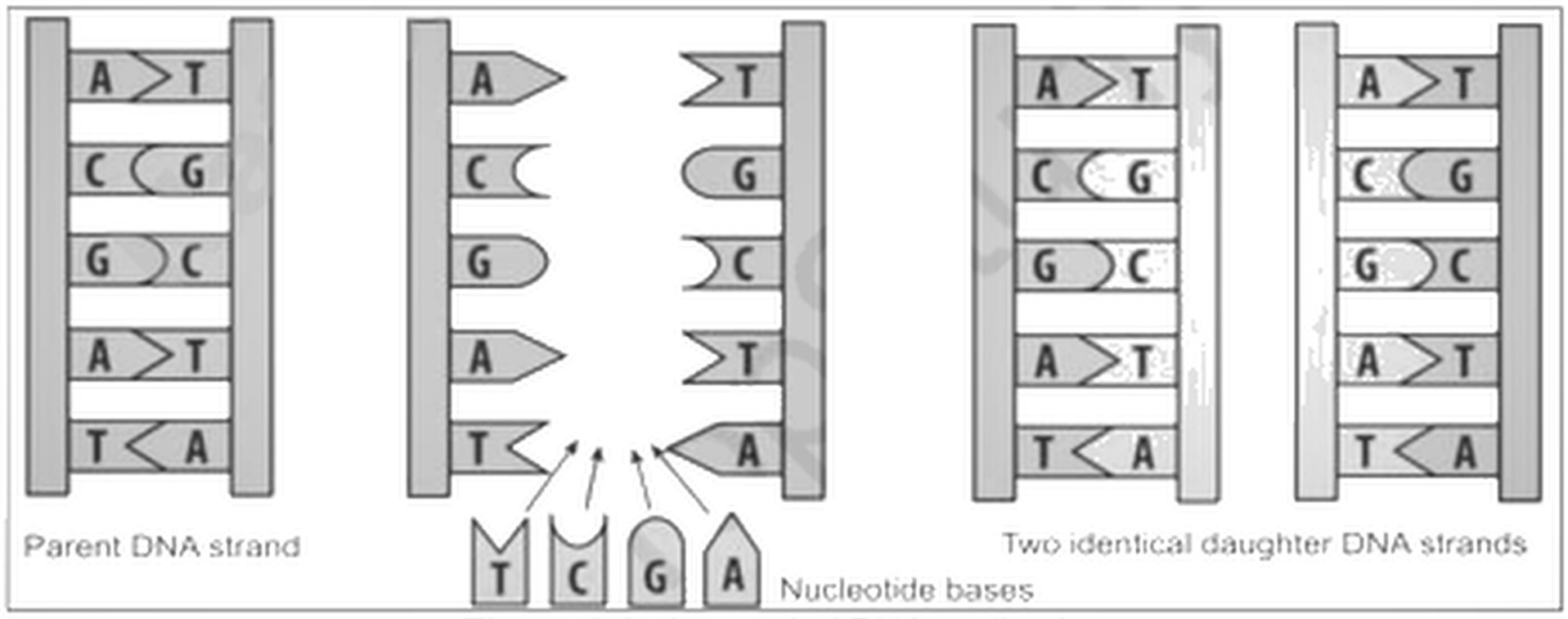
For making a copy of chromatid, the DNA has also to be copied. The copying process is called **replication**. This process ensures that each daughter cell will have a complete set of DNA molecules.

The main steps of DNA replication are as follows:

DID YOU KNOW?

Template is the coded instruction for the formation of a further molecule carried by a molecule of DNA. During DNA replication, the special enzyme that unwinds the double helix molecule of DNA is called helicase and base pairing and joining are carried out by an enzyme called polymerase and ligase.

1. The old strands that make up the parent DNA molecule unwind. The hydrogen bond between the nucleotides separate one by one. The hydrogen bond loosening can be linked to the opening of zipper. The interlocking teeth represent H-bond and each tooth is a base. There is a special enzyme that unwinds the DNA molecule.
2. As this occurs within the nucleus bases (tooth of the zipper) become exposed to the contents of the nucleus.
3. As the bases are exposed, new bases are added following the 'rule of base pairing'. In other words if the base on the strand is adenine (A) thymine (T) is added to the newly forming strand. Likewise guanine (G) is always paired with cytosine (C). With each new base phosphate and deoxyribose molecule takes their normal position.
4. The new nucleotides join to form a new strand. For example a strand that has



bases ACGAT produces a strand with the complementary bases TGCTA (Fig.3.2). The result is two DNA molecules identical to each other and to the original molecule. Note that, each DNA molecule resulting from replication has one original strand and one new strand (Fig.3.2). Base pairing and joining are carried out by special enzymes.

> The process of making identical copies of DNA double helix using existing DNA as a template for the synthesis of new DNA strands is called **DNA replication.**

Activity 3.1

OPENING OF DNA STRANDS IS LIKE THE OPENING OF A ZIPPER

Teacher will provide zippers to five groups of students considering it as DNA double helix and display a chart of DNA double helix and ask:

Q1. What do the two sides of zipper represent?

A1. Two sides of zipper represent two strands of DNA

Q2. What does inner side represent?

A2. The inner side of zipper represent nitrogenous bases bounded with hydrogen bonds between two strands.

Teacher will instruct the students to open the zipper.

Q3. What is happening during opening of zipper considering it as DNA double helix?

A3. The DNA double helix unzips and the weak hydrogen bonds between the bases are broken.

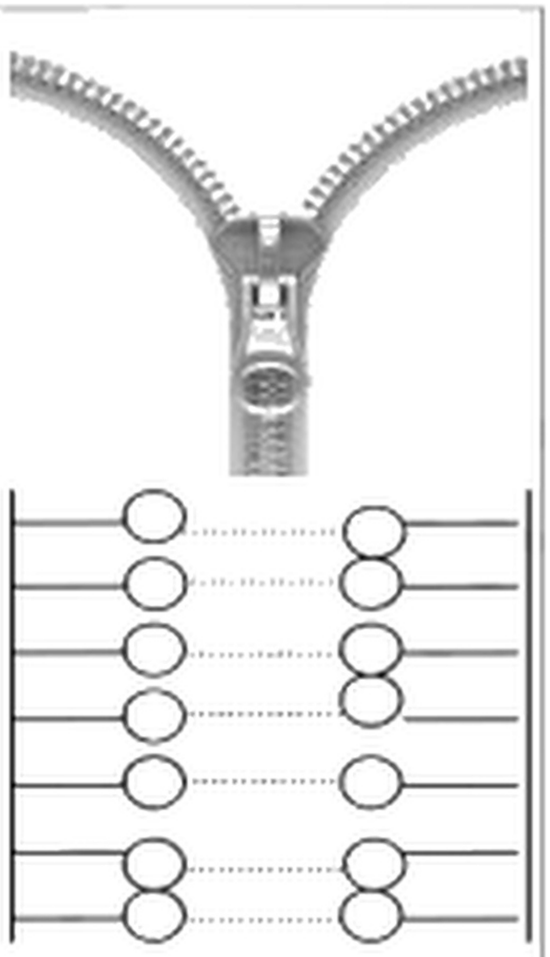


Figure 3.3: DNA replication

DID YOU KNOW?

Watson and Crick discovered the double helix structure of DNA in 1953. Each half of the DNA molecule could separate from the other and make an exact copy of it. This means that chromosomes and genes could also make exact copy of themselves when the cells divide. Watson and Crick were so excited at their discovery that they dashed out of the Cavendish Laboratory and ran down the street looking for people to tell. In 1962, Watson, Crick were awarded Nobel Prize for their work on DNA structure.

Reading

3.3 RELATIONSHIP BETWEEN DNA, GENES AND CHROMOSOMES

What is the relationship between DNA, genes and chromosomes? Recall basis of heredity in chapter 2. You have already identified chromosomes in the cell. The chromosome of a plant cell and an animal cell is made up of DNA and protein forming thread like fibres called **chromatin**. These fibres form a chromatin network in the nucleoplasm. During the cell division of a cell chromatin fibre condenses and coils up into separate structures called **chromosomes**. **DNA** is associated with basic protein molecules called **histones**. **Gene** is the unit of heredity. Now the question arises that where is gene present? When the male and female gametes fuse they form the zygote. What the zygote has received from the parents? The only thing contributed by the parents to the zygote or the offspring are the chromosomes. So the unit of characteristics or genes must be present on the chromosome. The genes are located linearly on the chromosomes. The location of the genes on the chromosomes is specific. The linear order of gene location on a homologous pair of chromosomes is identical. Now we know that gene is any group of 'three nucleotides' that forms a characteristic.

DID YOU KNOW?

How the genes work? A gene works by forming protein. A protein consists of amino acids. A DNA molecule however cannot directly control the sequence of amino acids. Why? Because DNA is found in the nucleus and making of protein occurs in the cytoplasm. According to the base sequence of DNA, another type of nucleic acid is made called messenger Ribonucleic acid (mRNA). According to base sequence of mRNA specific sequence of amino acid is formed in the protein.

3.4 BACTERIA

Bacteria are cells that are big enough to be seen under the light microscope. Bacteria are found everywhere. They are found in the air, in water, in the soil. They are also found outside and inside the body of plants and animals. Look at figure

Can you see the differences between the bacterial cell and an animal cell or a plant cell? The bacterial cell has a cell wall, but not made of cellulose as in the plant cell. There is no proper nucleus, just a loop of DNA and without any nuclear membrane. Many of the structures found inside other cells such as, mitochondria, Golgi apparatus, endoplasmic reticulum etc., are absent in a bacterial cell. Bacterial often have additional loops of DNA in the cytoplasm called **plasmids**. Some bacteria have **flagellum** and some are without flagellum. The flagella may be one, two or many. Some bacteria have hollow protein filaments called **pili**. They take part in the attachment on the surface and also in reproduction. The study of bacteria is called **bacteriology**. Now can you define a bacterium?

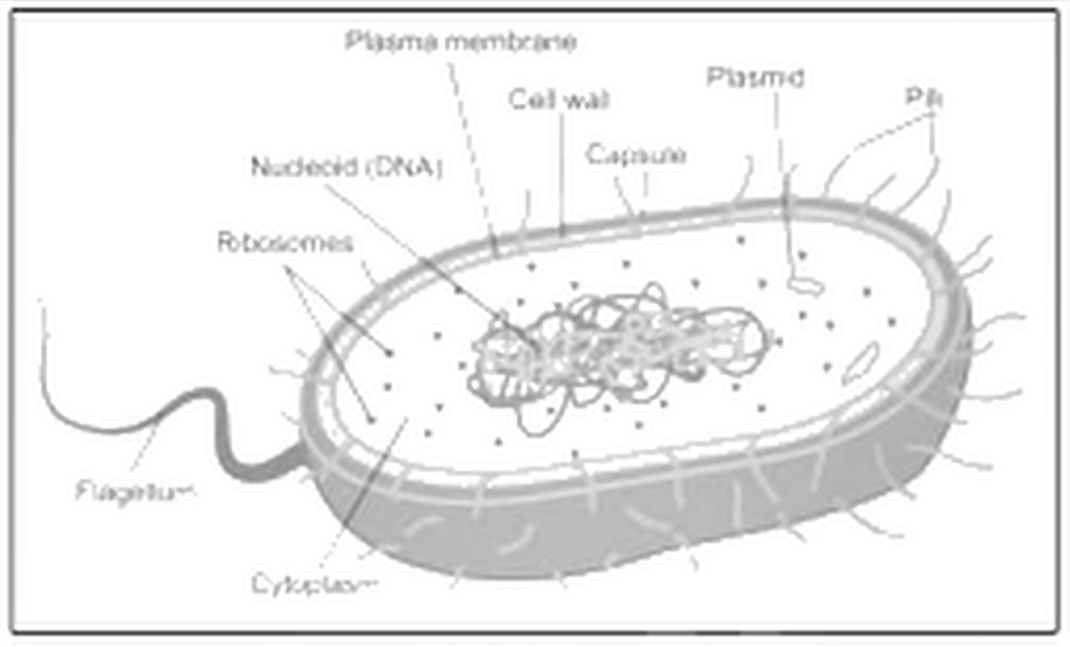


Figure 3.4: A bacterial cell

A bacterium is a unicellular micro-organism having cell wall not made of cellulose, no nuclear membrane, most of the structures found in a plant cell and animal cell are absent, but have ribosomes, cytoplasm, cell membrane, pili and plasmids.

3.4.1 How a Gene is introduced into a Bacterium?

Step 1: Two types of DNA are isolated: the bacterial plasmid and the human cell DNA containing the gene of interest (insulin).

Step 2: Both the plasmid and human DNA are treated with same restriction enzymes. The enzyme cuts the plasmids DNA as well human DNA at one specific restriction site. In making the cuts, the restriction enzyme creates sticky end on both the human DNA fragment and the plasmid.

Step 3: The human DNA is mixed with cut plasmid. The sticky ends of the plasmid base pair with the complementary sticky ends of the human DNA fragment.

Step 4: The enzyme **DNA ligase** joins the two DNA molecules. The result is a DNA plasmid containing insulin gene.

Step 5: This DNA plasmid containing insulin gene is added to a bacterium. The

Step 6: Bacteria divide rapidly. Every time a bacterium divides, the plasmid is replicated containing insulin gene. The insulin gene instructs the bacteria to make insulin (Figure 3.5).

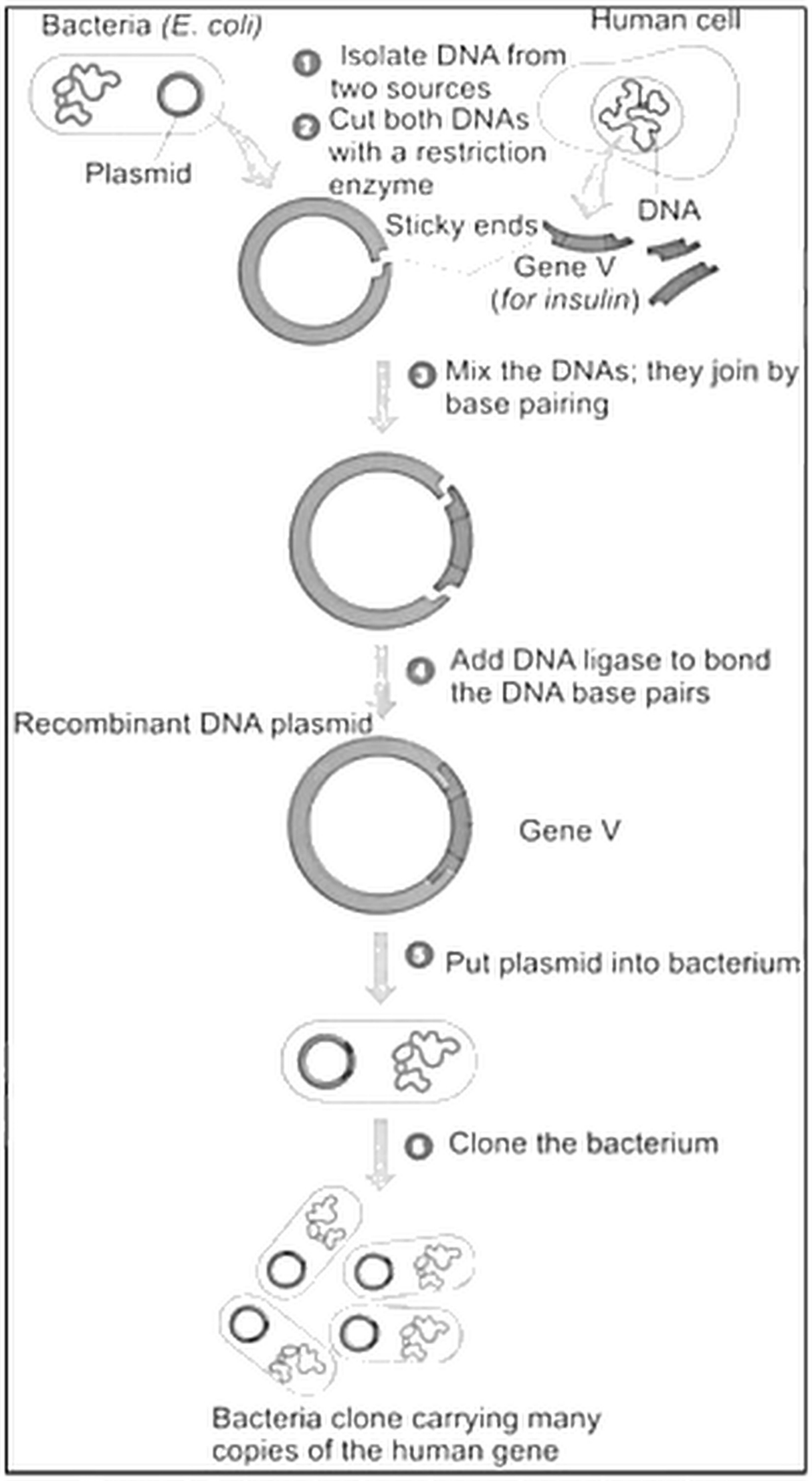


Figure 3.5: Introduction of gene into a bacterium

To make multiple copies of gene or organism is called **cloning**. The free-living organisms in the environment that have had a foreign gene inserted into them are called **transgenic organisms**. Can you name some biotechnological products used in daily life? Bread, yogurt, cheese, vinegar, soya sauce, leather, biodegradable plastic, bio-ethanol (bio-fuel) is some of the biotechnological products used in daily life.

Science Titbits

Biotechnology has been divided into three types on the basis of uses. The term **red biotechnology** is used for medical process such as production of antibiotics. **White biotechnology** or industrial biotechnology is the manipulation of organisms to produce useful chemicals such as enzymes. **Blue biotechnology** is concerned with the application of molecular biological methods to marine and fresh water organisms. It involves the use of these organisms. for the purposes of such as an increasing seafood supply.

3.5 GENETIC MODIFICATION

Genetically modified crops (GM crops, or biotech crops) are plants, the DNA of which has been modified using genetic engineering techniques, which are then used in agriculture.

1. Microorganism Resistance

Plants can suffer from infections caused by fungi, bacteria, viruses, nematodes, and other pathogens.

Fungus Resistance GM Plants

Fungi are responsible for a range of serious plant diseases such as blight, grey mould. Crops of all kinds often suffer heavy losses. Genetic engineering enables new ways of managing fungal infections through fungus resistant GM plants.

Virus Resistant GM Plants

Biotechnology can be used to make virus resistant crops. The most common way of doing this is that scientists insert special genes in the seed of plants. When seed germinate, the inserted genes are copied in all the cells of the plant. These plants make proteins that are harmless to the plants but poisonous to the viruses and other microorganisms

Figure 3.6: GM Golden rice

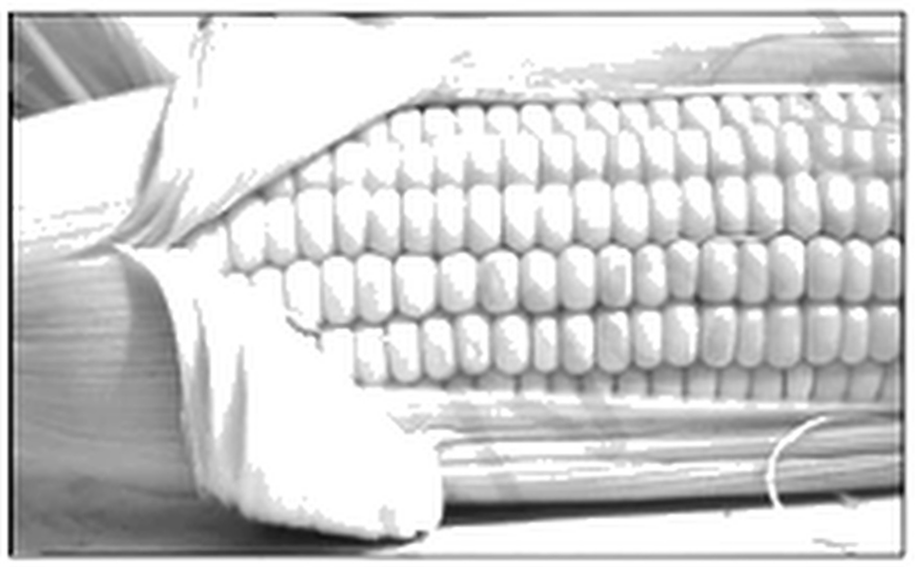
2. Improved Nutrition

The GM oilseed crops on the market today offer improved oil profiles for processing or healthier edible oils. GM plants that have been developed are maize and wheat etc., is enhanced with protein and other nutrients while golden rice developed by the International Rice Research Institute (IRRI), is a possible cure for Vitamin A deficiency. Such rice can help to treat patient of sight problem.

3. Quality of food

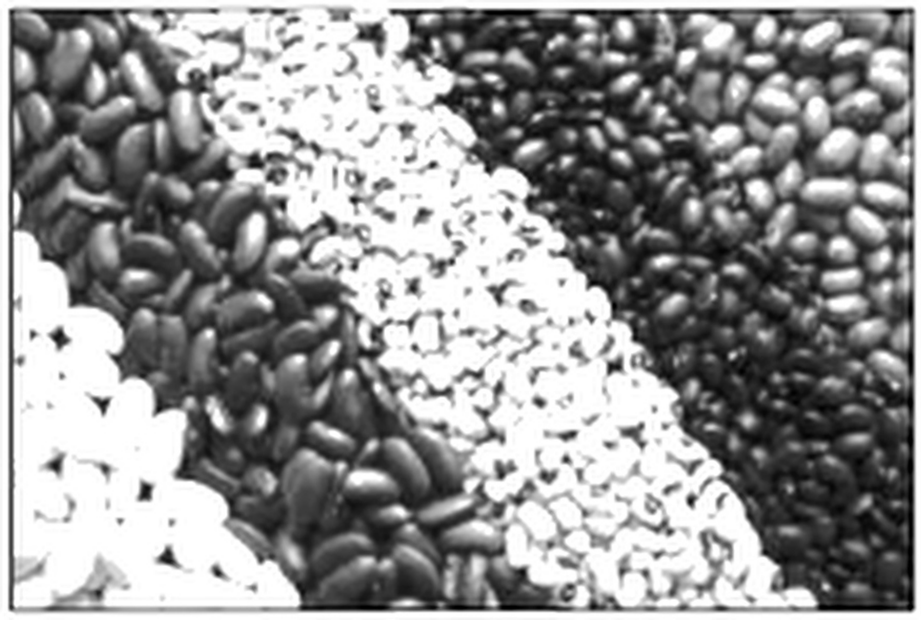
Through genetic modification quality of food has been improved in plants such as soya bean (soybean), maize, canola, squash, papaya, alfalfa, sugar beet, potato, rice, sugarcane, sweet peepers, and tomatoes. (a) GM bananas are larger

GM Banana



GM Sweet Corn

GM Tomatoes



GM Soya Beans

GM Cotton GM Canola

Figure 3.8: Genetically modified food crops

in size and grow more rapidly. (b) GM soya beans seeds germinate faster and oil produced from the seeds has more nutrients. (c) GM sugar beet crops are herbicide-resistant. (d) A variety of sweet corns have been developed. They contain insect killing gene. (e) GM tomatoes do not rot as quickly as normal tomatoes. (f) GM canola is less bitter than normal canola (h) GM cotton grows faster and has resistance against environmental problems.

3.6 LIFESAVING BIOTECHNOLOGY PRODUCTS

Genetic engineering has applications in medicine providing lifesaving drugs.

One of the advantages of biotechnology is that, it is due to biotechnology that mass production of proteins is possible, that are very difficult to obtain. In medicine, genetic engineering has been used to mass-produce insulin, human growth hormones human albumin, monoclonal antibodies, vaccines and many other drugs. Here we will discuss insulin and vaccines.

Science Titbits

Monoclonal antibodies are the same because they are made by identical immune cells that are all clones of a unique parent cell, in contrast to polyclonal antibodies which are made from several different immune cells. The part of the antigen that the antibody binds to is called the epitope. The antibody binds only to its particular epitope.

Insulin

Amongst the earliest uses of biotechnology, is the use of recombinant DNA technology to modify the bacteria *E. coli (Escherichia coli)* to produce **human insulin**. Prior to the development of biotechnology, insulin was extracted from the gland pancreas

Vaccines

Vaccines are used to make people immune to an infectious organism so they do not become ill when exposed to it. Vaccination generally involves injecting weak, live, killed or inactivated forms of viruses into the person being immunized. Vaccines produced through biotechnology do not cause illness. A vaccine for hepatitis B is now available. Vaccines are available through biotechnology for the inoculation of farm animals. There are vaccines for such illnesses like a hoof-and mouth disease and dysentery.

3.7 GENERAL APPLICATIONS OF BIOTECHNOLOGY

Genetic engineering has applications in agriculture, environment, health and food production and preservation.

3.7.1 Agriculture

Some applications of biotechnology in agriculture are as:

(a) Genes are inserted into the plants so that they can tolerate environmental problems e.g., extreme temperature and shortage of water. Legumes (plants that bear their fruit in pods, which are casings with two halves e.g) and cereals (grains used as food, such as wheat, barley etc.) are modified to make proteins needed by humans.

Science Titbits

Trinitrotoluene (TNT) is a chemical compound .This yellow-coloured solid is sometimes used as a reagent in chemical synthesis. but it is best known as a useful explosive material. RDX, an initials for Research Department explosive is an explosive nitro-amine widely used in military and industrial applications. It was developed as an explosive which was more powerful than TNT

(b) Many plants can tolerate herbicides which are sprayed to kill weeds.

(c) Genes of animals such a cows and goats have been altered to get more milk and proteins, Biotechnology improves crop insect resistance, enhances crop, herbicide tolerance etc.

3.7.2. Environment

Genetically modified plants have also been used for bioremediation of contaminated soils. Mercury, selenium and organic pollutants e.g., TNT and RDX have

been removed from soils by transgenic plants containing genes for bacterial enzymes. Naturally occurring bacteria that eat oil can be genetically engineered for cleaning up beaches after oil spills. Industry has found that bacteria can be used as bio-filters to prevent airborne chemical pollutants from being vented (an airhole) into the air. Scientists have developed a weed *Arabidopsis thaliana* that contains genes from bacteria that can clean up TNT and RDX-explosive contaminants from the soil.

3.7.3 Health

Biotechnology is used in health sector. It is used to create products including therapies and drugs, vaccines and new diagnostic and testing equipments.

(1) Therapeutics

New biological drugs include skin grown for burn victims, gene and stem cell therapies (see glossary). Bacteria and fungi have been modified for the production of antibiotics. Antiviral protein called **interferon** is produced by inserting the human gene into bacteria. Such proteins are used for the treatment of many viral infections e.g., hepatitis. Modified bacteria are used to produce growth hormone, which is used for treating persons suffering from low growth rate.

(2) Diagnostics

Test kits for HIV, or diabetes provide new, lower cost, options to test for devastating diseases quickly and effectively.

(3) Medical Devices

These include biosensors, stents, prostheses etc., (see glossary).

(4) Vaccines

New vaccines for childhood and adult diseases e.g., hepatitis vaccine have been developed.

Science Titbits

Currently, there are more than 250 biotechnology health care products and vaccines available to patients, many for previously untreatable diseases.

Projects 3.1

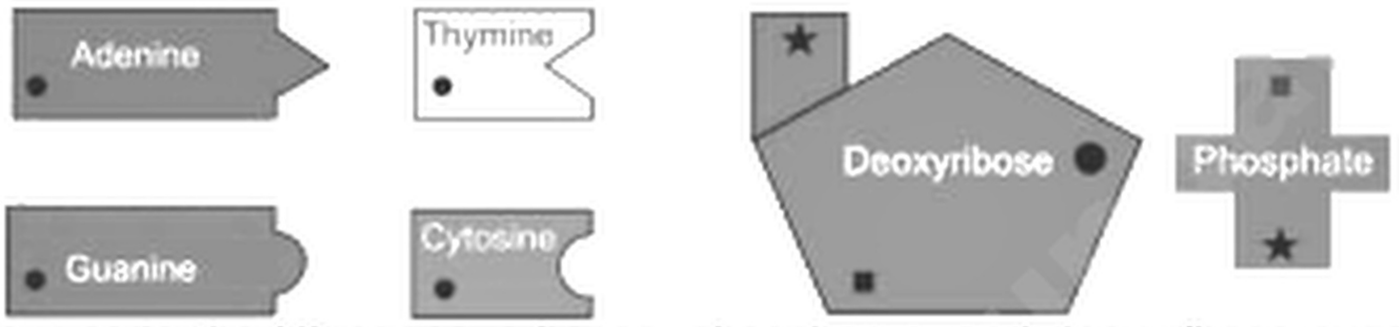
MAKING A MODEL OF DNA REPLICATION

Materials

(1) Cut outs of basic subunits of DNA (2) Colours or markers
(3) A pair of Scissors (4) Tape or glue (5) Paper and pencil

Procedure

1. Cut out all of the units needed to make the nucleotides from the handout provided. You can make 8 to 100 copies of it.



1. Colour code the Nitrogenous bases, phosphorus, and deoxyribose sugar as follows: Adenine = red, Guanine = green, Thymine = yellow, Cytosine = blue, Phosphate = brown, and Deoxyribose = purple.
2. Using the small squares and stars as guides, line up the bases, phosphates and sugars.
3. Now glue the appropriate parts together forming nucleotides.
4. Construct DNA model using the following sequence to form a row from top to bottom - cytosine (top most), thymine, guanine, and adenine (bottom most).
5. Let this arrangement represent the left half of your DNA molecule.
6. Complete the right side of the ladder by adding the complementary bases. You will have to turn them upside down in order to make them fit.
7. Your finished model should look like a ladder.
8. To show replication, separate the left side from the right side, leaving a space of about 6-8 inches.
9. Use the remaining nucleotides to complete the molecule using the left side as the base.
10. Build a second DNA model by adding new nucleotides to the right half of the original piece of the molecule.
    Tape the nucleotides together to form two complete DNA ladders.

Key Points

- Biotechnology is the way that we use living organisms in particular microbes, to produce useful substance.
- The process of making identical copies of DNA double helix using existing DNA as a template for the synthesis of new DNA strands is called DNA

- There is a special enzyme called helicase that unwinds the parent DNA molecule.
- Base pairing and joining are carried out by an enzyme complex called DNA polymerase and ligase.
- During replication each parent DNA strand of the parent molecule serves as a template for a new strand in the daughter molecule
- The genes are located linearly on the chromosomes. The linear order of gene location on a homologous pair of chromosomes is specific and identical. Gene is any group of 'three nucleotides' that forms a characteristic.
- Bacteria are unicellular micro-organisms that have cell wall not made of cellulose. They have no nuclear membrane. Bacteria have ribosomes, cytoplasm, cell membrane, pili and plasmids.
- Some of the biotechnological products used in daily life are bread, yogurt (yoghurt, yoghourt), cheese, vinegar, soy sauce, leather, bio degradable plastic, bioethanol (biofuel).
- Genetic modifications include microorganism resistance, improved nutrition and quality of food.
- Biotechnology lifesaving products includes the hormone insulin, and vaccines.
- The general applications of biotechnology in various fields include: agriculture, food production and preservation, environment and health.

Review Questions

1. Encircle the correct answer from the following choices.

(i) The replication of DNA takes place in the:

(A) nucleoplasm (B) cytoplasm

(C) cell membrane (D) nuclear membrane

(ii) During replication which sequence of nucleotides would bond with the DNA sequence TATGA?

(A) ATACT (B) AAAGA

(C) TATGA (D) TATGA

(iii) Which of the following nucleotides (s) bond (s) with adenine?

(A) thymine only (B) thymine and guanine

(C) cytosine (D) cytosine and guanine

(iv) Watson and Crick created a model of DNA. What is the name of this model?
(A) operon (B) single helix
(C) double helix (D) frame shift model

(v) It is mostly used in biotechnology
(A) animal cells (B) plant cells
(C) microorganisms (D) fungi

(vi) Biotechnology lifesaving products are:
(A) hormones (B) insulin and vaccines
(C) vaccines (D) growth hormones

(vii) DNA replication is a process in which
(A) copies of DNA are made (B) DNA is repaired
(C) DNA makes proteins (D) DNA breaks down

(viii) Which of the following component is used for carrying the gene of interest into a bacterium?
(A) plasmid (B) protein
(C) chromosome (D) chromatid

(ix) In future, "Golden rice" could help to treat
(A) sight problems (B) diarrhoea
(C) deafness (D) diabetes

(x) Genetically modified tomatoes are useful because they
(A) have more vitamins
(B) are resistant to microorganisms
(C) grow fast
(D) easy to cultivate

(xi) Which one is used to treat diabetes?
(A) growth hormone (B) vaccines
(C) interferon (D) insulin

(xii) Interferon is used for
(A) cleaning oil spills (B) treating sewage water
(C) treating bacterial infection (D) treating viral infection

Short Questions

2. Define the following: biotechnology, DNA replication, bacteria, bacteriology, plasmid, insulin, vaccine?

3. If 30% of a DNA molecule is Adenine, what percent is Cytosine?
4. What is the difference between?
   (a) chromatin and chromosome (b) biotechnology and bacteriology
5. Name a few biotechnological products.
6. What is meant by the term "genetically modified"?
7. Name a nucleic acid other than DNA.
8. Name a nucleotide other than adenine, thymine, cytosine and guanine.

Extensive Questions

9. Explain replication of DNA.
10. Describe the structure of a bacterium.
11. How a gene is introduced into a bacterium?
12. What are the general applications of biotechnology in agriculture?
13. What are the general applications of biotechnology in environment related issues?
14. What are the general applications of biotechnology in health related issues?
15. How is genetic modification important?

Science, Technology and Society Connections

- In Pakistan there are many biotechnology institutes. Make a list of such institutions and the names of the courses they offer to the students.
- Make a list of any five medicines which are being produced using biotechnology.

Answers of MCQs

(i)	A	(ii)	A	(iii)	A	(iv)	C	(v)	C
(vi)	B	(vii)	A	(viii)	A	(ix)	A	(x)	B
(xi)	D	(xii)	D						

4 POLLUTION AND THEIR EFFECTS ON ENVIRONMENT

CONTENTS

Woman lights firewood to cook food at her home. Children tend to get affected by the smoke being exposed from a young age.

This is a 15 days lesson
(periods including homework)

After completing this lesson, you will be able to:

- Explain the sources (natural and from human activities), properties and harmful effects of air pollutants.
- List problems in human organ systems caused by air pollutants.
- Plan and conduct a campaign that can help to reduce air pollution in their local environment.
- Explain the greenhouse effect.
- Describe the causes and effects of ozone depletion.
- Carry out a research to explain global warming and its likely effects on life on earth.
- Design a model to explain the greenhouse effect.
- Explain the formation of acid rain and identify its consequences on living and non- living things.
- Define deforestation.
- State the effects on deforestation on the environment.
- Identify human activities that have long term adverse consequences on the environment.
- Explain the importance of local and global conservation of natural resources.
- Suggest ways in which individuals, organizations and government can help to make earth a better place to live.

Reading

You must have seen smoke coming out of chimneys of factories or some car, buses etc., emitting black thick smoke. While passing through dirty stream, or pond etc., there is pungent smell and you are compelled to cover your nose. If your room or kitchen becomes full of smoke, your throat will chock. Can you breathe here easily? Something has been added to the air that makes breathing difficult. The release of any substance into the environment that adversely affects the lives and health of living things is called **pollution**. The substances that cause pollution are called **pollutants**. In this chapter we will discuss air pollution, harmful effects of pollutants, and effects of human activity on environment and how to save the Earth.

4.1 AIR POLLUTION

Air pollution began when humans first used fire. Air pollution, is mainly due to the incomplete burning of fuels such as coal, oil, petrol and wood. The air pollution is also due to human activities or natural occurrences e.g., biological decay, forest fires, and volcanic eruptions. The harmful substances released into the air include sulphur dioxide, carbon monoxide, oxides of nitrogen and chlorofluorocarbons (CFCs). Can you tell that: Where these pollutants come from? What are their properties? What harm they do? What can be done about them?

Figure 4.1: Air pollution

4.1.1 Sulphur dioxide

Source: The main source of sulphur dioxide is the burning of fossil fuel, e.g., coal, oil and natural gas. Natural sources of sulphur dioxide include release from volcanoes, biological decay and forest fires.

Properties: It is a colourless gas. It has a very irritating smell.

Effects: Inhaling sulphur dioxide causes coughing, chest pain and shortness of breath. It is poisonous. It will kill human being if its level reaches up-to 0.5%. It is one of the causes of bronchitis and lung disease.

4.1.2 Carbon monoxide

Source: Most of carbon monoxide comes from the exhaust gases of motor vehicles. This is due to incomplete combustion of fuel. The chimneys of industries also emit this gas.

Properties: It is colourless, tasteless and odourless gas, so it gives no warning of its presence.

Effects: Carbon monoxide ties up haemoglobin and prevents it combining with oxygen. A person may be killed if the level of carbon monoxide reaches 0.1% of the air.

4.1.3 Oxides of Nitrogen

Nitrogenous oxides are combination of oxygen and nitrogen, in air pollution e.g., nitrogen monoxide (NO) and (b) Nitrogen dioxide (NO_2).

Source: Nitrogen oxides are emitted into the atmosphere from motor vehicles. It is produced during thunderstorm. Agricultural fertilizers and the use of nitrogen fixing plants also contribute to atmospheric nitrogen monoxide NO. Natural sources of nitrogen oxides include volcanoes, oceans, biological decay and lightning strikes.

Properties: NO_2 is a dark brown, fuming liquid or gas with a pungent, acrid (biting) odour. NO is a colourless gas with a sharp, sweet odour, brown at high concentrations in air. NO_2 is highly soluble in water, to form nitric acid (a strong acid). NO is slightly soluble in water, to form nitrous acid (a weak acid).

Effects: NO reacts with other compounds to form nitric acid vapour. Inhalation of such particles may cause or worsen respiratory diseases such as bronchitis. NO reacts with volatile organic compounds in the presence of sunlight to form ozone. Ozone when inhaled damages lung tissues. Oxides of nitrogen combine with fog to form smog. The smog causes asthma, cough and wheezing.

4.1.4 Chlorofluorocarbons

Source: They are used as aerosol propellants, as cooling agents in refrigerators, freezers and air conditioners, and in foam packaging. When such devices work they release CFCs in air.

Properties: It contains chlorine, fluorine and carbon. They are non-toxic, non-reactive chemicals. They spread through the atmosphere without reacting with other substances and drift into the upper atmosphere. It is colourless, odourless and lighter than air in weight.

Effects: When CFCs are released into the atmosphere from aerosols, etc., they breakdown the ozone layer forming ozone hole.

DID YOU KNOW?

Micro-computers and sensors are taken up in aircraft to keep watch on the ozone layer. The sensor detects the thickness of the ozone layer and the micro-computer records the measurement.

DID YOU KNOW?

Many products contain chemicals that can destroy the protective layer of ozone that surrounds our planet. You should try to avoid products with the following kinds of chemicals:

(a) Chlorofluorocarbons (CFCs) (b) Halons (c) Carbon tetrachloride (d) Methyl chloroform

4.2 HARMFUL EFFECTS OF AIR POLLUTANTS

The problems in human organ systems caused by air pollutants include short term and long term health effects.

Short-Term Health Effects: Air pollution can cause irritation of the eyes, nose and throat. Headaches and nausea can also occur. Pollution can cause asthma attacks as well.

Long-Term Health Effects: Many diseases could be caused by air pollution without their becoming apparent for a long time. Diseases such as bronchitis, lung cancer, and heart disease, appear in people exposed to air pollution. Long-term exposure to air pollution has been associated with diseases of the central nervous system (CNS), including stroke, kidney and liver damage, increase a person's risk of heart attack and stroke.

Air pollutants are associated with birth and developmental defects which include low birth rate, low birth weight, growth retardation, and death of new born etc.

Project 4.1

PLAN AND CONDUCT A CAMPAIGN THAT CAN HELP TO REDUCE AIR POLLUTION IN YOUR LOCAL ENVIRONMENT.

For this purpose you can make placards, posters and can meet people of your area to create awareness about how to reduce air pollution. During your campaign convey people the following points to reduce air pollution:

(a) They should use public transport like bus or train instead of using cars.

(b) Uses energy i.e., light, water boiler, kettle etc., wisely to save fossil fuel and electricity.

(c) Plantation of trees is important as we know that plants absorb carbon dioxide and produces oxygen.

(d) Recycle and re-use things.

(e) Use filters or scrubbers (scrub: to rub hard) on chimneys to remove sulphur dioxide.

(f) Fit catalytic converters to the exhaust system of vehicles. The converters remove most of the nitrogen oxides and carbon monoxide.

(g) Use non-fossil fuels in factories. Examples of these fuels include: nuclear energy wind or water generated energy and solar power.

Reading

4.3 EFFECTS OF HUMAN ACTIVITIES ON ENVIRONMENT

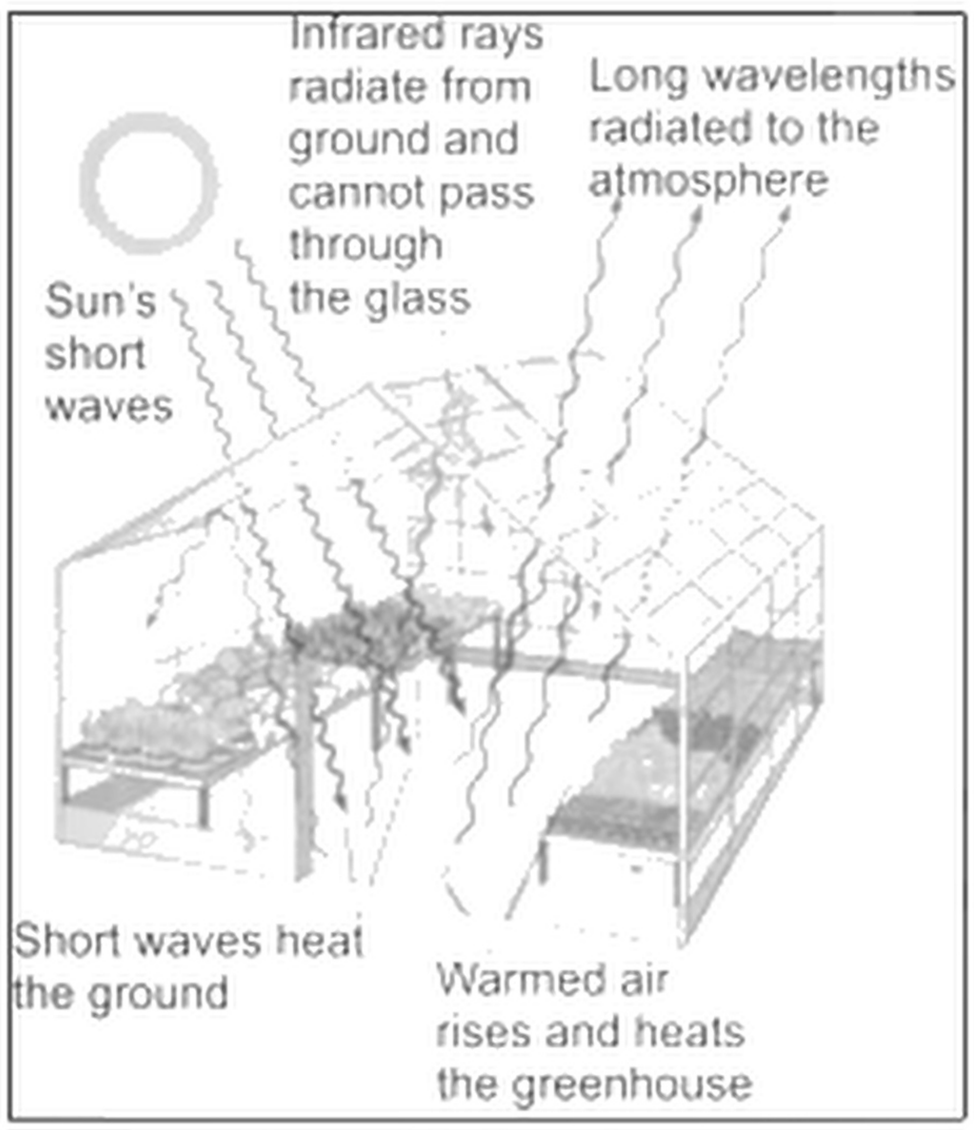
Many species of plants and animals have become endangered or extinct mainly due to human activities. These include environmental pollution and modification of habitats. All environmental problems are connected to

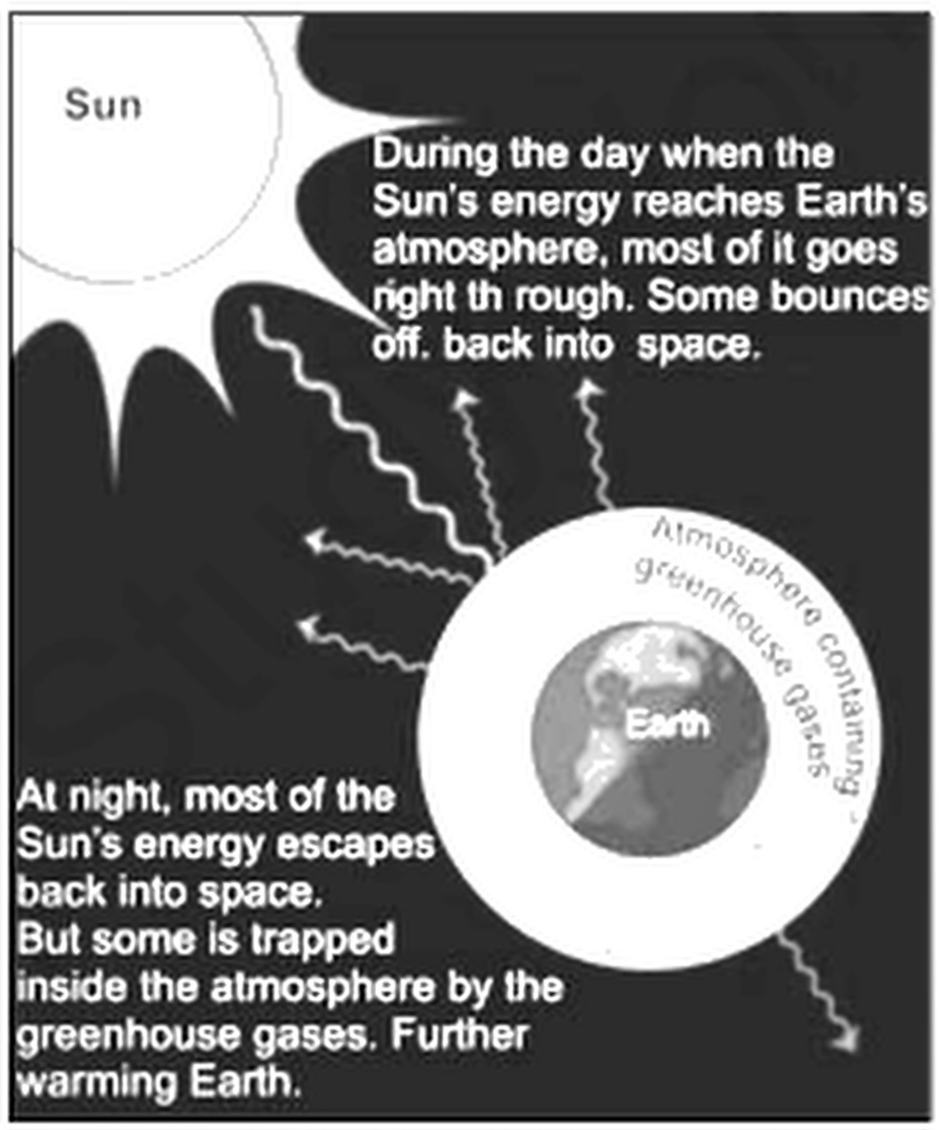
overpopulation. The increase in population requires more land for farms, homes, industry, roads, transports, hospitals, schools and food. Here we will see some of the major effects of human activities on environment i.e., greenhouse effect and global warming, ozone depletion, acid rain, wildlife, deforestation, lack of energy resources.

4.3.1 Greenhouse Effect

A greenhouse is a house made of glass. It has glass walls and a glass roof. People grow tomatoes and flowers and other plants in them. A greenhouse stays warm inside, even during winter. Sunlight shines in and warms the plants and air inside.

The sunlight can pass through the glass of the greenhouse. The Sun's short wave energy consists of ultraviolet, visible light, short wave infrared. Short waves heat the ground. The warm surface re-radiates the energy but in the form of long wave infrared rays, that cannot pass through the glass. Warm air rises and heats the greenhouse. Long wavelengths radiate to the atmosphere.





Science Titbits

Energy from sunlight is called the electromagnetic spectrum. Energy in the form of light waves travels from the sun to Earth. The distance from the peak of one wave to the peak of the next wave is the wavelength. We can see only the visible light. Infrared is invisible radiant energy with longer wavelengths than those of visible light. Two huge factors affect the global radiation balance, **short wave** radiation coming in from the Sun and **long wave** comes from the Earth. The Earth actually gives off radiation like the Sun. The wavelength of the Earth's energy is much longer.

4.3.2 How is Earth like a Greenhouse?

Our atmosphere is made mostly of nitrogen and oxygen, but also contains several other gases. These include carbon dioxide, methane, nitrous oxide, water vapour and ozone which are known as **greenhouse gases**. Earth's atmosphere does the same thing as the greenhouse. The carbon dioxide and water vapour act like the glass in a greenhouse. The natural situation in which heat is retained by the layer of greenhouse gases is called the **greenhouse effect**. During the day, the Sun shines through the atmosphere. Earth's surface warms up in the sunlight. At night, Earth's surface cools, releasing the heat back into the air. But some of the heat is trapped by the greenhouse gases in the atmosphere. That's what keeps our Earth warm.

Science Titbits

If the greenhouse gases were not present in the atmosphere, Earth would be 30 degree Celsius cooler than it is today.

4.3.3 Global Warming

The term used to describe increase in the average temperature of the biosphere is **global warming**. What is the cause of global warming? The first reason is the human activities such as the burning of fossil fuels, has led to an increase in the concentration of greenhouse gases in the atmosphere and sulphur dioxide emissions, which causes the formation of sulphate aerosols in the atmosphere.

What will be the effects of global warming on life on earth? The **effects of global warming** are:

(a) If the level of the sea rose, low lying areas of land would disappear under the sea. The coastal area would be flooded which will have adverse effect on plant and animal life.

(b) Glaciers of the world are melting at a faster rate, which causes flood in the river.

(c) Ice is melting in the Polar Regions. It is dangerous for the animals living there.

DID YOU KNOW?

Climate change was estimated to have been responsible for 3% of diarrhoea, 3% of malaria and 3.8% of dengue fever deaths worldwide in 2004. A paper by researchers from the University of the Oxford University and the University of Florida published in the science magazine "Nature" in May 2010 concluded that a warming climate has led to more widespread disease and death due to malaria.

(d) The rainfall pattern may be affected by global warming.

(e) The biodiversity i.e., the number of organisms living in an area are also affected.

(f) Climate change will effect agriculture and food production around the world.

(g) The amount of oxygen dissolved in the oceans may decline, with adverse consequences for ocean life.

Project 4.1

MAKING A MODEL SHOWING GREENHOUSE EFFECT

Introduction: In this activity, students discover that air trapped in a closed container will heat up more than the air in an open container when both are exposed to the same amount of energy from a light bulb. In a comparable (but different) way, the carbon dioxide in the atmosphere acts as a heat trap for energy from the sun.

Objective: Students test a physical model analogous to the atmospheric greenhouse effect. (See the diagram of the model)

Concept: Physical barriers can trap or slow heat exchange, causing increase in temperature.

Materials: (a) two cut of plastic bottles (b) two thermometers

(c) rubber band (d) transparent plastic wrap

(e) a pair of scissors (f) dark soil

(g) electric lamp/ light bulb

Procedure

1. Tape a thin piece of cardboard paper over the bulb of each thermometer to protect it from direct heat.
2. Add 3 mm of dark soil in each bottle.
3. The thermometer should then be tapped the side of each bottle about 2 inches from the top and above the level of soil.

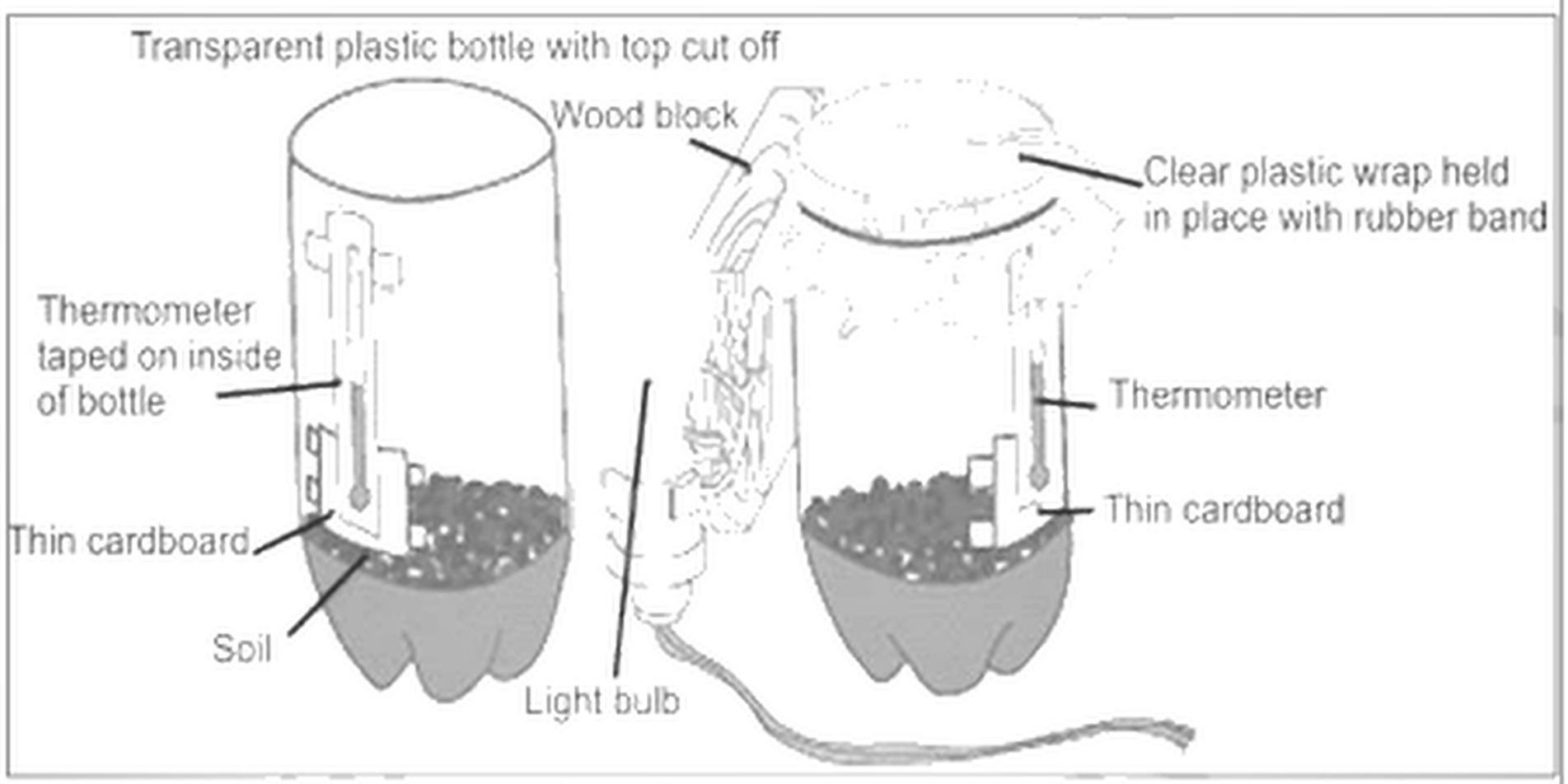


Figure 4.4: Experiment showing greenhouse effect

4. Place transparent plastic wraps over the top of one of the bottles and to close it tightly with rubber band.
5. Place both the bottles in sunlight directly or under a lamp (if the weather is cloudy).
6. Note the temperature in each bottle after one hour.

Drawing conclusions

1. Why did one bottle heat up more rapidly than other?
2. What caused the temperatures in the covered jar to change?
3. How is your model like the Earth's greenhouse effect?

Reading

4.3.4 Ozone Depletion

What is the ozone layer? The ozone layer is a concentration of ozone molecules in the stratosphere. About 90% of the planet's ozone is in the ozone layer. The layer of the Earth's atmosphere that surrounds us is called the **troposphere**. The **stratosphere,** the next higher layer, extends about 10-50 kilometres above the Earth's surface. Stratospheric ozone is a naturally-occurring gas.

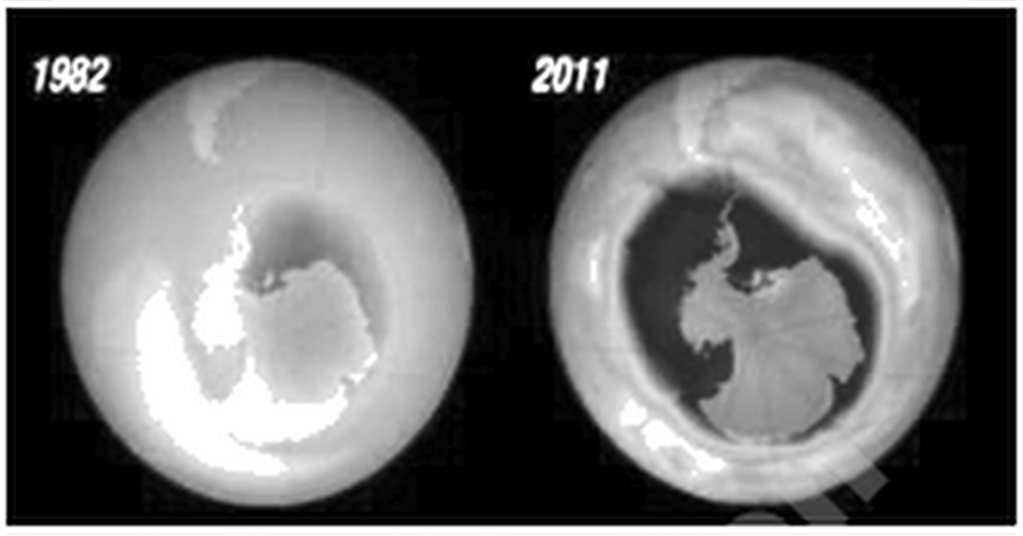


Figure 4.5: Ozone depletion

DID YOU KNOW?

In June 1980 it was discovered that there was a hole in the ozone layer over Antarctica during certain month. In 1988, a team of scientists working in the Arctic Ocean discovered that the ozone layer over Northern Europe was thinner than it had been.

How ozone depletion does occurs? It is caused by the release of chlorofluorocarbons (CFCs), hydro fluorocarbons (HCFCs), and other ozone-depleting substances (ODS), which were used widely as refrigerants, insulating foams, and solvents. The discussion here focuses on CFCs, but is relevant to all ozone depletions.

Ozone depletion in stratospheric ozone over Earth's Polar Regions is referred to as the **ozone hole.** Once in the stratosphere, the Cl atoms are liberated from the parent compounds by the action of ultraviolet light.

$$\mathbf{CFCl_3 + electromagnetic\ radiation \rightarrow Cl + CFCl_2}$$

A chlorine atom reacts with an ozone molecule, taking an oxygen atom with it (forming ClO) and leaving a normal oxygen molecule. The chlorine monoxide (i.e., the ClO) can react with a second molecule of ozone (i.e., O_3) to give another chlorine atom and two molecules of oxygen. The chemical shorthand for these gas-phase reactions is:

- $Cl + O_3 \rightarrow ClO + O_2$: The chlorine atom changes an ozone molecule to ordinary oxygen

Science Titbits

Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide), halons (used in fire extinguishers), and methyl chloroform (used as a solvent in industrial processes). As methyl bromide and halons are broken apart, they release bromine atoms, which are 60 times more destructive to ozone molecules than chlorine atoms.

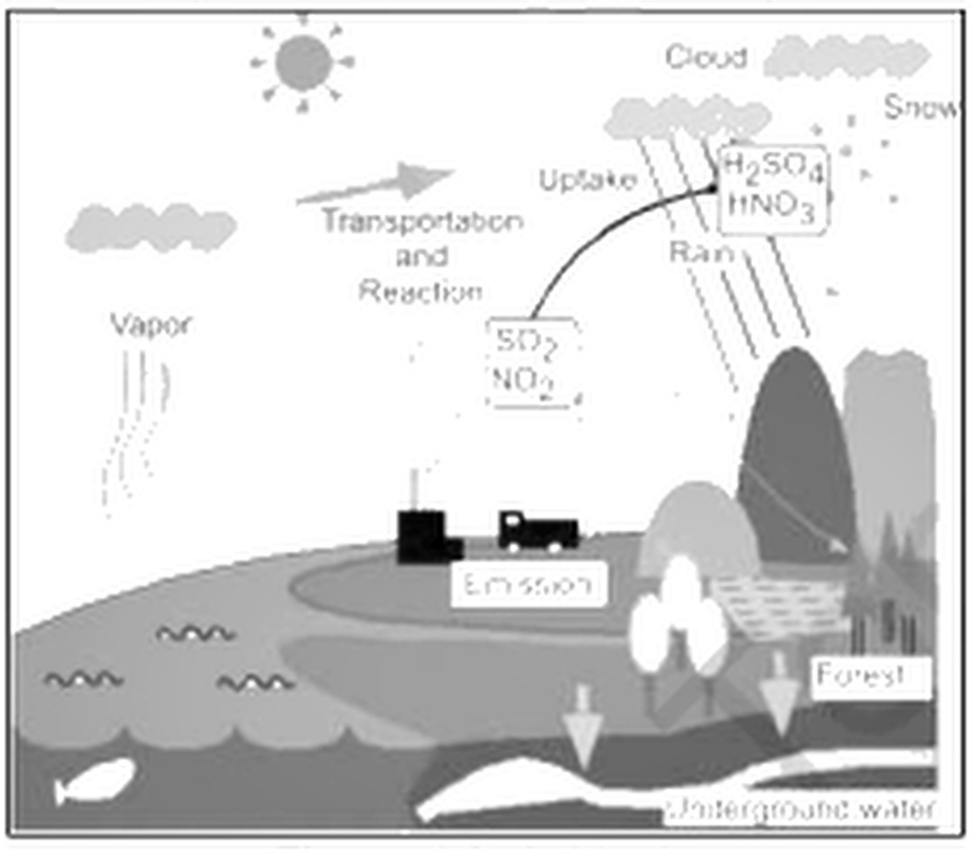
- $ClO + O_3 \rightarrow Cl + 2O_2$: The ClO from the previous reaction destroys a second ozone molecule and recreates the original chlorine atom, which can repeat the first reaction and continue to destroy ozone.

It is estimated that one chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere.

Why is the ozone layer important? Ozone layer filters the Sun's ultraviolet (UV) radiation. A diminished ozone layer allows more radiation to reach the Earth's surface. For people, overexposure to UV rays can lead to skin cancer, blindness, cataracts (eye lens become less transparent), and weakened immune systems. An excess of ultraviolet light kills phytoplankton, the minute plant life of the oceans which are the primary food on which the life in an ocean depends. UV rays can effect growth and flowering in some plants.

4.3.5 Acid Rain

How do sulphuric acid and nitric acid get into rain water? Tall chimneys emit sulphur dioxide and other pollutant gases, such as oxides of nitrogen. Air currents carry the gases away. The gases react with water vapour and oxygen in the air. Sulphuric acid (H_2SO_4) and nitric acid (HNO_3) are formed. The water vapour with its contents becomes part of a cloud. The cloud falls to Earth as acid rain or snow which may be hundreds of miles away from the source of pollution.



What harm does acid rain do? Acid rain damages life in farms and

forest. It kills aquatic organisms. Acid rain dissolves aluminium salts in the soil and passes them into rivers and lakes. These salts are poisonous to fishes. Acid rain adversely affects the nervous, respiratory and digestive system of man. Acid rain causes extensive damage to buildings and stone structures, for example the Tajmahal at Agra is eroding due to acid rain. (See page 116)

Activity 4.2

EFFECT OF ACID ON NONLIVING AND LIVING THINGS

Materials : Chalk, leaf, vinegar and bowl

Procedure :
1. Put chalk piece and leaf in two separate bowls.
2. Using eye dropper or teaspoon, drop vinegar onto the chalk, and on the leaf.

Observation: The chalk disintegrates and leaf becomes curled.

Result : Acid effects non-living and living hings.

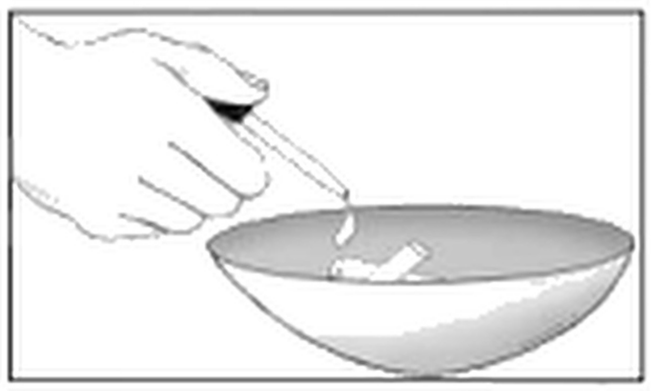


Figure 4.7: Effect of acid

Reading

4.3.6 Wildlife

Wild plants and animals are called **wildlife.** People have affected wildlife population. We take up more space on Earth for our homes and cities. We pollute habitats. These human activities change or destroy the **habitats** that plants and animals need to survive. Hunting has increased the rate of extinction of wildlife species by killing the organisms. Human activities have polluted air, land and water which have affected the wildlife. By introducing new species in any area has contributed to a significant loss of biodiversity. Because human populations are growing so fast animals and plants are disappearing 1000 times faster than they have in the past 65 million years.

4.3.7 Deforestation

The cutting down of trees, destruction of forest which leaves the soil barren is called **deforestation**. Why deforestation? There are many reasons why people

Figure 4.8: Deforestation

cut down trees. They cut trees for urban development, cultivation, grazing, timber and fibres etc. What are the damaging effects of deforestation on environment? The roots of the trees hold soil and water. With the trees removed, the soil is exposed directly to the force of rain and is removed. It is called **soil erosion**. The eroded soil is deposited in rivers and streams blocking the flow of water. The water levels in rivers rise rapidly causing **floods** to occur. With the top soil eroded, plant life cannot be supported. The land becomes barren. The destruction of land leading to desert like conditions is called **desertification**. Desertification leads to loss of habitats and extinction of many species of plants and animals etc.

DID YOU KNOW?

27,000 acres deforestation being carried out annually in Pakistan.

What are the human activities that have long-term adverse consequences on the environment? Humans effect the environment in several ways. Common effects include decreased water quality, increased pollution and greenhouse gas emissions, depletion of natural resources and contribution to global climate change. Humans introduce large quantities of nutrients, primarily through overuse of fertilizers. Too many nutrients can rapidly reduce water quality. The majority of air pollution is the result of human activities. Due to human activities global warming will bring about climate changes.

4.3.8 Lack of Energy Resources

The non-renewable energy resources include fossil fuels i.e., coal, oil and natural gases found in the Earth in fixed quantity. When these are consumed will not be available in future. So the search for other sources of energy is necessary.

4.4 SAVING THE EARTH

The term conservation is used to describe the wise management of natural resources including the preservation of habitats and wildlife. Our well-being depends on keeping a balance between using and protecting environment and resources. We must protect the environment for future use.

4.4.1 Solid Waste Management

Solid wastes are useless or unwanted material discarded as a result of human or animal activity. There are two types of solid wastes: (a) biodegradable e.g., fruits and vegetables etc. (b) non-biodegradable e.g., plastic, metal and glass etc. Solid waste management is the generation, separation, collection, transfer, transportation and disposal wastes. Waste treatment includes the following methods:

(a) Most wastes are dumped on the land or placed in landfills.

(b) The solid wastes can be converted into gas or oil. Solid wastes are burned at high pressure in an apparatus. It produces gas, which is used to generate electricity.

(c) Some wastes are treated biologically and biogas is produced.

4.4.2 Recycling of Materials

Recycling is one of the most important methods for conserving our natural resources. To form new things from used items is called **recycling**. Almost 20-30 percent of solid waste contains materials which could be recycled. Many of the

DID YOU KNOW?

What are the sources of solid wastes?

Houses : Appliances, newspapers, clothing, disposable tableware, food packaging, cans, bottles, food scraps, yard trimming.

Commercial buildings : Corrugated boxes, food wastes, office paper, and disposable tableware.

Institutions : Office paper, cafeteria and restroom waste, classroom wastes, yard trimmings.

Industries : Corrugated boxes, lunchroom wastes, and office papers, wood pellets.

Science Titbits

The digestion of organic waste by bacteria is called bioconversion. In this process methane is produced. It can be used as fuel. Biogas plants have been developed in many countries including Pakistan to supply gas for domestic purpose in villages.

Figure 4.9: Biogas plant

things we use every day, like paper bags, soda cans, and milk cartons, are made out of materials that can be recycled. For instance: (a) Paper can be re-pulped and reprocessed into recycled paper, cardboard and other paper products. (b) Broken glass can be crushed, re-melted and made into containers. (c) Some forms of plastic can be re-melted and fabricated into carpet fibre or cloth. (d) Food wastes and yard wastes can be composted to produce fertilizers and soil conditioners. Recycling reduces waste disposal and pollution. Recycling of sewage saves water.

4.4.3 Conservation of Natural Resources

Conservation of natural resources is the wise use of the earth's resources by humanity. What is the importance of local and global conservation of natural resources? Man activities can upset the balance of nature. Thus the conservation is necessary for the following reasons: (a) ensure the protection of plant and animal species and to prevent their extinction. (b) To prevent disruption of water and carbon cycles etc., and global warming. (c) Ensure the conservation of marine life, as marine fishes are a major source of human food. (d) Ensure the conservation of tropical rainforest, as many rainforest plants are source of raw materials for industries, medicinal drugs and food.

4.4.4 Environmental Campaign

Can you suggest ways in which individuals; organizations and government help you make earth a better place? How do we conserve the forest?

The non-government organizations (NGOs) and government organization organise different activities and programmes to promote public awareness on the issue of environment. The major activities in environmental campaign include:

(a) Seminar on global warming (b) Talks and debates on conservation of natural resources in educational institutions. (c) Teachers are trained on environmental issues (d) On June 5th every year environmental day is celebrated (d) Corner meeting with public on separation of solid wastes in different containers.

Key Points

- The release of any harmful substance into the environment that affects the living things is called pollution.
- The substances that cause pollution are called pollutants.
- The pollutants into the air include sulphur dioxide, carbon monoxide, oxides of nitrogen and chlorofluorocarbons.
- The main source of sulphur dioxide is the burning of fossil fuel. It causes bronchitis (inflammation of the lining of the bronchus) and lung disease.
- Carbon monoxide is emitted by vehicle engine due to incomplete combustion of fuel. Carbon monoxide prevents haemoglobin combining with oxygen.
- Nitrogen oxides are combination of oxygen and nitrogen. In the air pollution, nitrogen oxides refers specifically to NO and NO_2.
- The ozone layer is a concentration of ozone molecules in the stratosphere.
- CFCs breakdown the ozone layer allowing more ultraviolet light to penetrate into the Earth. Long exposure to ultraviolet light can cause skin cancer.
- When sulphur dioxide and oxides of nitrogen gases react with water vapour and oxygen in the air, sulphuric acid (H_2SO_4) and nitric acid (HNO_3) are formed. The rain which is mixed with these acids is called acid rain.
- Effects of acid rain on living organism are that it damages plant and animal life. Acid rain causes health problems in people such as asthma and permanent lung damage.
- Effects of acid rain on non-living objects are that it increases level of acidity of lakes and rivers. It has damaging effect on many objects, including buildings, statues, monuments and cars.

- People have affected wildlife population by damaging or destroying their habitats. Some species of plants and animals have become endangered species or extinct.
- The cutting down of trees of forest is called deforestation. It causes soil erosion, floods, desertification, reduction in rainfall.
- The non-renewable energy resources include fossil fuels i.e., coal, oil and natural gases found in the Earth in fixed quantity. The non-renewable energy resources are being consumed so will not be available in future.
- Solid waste management is the generation, separation, collection, transfer, transportation and disposal of waste.
- To form new things from used items is called recycling and is a method for conserving natural resources and saving energy. It reduces waste disposal and pollution. Recycling of sewage saves water.
- Conservation of natural resources is the wise use of the earth's resources by humanity. It protects animal and plant life, disruption of natural cycles, global warming. It ensures conservation of marine life, tropical rain forest.

Review Questions

1. Encircle the correct answer from the following choices.

(i) Which of the following affects the oxygen binding capacity of blood?

(A) oxides of nitrogen (B) carbon dioxide

(C) carbon monoxide (D) sulphur dioxide

(ii) The burning of fossil fuel contributes to all of the following except one:

(A) global warming (B) acid rain

(C) carbon dioxide (D) ozone depletion

(iii) Which of the following does not contribute to the greenhouse effect?

(A) CFCs (B) carbon dioxide

(C) methane (D) nitrogen

(iv) Which of the following is the primary cause of acid rain?

(A) burning tropical forest (B) burning high sulphur coal

(C) CFCs (D) nuclear power station

(v) Which one of the following is the cause of ozone depletion?

(A) a ozone hole over Antarctica

(B) at ground level ozone is a pollutant

(C) CFCs

(D) absorption of infrared radiation by ozone

(vi) The greenhouse effect could cause

(A) weather condition to remain constant

(B) increase in atmospheric temperature

(C) acid rain

(D) ozone depletion

(vii) Ozone depletion over the North Pole is called

(A) black hole (B) normal hole

(C) ozone hole (D) none of these

(viii) Which of these may contribute to global warming?

(A) ozone depletion (B) deforestation

(C) greenhouse effect (D) all of these

(ix) Air pollution include

(A) carbon monoxide (B) nitrogen

(C) oxygen (D) noise

(x) What is the cause of species extinction today?

(A) over hunting (B) habitat loss

(C) pollution (D) insecticides

(xi) Solid waste management is the

(A) disposal of waste (B) burning of waste

(C) recycling of waste (D) decaying of waste

Short Questions

2. Define: pollution, pollutants, global warming, ozone depletion, acid rain, wild life, deforestation, soil erosion, solid waste management, recycling of materials.

3. What are the causes of air pollution?
4. Why do power stations and factories have tall chimneys?
5. How does carbon monoxide act on the body?
6. List problems in human organ systems caused by air pollutants?
7. How can you reduce air pollution in your local environment?
8. What are the oxides of nitrogen?
9. What is greenhouse effect?
10. What causes the Earth's greenhouse effect?
11. Name three greenhouse gases.
12. What converts ozone into oxygen?
13. Why is the ozone layer becoming thinner?
14. What is the importance of ozone layer?
15. How is acid rain formed?
16. Why do lakes suffer more than rivers from the effects of acid rain?

Extensive Questions

17. What are the sources, properties and harmful effects of sulphur dioxide?
18. What conditions lead to the formation of carbon monoxide? What harm does it do?
19. What are the sources, properties and harmful effects of oxides of nitrogen?
20. What are the sources, properties and harmful effects of chlorofluorocarbons?
21. What are the harmful effects of air pollutants?

22. What are the ways to reduce air pollution in the environment?
23. What are the effects of human activities on environment?
24. What are the effects of global warming on Earth?
25. People have affected wildlife population. Justify.
26. In what ways does the recycling of materials help to save energy and conserve the environment?
27. What are the ways to conserve energy resources?

Science, Technology and Society Connections

- Identify environmental problems in your community.
- Organize/actively take part in poster exhibition at your school to promote awareness on environmental issue.

Answers of MCQs

(i)	C	(ii)	D	(iii)	A	(iv)	B	(v)	C
(vi)	B	(vii)	C	(viii)	C	(ix)	A	(x)	B
(xi)	A								

5

CHEMICAL REACTIONS

CONTENTS

This is a 14 days lesson (Period Including homework)

After completing this lesson, you will be able to:

- Define chemical reactions and give examples.
- Explain the rearrangement of atoms in chemical reactions.
- Explain the balancing of a chemical reaction.
- Define the Law of Conservation of Mass.
- Identify the nature of a chemical change in various reactions.
- Describe changes in the states of matter in a chemical reaction.
- Explain the types of chemical reactions with examples.
- Explain the energy changes in chemical reactions.
- Describe the importance of exothermic reactions in daily life.

Reading

In general, matter is built up of one or more of the three types of elementary particles i.e., atoms, molecules or ions. An **atom** is the smallest particle of an element which can take part in chemical reactions (e.g., gold). When two or more atoms combine, a much bigger particle, known as molecule is obtained. A **molecule** is the smallest particle of a substance that can normally exist separately and still retain the characteristics of that substance e.g., Hydrogen (H_2) water (H_2O).

Some substances are made up of charged particles called **ions**. There are two types of ions, the positive charged ions called **cations** e.g., Na^+ and the negatively charged ions called the **anions** e.g., Cl^-. For a given molecule which is composed of ions the total amount of positive charges carried by the cations and the negatively charge ions carried by the anions, are equal so the molecule as a whole is **electrically neutral**.

5.1 CHEMICAL CHANGES

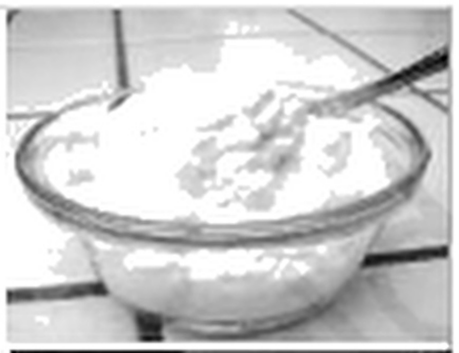
Matter can undergo changes. The change is of two types: physical change and chemical change. A physical change is one which is easily reversible and in which no new substances are formed.

Activity 5.1

SHOWING CHEMICAL CHANGES

Procedure

1. Add a few drops of lemon juice to milk. Then boil the mixture. What happens? A thick white substance called cottage cheese is formed. This is called curdling of milk.
2. Use a pair of tongs to hold a piece of magnesium ribbon in a Bunsen flame. What happens? The magnesium burns with a very bright flame and a white ash know as magnesium oxide is obtained.
3. Place some sugar in a crucible or metallic bowl. Heat it over a Bunsen flame. What do you notice? The sugar burns. The colour of the sugar will first change to brown then black. The black residue is carbon, which is entirely different from sugar.



Conclusion

The formation of cottage cheese, the burning of magnesium and the burning of sugar are chemical changes because new products are formed and the original starting materials cannot be recovered by physical means.

5.1.1 Chemical Reaction

A chemical change is called **chemical reaction**. A chemical reaction is a process in which chemical change occurs and new substance is formed. The substance which is used as starting material is known as **reactant**

A chemical change is one which is not easily reversible and in which a new substance is formed.

and substance which is formed by chemical reaction is known as **product**. So we can also say that transformation of reactants into products is known as chemical reaction. So a simple reaction can be written as

$$\text{REACTANT(S)} \longrightarrow \text{PRODUCT(S)}$$

$$A + B \longrightarrow AB$$

A chemical reaction is a process that leads to the transformation of one set of chemical substances to another.

In a chemical reaction, one or more than one substance gives rise to new substances. If two or more substances take part in a chemical reaction, we say that they react with each other.

Following are the examples of chemical change.

(1) The burning of a material e.g., coal, wood, paper, petrol etc. (2) Rusting (3) The cooking of food (4) The spoiling of food (5) Digestion of food (6) The curdling of milk (7) Photosynthesis (8)The addition of water to quicklime i.e., the slaking of lime.

Rearrangement of Atoms in Chemical Reactions

Why are new substances formed in a chemical change? The atoms rearrange themselves to form new substances in a chemical change. When burnt in air, carbon forms carbon dioxide. So, during chemical reactions, new product atoms are not created, and old reactant atoms are not destroyed. Atoms are rearranged as bonds are broken and formed. In chemical reactions, atoms rearrange to form products.

Science Titbits

When an apple is cut, an enzyme called polyphenol oxidase also known as "tyrosinase" is released from the cells of the apple and reacts with the oxygen in the air. This reaction causes the fruit to turn brown, similar to rust forming on metal. Almost all plants e.g., eggplant (brinjal) contain polyphenol oxidase. Lemon juice protects the apple from browning, because it is full of ascorbic acid (Vitamin C) and it has a low (acidic) pH level. Ascorbic acid works because oxygen will react with it before it will react with the polyphenol oxidase. The pH of lemon juice is 2, making it very effective against browning.

Figure 5.1: The atoms of carbon and oxygen rearrange themselves to form carbon dioxide

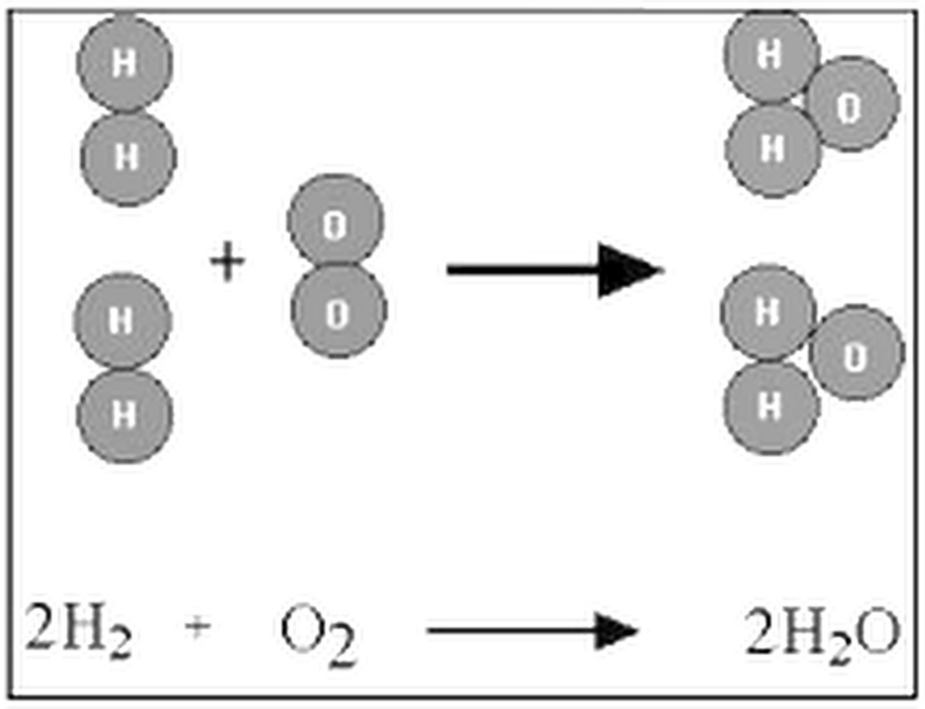


Figure 5.2: The bonds in the diatomic molecule of H_2 (hydrogen) and O_2 (oxygen) are broken, and new bonds are formed between hydrogen and oxygen atom

DO YOU REMEMBER?

A molecule of the substance, whether it is an element or a compound, could be represented by symbols. Such a representation is known as a chemical formula.

5.2 CHEMICAL EQUATION AND BALANCING

Chemists have devised a standard way to represent **chemical reaction,** by using chemical equations. A **chemical equation** uses chemical symbols to show that what happens during a chemical reaction. In this section we will learn how to write chemical equations and balance them.

5.2.1 Writing Chemical Equations

As we have already seen that in a chemical reaction, the substances that react are called **reactants** or sometimes **reagents**. The substances that are produced are called **products**.

Consider what happens when hydrogen gas (H_2) burns in air (which contains oxygen, O_2) to form water (H_2O). This reaction can be represented by the chemical equation where the + sign means "react with" and the ⟶ sign means "to produce". In an equation the formulae for the **reactants** are written on the left hand side of the

A Chemical equation is an expression for given chemical reaction and change in terms of symbol formula of reactant and products.

arrow and the formulae for the **products** are written on the right hand side of the arrow. The symbolic expression can be read:

$$H_2 + O_2 \longrightarrow H_2O$$

"Molecular hydrogen reacts with molecular oxygen to form water".

$H_2 + O_2 \longrightarrow H_2O$ is not a complete expression, because twice as many oxygen atoms are on the left side of the arrow (two) as on the right side (one). We can write a **balanced equation**, in which more information is given because it shows the relative numbers of atoms of each of the elements involved. The word **equation** is related to the word **equal**, an equation must have equal numbers of atoms of each element of each side. Such an equation is said to be **balanced** because it has the same number of atoms of each element on each side of the arrow.

Coefficients

The numbers that are written before the formulas (formulae) are called **coefficient**. They tell the relative number of formula units of reactants and products involved in a reaction and balance the number of atoms of each element involved. The coefficient multiplies everything in the formula. In a balanced chemical equation, the absence of a coefficient before a formula implies a coefficient 1.

We can balance equation for the reaction of hydrogen and oxygen by placing appropriate coefficient (2 in this case) in front of H_2 and H_2O:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

This balanced chemical equation shows that "two hydrogen molecules combine or react with one oxygen molecule to forms two water molecules". (Note that when the coefficient is 1, as in the case of O_2 in this equation, it is not shown).

Balancing Chemical Equations

In general, we can balance a chemical equation by the following steps:

1. Identify all reactants and products and write their correct formulas on the left side and right side of the equation respectively.

2. Begin balancing the equation by trying different coefficient to make the number of atoms of each element the same on both side of the equation. We can change the coefficient (the number preceding the formulas) but not the subscripts (the numbers within the formulas). Changing the subscripts could change the identity of the substance. For example $2NO_2$ means "two molecules of nitrogen oxide," but if we double the subscripts, we have N_2O_4 which is the formula of dinitrogen tetraoxide, a completely different compound.

3. Look for elements that appear only once on each side of the equation with the same number of atoms on each side: the formula containing these elements must have the same coefficient. Next, look for elements that appear only once on each side of the equation but in unequal numbers of atoms. Balance these elements. Finally, balance elements that appear in two or more formulas on the same side of the equation.

4. Check your balanced equation to be sure that you have the same total number of each type of atom on both sides of the equation arrow.

Let us consider a specific example. In the laboratory, small amounts of oxygen gas can conveniently prepared by heating potassium chlorate ($KClO_3$). The products are oxygen gas (O_2) and potassium chloride (KCl). From this information, we write

$$KClO_3 \longrightarrow KCl + O_2$$

We see that all the three elements K, Cl and O appear only once on each side of the equation, but only K and Cl appear in equal numbers of atoms on both sides. Thus $KClO_3$ and KCl must have the same coefficient. The next step is to make the number of O atoms the same side of the equation; we can balance the O atoms by placing 2 in front of $KClO_3$ and 3 in front of O_2.

$$2KClO_3 \longrightarrow KCl + 3O_2$$

Finally, we balance the K and Cl atoms by placing 2 in front of KCl.

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

As a final check, we can draw up a balance sheet for the reactants and products where the number in parentheses indicates the number of atoms of each element:

No. of atoms in reactants	No. of atoms products
K (2)	K (2)
Cl (2)	Cl (2)
O (6)	O (6)

Word equation

Summary of a chemical reaction naming reactants and products is called word equation. *Example:*

Magnesium + Oxygen → Magnesium oxide

4. Write the symbols of Physical states, like (g) for gas, (s) for solid, (l) for liquid and (aq) for aqueous solution etc., along with reactants and products.

Example: $CaCO_{3(s)} + HCl_{(l)} \longrightarrow CaO_{(s)} + CO_{2(g)} + H_2O_{(aq)}$

DID YOU KNOW?

Reversible reactions

Many reactions, such as burning fuel, are irreversible - they go to completion and cannot be reversed easily. Reversible reactions are different. In a reversible reaction, the *products* can react to produce the original *reactants* again. When writing chemical equations for reversible reactions, we do not use the usual one-way arrow. Instead, we use two arrows, each with just half an arrowhead - the top one pointing right, and the bottom one pointing left.

Example: $NH_4Cl \rightleftharpoons NH_3 + HCl$

Ammonium chloride ⇌ Ammonia + Hydrogen chloride.

5.3 LAW OF CONSERVATION OF MASS

Antoine Lavoisier (1743-1794), discovered the law of conservation of mass by showing that during a chemical reaction; matter is neither gained nor lost. His work involving measurement enabled us to conclude that the mass of products generated during a chemical reaction is the same as the mass of reactants used up.

Antoine Lavoisier

The Law of conservation of mass states that matter is neither created nor destroyed during a chemical reaction but changes from one form to another or there is no gain or loss of mass in a chemical reaction.

Activity 5.2

LAW OF CONSERVATION OF MASS

Objective: In this experiment we will determine, the change in the mass of a closed system during a chemical reaction.

Materials: (1) conical flask 250ml (2) solid stopper (3) small test tube (4) electronic balance (5) Calcium chloride ($CaCl_2$) solution (6) Sodium sulphate solution (Na_2SO_4)

Discussion: In this experiment you will be attempting to measure what change, if any, occurs in the mass of a closed system whenever a chemical reaction occurs. Before you begin this experiment you should have a clear understanding of the following concepts. What is the measurement uncertainty in each reading made on your balance? Why is it crucial to make your observations in a closed system and what are the elements of the closed system in this experiment.

Procedure

1. Put about 10ml of calcium chloride solution into a flask. Half fill the test tube with the sodium sulphate solution. Stopper the flask tightly. Determine the mass of the flask and its contents accurately.
2. Invert the flask so that the two solutions can mix. Re-measure the mass of the flask and its contents after the two solutions have mixed.

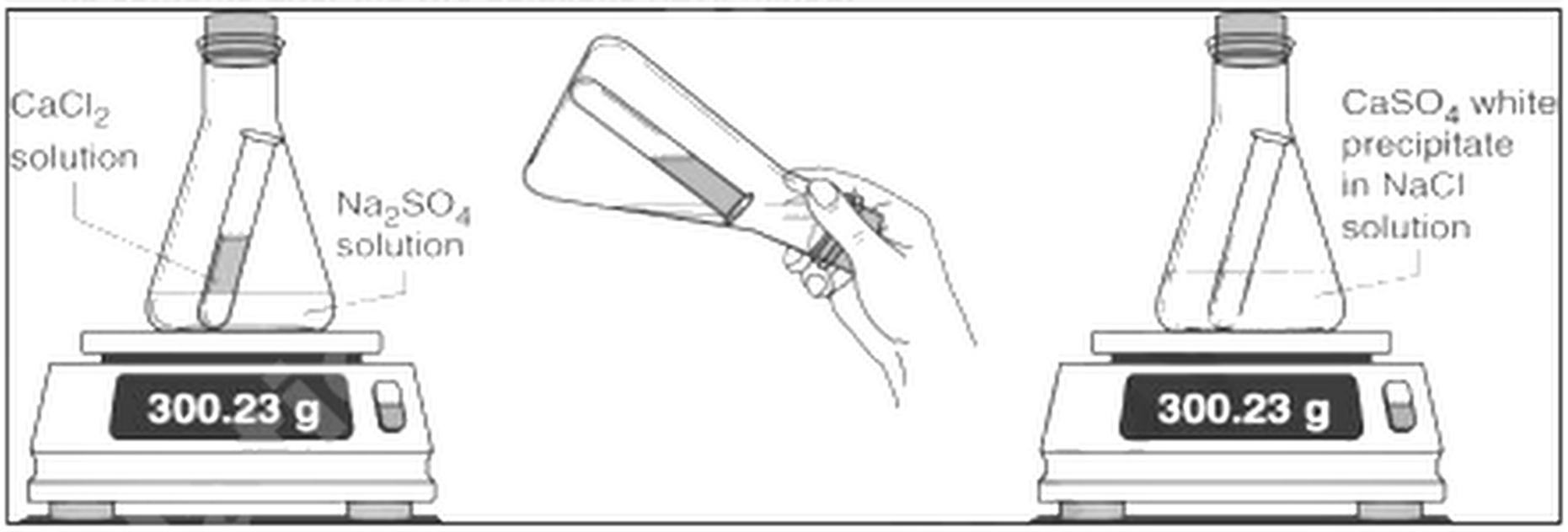


Figure 5.3: Law of conservation of mass

Questions:

1. How do you know a chemical reaction took place?
2. Write a word equation and the chemical equation for this reaction.
3. Was there a change in mass when this chemical reaction took place?
4. State the *Law of Conservation of Mass*

5.4 TYPES OF CHEMICAL REACTIONS

The most basic reactions involve combination, decomposition and displacement. Here we will study combination and decomposition reactions.

5.4.1 Combination Reactions

A reaction in which a single product is formed from two or more reactants (either elements or compounds) is known as a **combination reaction.** It is also known as synthesis or addition reaction.

A + B → AB

A combination reaction is a reaction where two reactants are combined to form one product.

Combination reactions are usually exothermic. For example, **Barium metal** and **Fluorine gas** will combine in a highly exothermic reaction to form the salt, Barium fluoride:

$$Ba + F_2 \uparrow \rightarrow BaF_2 + Heat$$

Another example is **Magnesium oxide** combining with **carbon dioxide** to produce **Magnesium carbonate**:

$$MgO + CO_2 \rightarrow MgCO_3$$

Another example is **iron** combining with **sulphur** to produce

Iron (II) sulphide:

$$Fe + S \rightarrow FeS$$

Reactions can fall into more than one category. For example the combustion of **Magnesium metal** is also a combination reaction as it releases Magnesium oxide and energy:

In this reaction when the bond forms between the reactants, heat is released.

A combination reaction can be of three types:

Type		Example	
A	Between two elements	$C + O_2 \rightarrow CO_2$	Carbon burns completely in oxygen to produce carbon dioxide.
B	Between two compounds	$2CaO + 2H_2O \rightarrow 2Ca(OH)_2$	Calcium oxide (lime) combines with water to produce calcium hydroxide (slaked lime).
C	Between one element and one compound	$2CO + O_2 \rightarrow 2CO_2$	Carbon monoxide combines with oxygen to produce carbon dioxide.

Activity 5.3

SHOWING COMBINATION REACTION

Procedure

1. Take a small amount of calcium oxide in beaker.
2. Add some water.

Observation

a. Milky white aqueous solution is obtained

b. Beaker is hot.

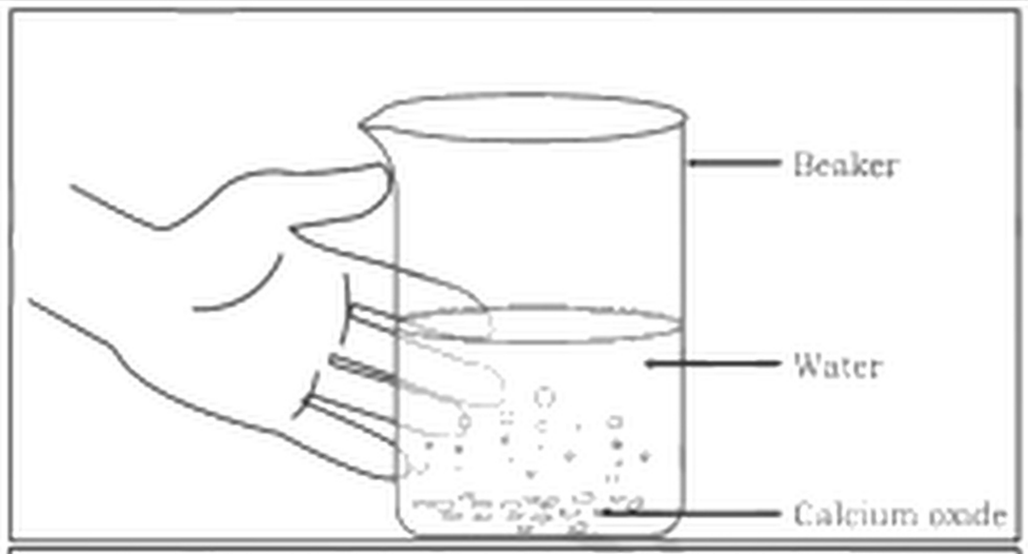


Figure 5.4: Combination reaction

Result

a. The milky white solution is aqueous slaked lime (calcium hydroxide), which is formed by combination reaction between calcium oxide and water.

b. Beaker is hot due to heat which is produced by this reaction by this reaction.

Reaction: Calcium oxide + Water → Calcium hydroxide + Heat

$$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2\,(aq)}$$

5.4.2 Decomposition Reactions

A reaction in which a single reactant breaks down into two or more than two simpler products (either elements or compounds) is known as **decomposition reaction.**

The general equation that describes a decomposition reaction is:

XY ⟶ X + Y

DID YOU KNOW

The digestion of food in our body is accompanied by a number of decomposition reactions. The major constituents of our food such as carbohydrates, fats proteins, etc., decompose to form a number of simpler substances. These substances further react, releasing large amounts of energy, which keeps our body working.

5.5 ENERGY CHANGES IN CHEMICAL REACTIONS

Most chemical reactions are accompanied by a heat change although this may sometimes be too small to be observable. Two types of heat changes can occur during a chemical reaction i.e., heat can be evolved or absorbed during the process depending on the relative heat content of the reactions and products.

5.5.1 Exothermic Reactions

Many chemical reactions release energy in the form of heat, light, or sound. These are exothermic reactions. Exothermic reactions transfer energy to the surroundings. The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to become hotter. The temperature increase can be detected using a thermometer.

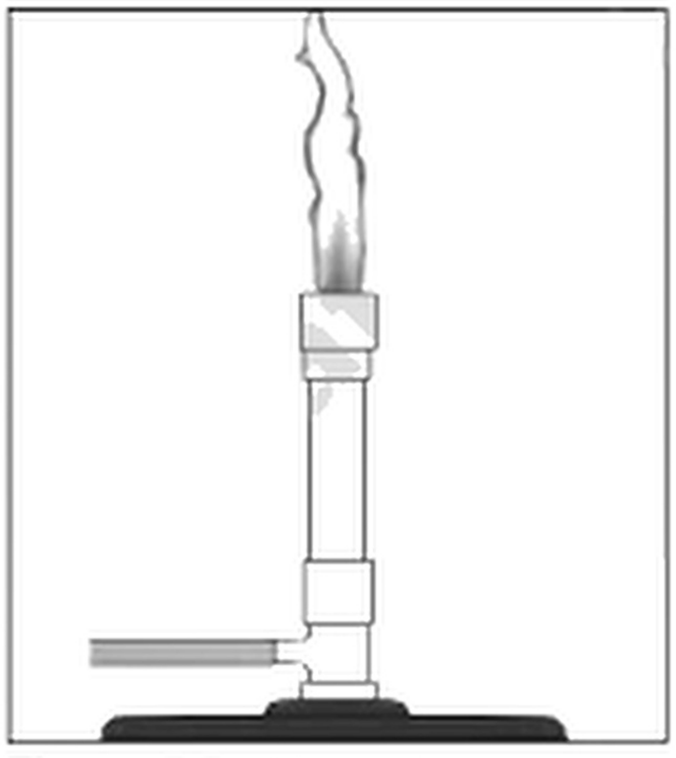


Figure 5.5: When a flame burns it transfers heat to its surroundings

Some examples of exothermic reactions are:

(1) Combustion (burning) (2) Many oxidation reactions, for example rusting or iron.

(3) Neutralization reactions between acids and alkalis. (4) Decomposition of vegetable matter into compost (5) The mixture of sodium and chlorine to form table salt.

An exothermic reaction is a chemical reaction that releases energy in the form of heat

Activity 5.4

(A) SHOWING EXOTHERMIC REACTION

Objective: Exothermic chemical reactions produce heat. In this reaction vinegar is used to remove the protective coating from steel wool, allowing it to rust. When the iron combines with oxygen, heat is released.

Materials: Thermometer, Jar with lid, steel wool, vinegar

Procedure

1. Place the thermometer in the jar and close the lid. Allow about 5 minutes for the thermometer to record the temperature, then open the lid and read the thermometer.
2. Remove the thermometer from the jar.
3. Soak a piece of steel wool in vinegar for 1 minute.
4. Squeeze the excess vinegar out of the steel wool.
5. Wrap the wool around the thermometer and place the wool/thermometer in the jar, sealing the lid.
6. Allow 5 minutes, then read the temperature and compare it with the first reading.

Observation

Not only does the vinegar remove the protective coating on the steel wool, but once the coating is off its acidity helps in oxidation (rust) of the iron in the steel.

The thermal energy given off during this chemical reaction causes the mercury in the thermometer to expand and rise up the column of the thermometer tube.

In the rusting of iron, four atoms of solid iron react with three molecules of oxygen gas to form two molecules of solid rust (iron oxide).

(B) SHOWING EXOTHERMIC REACTION

(TO BE DEMONSTRATED BY THE TEACHER ONLY. NOT TO BE DONE BY THE STUDENTS)

Figure 5.6: Heat is produced when quicklime is slaked

Procedure

Take some quicklime in a metallic vessel and add water to it. You will hear a hissing sound, and the water will start boiling. The quicklime, that looks like a stone forms a white paste with water. A new substance, called **slaked lime**, is formed and the process is called slacking of lime. So much heat is evolved during the change that the water starts boiling.

Conclusion

Since heat evolved during the change, it is an exothermic reaction.

(C) SHOWING EXOTHERMIC REACTION

Materials

Yeast solution 30 ml Hydrogen peroxide solution 60 ml, thermometer, small bowl, spoon, pencil, paper, measuring cup, measuring spoon, stopwatch that indicates seconds.

Procedure

1. Record the room temperature and then place the thermometer in the bowl.
2. The students will predict what will happen to the temperature when the hydrogen peroxide and yeast are combined.
3. Record the answers on the writing board or on chart paper.
4. Pour 60 ml of hydrogen peroxide solution into the bowl and record the temperature.
5. Add 30 ml solution yeast to the bowl and stir the mixture.
6. Record time and temperature readings every 30 seconds for a total of 4 minutes.

Observation

When mixed, hydrogen peroxide and yeast undergo a chemical reaction, which changes the hydrogen peroxide into water and oxygen gas - observed as bubbles and foam. The chemical reaction also produces energy in the form of heat. The increase in temperature can be determined by examining the overall increase in temperature during the reaction.

Importance of Exothermic Reactions in Daily Life

Exothermic reactions occur regularly and are important for everyday life. Following are some of the importance of the exothermic reactions in daily life.

1. Exothermic reactions are important to forensic sciences and particularly to fire and explosion investigation.
2. Fire, combustion, burning, steam condensing to liquid water, rusting, lighting a matchstick, etc., and any chemical reaction that gives off heat is important in daily life.
3. The energy used to power homes, schools and businesses is the product of an exothermic reaction. Motorized vehicles are propelled by an exothermic reaction
4. Combustion reactions are an extremely common exothermic reaction. A large portion of electricity is produced at power generation facilities by burning fuel sources such as methane and coal.

5. The human body receives the energy needed for cell function via an exothermic reaction. You consume food containing glucose, which is a carbohydrate. When that carbohydrate reacts with oxygen from the air that you breathe in, it gives energy, water and carbon dioxide. The energy is used to keep the body warm and maintain body temperature.
6. The steam condenses on the cooler skin, and in the process heat is evolved, which 'cooks' the tissue and produces blisters.

5.5.2 Endothermic Reactions

There are other chemical reactions that must absorb energy in order to proceed. These are endothermic reactions. These are reactions that take in energy from the surroundings. The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to get colder. The temperature decrease can also be detected using a thermometer.

> An endothermic reaction is one during which heat is absorbed from the surroundings.

Some examples of endothermic reactions are:

(1) Electrolysis (see glossary)
(2) The reaction between ethanoic acid and sodium carbonate.
(3) The thermal decomposition of calcium carbonate in a blast furnace.
(4) Photosynthesis is an example of an endothermic chemical reaction. In this process, plants use the energy from the sun to convert carbon dioxide and water into glucose and oxygen.

Activity 5.5

(A) FEELING AN ENDOTHERMIC REACTION

Materials: Citric acid solution /lemon juice, plastic cup, baking soda

Procedure

1. Mix citric acid solution in a plastic cup with baking soda solution.
2. Place two fingers into the cup to feel the reaction. You should feel it bubble more vigorously and your fingers should feel cold after a second.
3. Describe what you feel/felt. Can you explain where the heat in your fingers is going?

Explanation

When you put your fingers in the solution, it will bubble and speed up because you are giving the acid and the base mixture the heat energy it needs to get going and keep going. It is taking the heat from your fingers so your fingers will feel cold in the solution and when you remove them.

(B) SHOWING ENDOTHERMIC REACTION

Method: An 'endothermic reaction' absorbs energy or 'heat' in order to proceed, and the Temperature of the reaction drops. It can be seen in the following experiment:

Materials: plastic cup, lemon juice, baking soda, spoon, small thermometer, stop watch.

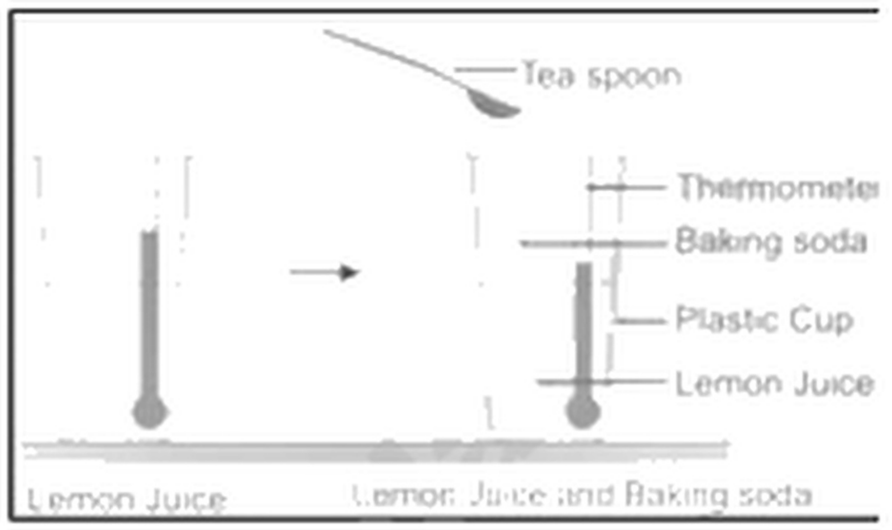


Figure 5.7: Endothermic reaction

Procedure

1. Place a small thermometer on the inside wall of a plastic drinking cup.
2. Add ½ a cup of lemon juice to the plastic drinking cup and leave it for about 10 minutes.
3. After the time has passed, read the thermometer and record the temperature of the juice as shown.
4. Remove the thermometer and add 1 teaspoon of baking soda to the lemon juice and stir with a spoon.
5. Place the thermometer back into the juice and take 5 readings after every 2 minute to see how the temperature drops.

(C) SHOWING ENDOTHERMIC REACTION

Materials: Glass, water, glucose.

Procedure: Hold a glass in your hand.

Pour some water into the glass. Add 2-3 spoons of glucose in it. Then stir it.

Result: The glass will be slightly colder.

Conclusion: The dissolving of glucose in water is an endothermic change.

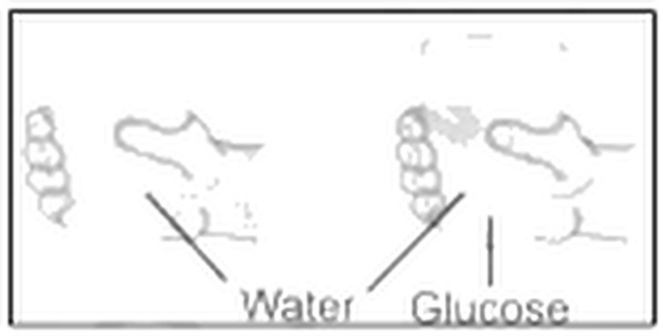


Figure 5.8: Heat is taken in when glucose dissolves in water.

TABLE 5.1 COMPARING EXOTHERMIC AND ENDOTHERMIC REACTIONS

Exothermic reactions	Endothermic reactions
1. Exothermic reactions transfer energy to the surroundings.	1. Endothermic reactions take in energy from the surroundings.
2. Exothermic reactions may occur spontaneously.	2. Endothermic reactions cannot occur spontaneously.

When trying to **classify a process** as exothermic or endothermic, watch how the temperature of the surroundings changes. An exothermic process releases heat, and causes the temperature of the immediate surroundings to rise. An endothermic process absorbs heat and cools the surroundings. Can you think of a way to test the classification of each of these processes?

TABLE:5.2 CLASSIFYING THE PROCESS AS EXOTHERMIC OR ENDOTHERMIC

Exothermic processes	Endothermic processes
1. making ice cubes	1. melting ice cubes
2. formation of snow in clouds	2. conversion of ice to water vapour
3. condensation of rain from water vapour	3. evaporation of water
4. mixing sodium sulphite and bleach	4. baking bread
5. rusting iron	5. cooking an egg
6. burning sugar	6. producing sugar by photosynthesis
7. combining atoms to make a molecule in the gas phase	7. splitting a gas molecule apart

Key Points

- A change in which no new substances are formed and which is easily reversible is called a physical change.
- A change in which new substances are formed and which is easily not reversible is called a chemical change.
- In a chemical change rearrangement of atoms takes place.
- Chemical changes, called chemical reactions, are represented by chemical equations.
- A chemical equation is the symbolic representation of a chemical change.
- In a chemical equation, the reactants are separated from products by an arrow.
- The reactants are written on the left and the products are written on the right side of the arrow.
- In a balanced chemical equation, the total number of atoms of each element on the reactant side is equal to the number of atoms on the product side.

- The balanced equation represents a chemical reaction. It not only identifies the reactants and products, but also gives quantitative information on the ratio of all substances involved in the reaction.
- To balance an equation, that is to make the numbers of atoms of each of the elements of the same on the two sides of the equation a coefficient is placed in front of each formula in the equation.
- Lavoisier summarized his ideas in the Law of Conservation of Mass, which states that matter is neither created nor destroyed during a chemical reaction.
- In a combination reaction, two separate substances combine to form a compound.
- In a decomposition reaction, a compound breaks down into its separate components.
- Exothermic reaction is a chemical reaction that liberates heat or energy when it is started.
- Endothermic reaction is chemical reaction that requires the addition of heat or energy in order to start.
- Exothermic reactions have importance in daily life. Provides energy to home, schools, etc., and propelling motorized vehicles.
- Exothermic reactions provide energy for metabolism in human and other vertebrates. Keep the body warm and maintain body temperature in birds and mammals.

Review Questions

1. Encircle the correct answer from the following choices.

(i) Which of the following is **not** a reversible change?

(A) The changing of water into steam (B) The melting of wax

(C) The burning of petrol (D) The freezing of water

(ii) Which of the following is a reversible change?

(A) The burning of wood (B) The melting of wax

(C) The curdling of milk (D) The cooking of food

(iii) During which of the following change a new substance is formed?

(A) melting (B) sublimation

(iv) Which of the following is NOT an irreversible change?
(A) The ripening of mango (B) The curdling of milk
(C) The condensation of water vapours (D) The slaking of lime

(v) Which of the following involves a fast chemical change?
(A) The burning of a matchstick (B) The rusting of iron
(C) The ripening of a mango (D) The growth of a plant

(vi) The numbers that are written before the formula
(A) reagent (B) products
(C) ratio (D) coefficient

(vii) The law of conservation of mass was discovered by
(A) Lavoisier (B) Dalton
(C) Newton (D) Darwin

(viii) A chemical reaction in which a compound breaks up into two or more separate substance
(A) combination reaction (B) decomposition reaction
(C) substitution reaction (D) displacement reaction

(ix) A chemical reaction in which two substances combine to form a new compound
(A) displacement reaction (B) substitution reaction
(C) combination reaction (D) combustion

(x) The production 'blisters' on human skin by the condensing steam is an example of
(A) exothermic reaction (B) melting
(C) combustion (D) endothermic reaction

(xi) Burning fuel, combining baking soda and vinegar, and decomposing water into hydrogen and oxygen are examples of chemical reactions. Which statement correctly identifies what occurs in all chemical reactions?
(A) Matter is either created or destroyed.
(B) Energy is either created or destroyed.
(C) Matter is converted into energy.
(D) Energy is transferred from one form to another.

(xii) Which of the following statement is true about the role of energy in all chemical reactions?
(A) All chemical reactions use energy to create matter.
(B) All chemical reactions convert matter into energy.
(C) All chemical reactions either release or absorb energy.
(D) All chemical reactions either create or destroy energy.

(xiii) Photosynthesis, baking a cake, and cooking an egg are all examples of chemical reactions. Identify the statement that correctly identifies the role of energy in each of these reactions.
(A) These reactions release energy.
(B) These reactions absorb energy.
(C) These reactions make energy.
(D) These reactions use up energy.

(xiv) Which of the following is necessary for ALL chemical reactions to occur?
(A) Enough energy to make the reaction occur.
(B) Enough matter to cause the reaction to occur.
(C) The presence of a catalyst to make the reaction occur.
(D) A stirring or shaking action to make the reaction occur.

(xv) The burning of gasoline and cell respiration are both chemical reactions that
(A) Destroy matter through burning.
(B) Create energy from matter.
(C) Release thermal energy.
(D) Absorb thermal energy.

(xvi) When glucose reacts with oxygen in our body's cells energy is released. This energy is used to move our bodies, heat our bodies, and perform all other body functions. Our body's ability to use glucose in this way means that
(A) Glucose must contain energy.
(B) Glucose must contain food.
(C) Glucose must be changed to fat.
(D) Glucose and oxygen are food.

(xvii) Flashlight batteries can be used for a limited amount of time due to which of the following?
- (A) All of the available mass of the chemicals in the batteries has been used up.
- (B) All of the available potential chemical energy has been converted into mass.
- (C) All of the available potential chemical energy has been converted into forms of kinetic energy.
- (D) All of the available electrical energy in the batteries has been converted into heat.

(xviii) The burning of gasoline is an example of a chemical reaction in which the chemical energy stored in the bonds between the molecules of gasoline is converted into other forms of energy during the burning process. Identify the true statement about the role of energy in the burning of gasoline.
- (A) Chemical energy is converted into thermal energy which is released.
- (B) Chemical energy is converted into thermal energy which is absorbed
- (C) Thermal energy is converted into chemical energy which is released.
- (D) Thermal energy is converted into chemical energy which is absorbed.

Short Questions

2. Define the following: matter, mass, atom, molecule, ion, cations, anions, element, mixture, compound, physical change, chemical change, reactants, products, chemical equation, coefficient, exothermic process, endothermic process.
3. Distinguish between: a compound and an element, a molecule and an atom, physical and chemical change, reactants and products, combination and decomposition reaction, exothermic and endothermic reaction.
4. What is a balanced equation?
5. What does a chemical equation represent?

6. Write balanced chemical equations for each of the following:

(a) $Ca + O_2 \longrightarrow CaO$

(b) $S + O_2 \longrightarrow SO_2$

(c) $N_2 + O_2 \longrightarrow NO_2$

(d) $Hg + O_2 \longrightarrow HgO$

(e) $Na + Cl_2 \longrightarrow NaCl$

(f) $Cu + O_2 \longrightarrow CuO$

(g) $H_2 + Cl_2 \longrightarrow HCl$

(h) $N_2 + H_2 \longrightarrow NH_3$

(i) $Zn + O_2 \longrightarrow ZnO$

(j) $C + O_2 \longrightarrow CO$

7. Determine what types of reaction each of the following reaction is:

(a) $2AgCl + light \longrightarrow 2Ag + Cl_2$

(b) $2Al + 3Cl_2 \longrightarrow 2AlCl_3$

(c) $Hg_2S + heat \longrightarrow Hg + S_8$

(d) $Li + O_2 \longrightarrow Li_2O$

8. State Law of conservation of mass.

9. Why is Antino Lavoisier famous for?

10. Write short notes on:

(a) chemical reaction (b) chemical equation

(c) decomposition reaction (d) combination reaction

Extensive Questions

11. Describe experiments showing chemical changes.

12. Give examples of chemical changes.

13. Describe rearrangements of atoms in chemical reactions.

14. How are chemical equations written?

15. How to balance chemical equations?

16. What are the essential features of a chemical equation?

17. Explain with experiment the conservation of mass.

18. Explain combination reaction with example.

19. Explain decomposition reaction with example.

20. Describe exothermic reactions with example and experiment.

21. Describe endothermic reaction with example and experiment.

22. What is the importance of exothermic reactions in daily life?
23. Compare exothermic and endothermic reactions.
24. What is the importance of endothermic reactions?

Science, Technology and Society Connections

- Observe any five chemical reactions occurring around you all the time, and fill the following given table:

Reactants	Reactants	Products	Addition	Decomposition	Endothermic	Exothermic
C	O_2	CO_2	✓			✓

Answers of MCQs

(i)	C	(ii)	B	(iii)	D	(iv)	C	(v)	A
(vi)	D	(vii)	A	(viii)	B	(ix)	C	(x)	A
(xi)	D	(xii)	C	(xiii)	B	(xiv)	A	(xv)	C
(xvi)	A	(xvii)	A	(xviii)	A				

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تو نشانِ عزمِ عالی شان ارضِ پاکستان
مرکزِ یقین شاد باد!

پاک سر زمین کا نظام قوّتِ اُخوّتِ عوام
قوم ، مُلک ، سلطنت پائندہ تابندہ باد!
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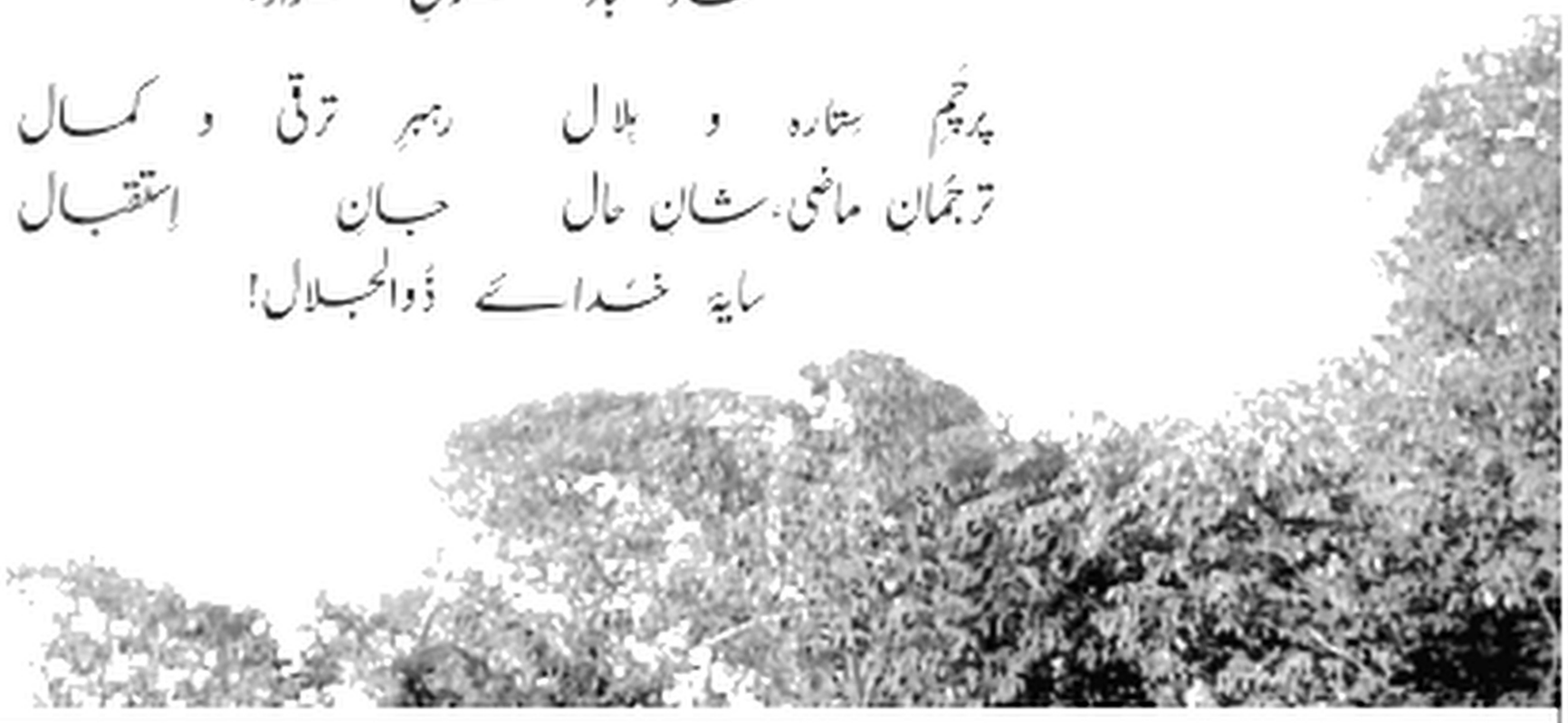

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