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ترجمہ: ”شروع اللہ کے نام سے جو بڑا مہربان نہایت رحم والا ہے۔“

GENERAL SCIENCE

7



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Sales Office: +92-42-37352492, Marketing Office: +92-42-37361291
Fax: +92-42-37112248

Karachi | Islamabad | Dubai | Manchester
+92-21-32639320 | +92-51-4450850 | +971-4-2348321 | +78-15020944

E-mail: info@goharpublishers.com

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Written by:

- **M. Akram**
(M.Sc)
- **Nazeer Ahmad**
(M.Sc)

Edited by:

S. M. Yunus

Designed by:

- **Waqas Javaid**
- **Syed Farrukh Gillani**

Prepared by:

Gohar Publishers,
11- Urdu Bazar Lahore.

Members of Review Committee:

- **Mr. Aurangzeb Rehman** Joint Educational Adviser, Ministry of CAD, Islamabad
- **Dr. Zaheer-ud-Din Khan** Ex-Professor, Department of Zoology, Govt. College University, Lahore
- **Mr. Riaz Muhammad** Ex-DEA (Curriculum Wing), Ministry of Education (Defunct), Islamabad
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- **Mr. Muhammad Anwar Sajid** Subject Specialist, Punjab Textbook Board, Lahore

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Human Organ Systems

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- describe various components of human digestive system.
- describe digestion and its importance.
- describe how digestive system helps in the digestion of various kinds of foods.
- identify common disorders of the digestive system.
- list the factors that lead to constipation and diarrhoea and the measures that can be taken to prevent them.
- describe the mechanism of respiration in humans.
- differentiate between breathing and burning processes.
- identify the common diseases of respiratory system and discuss their causes and preventive measures.



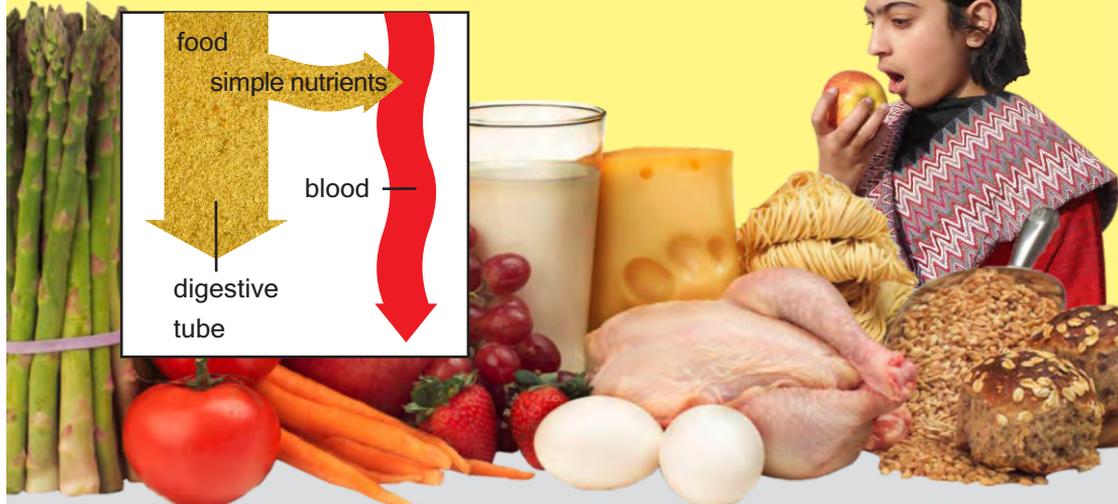
The human body is made up of trillions of cells. Cells group together to form tissues, organs and organ systems. The combined action of all the organ systems allows people to perform various activities like offering salah.

The human body is made of several organ systems that work together as one unit. In class VI we have learnt a little about the human body. In this chapter we shall learn more about the human digestive and respiratory systems.

1.1: Digestive System

Our body needs energy and food to move, grow and to stay alive. Our body cells cannot use the food in the form it is eaten by us. Our body changes it into simpler form. The process of changing the food into simpler form is called **digestion**. The parts of body that take part in the process of digestion form the **digestive system**.

Eating well is one of the most important things we can do to keep our body healthy. Different foods are the sources of nutrients. Nutrients are the useful parts of our food. Carbohydrates, proteins, fats, vitamins, minerals, etc. are the nutrients. Our digestive system breaks down nutrients into simple molecules. These simpler molecules can pass through the wall of digestive tube to enter the blood. The blood carries them to every cell to produce energy, or to become part of our body.



Where and How Digestion Occurs?

The process of digestion occurs in a long tube called alimentary canal. It starts from the mouth and ends at the anus (Fig. 1.1).

Mouth

The process of digestion begins from our mouth. Our teeth break the food into small pieces by cutting and grinding. The tongue mixes food with **saliva** which is secreted by salivary glands. Saliva starts the digestion of carbohydrates (starch and sugar). After some time, the food in the mouth becomes soft and moist. The tongue pushes this food to the back of our mouth.

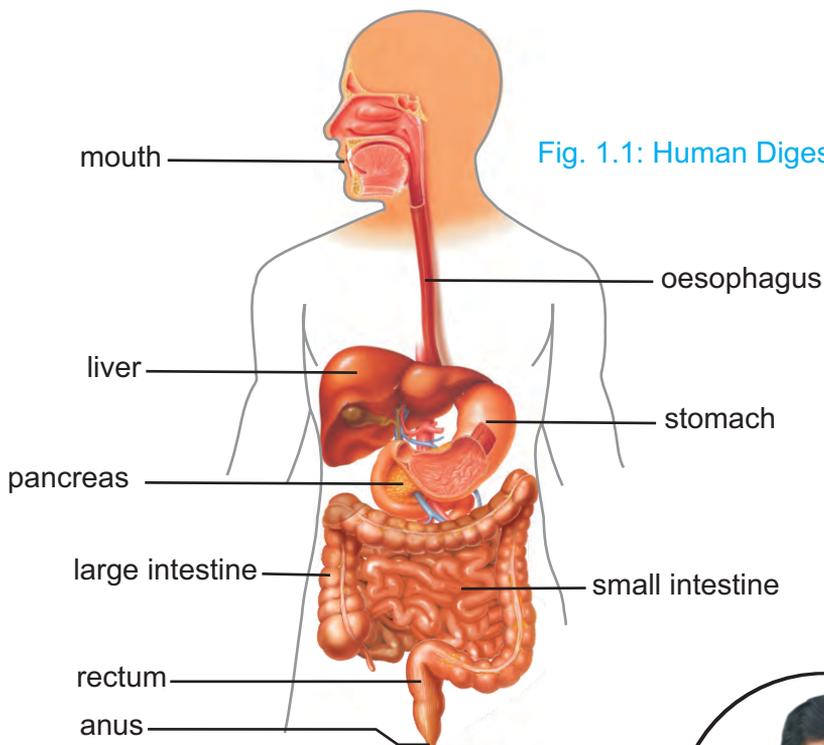


Fig. 1.1: Human Digestive System

Our teeth are the main tools we use to break down food in the mouth. We must take care of them to make them strong. Drink plenty of milk. Use tree twig (miswak) or brush to clean the teeth. Avoid too much sweets.



Oesophagus

The chewed food is then pushed from the mouth into the oesophagus. The oesophagus is a large tube that carries food from the mouth to the stomach.

The oesophagus uses wave-like muscular movements to push the food to the stomach. These wave-like movements are called peristaltic movements and process is called **peristalsis**.

 **Extend Your Thinking** Is it possible for food we eat to go into stomach and intestine even when we are upside down? Explain it.

Stomach

Our stomach is a large J-shaped muscular bag. It mixes the food with digestive juice. The digestive juice begins the digestion of proteins (meat, egg, milk, pulses, etc.). The food spends about four hours in the stomach.

The digestive juice in the stomach also contains an acid. The acid kills the germs present in our food. It also helps in the digestion of proteins.



Extend Your Thinking

Our stomach digests proteins (meat, etc.). Why does its juice not digest the stomach itself?

Small Intestine

As food leaves our stomach, it is passed on to the small intestine which is a long, thin tube coiled inside our abdomen. Final digestion of carbohydrates, fats and proteins occurs in the small intestine. Three organs help in the digestion of food here. These are the liver, pancreas and wall of the small intestine. The liver provides bile salts to make fats easier to absorb. The pancreas and intestinal walls secrete juices to digest the remaining food.

The absorption of the digested food also occurs in the last part of the small intestine. The inner surface of small intestine has many finger-like structures called **villi**. The digested food passes into the blood through the walls of the villi. The blood carries food particles to all parts of the body.

Large Intestine

The undigested part of the food passes into the large intestine. Here the undigested food has a large amount of water. The main job of large intestine is to absorb extra water. The undigested food becomes solid and is called faeces. The faeces is stored in the last part of the large intestine called the rectum. We pass the faeces out of our body through the anus.

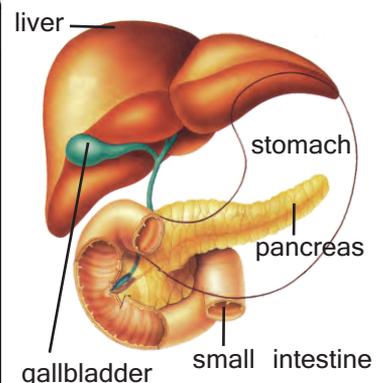
Supporters of the Digestive System

The liver, pancreas and gallbladder are not part of the digestive tube, but they are the supporters of our digestive system.

Liver: The liver produces bile to digest fat. It also breaks down harmful substances in the blood.

Gallbladder: The liver stores its bile in the gallbladder which releases it into the small intestine.

Pancreas: The pancreas makes juice to digest remaining carbohydrates, proteins and fats.



Tidbit

Sometimes **peristalsis** works in reverse and pushes the food in stomach up and out through mouth. This reverse process of peristalsis is called vomiting. It mostly happens when the food is unsuitable in some way.



Extend Your Thinking

If we bite a bread and chew it in our mouth for some time, it will taste sweet. Why?

1.2: Disorders of Digestive System

Some common digestive system disorders are diarrhoea, heartburn, constipation, ulcer, gas-trouble, etc. Here we shall discuss diarrhoea and constipation.

1.2.1: Diarrhoea

Diarrhoea is passing semi-liquid faeces. It may be caused by an infection, eating contaminated food, a reaction to some medicine or just anxiety or excitement.

Some of the most common symptoms of diarrhoea are: abdominal pain, cramping, bloating, nausea, loose motions, fever and bloody stools.

Diarrhoea can be fatal in case of severe dehydration. Therefore, drink plenty of liquids, otherwise dehydration may take place. Doctors prescribe antibiotics to treat diarrhoea. We can prevent diarrhoea by following the tips given below.

- Always wash your hands with soap after using the toilet.
- Wash all fruits and vegetables before cooking or eating.
- Don't eat uncooked meat and eggs.

Tidbit

Lemonade contains sugar and salt. Both sugar and salt help to absorb water in the body. So, use of lemonade is good during diarrhoea.

1.2.2: Constipation

Constipation is the painful or difficult passing of faeces. During the period of constipation some persons may pass faeces three or less than three times a week. It is a common digestive disorder in Pakistan.

Constipation is caused by taking food low in fibre, lack of physical activity, not drinking enough water, delay in going to the washroom, etc. We can avoid constipation by:

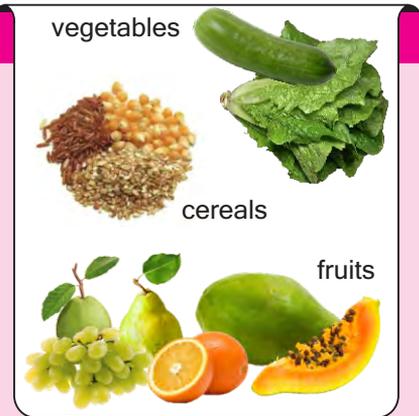
- adopting a proper lifestyle.
- taking regular exercise.
- eating lots of fibre food (fruit, vegetables and cereals).
- drinking plenty of water (at least 8 glasses everyday).
- going to the washroom when we have the urge.

Activity 1.1

Draw a labelled diagram of the human digestive system on a chart. Display this chart in your classroom. Identify and discuss the path of food in the body with your class fellows.

Fibre Keeps Our Digestive System Healthy

Dietary fibre holds water in it and softens the faeces in the large intestine, so that it can pass out of the body easily. We can keep our digestive system healthy by eating food with plenty of fibre. Dietary fibre is found in cereals (wheat, corn, barley, oat, etc.), fruits (pears, guavas, grapes, oranges, apples, etc.) and vegetables (spinach, mustard, cucumber, etc.).



1.3: Respiratory System

All living things need energy to move and grow. They get energy by breaking down food substances. We need oxygen to break down the food in every cell of our body. Our lungs take oxygen from the air during respiration (breathing).

Breathing is the process that moves air in and out of the lungs. **Respiration** is the process by which living organisms use oxygen of air and food to produce energy. Carbon dioxide is also produced during this process. The parts of body used in the process of breathing form the **respiratory system**.

Parts of Respiratory System

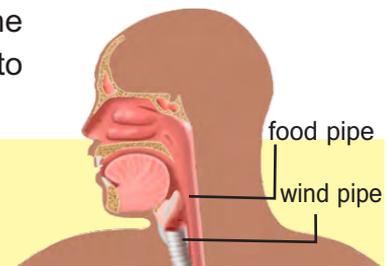
Our respiratory system consists of the nose and throat, the wind pipe (trachea), the breathing muscles and the lungs (Fig.1.2).

Nose and Throat

The air enters through our nose or mouth. Our nose has hair and mucous to clean, moisten and warm the air. Mucous is a sticky liquid. Dust particles and germs present in the air stick to the mucous.

The air enters the throat and passes through the larynx. Our vocal cords are present in the larynx to produce sound.

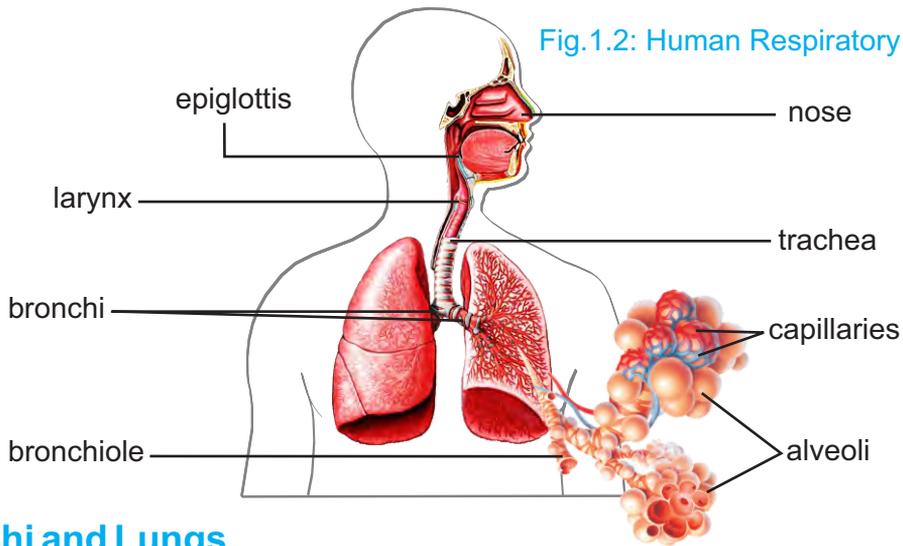
Our throat contains two pipes — one for the food and the other for breathing. It is the epiglottis which allows things to go down the right way. When we eat or drink something, the epiglottis covers the windpipe.



Trachea (Windpipe)

Air passes from the larynx into the trachea or windpipe. Our windpipe is made of C-shaped rings of cartilage. These rings keep our windpipe open. Mucous and tiny hair in the trachea also filter the air.

Fig.1.2: Human Respiratory System



Bronchi and Lungs

The trachea divides into two branches called bronchi (singular bronchus). Bronchi carry air into the lungs.

Our lungs are the most important organs of the respiratory system. In each lung the bronchus divides into smaller tubes called **bronchioles**. At the end of each bronchiole, tiny air sacs called **alveoli** are present. Alveoli are surrounded by blood capillaries. When we breathe in, the air enters the lungs and reaches the alveoli. Oxygen of the air passes through the walls of alveoli into the capillaries. The red blood cells carry this oxygen to every cell of our body. Cells in our body use oxygen and food to produce energy and carbon dioxide. The blood brings carbon dioxide back to the lungs. Carbon dioxide leaves our body when we breathe out.



Extend Your Thinking

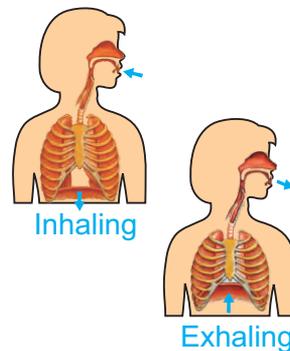
Why are we advised to breathe deeply after running a race?

How do we breathe?

Our lungs have no muscles. Two types of muscles work during the breathing process ; the intercostal muscles of ribs, and the dome-shaped diaphragm. The process of breathing is completed in two steps:

Inhaling: When the intercostal muscles pull our ribs outward and the diaphragm contracts, the air enters the lungs. It is called inhaling.

Exhaling: When the intercostal muscles and diaphragm muscles relax, the air moves out of the lungs. It is called exhaling.



1.3.1: Comparing Breathing and Burning

Breathing and burning processes can be compared.

- During both processes energy is released from a fuel.
- Both processes use oxygen and release carbon dioxide.

The main difference between the two processes is the rate at which they release energy. During breathing, release of energy is very slow than burning and its rate can be controlled.

Activity 1.2

Working Model of a Lung

You will need

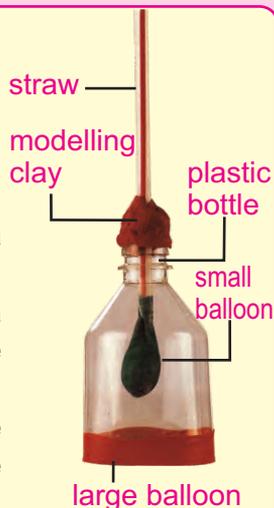
- 2 balloons (1 small, 1 large)
- drinking straw
- tape
- a pair of scissors
- modelling clay or wax
- small clear plastic bottle with bottom cut off

Procedure

1. Pull the opening of a small balloon over one end of a drinking straw. Use tape to attach the balloon to the straw.
2. Cut the neck of a large balloon. Ask your friend to hold a plastic bottle whose bottom has been cut off. Stretch the balloon over the cut end of the bottle (use tape).
3. Push the end of the straw with the small balloon into the mouth of the bottle. Then use modelling clay to seal the mouth of the bottle and to hold the straw in place.
4. Pull down the large balloon and observe what happens to the small balloon.
5. Now push the large balloon and observe its effect on the small balloon.

Things to think

Can you explain the movement of your lungs with the help of this activity?



1.4: Common Diseases of Respiratory System

Some common disorders of respiratory system are; common cold, influenza, pneumonia, tuberculosis and lung cancer. Here we shall discuss common cold and pneumonia.

1.4.1: Common Cold

The common cold is a common disorder of respiratory system. The virus of common cold can spread from person to person by coughing, sneezing or touching things of a common cold patient.

Symptoms of common cold are sore throat, cough, running nose, congestion, sneezing, headache, etc. We may have fever during the common cold.

There is no proper medicine for the common cold. However, you may observe the following measures. Get lots of rest, drink plenty of liquids and if symptoms persist, consult your doctor.

 **Extend Your Thinking**
Why does our voice become rough when we get infection in throat or catch cold?

1.4.2: Pneumonia

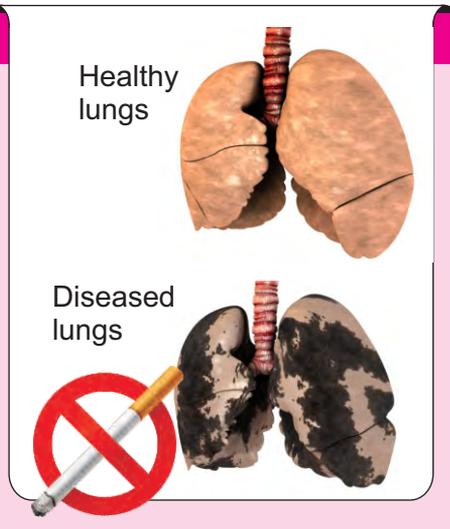
Pneumonia is an infection that affects the lungs. The lungs are made of small sacs called alveoli, which are filled with air. When a person has pneumonia, the alveoli are filled with pus, which makes breathing painful.

Pneumonia is the main cause of death in children worldwide. Common symptoms of pneumonia are cough, fever, nasal congestion, rapid breathing with wheezing sound, chest pain, loss of appetite, etc.

Visit your doctor as soon as possible to treat pneumonia. Your doctor may prescribe an antibiotic medicine. Vaccines can also be used to prevent pneumonia. Wash your hands frequently to avoid germs. Use a tissue or handkerchief when you cough or sneeze.

Keep Your Lungs Healthy!

1. Fruit and vegetables contain vitamins. Vitamins keep our lungs healthy.
2. Exercises like running, walking, swimming, jumping, cycling, etc. are good for our lungs.
3. Avoid smoking. Smoking is the main cause of lung cancer.
4. Leafy green vegetables contain such chemicals that are good for our lungs.



Science, Technology and Society

Adulteration of food affects our digestive system badly. Pollution especially air pollution, affects our respiratory system. Why do we think government should take action against adulteration and pollution?

Key Points

- ⦿ Mouth, oesophagus, stomach, small and large intestines, liver and pancreas are the components of human digestive system.
- ⦿ Digestion is a process of changing the food into simpler form. This process helps our body to get important nutrients.
- ⦿ Some parts of our digestive system secrete chemicals which change carbohydrates (in mouth), proteins (in stomach) and fats into simpler substances. These substances are then absorbed into blood.
- ⦿ Diarrhoea, heartburn, constipation, ulcer, gas-trouble, etc. are some common disorders of digestive system.
- ⦿ Diarrhoea may be caused by an infection, by eating contaminated food or a reaction to some medicine.
- ⦿ Washing hands frequently and washing fruits and vegetables before eating or cooking can help to prevent diarrhoea.
- ⦿ Constipation may be caused by taking food low in fibre, lack of physical activity, not drinking enough water, etc.
- ⦿ We can prevent constipation by eating food rich in fibre, by drinking plenty of water and by taking regular exercise.
- ⦿ Our respiratory system helps to produce energy which we use in our activities.
- ⦿ Breathing and burning are similar processes, but release of energy is very slow during breathing.
- ⦿ Common cold, influenza, pneumonia, tuberculosis, lung cancer, etc. are some common disorders of the respiratory system.
- ⦿ We can keep our lungs healthy by eating fruits and vegetables, and by taking regular exercise.

Questions

1. Complete each of the following sentences by writing the correct term.

- i. The process of breaking down of food _____
- ii. Muscular contractions that move food _____
- iii. The grape-like clusters of tiny thin-walled balloons in lungs _____
- iv. The dome-shaped muscle at the bottom of our chest _____
- v. The process of getting air into and out of the lungs _____

2. Encircle the correct answers in the following.

- i. The place where digested food is absorbed:
(a) small intestine (b) large intestine
(c) stomach (d) mouth
- ii. What part of our body contracts and moves down when we inhale?
(a) bronchioles (b) alveoli
(c) diaphragm (d) kidneys

- iii. Air is moistened, filtered, and warmed in the:
 (a) oesophagus (b) nose
 (c) mouth (d) stomach
- iv. A large muscle that separates the chest cavity from the abdominal cavity and helps in breathing:
 (a) larynx (b) trachea
 (c) diaphragm (d) alveolus
- v. Which produces juice for the final digestion of proteins, fats and carbohydrates?
 (a) mouth (b) large intestine
 (c) pancreas (d) gallbladder
- vi. The reverse process of peristalsis:
 (a) breathing (b) burning
 (c) vomiting (d) blood circulation

3. Give short answers.

- i. How is carbon dioxide produced in our body?
 ii. How is small intestine important in our digestive system?
 iii. Why are we provided with teeth?
 iv. What are alveoli?
 v. Briefly describe the mechanism of breathing.
 vi. What measures can one take to prevent diarrhoea?

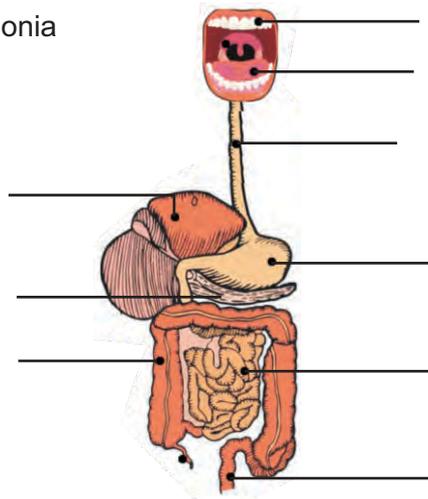
4. Explain the process of digestion of food in the mouth and the stomach.

5. Describe the human respiratory system.

6. Write notes on the following:

- i. Constipation ii. Pneumonia

7. Label the diagram.



Computer Links

For more information visit:

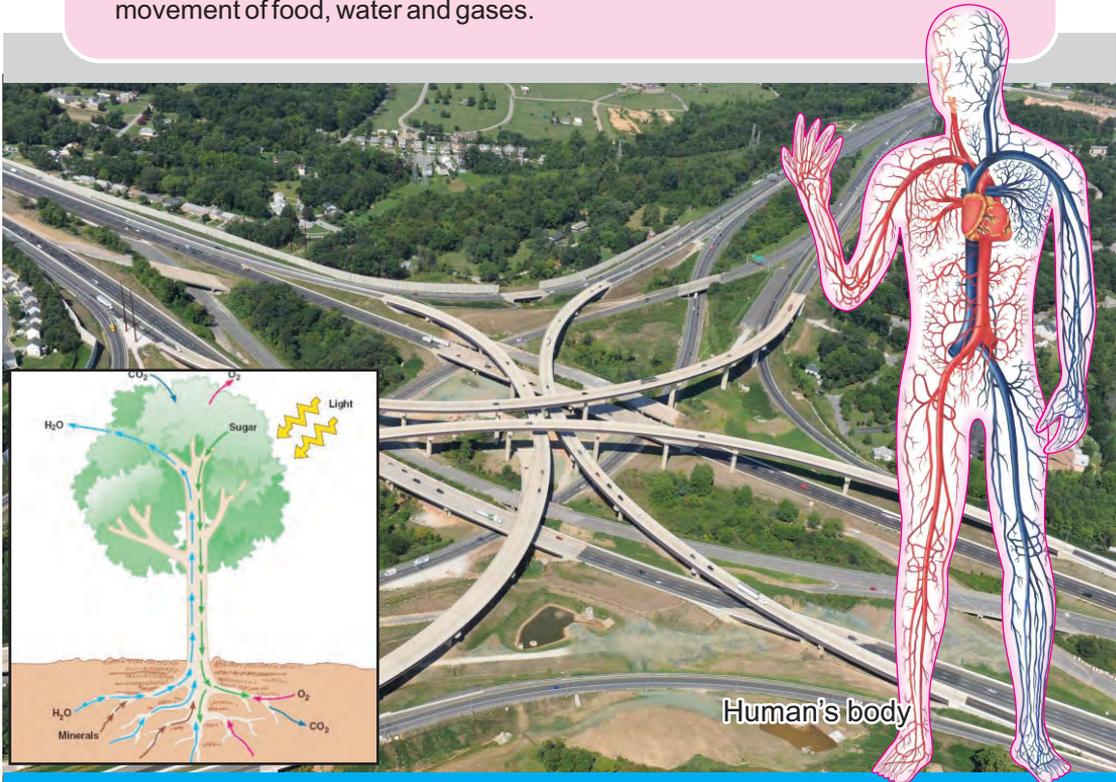
- <http://kidshealth.org/kid/htbw/lungs.html>
- http://www.stcms.si.edu/hbs/hbs_student.htm

Transport in Humans and Plants

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain the transport system in humans.
- ▶ describe the structure and function of heart and blood vessels.
- ▶ explain the working of the circulatory system.
- ▶ identify scientific developments that provide alternatives for dysfunctional body parts such as artificial tissues and organs, and their transplantation.
- ▶ find out that some disorders in human transport system can be affected by diet.
- ▶ describe the absorption of water in plants through roots.
- ▶ explain how the structure of the roots, stem, and leaves of a plant permit the movement of food, water and gases.



The highway system of a city helps to move food, water, petrol, garbage, and other goods. Similarly, the transport systems help to move food, water, gasses and wastes throughout our body and a plant's body.

We have learnt in the previous chapter that our body needs food and oxygen to produce energy. Wastes are also produced in our body. How do materials move in our body? The supply of food, water, oxygen, etc. and removal of wastes from our body is called **transportation**. The blood circulatory system in our body serves this purpose.

2.1: Human Blood Circulatory System

Our circulatory system comprises the heart, blood vessels and blood. Our heart is a pumping organ. It pumps the blood in blood vessels.

The Heart

Our heart is a muscular organ about the size of our fist. The heart is found in our chest. It pumps oxygen-poor blood (deoxygenated blood) to the lungs and oxygen-rich blood (oxygenated blood) to the body. There are four chambers in our heart; two upper chambers called **atria** (singular atrium) and two lower chambers called **ventricles** (Fig.2.1).

The ventricles of our heart are larger than the atria. Both atria contract at the same time, and so the ventricles. The blood passes from the atria into the ventricles. There is a valve between each atrium and ventricle on the both sides of the heart. These valves keep the blood flowing in one direction. Deoxygenated blood from the body enters the right atrium and oxygenated blood from the lungs enters the left atrium of our heart. The right ventricle pushes the blood to the lungs and the left ventricle pushes the blood to the body.

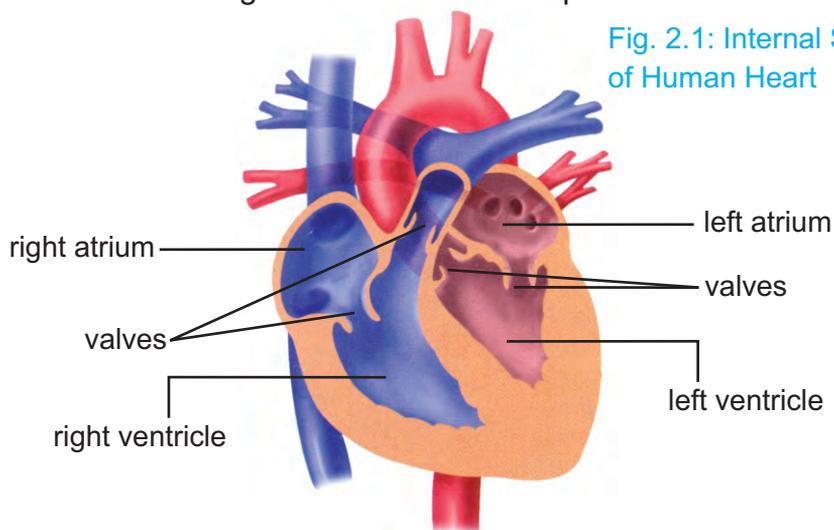


Fig. 2.1: Internal Structure of Human Heart

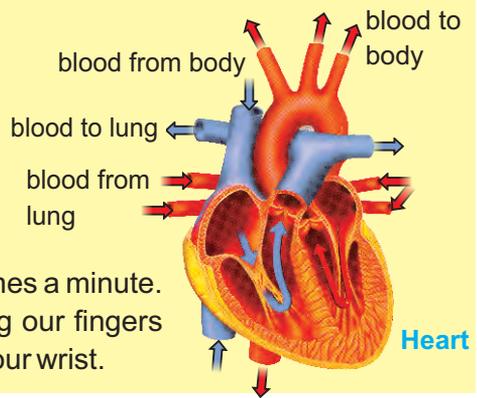


Extend Your Thinking

What do you think would happen if blood entering the heart is mixed with blood leaving the heart?

How Does Our Heart Work?

Human heart acts as a double pump. Blood from lungs and other body parts enters the atria. The two atria contract at the same time and push the blood to ventricles. It is one pump. Now both ventricles contract at the same time and pump the blood to lungs and other body parts. It is the second pump. Our heart beats about 70 times a minute. We can feel our heart beat (pulse) while placing our fingers below the base of the thumb on the underside of our wrist.



Blood Vessels

The blood travels throughout the body through blood vessels (Fig.2.2). The three types of blood vessels are arteries, capillaries and veins.

Arteries

Arteries are the blood vessels that carry blood away from the heart (Fig.2.3). Arteries have thick and flexible walls. Most of the arteries carry oxygenated blood, but pulmonary arteries carry deoxygenated blood to the lungs. Arteries divide many times to form smaller tubes, called **capillaries**.

Capillaries

Capillaries are the smallest blood vessels in the body (Fig.2.3). They are so small that red blood cells flow through them one cell at a time. Food and oxygen from the blood of capillaries diffuse into the cells. Waste materials and carbon dioxide from the cells diffuse into the blood of capillaries. Capillaries again join to form the larger blood vessels called **veins**.

Veins

Veins are the blood vessels that bring blood back to the heart (Fig.2.3). Most of the veins bring deoxygenated blood back to the heart, but **pulmonary veins** bring oxygenated blood from the lungs to the heart.

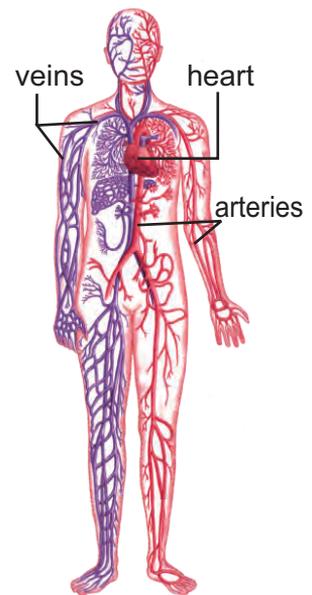


Fig. 2.2: Human Circulatory System

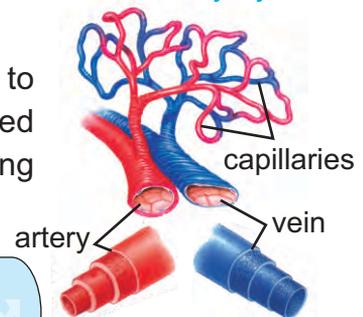


Fig. 2.3: Blood Vessels



Extend Your Thinking

How is the structure of capillaries related to their function?

Activity 2.1

Exercise and Your Heart

1. Feel the pulse on your wrist while sitting on the chair. Using a watch, count the number of pulses for 15 seconds. Then multiply this number by 4 to find the number of heart beats in 1 minute.
2. Do jumping in place for 30 seconds and then stop. Count the number of pulses.
3. After taking rest for 5 minutes, count your pulse again.

Compare the heart beat rates in the two situations.

Things to think

How did exercise affect your heart beat rate?



Extend Your Thinking

Explain how our circulatory system completes the work of our digestive and respiratory systems.

2.2: Diet Affects Our Circulatory System

Our diet and lifestyle affect our circulatory system and cause many diseases such as heart attack, blood pressure, diabetes, asthma, etc.

2.2.1: Heart Attack (Myocardial Infarction)

The heart is made of muscle cells. These cells, just like other cells in the body, must receive oxygen and food through circulatory system. The blood vessels which supply oxygen and food to the heart are called **coronary arteries**.

A hard substance called plaque can build up in the walls of coronary arteries. This plaque is made of fat and other cells. The coronary arteries may become narrow due to plaque. Sometimes a blood clot forms on the plaque and blocks coronary arteries. Due to this, the blood cannot reach a part of the heart. This part of the heart begins to die due to lack of oxygen and food. The death of a part of heart is called a **heart attack** or myocardial infarction. If too much heart muscle dies, the heart is unable to pump the blood and the person could die.

Heart attack symptoms may include: chest pain, shortness of breath, heavy sweating, etc. which is a medical emergency. Call 1122 or another ambulance.

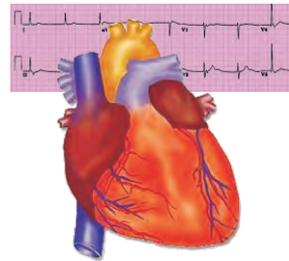


Fig. 2.4: ECG report can help to diagnose heart attacks.

Avoid Heart Diseases

Act upon the following tips and keep your heart and blood vessels healthy.

- 🍌 Take foods high in fiber and low in fat.
- 🏃 Take regular exercise to increase blood circulation throughout your body.
- 🚭 Don't smoke. Smoking can increase your blood pressure.



2.2.2: High Blood Pressure (Hypertension)

High blood pressure is a disorder of circulatory system. Blood pressure is the amount of force exerted by blood against the walls of the arteries. If the blood pressure of a person remains above the normal value (120/80), the condition is called high blood pressure or **hypertension**.

The increased blood pressure can damage blood vessels and the result may be the failure of kidneys and heart. People with high blood pressure may have the symptoms such as, headache, fatigue, blurred vision, nosebleeds, etc. Foods high in fat, high salt intake, smoking, obesity, diabetes, lack of exercise, etc. raise the risk of high blood pressure.



Fig: 2.5. A sphygmomanometer is used to measure the blood pressure.

Science, Technology and Society

Smoking can cause heart diseases. It has been found that a person who smokes is more likely to have heart problems than someone who does not smoke. A chemical in tobacco smoke causes blood vessels to become more narrow. The blood pressure of a smoker may increase. The heart works harder to pump blood through these narrow vessels. Heart patients are also asked not to smoke. Why cigarette brands should not be advertised?

2.2.3: Diabetes

Diabetes is a disease in which a person has high blood sugar, because his/her body does not produce enough insulin. Insulin is the chemical that is produced in our pancreas (Fig.2.6). Insulin helps to decrease blood sugar. Without insulin a person develops diabetes.

Loss of weight, frequent urination, excessive thirst and hunger, etc. are some of the symptoms of diabetes.

If the patient does not control the level of blood sugar, he/she may be at the risk of loss of eyesight and hearing, heart attack, gum disease, kidney disorder, etc.

A person can control his/her blood sugar level by taking medicines, eating proper diet and taking exercise.

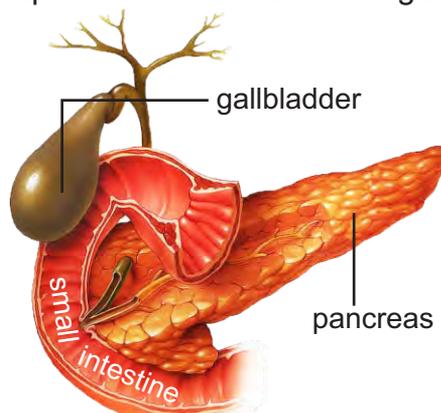


Fig: 2.6. Insulin is produced in the pancreas.

Carbohydrates have a big impact on our blood sugar level. Extra fats are not good. We need to take these foods carefully. Some vegetables and fruits are useful for a diabetic patient.

2.2.4: Asthma

Asthma is an allergy that causes the airways of the lungs to swell and narrow. A person with asthma may wheeze (a whistling sound when he or she breathes), cough, and feel tightness in the chest.

The things that can cause asthma are called **allergens**. Dust mites, pollen grains and some foods may cause asthma.

Symptoms of an asthma attack may be cough, shortness of breath, wheezing, extreme difficulty in breathing, chest pain, sweating and increased pulse rate. Severe asthma attack may lead to death.

It is not easy to cure asthma, but one can be normal and active even with asthma.

-  Try to avoid the allergens of asthma.
-  Use plenty of water, it will give you relief.
-  On advice of a doctor, use medicines or inhaler (Fig.2.7).



Fig:2.7: An inhaler is used to relief asthma.

Transplantation

Sometimes an organ in the body of a person may stop its working because of a disease or injury. In the past, failure of a major organ resulted in the death of the patient. But, now scientists have found the solution of this problem.

An organ **transplant** replaces a failing organ with a healthy organ. A doctor removes an organ from a healthy person and places it in the patient's body. The patient again lives a normal life after transplantation.

Not all organs can be transplanted. Organs most oftenly transplanted are:

- **The kidney** because of diabetes or other kidney problems.
- **The liver** because of serious liver disorders.
- **The heart** because of heart failure.
- **The pancreas** because of diabetes.
- **The lung** because of serious respiratory disorders.

People who have organ transplants must take medicines regularly the rest of their lives to stay healthy.

Sometimes artificial organs are also used to restore a function in the body of a person. An **artificial organ** is a man-made device that replaces a missing natural organ. Artificial legs, arms, bones, arteries, eyes, teeth and ears are common to transplant now-a-days. The scientists who design and build artificial body parts are called **biomedical engineers**.



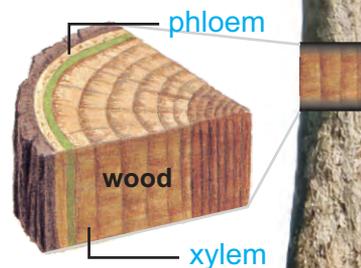
2.3: Transportation in Plants

Plants do not have a circulatory system like humans and animals, but they too need to move water and food from one part to the other. How do plants transport materials? Plants transport water and minerals from roots to leaves through xylem vessels. Phloem transports prepared food from leaves to all other parts (Fig.2.8).

2.3.1: Absorption of Water in Plants Through Roots

The water enters the plant body through its roots. There are thousands of tiny root hairs on each root. The soil surrounding the roots has higher amount of water and minerals than inside the root cells. Water and dissolved minerals from the soil absorb into the root hairs by diffusion. Diffusion is the movement of a substance from where it is in large amount to where it is in small amount.

As water in roots increases, a pressure is produced in the root cells to push water and minerals up in the plant. But this pressure of roots can only lift water up to a certain height. How does water reach in leaves of tall trees?



2.3.2: Transpiration

In tall trees, water is pulled up through the xylem when it is evaporated from the leaves. Once in the xylem pipes, water forms unbroken columns from the roots, through stem and into the leaves. The loss of water by evaporation from plants is called **transpiration**. As water transpires, more water is drawn from the xylem. This movement of water exerts a pull on the water within the xylem. As water moves out of the leaves, more water moves up from the stem. Roots absorb more water from the surrounding soil to maintain the water column in stem and leaves.

Fig: 2.8. Xylem and phloem tissues inside the plant body transport water and food.



Extend Your Thinking

What would happen to a plant if its leaves were covered with waterproof petroleum jelly?

Activity 2.2

Transpiration in Plants

You will need:

- 4 clear plastic glasses
- ice-cream stick
- a leaf of water plant with a stalk
- cardboard (2 pieces)

Procedure

1. Fill two of the glasses about two-third full of water.
2. Make holes in the pieces of cardboard and pass the leaf stalk and ice-cream stick through them.
3. Place the cardboards with the leaf and ice-cream stick over the glasses of water.
4. Cover the glasses with leaf and ice-cream stick with empty glasses.
5. Place the glasses in sunlight for a day.

Observe it all the next day. The glass over ice-cream stick is still clear. The glass over plant leaf looks foggy because of transpiration.

Things to think

Why do people sit and relax under trees in hot summer days?



2.4: Translocation

Plants prepare food in their leaves. The prepared food is carried by phloem to all parts of a plant. The movement of prepared food from leaves to those parts of plant body where it is needed is called **translocation** (Fig.2.9). How is solid food transported from one part of the plant to the other?

Pressure Flow Hypothesis

We can explain the movement of solid food through the phloem by “pressure flow hypothesis”. According to this hypothesis water from nearby xylem enters the phloem and mixes with the food forming a solution. This solution flows under pressure through the phloem. The pressure is created by the difference in amounts of water in phloem and nearby xylem.

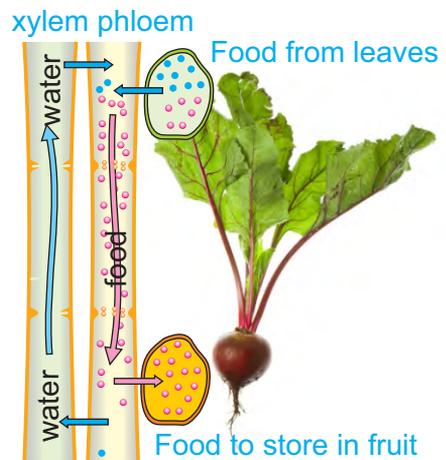


Fig: 2.9 Food moves through phloem in solution form.

2.4.1: Structure of Plant Parts and Transportation

Nature has made the plant parts in such a way that their structures permit the movement of materials.

Structure of Roots

From the moment a seed grows, its root starts to search water and minerals in the soil. Roots have branches that play an important role in absorption of water.

The root hair on the roots absorb water and minerals from the soil (Fig. 2.10). Roots have xylem tissues to move water and minerals from the soil up through the stems, to the leaves. Phloem tissues in roots help to transport food.

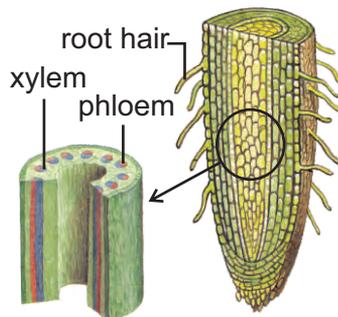


Fig. 2.10. The structure of root suits to the transport of materials.

Structure of Stem

Many plants such as mustard (sarsoon) have a waxy layer cuticle around the stem to reduce water loss. Bark also reduces water loss in plants. Phloem tissues in the stem transport food made in leaves. Xylem tissues carry water from roots to the leaves.

Structure of a Leaf

Leaves are the food factories of plants. Upper layer of a leaf has a waxy layer cuticle to reduce water loss. Lower layer of a leaf has stomata. Exchange of gases and transpiration take place through stomata. Midrib and veins of a leaf have xylem and phloem tissues. These tissues transport water and food throughout the leaf (Fig.2.11).

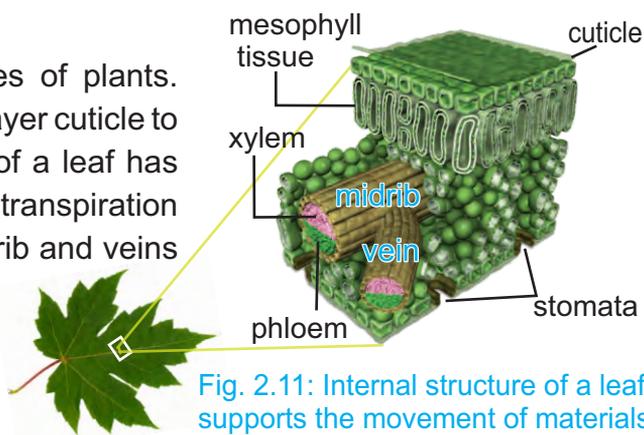


Fig. 2.11: Internal structure of a leaf supports the movement of materials.

Tidbit

Many stomata are present in the lower surface of each leaf. There can be as many as 200 stomata or more in an area equal to the size of the head of a pin.

Activity 2.3

Movement of Water in Plants

You will need: • a clear plastic glass • celery stem • dropper
• red ink • water

Procedure

1. Pour some water in the clear plastic glass. Add a few drops of red ink to water.
2. Take a celery stem, cut its edge and place it in the water.
3. Place the glass with celery stem in sunlight.

Observe the stem after 2 hours. You will see red lines in the leaves. If you cut a cross section of the stem you will also see the red colour inside it.

Things to think

Through which tiny pipes does water move within the stem?



Key Points

- ⊙ Our blood circulatory system delivers food and oxygen to our body cells and carries carbon dioxide and other wastes away from them.
- ⊙ Human heart has four chambers, two atria and two ventricles. Heart pumps the blood into blood vessels, i.e. arteries, capillaries and veins.
- ⊙ An organ transplant replaces a failing organ with a healthy one from another person. Organs transplanted more often are the kidney, heart, lung and liver.
- ⊙ Our diet and lifestyle also affect our circulatory system and may cause some disorders, such as heart attack, high blood pressure, diabetes, asthma, etc.
- ⊙ Tiny root hair on roots help to absorb water and minerals from the soil. Root pressure pushes water up the plant.
- ⊙ Transportation in plants takes place through xylem and phloem.
- ⊙ Structures of roots, stem and leaves of plants help in transportation of water, minerals and food.

Questions

1. Complete each of the following sentences by writing the correct term.

- Blood vessels which carry blood towards heart _____
- Blood vessels which supply blood only to the heart _____
- Transports food in a plant body _____
- Pores to exchange gases in plants _____
- Transports water and minerals from roots to leaves _____

2. Encircle the correct answers in the following.

- Blood is carried away from the heart in:
(a) arteries (b) veins
(c) nerves (d) ureters
- Where does the exchange of food, oxygen and wastes occur in the human body?
(a) in arteries (b) in veins
(c) in capillaries (d) in coronary arteries
- Why does the blood turn dark red as it circulates through the body?
(a) It starts to clot.
(b) It gets old and dirty while flowing through the body.
(c) The oxygen in it is replaced with carbon dioxide.
(d) The farther blood is from the heart, the more dark red it is.
- The movement of prepared food from leaves to those parts of plant body where it is needed is called:
(a) transpiration (b) translocation
(c) osmosis (d) active transport

- v. Which chamber of the heart receives the oxygenated blood from the lungs?
(a) right atrium (b) left atrium
(c) right ventricle (d) left ventricle

- vi. The loss of water by evaporation from plants is called:
(a) translocation (b) transpiration
(c) pressure flow (d) diffusion

3. Give short answers.

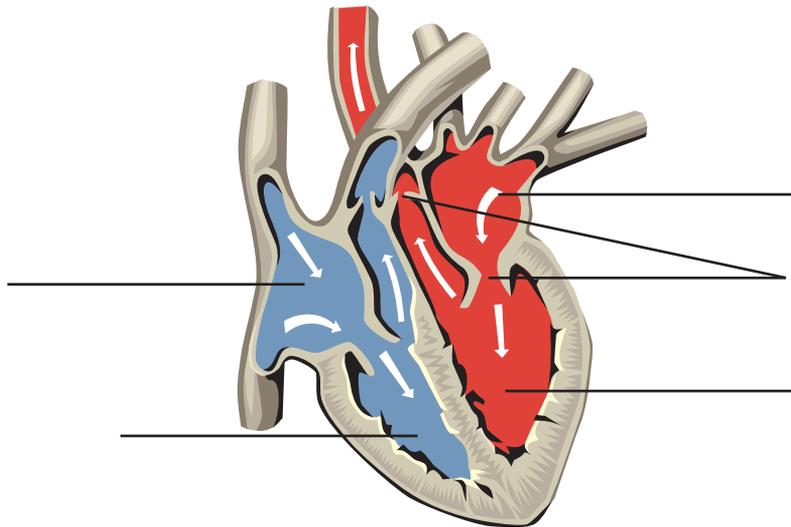
- i. What do you mean by oxygenated blood?
ii. What is the estimated size of our heart?
iii. Which arteries carry deoxygenated blood from heart to the lungs?
iv. Name at least two diseases that can damage our kidneys.
v. Which tissue does transport water in plants?
vi. Name three parts of the circulatory system.
vii. Explain why it is important to circulate blood through the body.
viii. How many chambers does the human heart have? Give names.

4. Describe the structure of human heart.

5. Compare the structures and functions of blood vessels.

6. Describe that structure of a plant's root permits the movement of materials.

7. Label the diagram.



Computer Links

For more information visit:

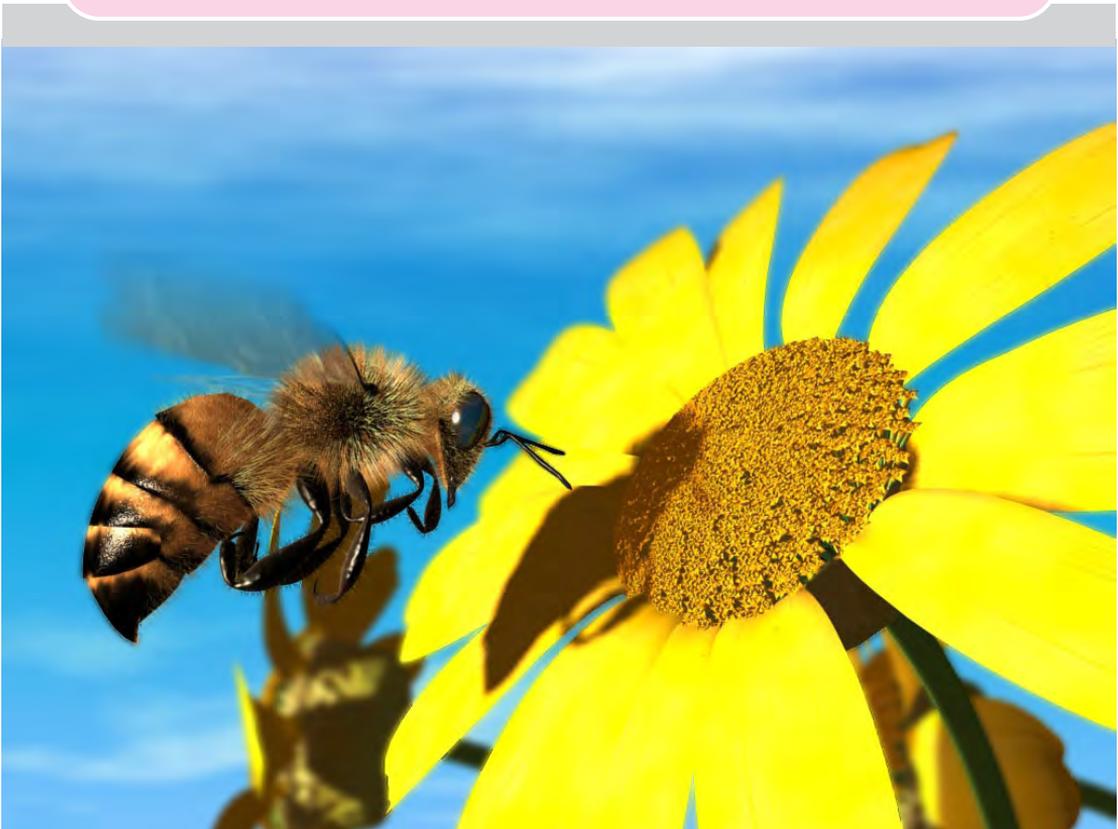
- <http://www.biologymad.com/master.html?http://www.biologymad.com/plantransport/plantransport.htm>
- http://kidshealth.org/parent/general/body_basics/heart.html#

Reproduction in Plants

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ define pollination.
- ▶ compare self and cross-pollinations in plants.
- ▶ list various factors involved in cross-pollination.
- ▶ investigate plants, which are cross-pollinated.
- ▶ differentiate between sexual and asexual reproduction.
- ▶ describe fertilization.
- ▶ describe seed and fruit formation.



A flower's colourful petals attract insects that pollinate the flower. Pollen grains stick to their bodies. Thus, they carry the pollen grains to part of the flower that makes seeds.

All living things reproduce. **Reproduction** is the process by which organisms produce more organisms like themselves. It is a basic characteristic of living things. Flowering plants mostly reproduce through flowers. One major process in the reproduction of flowering plants is pollination. Pollination helps to produce new seeds that grow into new plants.

3.1: Pollination

The transfer of pollen grains from the anther of a flower to the stigma of the carpel is called **pollination**. With the help of this process, the male sex cell (sperm) reaches the female sex cell (egg). Sex cells are also called gametes. Wind, insects, animals and water are the agents for pollination in different plants.

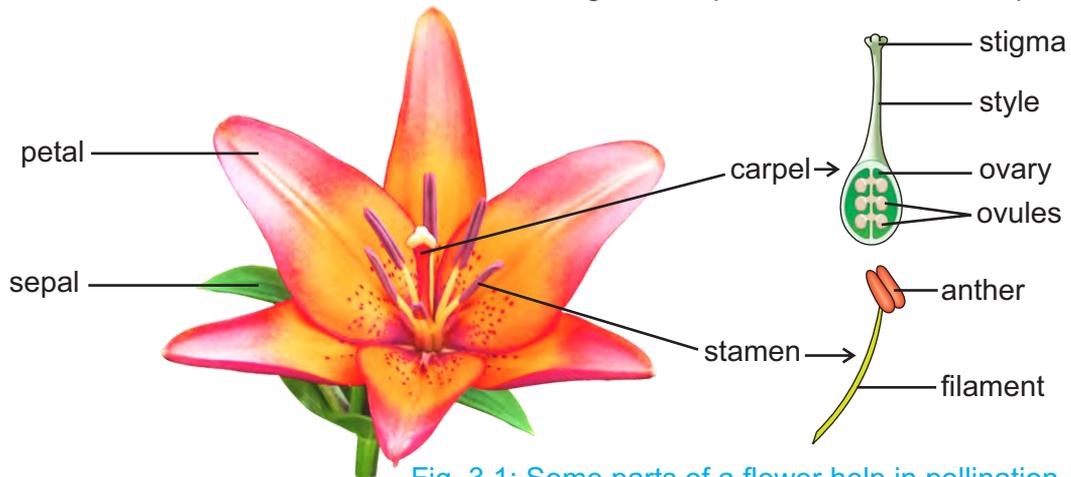


Fig. 3.1: Some parts of a flower help in pollination.

Parts of a Flower

Most flowers have four main parts, i.e. sepals, petals, stamens and carpels. Green **sepals** protect the flower from the Sun and rain in bud form. The coloured **petals** attract insects and other animals for the pollination of the flower. **Stamens** are the male parts of a flower. Each stamen has a filament and an anther. Pollen grains are produced in anthers. **Carpels** are the female parts of a flower. Each carpel has a sticky stigma, a style and an ovary. Ovules are present in the ovary.

3.2: Kinds of Pollination

There are two kinds of pollination, i.e. self-pollination and cross-pollination.

The transfer of pollen grains from the anther to the stigma of the same flower or another flower on the same plant is called **self-pollination** (Fig.3.2). Pea, tomato, rice plants, etc. are self-pollinated.



Fig.3.2:
Self-pollination

The transfer of pollen grains from the anther of a flower to the stigma of a flower on another plant of the same kind is called **cross-pollination** (Fig.3.3). Poplar, willow, apple, papaya trees, etc. are cross-pollinated plants. For cross-pollination, the plants must grow flowers at the same time. Cross-pollination usually happens in plants near each other. Cross-pollination produces stronger plants as compared to the self-pollination.

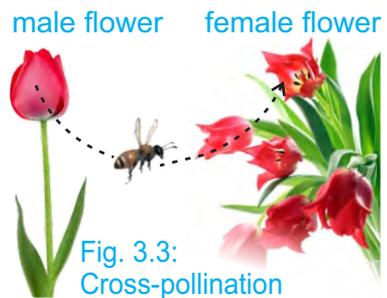


Fig. 3.3:
Cross-pollination

Some flowers have special features that favour cross-pollination, e.g. coloured petals, long and sticky stigmas, nectar and fragrance.

Extend Your Thinking What helps the pollen grains to stay on the tip of the style after they land there?

3.3: Agents of Pollination (Pollinators)

The agents that carry pollen grains from the anthers of flowers to the stigmas are called **pollinators**. Wind, water, insects, birds and bats, etc. are a few pollinators.

Pollination by Wind

The wind picks up pollen grains from one flower and blows it onto another (Fig.3.4). Wind-pollinated plants have long stamens and carpels. Most grasses depend upon wind for their pollination.



Fig: 3.4. Wind pollinated flowers produce a large number of pollen grains.

Extend Your Thinking Grasses do not have bright-coloured flowers. How might this be related to the way these plants are pollinated?

Pollination by Animals

Insects and some other animals can also transfer pollen grains when they move from one flower to the other (Fig.3.5). Bright coloured petals, charming shapes, nectar guides and pleasant smell attract animals towards flowers. Pollen grains have rough and sticky surfaces, due to which they stick to animals' bodies.



Fig: 3.5. Pollen grains stick to the bodies of bees as they visit flowers for food.

Pollination by Water

Pollination by water is not common but a few plants release their pollen grains into the water. The pollen grains move slowly along the water currents and reach other aquatic plants. Hydrilla, Vallisneria, etc. are water-pollinated plants (Fig.3.6).



Fig: 3.6. Vallisneria is an aquatic plant in which cross-pollination occurs.

Tidbits

- Squirrels pollinate flowers of silk cotton tree.
- Bats pollinate flowers of cactus plants at night.

Activity 3.1

Observing the Pollen Grains

You will need: ● a microscope ● glass slides ● cover slips
● anthers of different flowers

Procedure

1. Under the supervision of your science teacher, place a drop of water on a slide and put the anther of a flower onto it.
2. Put on a cover slip on the slide.
3. Study the pollen grains through a microscope.
4. Repeat the procedure for other flowers.
5. Draw diagrams of different pollen grains you see through the microscope.



3.4: Kinds of Reproduction

Plants can reproduce in different ways. Non-flowering plants reproduce by producing spores. Flowering plants produce seeds.

The type of reproduction in which a cell from only one parent develops into offspring is called **asexual reproduction**. Various methods of asexual reproduction are commonly found in plants. We have already studied cutting, grafting and layering in plants in the previous classes.

When two gametes one from each parent combine to form a zygote, the process is called **sexual reproduction**. Flowers are responsible in plants for sexual reproduction. The zygote formed in this process transforms into seed.

Zygote: A male gamete (sperm) and a female gamete (egg) fuse to form a zygote. Later, the zygote develops into the seed and the seed grows into a new plant.

Do You Know?

Potatoes use asexual reproduction. If we look at a potato tuber, we can see little buds, or eyes. Each of these little buds can grow into a new potato plant.

3.5 Fertilization in Plants

The surface of the stigma in a flower is sticky and pollen grains stick to it. Here, a pollen tube grows out from each pollen grain. Two sperms are present in this pollen tube. The tube grows downward through the style and enters the ovary. Pollen tube finally enters an ovule and releases its sperms in it. One of the sperms combines with the egg to form zygote (Fig.3.7). The other sperm combines with another cell to make the store of food.

The process of fusion of sperm with the egg is called **fertilization**.

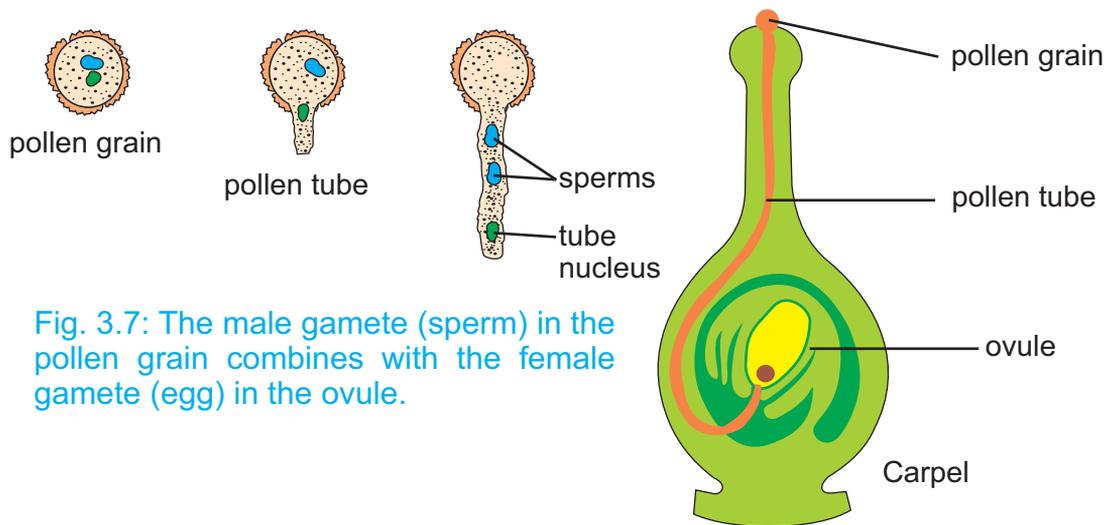


Fig. 3.7: The male gamete (sperm) in the pollen grain combines with the female gamete (egg) in the ovule.

Changes after Fertilization

After fertilization, several changes take place in the flower. The sepals, petals and stamens dry up and fall off. The fertilized egg inside the ovary develops into embryo. Ovules become seeds. The ovary grows large and develops into a fruit. The fruit protects the seed or seeds.



Extend Your Thinking

The papaya plant has male and female parts on separate plants. Why is a lonely papaya tree hard to see with fruit?

Activity 3.2

Identifying the Parts of a Flower

Pluck a flower from a garden. Take a pair of forceps and carefully separate the parts of the flower under the supervision of your science teacher. Identify the sepals, petals, stamens and the carpels. Also identify the filament and anther of a stamen, stigma, style and ovary of the carpel. Draw the diagrams of stamen and carpel.

Activity 3.3

Observing the Formation of Fruit

Under the supervision of your science teacher, visit an orchard of some fruit producing plants near your school. Observe the flowers developing into fruit. Which part of the flowers is developing into fruit?



3.6: Formation of Seeds and Fruits

Many plants grow and bear fruit to protect their seeds. A seed protects the embryo inside it. In addition, shapes of seeds and fruits help in their dispersal.

Seeds

After fertilization an ovule becomes a seed. The embryo and its store of food are covered by a tough seed coat.

The most important part of a seed is its embryo. Embryo grows into a new plant. The embryo consists of the following parts (Fig.3.9).

Radicle

This part of the embryo develops into the first root of the new plant.

Plumule

This part of the embryo develops into the first shoot (stem) of the new plant.

Cotyledons

This part of the embryo supplies food to the growing young plant.

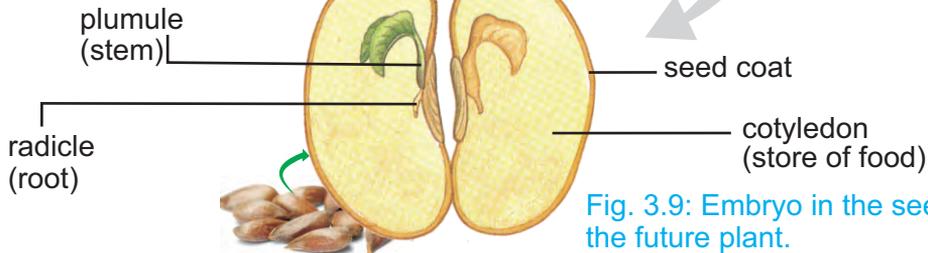


Fig. 3.9: Embryo in the seed is the future plant.

Ovary of the flower

Fig.3.8. Ovary of the flower develops into the fruit.



Activity 3.4

Take some gram seeds and soak them in water for a few hours. They swell up after absorbing water. Now remove the seed coat and examine its parts.

Activity 3.5

Comparing Flowers and Seeds

You will need: • monocot and dicot flowers
• monocot and dicot seeds • a sharp knife • forceps

Procedure

1. Under the supervision of your science teacher, collect flowers and seeds of some monocot plants and some dicot plants.
2. Take a monocot and dicot flower. Remove and count their sepals. Do the same with the petals.
3. Identify, remove, and observe the stamens and carpels of the flower.
4. Take a seed of a monocot plant and dicot plant. Cut the seeds in half and observe the embryos.
5. Locate and observe the cotyledons in the seeds.



Things to Think

- i. What is the function of the outer covering and stored food of a seed?
- ii. What parts are the same in monocot and dicot flowers and seeds?

Fruit

The ripened ovary is called a fruit. The ovary wall forms the fruit wall, called the **pericarp**. Inside the ovary, ovules develop into seeds. The matured fruit may contain single or many seeds.

The pericarp has three layers in most fruits like peaches and mangoes (Fig.3.10). The outer layer is skin, the middle layer is fleshy and the inner layer is tough or hard. Some fruits have hard and dry pericarp, e.g. nuts.

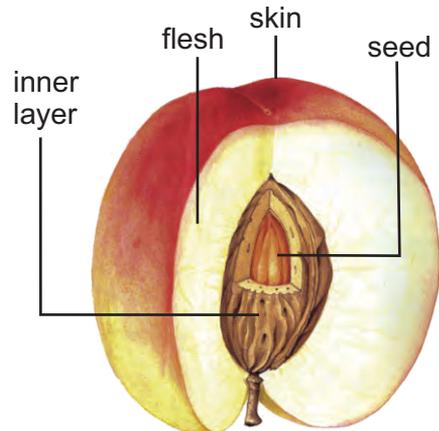


Fig. 3.10: Plants produce fruit to disperse their seeds.



Extend Your Thinking

Which fruits are eaten as vegetables?

Do You Know?

Plants do not produce flowers and fruits for us, but to protect and disperse their seeds.

Science, Technology and Society

Many plants such as snakeroot and ginger have been used as medicines. Most medicines used today are obtained from plants. Scientists are trying to obtain more medicines from plants. Why do you think that different kinds of plants should be protected?

Key Points

- ⊙ Pollination is the transfer of pollen grains from the stamen to the carpel of a flower.
- ⊙ There are two kinds of pollination, i.e. self-pollination and cross-pollination.
- ⊙ Self-pollination is the transfer of pollen grains from anther to the stigma of the same flower or another flower on the same plant.
- ⊙ Cross-pollination is the transfer of pollen grains from the anther of a flower to the stigma of another flower on another plant of the same kind.
- ⊙ Coloured petals, long and sticky stigmas, nectar and fragrance are some factors that favour cross-pollination in plants.
- ⊙ Poplar, willow, apple, papaya, trees, etc. are cross-pollinated.
- ⊙ Plants reproduce both by asexual reproduction and sexual reproduction.
- ⊙ Asexual reproduction is the reproduction in which a cell from only one parent develops into offspring.
- ⊙ In sexual reproduction, two gametes from both parents combine to form a zygote.
- ⊙ Fertilization is the process of fusion of sperm and egg.
- ⊙ After fertilization the ovary of a flower changes into fruit while the ovules become seeds.

Questions

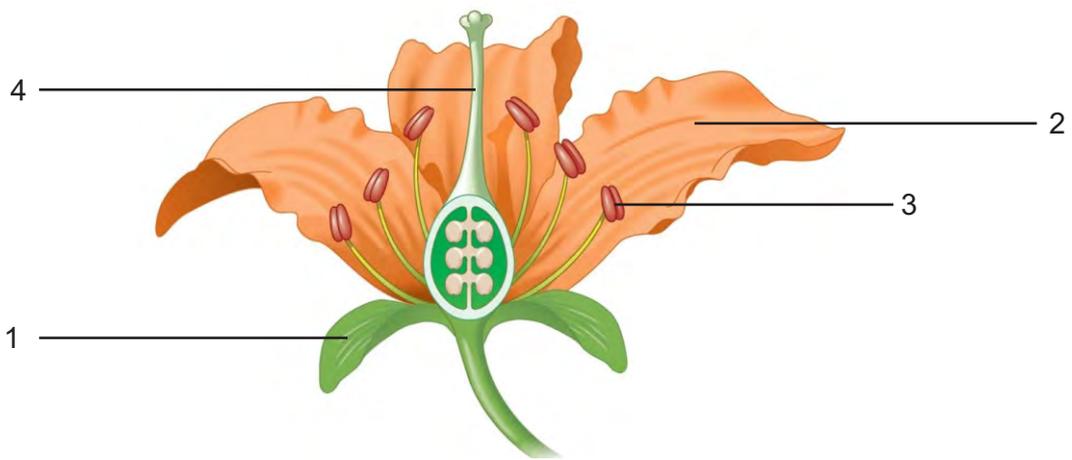
1. Complete each of the following sentences by writing the correct term.

- i. It protects a seed _____
- ii. Male and female sex cells _____
- iii. The exchange of pollen grains between two plants of similar type _____
- iv. Most grasses are pollinated by _____
- v. It is present in the ovary of the flower and develops into seed _____

2. Encircle the correct answers in the following.

- i. The part of a plant that forms seeds is the:
(a) stem (b) root
(c) leaf (d) flower
- ii. When a bee visits a flower:
(a) Seeds stick to its body. (b) Cones stick to its body.
(c) Pollen grains stick to its body. (d) Fruit sticks to its body.
- iii. Which structure is helpful to the pollen grains to carry sperms to the ovary?
(a) cotyledon (b) carpel
(c) pollen tube (d) seed
- iv. The sticky part of a flower is called:
(a) sepal (b) stamen
(c) ovary (d) stigma
- v. Asexual reproduction involves:
(a) two gametes (b) a single parent plant
(c) only male sex cell (d) fertilization

3. **Give short answers.**
 - i. Differentiate between asexual and sexual reproduction.
 - ii. What are the male and female parts of a flower?
 - iii. Define pollination.
 - iv. Name a few pollinators.
 - v. Define a sperm and an egg.
 - vi. Which part of a seed develops into the first root?
4. **Write a detailed note on pollination in plants.**
5. **Explain fertilization in plants.**
6. **Describe the structure of a seed.**
7. **Write a note on fruit.**
8. **Label the parts of the flower and write the purpose of each part.**



1. _____
2. _____
3. _____
4. _____

Computer Links

- For more information visit:
- en.wikipedia.org/wiki/plant_reproduction
 - <http://www.desktopclass.com/education/9th-10th/seed-and-fruit-formation-10th-biology-lesson-16-4.html>

Environment and Feeding Relationships

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain the ecosystem.
- ▶ define the term habitat.
- ▶ compare the different kinds of habitats.
- ▶ investigate the various features that allow animals and plants to live in a particular habitat.
- ▶ identify the factors that cause daily and yearly changes in a habitat.
- ▶ explain how living things adapt to daily and yearly changes in their habitat.
- ▶ explain the ways in which living things respond to changes in daily environmental conditions such as light intensity, temperature and rainfall.
- ▶ explain why food chains always begin with a producer.
- ▶ illustrate the relationship between producers and consumers.
- ▶ describe two food chains in the environment around them.
- ▶ explain a food web.



Living things are all around us. They are in air, on land and in water.

Environment of an organism consists of all the living and non-living things around that organism. These living and non-living things affect the life of organism in one way or the other. We have learnt in class VI that organisms live where they can have their needs met. All the organisms depend on each other and on non-living things in an environment, we shall discuss it in this chapter.

4.1: Ecosystems

A system formed by the interaction of living organisms and non-living things in an environment is called an **ecosystem**. An ecosystem may be large, like a desert, or small, like a decaying log. Deserts, seashores, rivers, mountains, oceans, grasslands and rain forests are also some of the ecosystems.

4.1.1: Parts of an Ecosystem

All ecosystems are made of two parts:

1. The living or **biotic** part
2. The non-living or **abiotic** part

All the plants, animals, fungi and microorganisms make the living or biotic part of their ecosystem. Organisms of the same kind living and reproducing in a particular area is called **population**. All the populations of different kinds of organisms living together in an area make a **community** (Fig.4.1). Air, water, soil, sunlight and temperature make the non-living or abiotic part of an ecosystem.



Fig: 4.1. The number of wolves in this forest is their population. The wolves and all other animals, plants, microorganisms are included in the community of the forest ecosystem.

4.2: Habitat

The place where an animal or plant lives and reproduces is called its **habitat**. A habitat provides the things an organism needs, i.e. food, water, shelter, etc. Many populations of organisms live in each habitat.

4.3: Kinds of Habitats

Organisms live in different kinds of habitats. An organism has special features to live in its habitat.

1. The Grassland Habitat

Grassland is a grassy, windy, partly-dry area. These areas receive a medium amount of rain. The soil found here is very fertile. Grasses are the producers in a grassland habitat. Mostly grazing animals like the sheep, goats, cows, antelopes, buffaloes, and deer are a few examples that are found in a grassland. A few flesh-eaters like cheetahs, foxes, wolves and a few birds like owls, eagles, hawks, etc. are also found in this habitat (Fig.4.2). Many kinds of insects are also found in grasslands.



Fig: 4.2. A grassland habitat

2. The Pond Habitat

A pond is an aquatic habitat which is rich in life. Plants like algae, duckweed, water lily, etc. are found in water. The animals like fishes, pond skaters, wolf spiders, snails, frogs and microscopic organisms are also found in the pond habitat (Fig.4.3).



Fig: 4.3. A pond habitat

3. The Desert Habitat

Deserts are the driest land areas. They receive very little rainfall. Rainwater quickly drains away due to the sandy soil. Some plants and animals have adapted to the limited supply of water. Cacti, euphorbia, lizards, snakes, kangaroo rats, camels, etc. are found in a desert habitat (Fig.4.4).



Fig: 4.4. A desert habitat

4. The Rainforest Habitat

Rainforests are always wet. They receive rain the whole year. A large number of plant types (herbs, shrubs and trees) is found here. Several varieties of butterflies, snakes, lizards, frogs, parrots, cockatoos, humming birds, cats and jaguars are also found in this habitat (Fig:4.5).



Fig: 4.5. A rainforest habitat



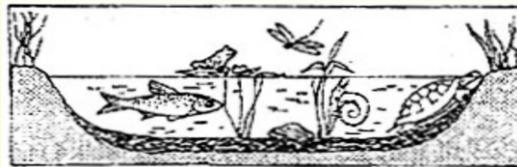
Extend Your Thinking

Explain, why a limited plant and animal life is found in deserts?

Activity 4.1

Observing a Pond Habitat

- Visit a nearby pond under the supervision of your science teacher.
- Observe the pond habitat and fill the table given below.



Producers	Consumers	Abiotic factors

4.3.1: The Factors Causing Changes in a Habitat

We know that light, temperature, air, soil and water are abiotic factors of the environment. Changes in these factors bring changes in the populations of a habitat. Some other natural factors and humans also cause changes in habitats.

Sunlight is the basic source of energy on the Earth. Plants use light energy to make their own food. All forms of life on the Earth depend directly or indirectly on green plants for food. They also need light for their survival (Fig.4.6). Light intensity affects the number of plants in a habitat. Decrease in number of plants may result in the decrease of animals' number in the habitat.



Fig: 4.6: Most plants and animals need light to survive.



Extend Your Thinking

How is the Sun important to the food supply of an ecosystem?

Temperature can also bring change in the population of a habitat. Any extraordinary rise or fall in temperature may disturb the habitat. For example, warm water contains less oxygen. What happens to the aquatic animals in the water as it gets hotter?

Water is essential for life. Where there is more water, more organisms are found there. Availability of water in a habitat can greatly influence its organisms.

Migration is another factor that changes the size of populations of a habitat. When a few individuals come to an area, it increases the size of the population in

that area. Organisms migrate in search of better living places.

Natural disasters such as droughts, floods, earthquakes, etc. can bring changes in habitats.

A **drought** is a period when there is no rain for a long time in an area. The ponds or streams may dry up during a drought (Fig.4.7). Most pond plants and animals die or move to other ponds. Some crops do not grow in the area affected by a drought.



Fig: 4.7: Droughts and floods bring rapid changes in habitats.

When an area gets a lot of rain for a long time, there may be a **flood** in that area (Fig.4.7). Many plants and animals die or move to other drier places during a flood.

Sometimes **lightning** strikes a tree in a forest, causing forest fires. Plants and trees are burned and destroyed (Fig.4.8). Some animals die, others may move to safer places. It takes many years for a forest to grow back.

Earthquakes are sudden shocks of the Earth's surface. Earthquakes can change a habitat very quickly. On October 8, 2005, a massive earthquake damaged a widespread area across Pakistan. Over 70,000 people lost their lives. A large number of animals and plants were also destroyed.



Fig. 4.8: Sometimes lightning destroys the whole habitat.

Extend Your Thinking



Two kinds of birds live in the same tree. Kind A eats ants that live in the tree. Kind B eats ants and caterpillars. Which species is more likely to survive if the ant population decreases? Why?

How People Change Habitats

Human activities also change habitats. When habitats change, some organisms die or leave the habitat.

Farming is very important to human survival. People clear forests to get land for farming. People also cut down trees to get wood or paper. In this way they destroy the natural habitats of several plants and animals.

Pollution is another agent that brings changes in habitats. Pollution harms the land, water or air. Pollution is harmful to people, animals and plants. It destroys many habitats. Land pollution affects the land, destroying life, the environment and its habitats (Fig.4.10).

Air pollution affects the air we breathe in. Factories and motor vehicles add air pollution to the environment (Fig.4.11). Air pollution damages our health and our environment.



Fig. 4.9: Water pollution destroys water habitats.



Fig. 4.10: Litter kills plants and causes animals to get sick or die.



Fig. 4.11: Air pollution causes acid rain that can destroy pond or lake habitats.



Fig. 4.12: Forests clean the air. We need forests to help keep the air clean.

How to Protect Habitats

Everyone can help protect habitats by saving the resources. Reducing, reusing, and recycling are three ways to save resources and protect ecosystem.

- **Reduce** means to cut down the use of resources.
- **Reuse** means not to throw away things that can be used again.
- **Recycle** means to make new things from the used material.

Activity 4.2

Effect of Salts on the Growth of Plants

You will need

- 3 plastic cups
- garden soil
- 24 watermelon seeds
- normal water
- salty water
- very salty water

Procedure

1. Make holes in the bottom of plastic cups with a nail.
2. Label the cups A, B and C.
3. Fill two-third of the cups with garden soil.
4. Sow 8 watermelon seeds in each cup.
5. Add some normal water to cup A, salt water to cup B and very salty water to cup C.
6. Every day add some more water to each cup.
7. Observe the cups every day for ten days and collect the data.

Number of seeds germinating to plants			
	cup A	cup B	cup C
Day 1			
Day 2			

Things to think

- i. How did salt in the habitat change the growth of plants?
- ii. Why did more plants grow in the cup A?

4.3.2: Adaptations of Organisms to Live in a Habitat

Plants and animals live in different habitats. They develop special features that help them to live in their habitats. These special features are called adaptations. An **adaptation** is a change in the organism's body or behaviour that helps it to survive in its habitat. Organisms that are not well adapted to their habitats may not survive.

Aquatic Habitats

Animals and plants living in aquatic habitats have such body parts that help them to live in water.

1. Streamlined body shape is an important adaptation for animals to move easily through water.
2. Webbed feet of ducks, seagulls and frogs work like oars to help move in water (Fig.4.13).
3. Floating plants like water hyacinth, duckweed and water lily have floating leaves and submerged roots. Their bodies contain air spaces. Their leaves have waxy covering to prevent water from collecting on them.



Fig.4.13: Webbed feet of a frog help to move in water.



Extend Your Thinking

All the plants and animals of an aquatic habitat will find difficulties in living in other habitats. Why?

Land Habitats

Animals and plants living in land habitats also have adaptations to adjust well in their surroundings.

1. The arctic fox and polar bear have thick fur on their bodies. This thick fur keeps the body of these animals warm in freezing cold. Snowy owl has a thick coat of feathers.
2. Plants and animals of deserts are adapted to live in scorching heat. Some desert plants have tough, thick surfaces and thin, spiny leaves to reduce water loss. Most animals, such as gecko(lizard) and jackrabbit conserve water by living underground during the day and coming out at night. Camel's feet and large stomach are the adaptations to live in deserts (Fig.4.14).
3. Bird song, the roars of lions, howling of wolves, etc. are the adaptations of behaviour. Animals send and receive messages using sound (Fig.4.14).
4. Plants, too, have many adaptations to help them survive. Trees in rainforests grow very tall to get the sunlight (Fig.4.14).

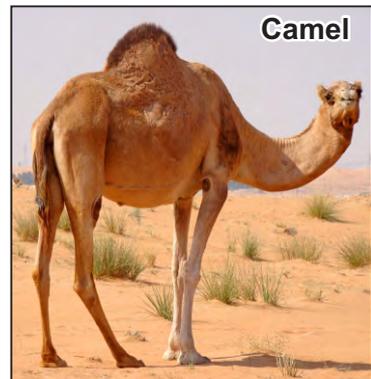
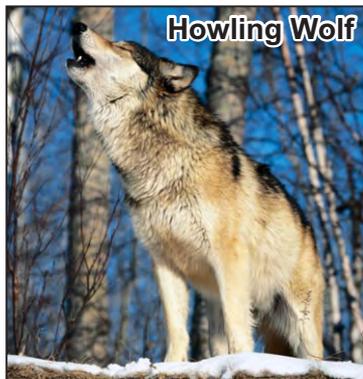
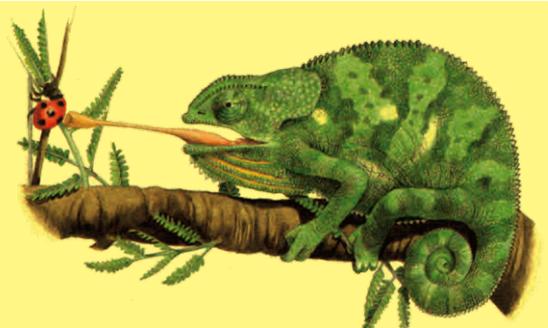


Fig. 4.14: Some adaptations in animals and plants

Tidbit

The chameleon can change its colour and has a long sticky-tipped tongue. These adaptations help it to catch insects.



4.4: Biotic Components and Their Relation with Food Chains and Food Webs

Every living thing needs energy. Energy in an ecosystem passes from one organism to another. The basic source of energy on Earth is sunlight. Plants use sunlight and make food. Thus, plants are the **producers**.

Animals cannot make their own food. They eat plants or other animals that eat plants. Thus, animals are the **consumers**. A consumer may be a primary consumer (herbivore), a secondary consumer or a tertiary consumer. Organisms eat organisms and are in turn being eaten by others. This feeding relationship among organisms is called a **food chain**. Most food chains start with producers like:

grass → zebra → lion
leaves → caterpillar → bird → hawk

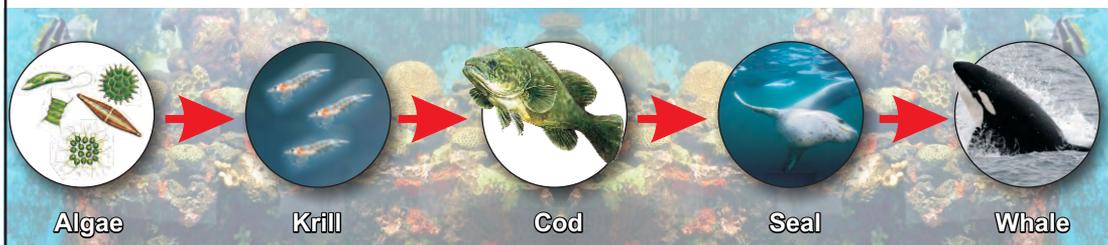
Green plants are producers so, they are the first in most food chains. Animals that feed on plants are the second in a food chain. They are called primary consumers. Animals that eat primary consumers are called secondary consumers. Secondary consumers may be eaten by tertiary consumers.

EXAMPLES OF FOOD CHAINS

1- In a grassland habitat a grasshopper eats grass. A snake may eat this grasshopper. This snake may become the food of a hawk.



2- Algae are the producers in this sea food chain while others are consumers.



Extend Your Thinking

Even though secondary consumers do not eat plants, how are plants important to their food supply?

Activity 4.3

Food Chains

A plant or an animal in a food chain is called a link.

(a) Construct two food chains with

(i) three links (ii) four links

(b) Write down the producers, primary consumers, secondary consumers and tertiary consumers in food chains constructed in part (a).

Food Web

An organism can be a part of many food chains. Several food chains in an ecosystem overlap to form a network called **food web**.

Example 1: A lion does not feed entirely on deer but it also hunts cows and goats. Similarly owl and hawk may also take different organisms as their food. So, most animals feed on one or more than one kind of animals. Therefore many food chains form a kind of network or a food web.

Example 2: A snake does not feed on frog alone. It also eats birds, rats and even rabbits. Birds eat grains. They also eat insects, spiders and worms. If we arrange food chains in an ecosystem, it takes the form of a web (Fig.4.15).

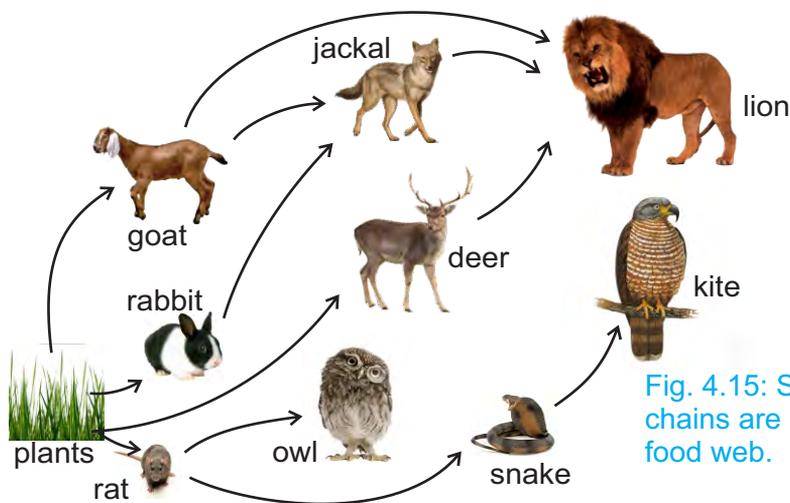


Fig. 4.15: Several food chains are present in a food web.



Extend Your Thinking

What will happen to all animals of a food web, if green plants are removed?

Science, Technology and Society

Bacteria and fungi are decomposers. They break down the dead bodies of plants and animals into simpler substances. These substances mix with soil and again are available to green plants to make their food. Without decomposers recycling of nutrients is impossible. How can we use decomposers to reduce the use of expensive chemical fertilizers in our country?

Key Points

- ⦿ Ecosystem is the system formed by the interaction of living organisms and non-living things in an environment.
- ⦿ A habitat is the natural home of an organism where it lives and reproduces.
- ⦿ Grassland is a grassy, windy, partly-dry area. A pond habitat is rich in life. Deserts are the driest land areas with a few number of plants and animals. A large number of plants and animals is found in a rainforest.
- ⦿ Plants and animals adapt to live in a particular habitat.
- ⦿ Light intensity, temperature, water, droughts, floods, earthquakes, etc. are the factors that can bring changes in a habitat.
- ⦿ People can also bring changes in habitats by adding pollution.
- ⦿ Animals and plants adapt to their environment for their survival.
- ⦿ Green plants make food, so they are producers. Animals eat plants so they are consumers.
- ⦿ A food chain and a food web are feeding relationships among organisms.
- ⦿ The feeding relationship among organisms is called a food chain.
- ⦿ Several food chains in an ecosystem overlap to form a network called food web.

Questions

1. Complete each of the following sentences by writing the correct term.

- i. The basic source of energy for every ecosystem _____
- ii. Any living thing in the environment _____
- iii. All the populations living in an area make a _____
- iv. Several food chains overlap in a _____
- v. Breakdown the bodies of dead animals and plants _____

2. Encircle the correct answers in the following.

- i. The sunlight energy enters in an ecosystem through:
(a) plants (b) decomposers
(c) animals (d) water
- ii. Organisms that make their own food are called:
(a) producers (b) heterotrophs
(c) consumers (d) decomposers
- iii. Bacteria and fungi are:
(a) decomposers (b) producers
(c) grazers (d) predators
- iv. Which one is a producer in an ecosystem?
(a) lion (b) hawk
(c) plant (d) rat
- v. Which organisms have maximum amount of energy in a food chain?
(a) primary consumers (b) secondary consumers
(c) tertiary consumers (d) producers

- vi. A group of tigers living and reproducing in a forest is an example of:
 (a) a community (b) a population
 (c) an ecosystem (d) a habitat

3. Give short answers.

- i. What kinds of organisms are these at the start of most food chains?
 ii. Name biotic factors of an ecosystem.
 iii. How are producers, consumers and decomposers related to each other?
 iv. Define an ecosystem.
 v. What do you mean by community in an ecosystem?
 vi. Name the ways by which we can save our natural resources.

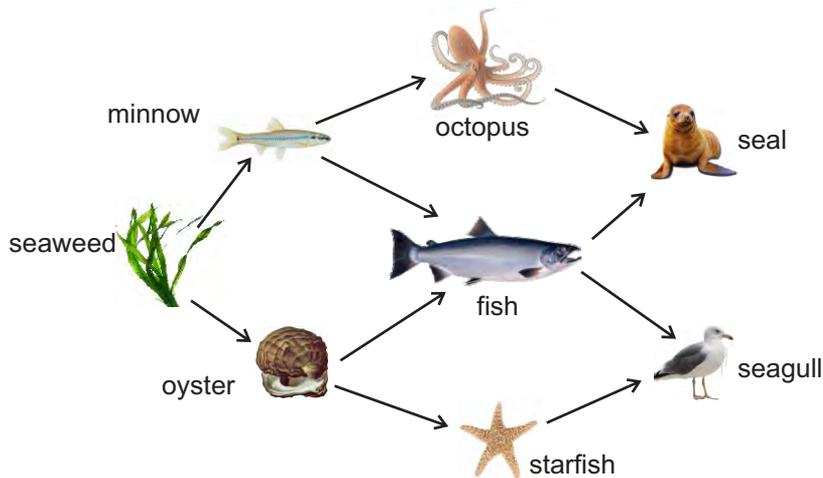
4. What is a habitat? Describe its few kinds.

5. Describe factors that can bring daily and yearly changes in the habitat.

6. Describe adaptations of some aquatic animals to live in their habitat.

7. Explain a food chain and a food web with examples.

8. Look at the following food web and answer the questions given below.



- i. Name the producer in the food web.

- ii. From where does the producer gets energy?

- iii. Name three consumers in the food web.

- iv. Write down two food chains in this food web.

Computer Links

For more information visit:

- http://www.bbc.co.uk/schools/ks3bitesize/science/organisms_behaviour_health/food_chains/revise2.shtml
- <http://www.geography.learnontheinternet.co.uk/topics/ecosystem.html>

Water

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ describe the ways in which clean water is vital for meeting the needs of humans and other living things.
- ▶ identify the sources of water.
- ▶ recognize the substances present in water that make the water impure.
- ▶ suggest different ways to clean the impure water.
- ▶ describe various uses of water in our country.
- ▶ investigate the consumption of water in our daily life and suggest ways to reduce wastage of water.



All is born of water. (Al-Quran)

Water is the most common compound on Earth and its atmosphere. It covers more than 70% of the surface of the Earth. It exists in three physical states of matter, i.e. solid (ice), liquid (water), and gas (water vapours and steam).

Water freezes at 0°C and boils at 100°C. The temperature at which water converts into ice is called its freezing point (F.P.) and the temperature at which water starts boiling is called its boiling point (B.P.).

Water H₂O

We know that everything is made of atoms. Atoms join together to form molecules. A water molecule has three atoms: two hydrogen (H) atoms and one oxygen (O) atom. A single drop of water contains billions of water molecules.

5.1: Water for Life

All living things need water to survive. Plants, fish, insects, birds and other animals all need water to grow. Green plants must have water to make food during photosynthesis. Some plants and animals live only in water. Aquatic animals use oxygen dissolved in water. Aquatic plants use carbon dioxide dissolved in water.

Our body also needs water. Water makes up about two-third of our body. Water helps us in several ways. Water helps to digest our food. It helps to remove waste products from our body. Water keeps our body cool in hot weather by sweating which is mainly water.



Fig. 5.1: Our body needs water to use in different processes.

Tidbit

We might be able to live for a month without food, but we cannot survive without water for more than a week.



Extend Your Thinking

How does water help us to live?

Facts about Water

- Water makes up 95% of our blood, 75% of our brain, and 85% of our lungs. Overall, our bodies are 60–70% of water.
- A tomato is about 95% water. An apple is about 85% water.
- Pure water has no colour, no taste and no smell.



5.2: Sources of Water

Water is present not only on the surface of the Earth but also beneath its surface.

5.2.1: Surface Water

About 97% of Earth's surface water is found in the oceans. It is salt water. Only 3% of water is fresh water which is present on the surface of the Earth, in the air (water vapours) and under the ground.

Ocean Water

Ocean water is a mixture of dissolved gases and salts in pure water. The major dissolved gases in ocean water are nitrogen, oxygen and carbon dioxide. The major dissolved salts are sodium chloride (table salt), magnesium chloride, magnesium sulphate and calcium sulphate, etc. Sodium chloride is the most abundant salt in ocean water. Ocean water is unusable for drinking because of salts. Some countries like Saudi Arabia, Kuwait, etc. remove salts from the ocean water to make it drinkable.

Fresh Water

Most of the fresh water is frozen. The frozen water is found in mountains in the form of glaciers. Snow accumulates year after year to form ice sheets. These ice sheets are called **glaciers**. Fresh water is also found in streams, rivers, lakes and ponds. At some places where ground is low, the water stays for part of the year and makes the ground very wet. Such places are called **wetlands**. Pugri, Kur and Kharki are a few wetlands in Sind Province. The water in wetlands moves down into the soil and becomes groundwater.

5.2.2: Water Beneath the Surface of Earth

Recall what happens to rain when it falls! Rainwater can evaporate, run off the surface, or soak into the ground. The water that soaks into the ground is called **groundwater**. The top level of groundwater in an aquifer is the **water table**. The level of water table changes during the year. It rises when water is added by rain. It becomes lower when there is a drought. People dig wells to bring groundwater to the surface.



Fig. 5.2: Why is the Earth also called the water planet?



Fig. 5.3: Some people use hand pumps to bring groundwater to the surface.

Tidbit

At some places, the water table rises and reaches near the surface of the soil. This water may come out in the form of spring or geyser. Several natural springs are found in Nathia Gali (KP Pakistan).

5.3: Impurities of Water

We need clean drinking water. Our water resources are becoming unfit due to the presence of impurities in water. Water may have germs. It may also have salts, dirt or other chemicals in it.

The addition of harmful substances into the water is called **water pollution**. Harmful and unwanted substances in water are called **pollutants**.

We can classify water pollutants into different groups.

1. Bacteria, virus and other microorganisms are disease causing pollutants.
2. Acids, salts, etc. are water-soluble pollutants. These pollutants can increase the growth of algae in the water. The presence of algae can block the sunlight to reach other plants in the water. Plants cannot make their own food and die. As a result, fish and other aquatic animals also die.
3. Oil, plastic and pesticides are also harmful to all plants and animals in the water.

 **Extend Your Thinking**
You are hiking and you are thirsty. Would you drink water from a stream?
Why or why not?

Sources of Water Pollution

The three major sources of water pollution are human wastes, industrial wastes and chemical run off.

Human Wastes

People release sewage into drains which carry it to rivers. Sewage from houses contains fat, toilet wastes, food particles, detergents, harmful bacteria, etc. These human wastes not only cause diseases in human beings but also destroy aquatic life.

Industrial Wastes

Industries release a large number of toxic chemicals into rivers and canals (Fig.5.4). Smoke and toxic gases released from industries also cause the rain water to become **acid rain**. These chemicals can kill fish and other aquatic animals and plants.

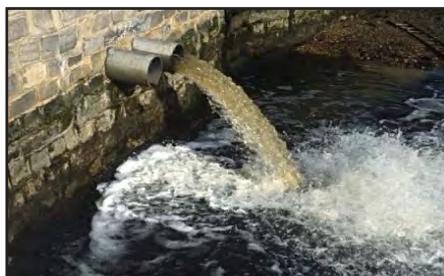


Fig. 5.4: Industries add chemicals to water resources.

Fertilizers

Farmers use fertilizers and pesticides in their crops (Fig.5.5). The rainwater carries these chemicals to water resources and causes water pollution. This polluted water is not fit for aquatic plants and animals.



Fig. 5.5: Fertilizers can also cause water pollution.

Activity 5.1

Is polluted water drinkable? (Group Activity)

You will need

- four glasses
- canal water
- pond water
- tap water
- ink

Procedure:

1. Take four glasses. Pour some canal water into glass No.1, some pond water into glass No.2 and some tap water into glasses No.3 and 4.
 2. Pour a few drops of ink into glass No.4.
 3. Ask the participants what kind of water they would like to drink from these glasses.
- In the light of their answers, what did you conclude from this activity?

Activity 5.2

How Fertilizers Affect the Growth of Algae

You will need

- two glass bottles
- tap water
- pond water
- fertilizer

Procedure

1. Label the two glass bottles A and B.
2. Pour water into each bottle up to three-quarters full.
3. Add water from a pond to fill the remaining parts of the bottles.
4. Add a little amount of fertilizer to bottle A only.
5. Put the bottles in the sunlight.
6. Observe the bottles everyday for a week.

Things to think

- i. Why was there more algae in the bottle A?
- ii. Can you explain the growth of algae in a pond or lake near fields?



Soft and Hard Water

The water which gives rich lather with soap is called **soft water**. The water we use in house is soft water. The water which does not give good lather with soap, but forms curds is called **hard water**. Sea water is hard water. Water becomes hard when chloride, sulphate or carbonate salts dissolve in it.



Extend Your Thinking

Why do cities and towns purify water before it is supplied to homes?

5.4: Cleaning of Water

Water may have germs, dirt, salt and other things dissolved in it. All of these things must be removed before drinking the water. The process of removing impurities from water is called **purification of water**. We can use following methods to purify water.

1. By Filtration

In laboratory, we can purify water by this method on small scale. Impure water is passed through a filter paper. Suspended particles and insoluble salts are left on the filter paper whereas clear water is obtained in the beaker.

To remove dissolved substances present in the water, special membranes can be used. These membranes have microscopic pores to separate dissolved substances from the water.

2. By Boiling

Boiling is the safest way to purify water. In villages, people can easily use this method to purify their drinking water. Bacteria, germs and other microorganisms present in water are killed by boiling water for 15 to 30 minutes. The water is cooled before drinking.

3. By Chlorination

If boiling is not possible we can add liquid house hold bleach to the water. Bleach contains chlorine. For this purpose, place the water in a clean container. Add the amount of bleach or chlorine according to the table below:

Volume of clear water	Amount of 5-6 percent liquid chlorine bleach
1 litre	3 drops
2 litre	5 drops
1 gallon	1/8 teaspoon

4. Use of Potash Alum

We can add potash alum to the water to purify it. Sand, clay and other suspended impurities of water will settle down. Water will be pure after decantation.

In Lahore city, District Government has installed **Water Filtration Plants** near tube-wells to provide citizens with pure clean water.

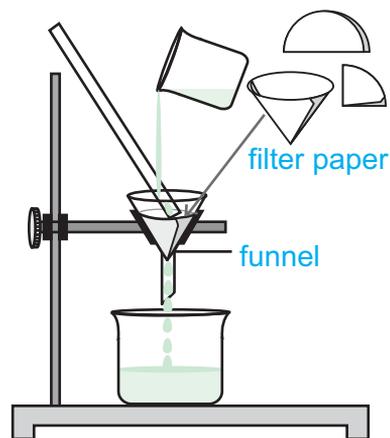


Fig: 5.6. In laboratory, a filter paper is used to purify water.



Do You Know?

- Water coming out of a natural spring may contain sulphur. Presence of sulphur makes this water germicidal. People use water of such spring to treat skin diseases.
- Every year, a large number of children die because of water-related diseases such as diarrhoea.

Distillation

We get clear tap water, but it is not pure. It may contain some salts and bacteria in it. We can use the process of distillation to separate impurities from water. In simple **distillation**, the water is heated to convert into steam. Then the steam is cooled down into distilled water (Fig.5.7).

Impure water is boiled in a closed container (flask). Water vapour from the surface of boiling water pass through a pipe into a vessel called a condenser. The condenser is a tube surrounded by a large tube through which cold water is passed to cool the water vapours. As the water vapours pass through the condenser, they lose heat and become liquid water. This distilled water is collected in a separate container (beaker). Solid impurities remain at the bottom of the flask.

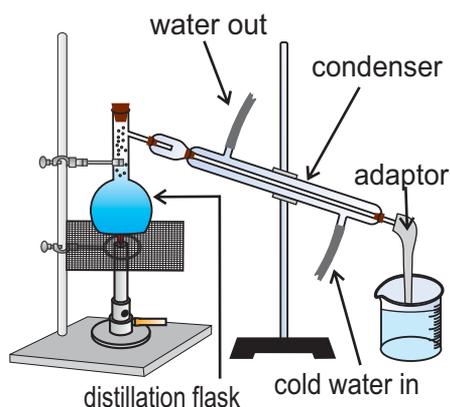


Fig. 5.7: We can obtain the purest form of water by the process of distillation.

Activity 5.3

Distillation Process

- You will need:**
- salt water
 - spoon
 - a small cup
 - a glass bowl
 - plastic sheet
 - tape
 - marble

Procedure

1. Take some amount of salt water in the glass bowl. Put a small cup in middle of the bowl.
2. Cover the bowl with plastic sheet. Use tape to hold the plastic sheet. Put a marble on the plastic sheet.
3. Place the apparatus in sunlight for several hours.
4. Remove the plastic sheet and cup from the bowl. Let the water evaporate from the bowl.

Observe the bottom of the small cup and the bowl.

Questions

- i. What did you find in the bottom of the cup and the bowl?
- ii. From where did the water come in the cup?



5.5: Uses of Water

People in Pakistan use water in homes, agriculture, as a source of energy (hydroelectricity) and in industries.

In Homes

A large quantity of water is used in our homes. We use water in washing, cleaning, brushing the teeth, flushing the toilet, cooking and drinking. People use most of the water in their kitchens and bathrooms.

In Agriculture

Plants need water to grow. Our farmers use 88% of our fresh water in fields to grow crops and vegetables.

As a Source of Energy—Hydroelectricity

The potential energy of water is used to move propellers of turbines. Turbines in turn run generators that produce electricity which is called hydroelectricity. There are five major and several small hydroelectric projects in Pakistan.

In Industries

Industries use water in a number of ways. Beverage and food industries use water as a raw material. Factories use water to clean and wash metal surfaces. Heavy mechanical complexes, oil refineries and nuclear reactors use water for cooling purposes.

Tidbit

People also use water for water sports such as swimming, fishing, sailing, etc. We can enjoy water sports in water parks.

How to conserve water?

There is only a limited amount of fresh water that we can use. We can save water by acting upon following tips:

- Turn off the tap when you brush your teeth or take water in a tumbler.
- Wash fruits and vegetables in a bowl.
- Don't wash dishes under running water.
- Only use washing machine with a full load.
- If you have a lawn, water it early in the morning or late in the afternoon so the Sun would not evaporate the water.
- Check regularly the leaks in water pipes and get them repaired immediately.

Science, Technology and Society

Paper mills, oil refineries, chemical industries, heavy mechanical complexes and nuclear power plants should conserve water by:

- reducing water use.
- reusing water.
- recycling of water.

Key Points

- ⦿ Water is the most essential part of life. Plants, fish, insects, humans and all other animals need water to survive.
- ⦿ Water is present not only on the surface of the Earth but also beneath its surface.
- ⦿ Rivers, lakes, ponds, glaciers, wetlands, etc. are the sources of fresh water. Water is also present in seas and oceans.
- ⦿ Harmful and unwanted substances are making the water polluted.
- ⦿ Microorganisms, acids, oil, pesticides, etc. are water pollutants.
- ⦿ The process of removal of impurities from water is called purification of water. We can clean water by filtration, boiling, chlorination and adding potash alum.
- ⦿ We use water in homes, agriculture, industries and to generate electricity.
- ⦿ Water is precious, we need to conserve it.

Questions

1. Complete each of the following sentences by writing the correct term.

- i. Large sheets of ice are called _____
- ii. The process of removal of impurities of water _____
- iii. Rivers, lakes and ponds are the sources of _____
- iv. Harmful and unwanted substances in water _____
- v. Toxic gases in the air react with rain water to make _____

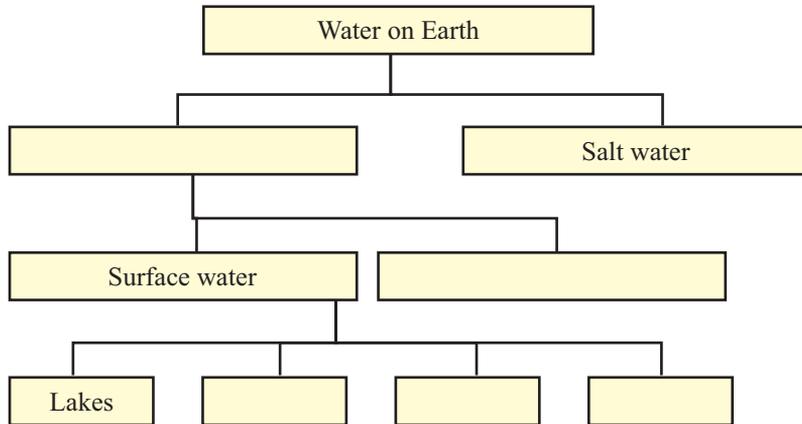
2. Encircle the correct answers in the following.

- i. Drinking water sources can be contaminated by:
(a) natural materials (b) run-off from fields and roads
(c) forests (d) mountains
- ii. What percentage of the Earth's water supply is fresh water?
(a) 3% (b) 5%
(c) 10% (d) 15%
- iii. We can get the purest form of water:
(a) by boiling water (b) by distillation process
(c) from tube-wells (d) from rivers
- iv. Heavy mechanical complexes use a large amount of water for:
(a) cooling (b) freezing
(c) washing (d) wasting
- v. Which one is not the source of water pollution?
(a) human wastes (b) industrial wastes
(c) fertilizers (d) rain water

3. Give short answers.

- i. Why is fresh water important?
- ii. Where is most of the fresh water found?
- iii. Why is the most of the Earth's water salty?
- iv. If water runs downhill to the seas, what are some ways that make fresh water polluted?
- v. Why clear water is not necessarily safe to drink?

4. Explain how water is the most essential part of life.
5. What makes our water impure?
6. How can we preserve water?
7. Describe a few methods to clean water.
8. Complete the concept map given below.



Safe water is our right!

“Access to safe water is a fundamental human right. Contaminated water jeopardizes both physical and social health of all people. It is an affront to human dignity”.

(United Nations Organization – 2003)

Computer Links

For more information visit:

- <http://en.wikipedia.org/wiki/Water>
- http://www.drinktap.org/kidsdnn/Portals/5/story_of_water/html/facts.htm

Structure of an Atom

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ describe the structure of an atom.
- ▶ differentiate between atomic and mass number.
- ▶ draw diagrams of the atomic structure of the first eighteen elements in the periodic table.
- ▶ define valency.
- ▶ explain formation of ions.
- ▶ differentiate between cations and anions.
- ▶ describe isotopes and their uses in medicine and agriculture.
- ▶ identify the types and number of elements present in simple molecules and compounds.
- ▶ make chemical formulae from list of anions and cations.
- ▶ state the law of constant composition and give examples.



Everything is made up of different kinds of atoms.

We have learnt in class VI that **atom** is the smallest particle of matter that can not exist independently. Everything in the universe is made up of atoms. Our body is also composed of several trillions of atoms. A Greek philosopher Democritus gave the idea of atom for the first time. Then, in 19th century John Dalton from England presented the first atomic model. According to him, all matter is composed of atoms. Atoms can neither be created nor destroyed.

6.1: Structure of an Atom

Is there any particle smaller than atom? Sure, there is. Atoms are made of even smaller particles called electrons, protons and neutrons. The central part of the atom is called the **nucleus**. Protons and neutrons are present in the nucleus.

Electrons revolve around the nucleus. An electron has negative charge. Its mass is extremely small.

A **proton** has positive charge. The number of protons in an atom is equal to the number of electrons revolving around the nucleus. It has a mass 1837 times greater than that of electron.

A **neutron** has no charge. This neutral particle is also found in the nucleus of an atom. The mass of a neutron is almost equal to the mass of a proton.

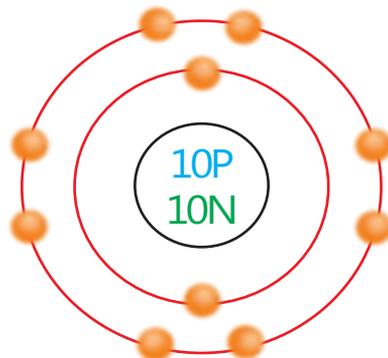


Fig.6.1: Structure of Neon atom



Extend Your Thinking

How protons, neutrons and electrons are alike and different?

Why is atom neutral?

Although electrons and protons in an atom have charges, but atom as a whole has no charge. In an atom, the number of protons is equal to the number of electrons. As a result, the total positive charge of protons balances the total negative charge of electrons. Because of it, the atom is neutral.

6.2: Atomic and Mass Numbers

Atomic Number (Z)

The number of protons present in the nucleus of an atom is called the **atomic number**. It is represented by Z.

The hydrogen atom has one proton in its nucleus; its atomic number is 1. Carbon atom has six protons in the nucleus; its atomic number is 6. An oxygen atom has 8 protons in the nucleus. What will be the atomic number of oxygen?

Each element has its own atomic number. We can identify an element by its atomic number.

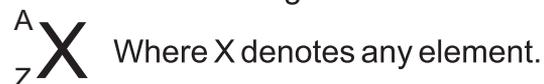
Mass Number (A)

The sum of protons and neutrons in the nucleus of an atom is called its **mass number**. It is represented by A.

The hydrogen atom has only one proton in its nucleus, its mass number is also 1. Carbon has 6 protons and 6 neutrons. Its mass number is 12. We can use atomic numbers and mass numbers to find the number of neutrons in atoms.

$$\text{Mass number (A)} = \text{Number of protons (Z)} + \text{Number of neutrons (N)}$$

General symbolic representation of an element is thus given as:



Example: Oxygen atom has atomic number 8 and mass number 16. What would be the number of neutrons in its nucleus?

Extend Your Thinking
Tungsten is an element with 74 protons and 109 neutrons. What is tungsten's atomic number? How many electrons does tungsten have?

Activity 6.1

Calculate the number of protons, electrons and neutrons in a sodium atom (${}^{23}_{11}\text{Na}$).

6.3: Distribution of Electrons in Shells

We know that electrons revolve around the nucleus of an atom. The paths of movement of electrons around the nucleus are called **shells**. Electrons are distributed in different shells. Shells are also called as energy levels. These shells are labeled as K, L, M, N, O, P, Q, etc. K is the first shell. We can calculate the number of electrons in a shell using the formula:

$$\text{Number of electrons in a shell} = 2n^2 \quad (\text{'n' is the number of shell})$$

Shell number	Maximum number of electrons
Shell number 1 or K-shell	$2n^2 = 2(1)^2 = 2$
Shell number 2 or L-shell	$2n^2 = 2(2)^2 = 8$
Shell number 3 or M-shell	$2n^2 = 2(3)^2 = 18$

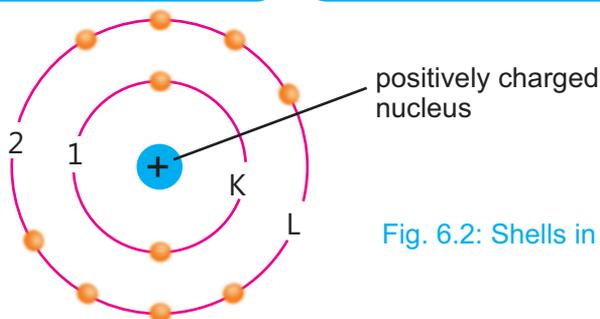
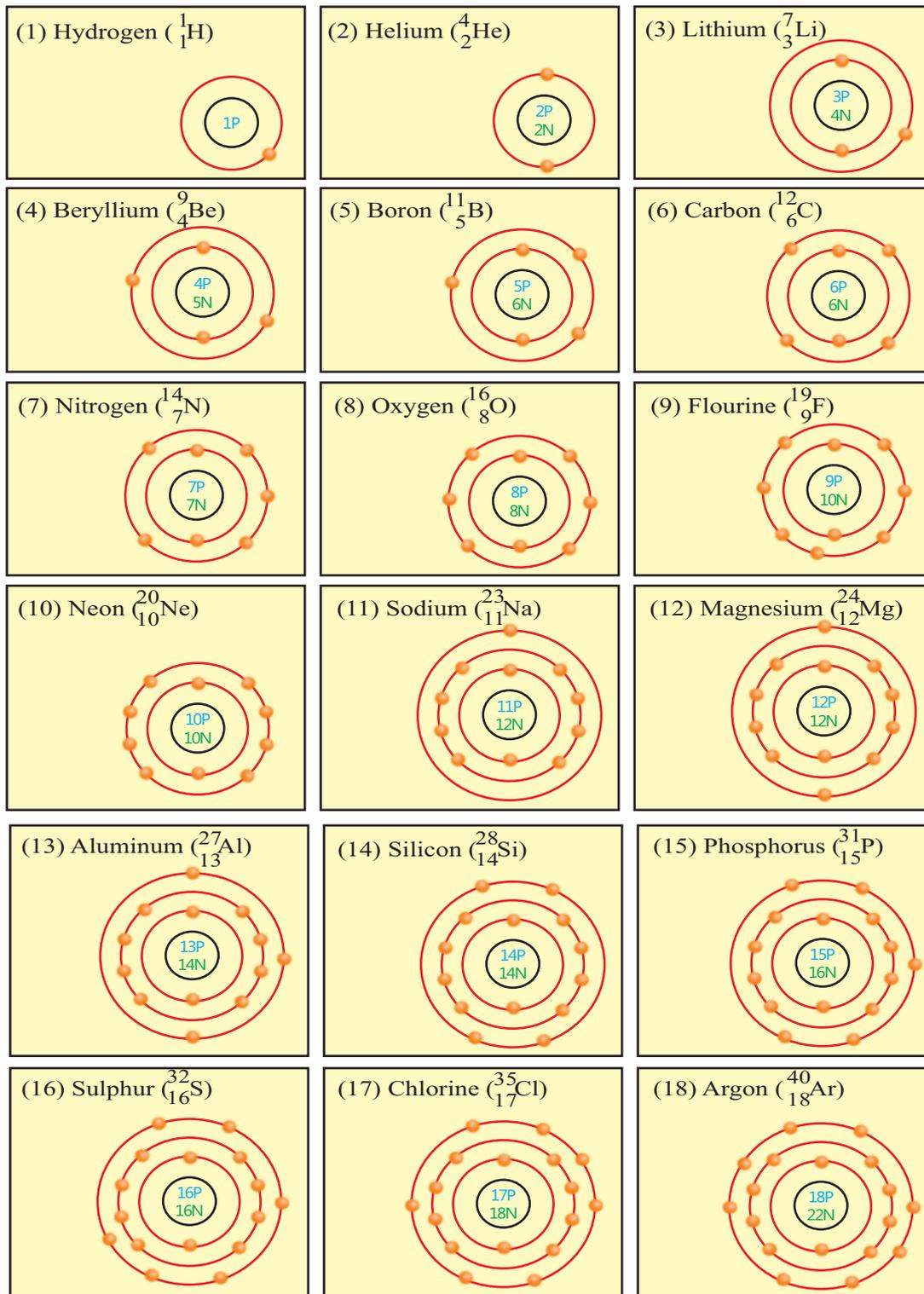


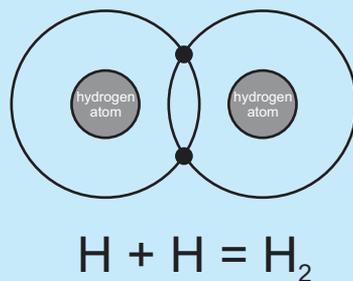
Fig. 6.2: Shells in an atom

Atomic Structure of the First Eighteen Elements



Why do atoms combine?

Atoms combine with other atoms but they stop reacting with other atoms (become stable) when their outermost shell is complete having 8 electrons, or they have only one shell (K-shell) with 2 electrons. For this purpose an atom can lose, gain or share its electrons with other atoms. Two hydrogen atoms combine to form a hydrogen molecule (H_2) by sharing electrons.



6.4: Valency and Ions

Valency

Valency is the capacity of an atom to combine with the other atom. Valency can also be defined as follows. “The number of electrons that an atom wants to lose, gain or share is called its valency.” For example, sodium atom (Na) loses one electron. Its valency is ‘1’. Fluorine atom (F) gains one electron. Its valency is ‘1’. Hydrogen (H) shares one electron. Its valency is also ‘1’. Copper, magnesium, oxygen, etc. have valency number ‘2’. The valency of aluminium and nitrogen is ‘3’. The valency of carbon atom is ‘4’.

Ion

An atom with positive or negative charge is called an **ion**. For example, sodium ion (Na^+), chloride ion (Cl^-), oxide ion (O^{2-}), copper ion (Cu^{2+}), etc.

When an atom releases its one or more electrons from the outermost shell, the number of protons more than that of electrons. It becomes a positive ion or **cation**. When an atom absorbs one or more electrons in its outermost shell, the number of electrons increases. It becomes a negative ion or **anion**. Positive ions and negative ions attract each other to form compounds. See the table 6.1.

Cations		Anions	
H^{1+}	Hydrogen	F^{1-}	Fluoride
Na^{1+}	Sodium	Cl^{1-}	Chloride
Ag^{1+}	Silver	O^{2-}	Oxide
Mg^{2+}	Magnesium	S^{2-}	Sulfide
Al^{3+}	Aluminium	P^{3-}	Phosphide



Extend Your Thinking

When a glass rod is rubbed with silk, the rod becomes positively charged. What type of particle in the atoms in the rod has been removed?

How is sodium chloride (NaCl) formed?

1 One electron transfers from sodium atom to chlorine atom. Sodium atom has 1 electron in its outermost shell. Chlorine atom has 7 electrons in its outermost shell.

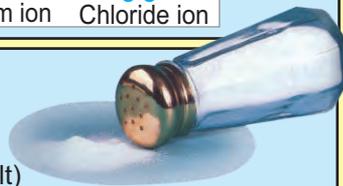


2 After losing one electron, sodium atom becomes sodium ion (Na^+). The chlorine atom gains one electron to become chloride ion (Cl^-).



3 Negative and positive ions attract each other to form sodium chloride (NaCl).

Sodium chloride (table salt)



Activity 6.2

The valency of each element shows the number of electrons that the atom releases or gains. Find the number of electrons released or gained for each element.

Elements	Valency	Number of electrons released	Number of electrons gained
Potassium	1+		
Oxygen	2-		
Calcium	2+		
Chlorine	1-		

6.5: Isotopes and their Uses

All atoms of an element always have the same number of protons. However, the number of neutrons may be different in some of these atoms. It means some atoms of the same element may have different mass number than the others.

The atoms of the same element having same atomic number but different mass numbers are called **isotopes**.

Hydrogen (H) has three isotopes. An atom of hydrogen may have zero, one or two neutrons in its nucleus. Protium (${}^1_1\text{H}$), Deuterium (${}^2_1\text{H}$) and Tritium (${}^3_1\text{H}$) are three isotopes of hydrogen.

Carbon (C) has three isotopes, i.e.

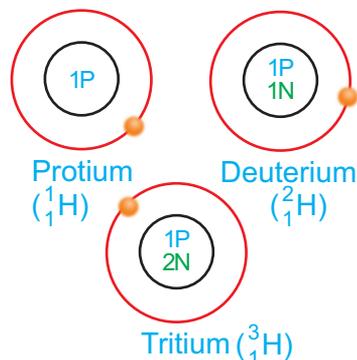


Fig. 6.3: Hydrogen has three naturally occurring isotopes.

Isotopes are of great importance in the fields of medicine and agriculture.

1. **Carbon–14** is used to calculate the age of plants.
2. **Nitrogen–15** is used to study the effects of nitrogenous fertilizers in plants.
3. **Sodium–24** is used to study circulation of blood.
4. **Phosphorus–32** is used in treatment of blood cancer and bone diseases.
5. **Chromium–51** is used to study red blood cells in patients with blood deficiency.
6. **Iron–59** is used to study absorption of iron in human body.
7. **Cobalt–60** is used in cancer treatment.
8. **Iodine–131** is used to treat a disease called goiter.

6.6: Molecules and Chemical Formulae

6.6.1: Molecule

A **molecule** is the smallest particle of an element or a compound that can exist independently and shows all the properties of that element or compound. It may be a monoatomic molecule such as helium (He), neon (Ne), etc. Two or more atoms can also be present in a molecule. For example, water (H_2O), hydrogen gas (H_2), glucose ($\text{C}_6\text{H}_{12}\text{O}_6$), etc.

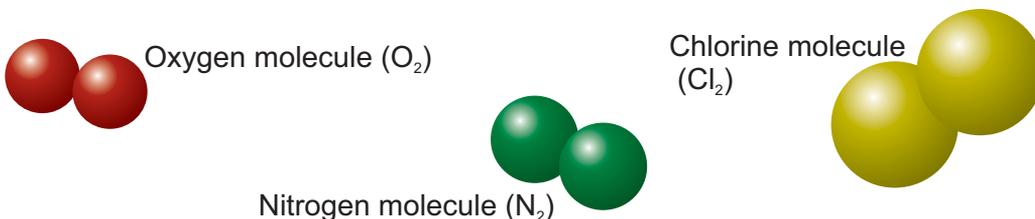


Fig. 6.4: Atoms of the same kind combine to make a molecule of that element.

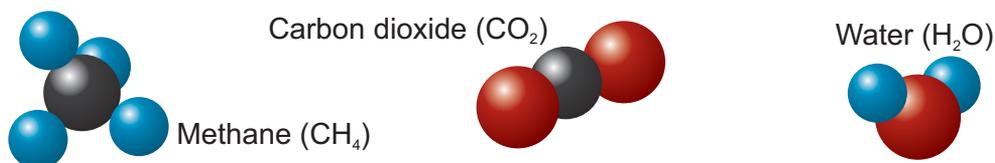


Fig. 6.5: Atoms of different kinds combine to make a molecule of a compound.

Activity 6.3

Write the number and types of atoms present in each of the following:

- | | |
|---|---|
| (a) Carbon tetrachloride (CCl_4) | (c) Calcium carbonate (CaCO_3) |
| (b) Sodium hydroxide (NaOH) | (d) Ammonia (NH_3) |

6.6.2: Chemical Formula

Describing a molecule in the form of symbols and valencies is called the **chemical formula**. The chemical formula of a molecule shows:

- kinds of elements in the molecule
- number of atoms of each element

For example, H_2 represents a molecule of hydrogen gas. It contains two hydrogen atoms. Similarly, CO_2 is the formula of carbon dioxide gas which shows that two atoms of oxygen combine with one carbon atom.



Fig. 6.6: H_2 is the chemical formula of hydrogen molecule and CO_2 is that of carbon dioxide.

Writing a Chemical Formula

The chemical formula of a molecule of an element is denoted by the symbol of that element with a subscript. The subscript tells the number of atoms present in the molecule.

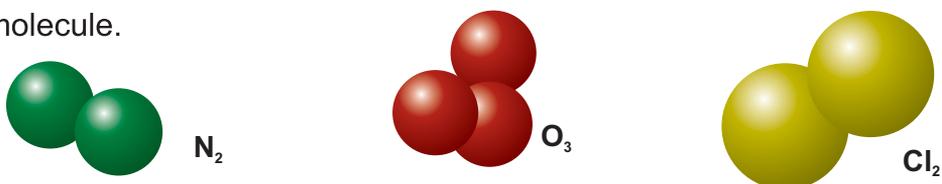


Fig:6.7: Nitrogen molecule (two atoms of nitrogen)

Fig:6.8: Ozone molecule (three atoms of oxygen)

Fig:6.9: Chlorine molecule (two atoms of chlorine)

The chemical formula of a molecule of a compound is denoted by the symbols of all elements present in that molecule. A subscript is given, when two or more atoms of an element are present. When no subscript is given, the number of atom is assumed as "1".



Fig:6.10: Water molecule (One oxygen atom combines with two hydrogen atoms.)

Fig:6.11: Methane molecule (One carbon atom combines with four hydrogen atoms.)

How to pronounce a formula?

You can pronounce a chemical formula as follows:

H_2O (water) is pronounced as: H two O

$C_{12}H_{22}O_{11}$ (sugar) is pronounced as: C twelve H twenty two O eleven.

6.6.3: Making Chemical Formulae of Ionic Compounds

When a positive ion (cation) attracts a negative ion (anion), an **ionic compound** is formed. Sodium chloride (NaCl), magnesium chloride (MgCl₂) are examples of ionic compounds. To write the formula of an ionic compound, follow these steps:

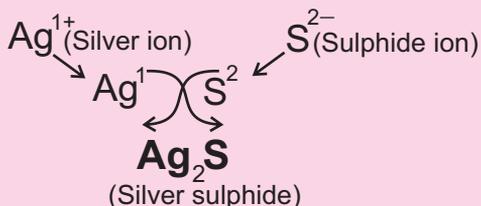
Step 1: Write the symbol of positive ion (cation) on the left and symbol of negative ion (anion) on the right. You may use table 6.1.

Step 2: Put the valency number of each ion with its charge on its top right side.

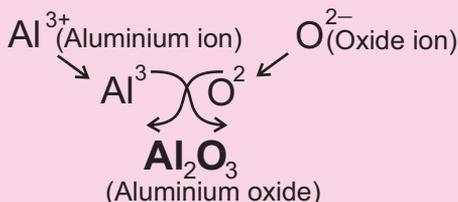
Step 3: Interchange the valency numbers of both ions and write them on lower right side of each ion. Omit the +ve and -ve signs which cancel each other. Remember that number '1' is also omitted. This method of writing chemical formulae is called **crisscross method**.

Examples

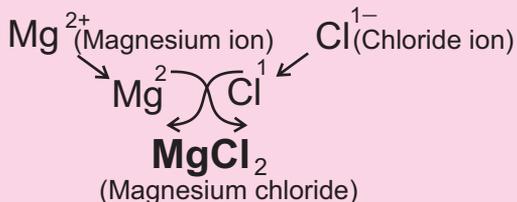
1. Write the formula for a compound of silver and sulphur ions, i.e. silver sulphide.



2. Write the formula for the compound composed of aluminium and oxygen ions.



3. Write the formula for the compound composed of magnesium and chlorine ions.



Activity 6.4

Make chemical formulae for the following ionic compounds:

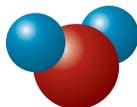
- Sodium chloride
- Potassium bromide
- Aluminium chloride
- Magnesium iodide
- Calcium chloride
- Copper oxide

6.7: Law of Constant Composition

Composition refers to the type and number of atoms present in a substance. In the late 1700, a French scientist **Joseph Proust** studied the chemical compounds and presented The Law of Constant Composition. The law states that **the composition of a compound is always the same regardless of how the compound was made or obtained.**

1. Water can be obtained from many sources (river, well, sea, etc.), but its composition is always the same. There are 2 atoms of hydrogen and 1 atom of oxygen present in a molecule of water (H_2O).

Water (H_2O)



2. Carbon dioxide (CO_2) is produced in a number of ways, but its one molecule always consists of one carbon atom and two oxygen atoms.



Carbon dioxide (CO_2)



Fig. 6.12: Joseph Proust (1754-1826) was a French chemist. In 1794, he presented “The Law of Constant Composition”.

Science, Technology and Society

An isotope is one of two or more atoms having the same atomic number but different mass numbers. Some isotopes release radiation all the time. These isotopes are called radioisotopes. Radioisotopes can be used for human welfare. Food irradiation is a method to make food safer for a long time. The radiation from a radioisotope kills microorganisms (bacteria, etc.) present in the food. Find some more uses of radioisotopes.

Key Points

- ⦿ An atom is made of smaller particles called electrons, protons and neutrons.
- ⦿ Atomic number is the number of protons in an atom, while mass number is the sum of protons and neutrons in the nucleus of an atom.
- ⦿ Electrons of an atom revolve around the nucleus in specific orbits or shells.
- ⦿ Valency is the capacity of an atom to combine with the other atom.
- ⦿ An ion is the atom with positive or negative charge.
- ⦿ When an atom releases its one or more electrons, it becomes a positive ion (cation).
- ⦿ When an atom absorbs electrons in its outermost shell, it becomes a negative ion (anion).
- ⦿ Isotopes are the atoms of the same element, having same atomic number, but different mass numbers. Isotopes are used in medicines and industries.
- ⦿ A chemical formula is the description of a molecule in the form of symbols and valencies.
- ⦿ The Law of Constant Composition states that the composition of a compound is always the same, regardless of how the compound was made or obtained.

Questions

- Complete each of the following sentences by writing the correct term.**
 - Two or more atoms of the same element with a different number of neutrons _____
 - The atomic particle with no charge _____
 - It is the number of protons in an atom _____
 - An atom with positive or negative charge _____
 - A molecule having one atom in it _____
- Encircle the correct answers in the following.**
 - An atom has no overall charge if it contains equal number of:
(a) electrons and neutrons (b) electrons and protons
(c) protons and neutrons (d) positrons and neutrons
 - Isotopes are found because atoms of the same element can have different number of:
(a) protons (b) electrons
(c) neutrons (d) none of the above
 - In the chemical formula CO_2 , which of the following is shown by subscript 2?
(a) There are two oxygen ions. (b) There are two oxygen atoms.
(c) There are two carbon atoms. (d) There are two CO_2 molecules.
 - The atomic number of fluorine (F) is 9. Its mass number is 19. How many neutrons are present in its atom?
(a) 7 (b) 8
(c) 9 (d) 10
 - The number of electrons in N-shell can be:
(a) 2 (b) 8
(c) 18 (d) 32

3. Give short answers.

- i. What does give the positive charge to the nucleus of an atom?
- ii. Define a cation and an anion?
- iii. What is chemical formula?
- iv. List the names, charges and locations of three kinds of particles that make up an atom.
- v. How are the isotopes of an element alike and how are they different?
- vi. A chlorine atom has 17 protons and 18 neutrons. What is its mass number? What is its atomic number?
- vii. Why the electrical charge on an atom is zero, or neutral?

4. Describe the structure of an atom.

5. What is an ion? How ions are formed?

6. Define the term isotope. Write about the applications of isotopes in the fields of medicine and agriculture.

7. State The Law of Constant Composition and give examples.

8. Using the table 6.1, make formulae of the following:

- Silver chloride _____
- Sodium oxide _____
- Aluminium chloride _____
- Hydrogen sulphide _____
- Magnesium fluoride _____
- Sodium Phosphide _____

**Computer
Links**

For more information visit:

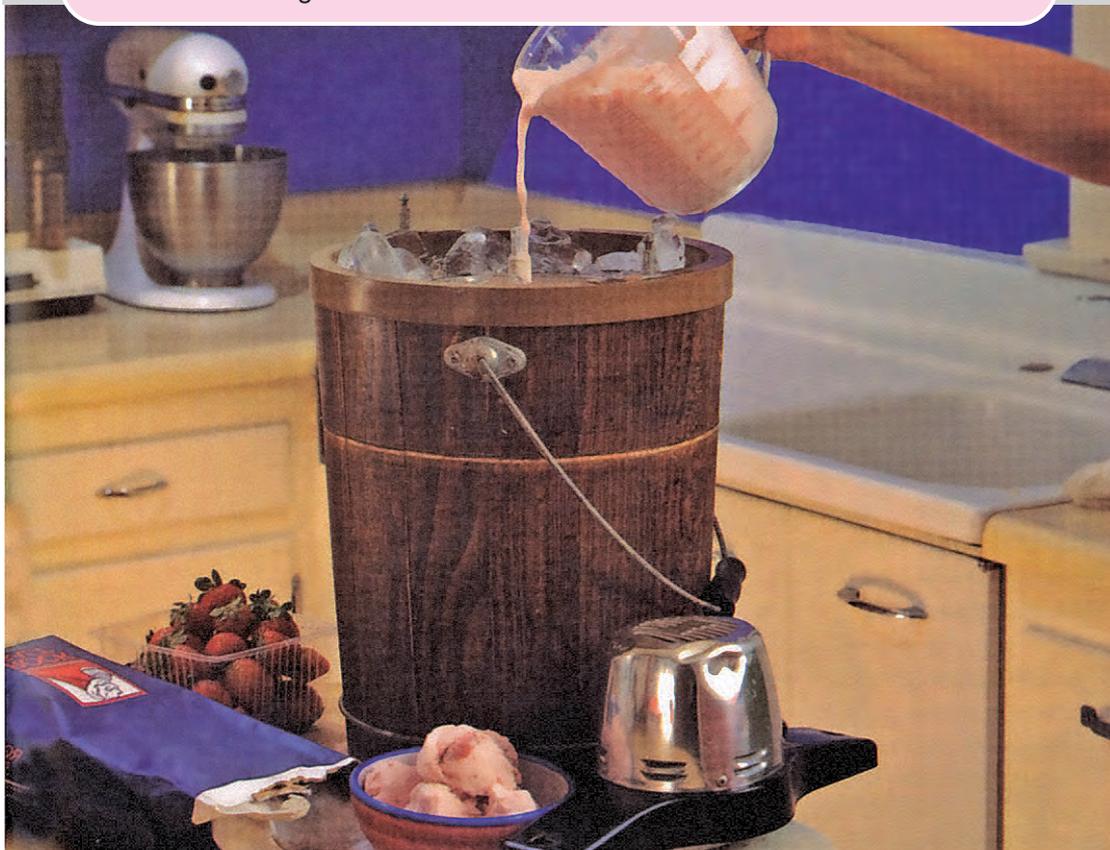
- <http://www.nyu.edu/pages/mathmol/textbook/atoms.html>
- <http://www.scribd.com/doc/49007676/symble-formula-valency>

Physical and Chemical Changes and Processes

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ differentiate between physical and chemical changes.
- ▶ identify the physical and chemical changes taking place in environment.
- ▶ explain the use of hydrocarbons as fuels.
- ▶ explain the use of physical and chemical properties of fertilizers, which make them useful in agriculture.
- ▶ discuss harmful effects of improper use of fertilizers.
- ▶ describe the chemical process in which vegetable oil changes into fat.
- ▶ describe the simple process for the manufacture of plastics.
- ▶ distinguish between reversible and non-reversible changes in materials.
- ▶ identify a variety of reversible and non-reversible changes in materials and in their surroundings.



We observe many changes in our everyday life.

Changes in materials are going on around us all the time. Leaves change their colour; trees shed their leaves, milk changes to curd, and iron nails rust in moisture. Some changes around us are slow and some are fast. In this chapter we will study about changes in matter.

7.1: Types of Changes

Most of the changes in materials are of two main types, i.e. physical changes and chemical changes.

Physical Changes

A **physical change** is one in which only the physical properties of a substance change and its chemical composition remains the same. Size, shape, colour, etc. are the physical properties of a substance.

Physical changes are temporary and can easily be reversed. Freezing of water, cutting fruit into pieces, switching on the bulb, dissolving of something into another, etc. are some examples of physical changes (Fig.7.1).

Ice melts or water freezes, it does not change the composition of water (H_2O). Melting of ice or freezing of water are physical changes.



Fig. 7.1: Cutting fruit and melting of wax are examples of physical changes.



Extend Your Thinking

Explain the presence of puddle of water on the sidewalk one day and its absence on the next day.

Activity 7.1

Dissolving of Table Salt into Water

You will need:

- table salt
- spoon
- spirit lamp
- beaker
- water
- tripod stand
- match stick

Procedure

1. Take some water in the beaker.
2. Dissolve some amount of table salt in the water.
Is the sugar visible in the water?
3. Put the beaker on the tripod stand.
4. Boil off the water in the beaker. What does remain in the beaker?

Things to think

How dissolving of table salt into water is a physical change?



Chemical Changes

A **chemical change** is one in which a new substance is formed.

Chemical changes are permanent and are not easy to reverse. Burning of paper, rusting of iron, turning of milk into yogurt, cooking of food, etc. are some examples of chemical changes (Fig.7.2).



Fig. 7.2: Turning of milk into yogurt, burning of coal and rusting of iron are some examples of chemical changes.

Coal is carbon. When we burn coal, it changes into smoke, energy and ash. So, burning of coal is a chemical change because new substances are formed during this process.

Some Clues to Chemical Changes

- Formation of gas bubbles
 - Change of colour
 - Releasing and absorbing of energy
- If any one of the above clues takes place, it shows the chemical change.



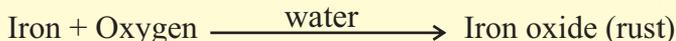
Extend Your Thinking

When we chew food, what type of change are we causing to the food, a physical change or a chemical change?

Activity 7.2

Rusting of Iron

Put a few iron nails in half-filled glass of water. After a few days observe the nails. Iron has reacted with oxygen in water. It is called rusting of iron. What type of change is this?



Activity 7.3

Reaction of Marble with Bleach

Pour some amount of bleach on a piece of marble. Observe what happens.

The marble reacts with the bleach and produces bubbles. Is it a physical change or a chemical change?



Activity 7.4

Observing a Chemical Change

You will need: • balloon • spoon • baking soda
• vinegar • narrow-necked bottle

Procedure

1. Pour some amount of baking soda into the balloon.
2. Add several spoonfuls of vinegar to a narrow-necked bottle.
3. Stretch the opening of the balloon over the mouth of the bottle, as shown in the picture.
4. Lift the balloon and hold it above the bottle so that the baking soda falls into the bottle.

Observe the changes that take place when the baking soda mixes with the vinegar.

Things to think

- i. What happened to the balloon?
- ii. Are baking soda and vinegar still present, or have they changed into new substances?
- iii. What clue did you observe that a chemical change takes place inside the bottle after the mixing of baking soda with the vinegar?



7.2: Applications of Chemical Changes

As a result of chemical changes new products are formed. We are living in the world of chemical changes. Chemical changes are taking place in our bodies, in our vehicles and in our environment. Sometimes chemical changes form harmful substances (Fig.7.3).



Fig. 7.3: Factories release toxic gases which react chemically with rain water. The rain water becomes acidic. Acid rain destroys forests. Acid rain is the result of chemical changes.



Extend Your Thinking

Why do you think chopping of wood is a physical change but burning of wood is a chemical change?

7.2.1: Use of Hydrocarbons as Fuels

Burning of fuels is another example of a chemical change. Fuel that we use to run our vehicles or factories consists of substances known as hydrocarbons. A **hydrocarbon** is a compound consisting of only hydrogen and carbon atoms. These hydrocarbons are mostly obtained from crude oil (petroleum). When hydrocarbons burn in the presence of oxygen their chemical compositions change. As a result of burning of hydrocarbons, a lot of heat is produced. People use the heat for various purposes such as cooking, heating, movement, etc.



Fig.7.4: The fuel used in motor vehicles is a hydrocarbon.

7.2.2: Use of Fertilizers in Agriculture

Repeated cultivation of crops decreases the fertility of soil. Farmers use certain substances to increase the fertility of the soil. A substance which adds minerals to the soil is called a **fertilizer**. It may be a natural fertilizer or a chemical fertilizer. Chemical fertilizers are prepared in factories. Many chemical changes take place during their preparation. Most fertilizers supply nitrogen (N), phosphorous (P) and potassium (K) elements to the soil (known as NKP).

Physical properties of fertilizers such as particle size and their hardness are very important. Small-sized particles of a fertilizer dissolve easily in water. Hard particles are better than soft ones because they release nutrients gradually.



Fig. 7.5: Chemical fertilizers increase the production of crops.

A **liquid fertilizer** is a clear solution. It contains the nutrients essential for plants. Liquid fertilizers are dustless and they reach to every plant easily.

Harmful Effects of Improper Use of Fertilizers

In case of excess spreading, some fertilizers are not absorbed by the plants. These fertilizers may reach into canals and rivers causing water pollution and encourage the growth of algae. During the manufacture of chemical fertilizers a lot of fossil fuel such as coal and natural gas is used, due to which our fossil fuel reserves are reducing quickly.

Waste materials of plants and animals are called manure. **Manure** is rich in nutrients needed by the soil. Chemical changes in manure increase the production of crops.

7.2.3: How does Vegetable Oil Change into Fat?

A chemical process called hydrogenation changes vegetable oil into solid fat (Banaspati ghee). When hydrogen is passed through vegetable oil in the presence of nickel, it converts into solid fat. This process is called hydrogenation. Vegetable oil is liquid while fat (ghee) is solid at room temperature. A large amount of heat is used to bring about this chemical change.



Fig.7.6: Vegetable oil combines with hydrogen and converts into solid fat or ghee.



Margarine is the result of chemical changes. It is a mixture of hydrogenated vegetable oil and skimmed milk. In hydrogenation, hydrogen is passed through the vegetable oil. Some people use margarine in place of butter.



7.2.4: Plastics

Plastics are also the result of chemical changes. A **plastic** is any material that can be moulded into any form. Plastics are very large molecules made from many smaller molecules called monomers. That is why plastics are also called polymers (long molecules made from smaller molecules). Monomers are obtained from crude oil. Polyethylene, polyvinyl chloride (PVC), etc. are some examples of plastics.

By heating, plastics can be moulded into a number of shapes in form of toys, cups, bottles, utensils, etc. Plastics do not decay and therefore are a cause of pollution. Recycling is the best way to deal with pollution caused by plastics.

Activity 7.5

Making Plastic

You will need: • cup • spoon • white glue • water • borax • blue ink

Procedure

1. Take some amount of glue in the cup. Add a few drops of blue ink to the glue and mix.
2. Add water to the glue and stir the mixture thoroughly with the spoon.
3. Add borax to the mixture as you stir it. Observe the changes in the appearance of the mixture. Continue adding the borax until no more liquid is visible.
4. Pick up the material and give it different shapes.
 - Can you compare the new compound with plastic?



7.3: Reversible and Irreversible Changes

A change that can go forward or backward is called a **reversible change**. It is a temporary change. We can get the same thing again. Melting of ice into liquid water, switching on a tube light, increase of heartbeat during running, mixing of salt in water, wetting a dry cloth, etc. are reversible changes.

A change that cannot go back is called a **irreversible change**. It is a permanent change. We cannot again get the thing in its original form. Turning of milk into yogurt, mixing of plaster of Paris with water, burning of paper and wood, rotting egg or fruit, etc. are examples of irreversible changes. How can we relate reversible and irreversible changes to physical and chemical changes?



Fig. 7.7: Identify reversible and irreversible changes in given examples.



Extend Your Thinking

When sugar is heated for a long time, it forms a solid black substance. Identify it as a reversible or irreversible change.

Activity 7.6

Reversible and Irreversible Changes

Make lists of reversible and irreversible changes around you. Also discuss these changes with your friends and teacher.

Science, Technology and Society



Many people use plastic bags for grocery, but some people prefer paper bags. Both of these bags come from natural resources which are rapidly reducing.

Decide which bag should be used for grocery.

- Paper bags can hold more items than plastic bag. Paper bags come from trees.
- Plastic bags are light weight and waterproof. Plastic bags are usually non-biodegradable. They cause land pollution. Plastic bags can be recycled.

The Right Choice

Both paper and plastic bags have some advantages and some disadvantages. But the best choice may be neither paper nor plastic. One reusable cloth bag could replace hundreds of paper and plastic bags.

Key Points

- In a physical change, only shape, size or physical state of a material change. In a chemical change, a material changes into a new material.
- Boiling and freezing of water, cutting fruit into pieces, switching on the bulb, etc. are some physical changes. Rusting of iron, burning of paper, cooking of food, etc. are some chemical changes.
- Hydrocarbons burn in the presence of oxygen and change into heat, water and carbon dioxide. This heat is used for different purposes.
- Chemical fertilizers, banaspati ghee and plastics are the result of chemical changes.
- The size and hardness of grains of chemical fertilizers help to release nutrients gradually in the soil.
- Improper use of chemical fertilizers can cause water pollution.
- A chemical process hydrogenation, changes vegetable oil into solid fat.
- Plastics are very large molecules which are made from many smaller molecules called monomers.
- In reversible change the product formed can again go back to its original form. In an irreversible change, the product formed cannot again go back to its original form.
- Boiling or freezing of water, melting of wax, etc. are examples of reversible changes. Rotting of egg or fruit, turning of milk into yogurt, etc. are examples of irreversible changes.

Questions

- Complete each of the following sentences by writing the correct term.**
 - A change in size, shape or state of matter _____
 - Results in new substances with different properties _____
 - Farmers use to increase crop production _____
 - A compound containing only carbon and hydrogen atoms _____
 - A polymer that can be easily moulded _____
- Encircle the correct answers in the following.**
 - Burning a match stick is an example of a:
(a) physical change (b) chemical change
(c) change in pressure (d) change of colour
 - Which one is a physical change?
(a) frying an egg (b) breaking a wooden stick
(c) burning of candle (d) toasting a bread
 - An example of a chemical change is:
(a) boiling of water (b) evaporation of water
(c) burning of paper (d) melting of ice

- iv. The red colour of a rose turns brown. It is a:
 (a) physical change (b) chemical change
 (c) reversible change (d) sudden change
- v. The vegetable oil is changed into banaspati ghee (solid fat) by the addition of:
 (a) nitrogen (b) carbon
 (c) oxygen (d) hydrogen
- vi. A chemical change results in a:
 (a) loss of matter (b) solution
 (c) phase change (d) different kind of matter

3. Give short answers.

- i. What is meant by a physical change?
 ii. Define a chemical change.
 iii. Give an example to show that people change the environment.
 iv. What is hydrogenation?
 v. What is a plastic?

4. Explain with examples that a chemical change brings change in the properties of a substance.

5. Write brief notes on:

- i. Plastics ii. Change of vegetable oil into fat**

6. How are fertilizers useful and harmful for us?

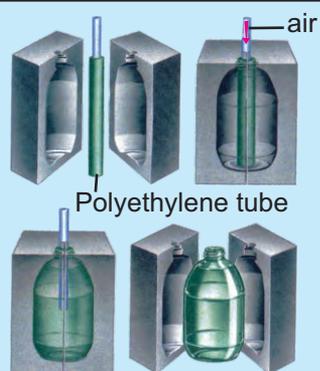
7. Explain reversible and irreversible changes with examples.

Making of Plastic Soft Drink Bottles

Amazingly, the making of plastic soft-drink bottles is same as to blow up a balloon.

- ❖ A tube of warm polyethylene is placed inside a bottle-shaped mould.
- ❖ After closing the mould, compressed air is blown into the polyethylene tube. The tube expands and takes the shape of the mould.

The mould is then opened. Your soft-drink bottle is ready for filling.



Computer Links

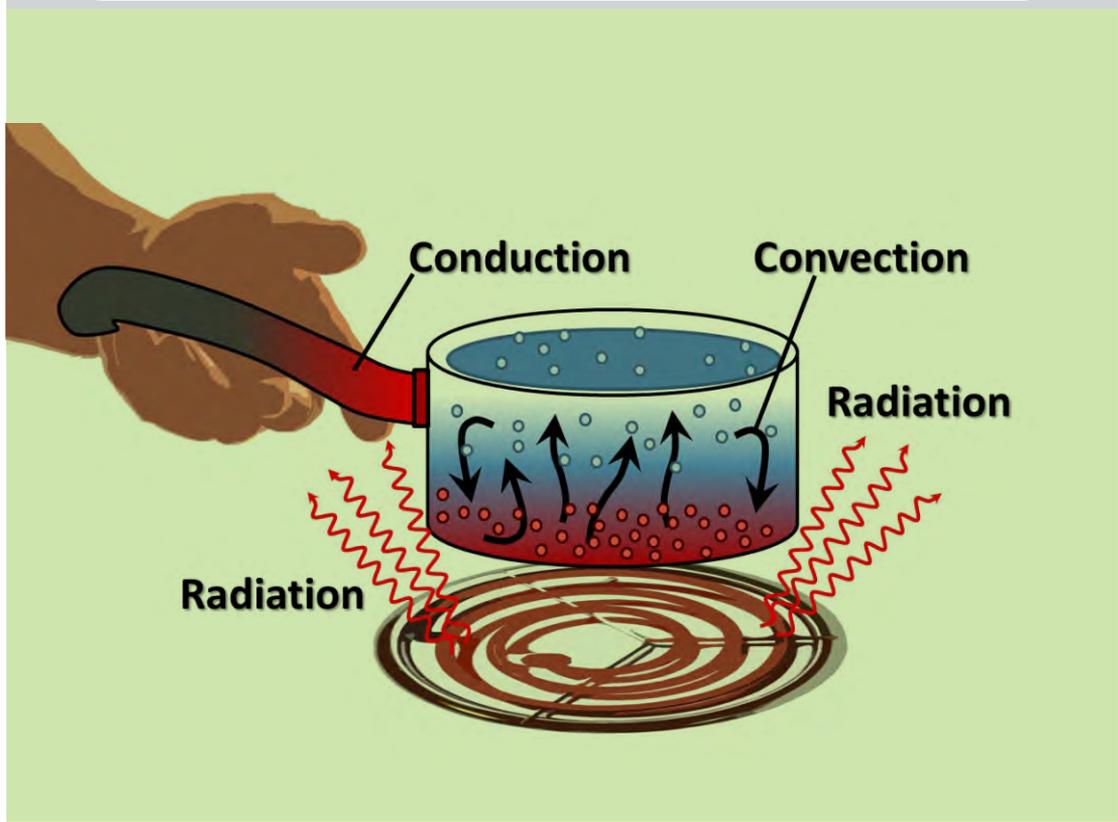
- For more information visit:
- <http://www.learnnext.com/lesson/CBSE-VII-Science-Physical-and-Chemical-Changes.htm>
 - http://en.wikipedia.org/wiki/Chemical_process

Transmission of Heat

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain the flow of heat from hot body to a cold body.
- ▶ explain conduction, convection and radiation through experimentation.
- ▶ recognize the three modes of transfer of heat from environment.
- ▶ suggest how birds can glide in the air for hours.
- ▶ identify examples of appliances that make use of different modes of transfer of heat.
- ▶ list heat-conducting materials in their surroundings.
- ▶ describe the working and principle of vacuum flask.
- ▶ explain how a vacuum flask reduces the transfer of heat.



Heat can be transferred from one object to the other by three methods, i.e. conduction, convection and radiation.

We have learnt in class VI that kinetic energy is the energy of any matter in motion. The small particles that make up matter are constantly moving. They have kinetic energy. The kinetic energy of particles in matter is called **thermal energy**. When thermal energy is transferred, it is known as heat. The word thermal means 'heat'.

Heat is the thermal energy that flows from an object. Heat flows from an object at higher temperature to an object at lower temperature. In this chapter, we shall learn about different modes of heat transfer.

8.1: Transfer of Heat

Imagine your teacher has brought packets of dates to distribute in your class. The teacher has three options.

Option 1: The teacher can give a packet of dates to first student and ask him/her to pass on to the next student and then next student passes it further. In this way, each one of you will receive a packet without moving from your place.

Option 2: The teacher can ask students to line up and come to his table one by one. After receiving the packet every student moves back to his/her seat.

Option 3: The teacher can just throw a packet towards each one of you without any movement on your part. Much the same way heat energy transfers from a hot body to a cold body.

The transfer of heat energy from one object to the other is called **transmission of heat**. Heat energy transfers in three ways, i.e. conduction, convection and radiation.

8.2: Conduction

If one end of a metal spoon is heated with a flame, the other end will also get heated up after a while (Fig.8.1). The heat energy is transferred from one end of the spoon to the other without the actual movement of particles (atoms or molecules) of the spoon. Such a mode of transmission of heat is called conduction. It resembles the example given above in option 1.

The transfer of heat through matter without the actual movement of particles from their position is called **conduction**. Conduction occurs in solids, liquids and gases, but solids usually conduct heat better than liquids or gases.

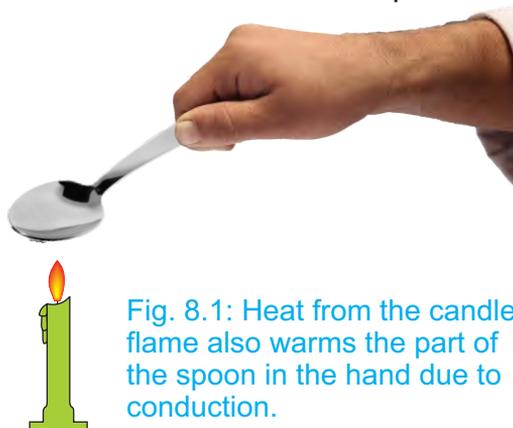


Fig. 8.1: Heat from the candle flame also warms the part of the spoon in the hand due to conduction.

In solids, the particles are held very close to each other. They vibrate constantly. When we heat one part of a solid, the particles gain heat energy and start vibrating faster. During their vibration they bump into nearby particles and also cause them to vibrate fast. In this way, the particles of hot part of a solid transfer heat to those in the colder parts.

 **Extend Your Thinking**
Why does conduction not occur at all in a perfect vacuum?

Activity 8.1 Observing Conduction

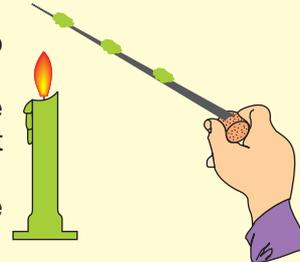
You will need:

- metal rod or knitting needle
- cork
- candle

Procedure

1. Push one end of the metal rod or knitting needle into the cork. Use the cork as a handle.
2. Light the candle. Burning candle will melt and change into liquid wax. Drop this melting wax on to the rod at three different points. Let the wax cool.
3. Heat the free end of the rod on the candle. Note the time when the wax at three different points melts.

- On which point will the wax melt first?



8.3: Good and Bad Conductors

Different materials conduct heat at different rates.

Materials which allow heat to flow through them easily are called **good conductors** of heat. Solids such as metals are good conductors of heat.

Materials which do not allow heat to flow through them easily are called **bad conductors** of heat or **heat insulators**. Solids such as wood, glass, plastic, styrofoam, etc. are bad conductors of heat. All liquids (except mercury which is a liquid metal) and gases are also bad conductors of heat.

Good Conductors	Insulators
silver	air or any gas
copper	cork
aluminium	glass
iron	plastic
mercury	wood



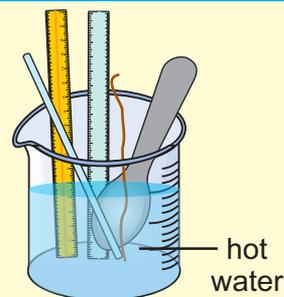
Fig. 8.2: The metal part of the frying pan allows heat to pass through but its plastic handle does not.

Activity 8.2

Some materials are conductors of heat and some are insulators

Take some hot water in a beaker. Take a steel spoon, a glass rod, a plastic scale, a wooden scale and a piece of thick copper wire. Dip one end of each of these in the hot water. Wait for 2-3 minutes.

Then touch the other end of each article with your fingers. Which ones become hot (conductors of heat) and which ones do not (insulators).



Why metals are better conductors than non-metals?

All solids (metals and non-metals) are made of tiny particles called molecules. But, some solids conduct heat better than others.

Let us put a metal and a plastic spoon in hot water. Which one is a good conductor of heat, metal or plastic?

When both spoons receive heat energy, the particles (atoms or molecules) at the hot end of each spoon vibrate fast and bump into neighbouring particles. These particles transfer heat energy to next neighboring particles (Fig.8.3,8.4).

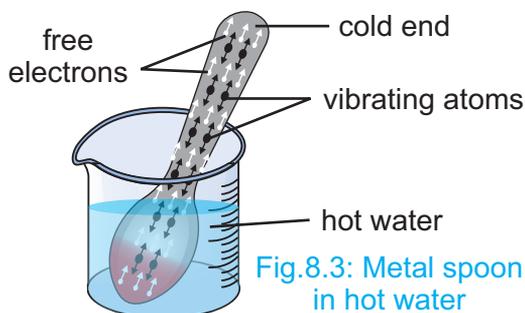


Fig.8.3: Metal spoon in hot water

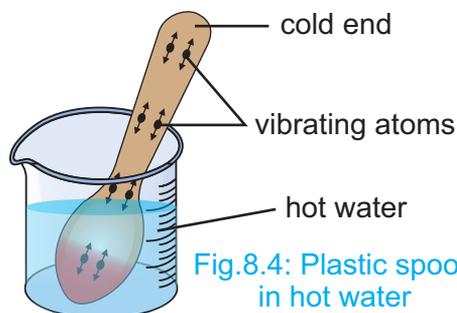


Fig.8.4: Plastic spoon in hot water

Particles in metals are packed more closely together than non-metals. Metals can transmit heat energy more readily than non-metals (wood, plastic, etc.). The presence of free electrons also speeds up the transfer of heat in metals. When the metal spoon gets heated, the free electrons gain kinetic energy and move farther towards the colder parts of the metal spoon. They bump into the atoms in the colder parts and transfer heat energy to them. In metals, heat energy is transferred from one place to another both by the vibrations of particles as well as by the movement of free electrons. That is why metals are good conductors of heat than non-metals (insulators).

Extend Your Thinking



Many fast food restaurants pack their hot sandwiches/pizzas in styrofoam boxes instead of wrapping them in ordinary paper. Why is the styrofoam used?

Conduction in Liquids and Gases

The process of conduction in liquids and gases is very slow as compared to solids (metals). The particles in liquids and gases are not held closely together. The particles have less chances to bump into other particles in liquids and even lesser in gases. That is why, the transfer of heat energy from fast-moving particles to neighbouring particles is slow. Water and air are bad conductors of heat.

Activity 8.3

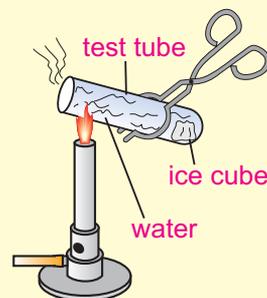
Water is a bad conductor of heat.

Water and most other liquids except mercury are bad conductors. To show this:

1. Wrap an ice cube in wire gauze and drop it in a test tube almost filled with water. It will settle down.
2. Hold the test tube and heat it near the neck with a Bunsen flame/ spirit lamp.

Observe

Soon the water in the upper part of the test tube will start to boil, but the ice at the bottom melts very slowly. It shows that water is a bad conductor of heat.



8.4: Everyday Applications of Conduction of Heat

Conduction plays an important role in our lives.

1. Cooking utensils, electric kettle, iron, soldering iron, etc. are made of metals to conduct heat quickly. Their handles are made of plastic or wood which are bad conductors.
2. Birds have feathers which keep their bodies warm because feathers are bad conductors of heat (Fig.8.5).
3. Woolen clothes and blankets slow down the transfer of heat. It so happens because the wool traps air in it. The air is a bad conductor of heat.
4. Ice is covered with jute rugs to reduce its melting speed. Jute is a bad conductor of heat.
5. An insulating material (e.g. styrofoam) is filled between the double walls of a refrigerator. It reduces the transfer of heat across the walls of the refrigerator.
6. Double-pan windows are used in buildings to



Fig. 8.5: Birds have feathers which are bad conductor of heat.



Fig. 8.6: Polyester is a poor conductor of heat. It can keep our body warm during winter.

slow the transfer of heat. Air between the two layers of glass acts as an insulator.

7. Thermos bottles use air or a vacuum to slow the transfer of heat by conduction.

Tidbits

- The plastic water cooler and hot pots have double walls. The styrofoam and air between the walls reduce transfer of heat by conduction.
- Marble has been used in buildings and monuments since long times. It is not only beautifies the buildings but also acts as an insulator.

8.5: Convection

Unlike particles of solids, particles in liquids and gases move from one place to another. Take a beaker and put small pieces of paper in it. Fill half of the beaker with water. Heat the beaker by a spirit lamp. We shall see that pieces of paper rise to the top of water, move sideways and sink to the bottom. The water in the beaker also gets warm. The molecules of water absorb heat energy from the bottom of the beaker and rise to the top. Other surrounding molecules of water come to the bottom to absorb heat energy.

The transfer of heat in which molecules of a medium actually move to the source of heat energy to absorb heat and then move away from it, is called **convection**.

Convection occurs in liquids and gases only because their molecules can move freely. The molecules of a solid are held closely together. They cannot move freely, therefore, convection is not possible in solids.

The upward and downward movement of molecules of water or air is called a **convection current**.



Fig.8.7: Motion of the paper pieces in water is due to convection of heat.

Activity 8.4

Convection in Liquids

You will need

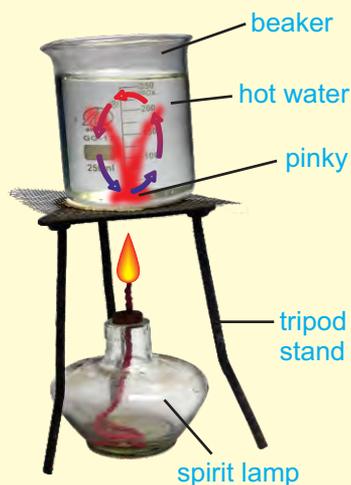
- a beaker
- water
- tripod stand
- spirit lamp
- potassium permanganate crystals (pinky)

Procedure:

1. Fill the beaker two-thirds with water.
2. Place the beaker on a tripod stand.
3. Place a crystal of potassium permanganate (pinky) at the bottom of the beaker gently using a straw.
4. Now, heat the water by placing the spirit lamp just below the crystal. What did you observe?

Explanation

When water is heated, the water near the flame gets hot. Hot water rises up. The cold water from the sides moves down towards the source of heat. This water also gets hot and rises. Water from the sides moves down to take its place. This process continues till the whole water gets heated. This mode of heat transfer is known as convection.



Activity 8.5

Convection in Gases

You will need

- a box with two holes at the top (convection box)
- paper/cloth
- matchbox
- candle
- plastic sheet

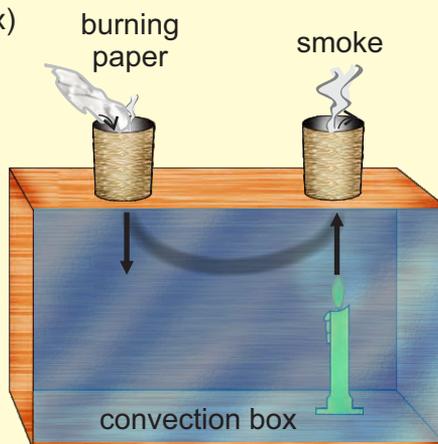
Procedure

1. Light a candle and place it under one of the holes in the convection box.
2. Bring a burning piece of paper/cloth near the hole other than the candle.

Observe the path of the smoke in the convection box.

What happens?

As the warm air weighs less than the surrounding air, it rises out of the hole above. The cooler and heavier surrounding air enters the box through the other hole to take the place of the air which left the box. This movement of air in and out of the holes due to the difference in weights, sets up a convection current.



8.6: Winds and ocean currents

We know that convection is the transfer of heat by the actual movement of the particles in materials. Winds and ocean currents are examples of effects of convection.

The heat of the Sun heats up the surface of the Earth and the air near it also gets hot. The air expands and gets lighter. So, it rises up and cool air from the neighbouring regions moves in to fill its space. The rising warm air reaches upper colder layers of the air and cools down. Cool heavy air sinks to the Earth in cold regions to blow again to take the place of the rising air. Thus, convection currents are setup and the wind-system goes on.

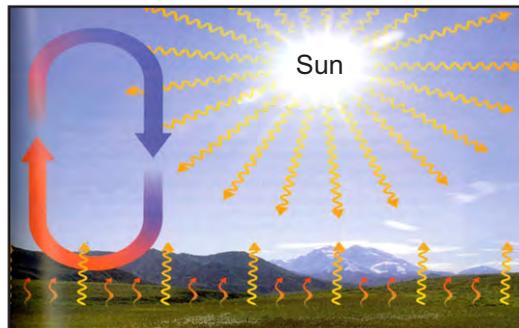


Fig.8.8: Convection causes winds.

Ocean currents are also set up due to convection of heat. Water of the hot regions of an ocean gets hot, it expands and gets lighter, but water in the colder regions remains cold and heavy. Hot water moves along the surface of the ocean towards the colder regions. The cold water flows below the surface of the ocean towards the hot regions. In this way, ocean currents are set up.

Convection and Gliding Flight of Birds

Convection currents also take place in atmosphere. The heat from the Sun warms the air near the ground. The warm air expands and becomes lighter in weight. As warm air rises, colder air rushes in to fill its place near the ground. This process continues. Birds like eagles, hawks, vultures and gulls take advantage of this phenomenon. They enjoy gliding. During gliding flight a bird does not move its wings, but glides on air currents. A lot of energy of birds is saved during gliding.



Some birds use convection currents to glide for hours.

8.7: Everyday Applications of Convection Currents

We can observe the use of convection currents in our surroundings.

1. **Household ventilation** can make our house cool. The air which we breathe out is warmer and lighter. It moves up in the room to go out of the ventilators near the top side of the walls. Fresh and cool air enters the room through windows and doors.

- In a **domestic water Heater**, water is heated in the boiler by gas burner or heating coil. The hot water expands and becomes lighter in weight. This water rises and flows into the upper part of the water heater. To take the place of hot water, cold water from storage tank (cistern) falls to the lower part of the water heater to become hot. We take the hot water from the tap attached to the water heater. Convection currents help in the continuous supply of hot water.
- An **air conditioner** also uses convection currents cool a room. Air conditioners are installed near to the ceiling. The fan of an air conditioner blows cool dry air. The cool air is heavier in weight, so it sinks. The warm air of the room rises because it becomes lighter in weight. The air conditioner draws this warm air to make it cool. In this way, the air circulates again and again till desired temperature is reached.



Fig.8.9: Convection currents heat up water in a water heater.

Tidbits

In an oven, the heater is placed at the bottom. The convection current transfers heat to all the parts of the oven.

8.8: Radiation

The transfer of heat energy from a hot body to a cold body directly, without heating the space in between the two bodies is called **radiation**.

When we sit in the sun or in front of a heater, we feel warmth. Heat energy reaches us by radiation. This heat cannot reach us by conduction because air is a bad conductor of heat. Similarly, this heat cannot reach us by convection, as the hot air rises upward, rather than sideways. If we put a cardboard or a plastic sheet between us and the source of heat, we no longer feel warmth. So, we can say that heat from the Sun or a heater reaches us by radiation which requires no medium (Fig.8.10).

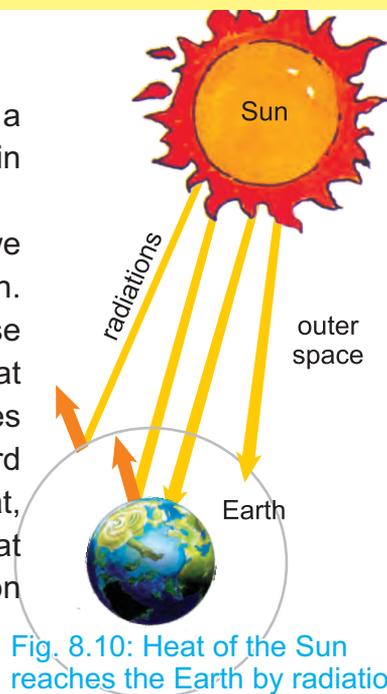


Fig. 8.10: Heat of the Sun reaches the Earth by radiation.



Extend Your Thinking

Why is radiation the only type of heat transfer by which the Sun's energy can move to the Earth?

8.9: Experiments on Radiation and Absorption

Objects absorb and radiate heat at the same time. Whether all objects absorb and radiate heat equally? To study it let us perform some activities.

Activity 8.6

A good absorber of heat is a good radiator of heat.

You will need: • black-coloured can • silver-coloured can
• laboratory thermometer • cold water • hot water

Procedure

1. Fill two thirds part of each can with cold water.
2. Put a thermometer in each can and record temperatures.
3. Place both cans in bright sunlight. Observe and record the temperature of each can after about 10 minutes. The temperature of water in black can is higher because it has absorbed more heat from the Sun.
4. Again fill the cans with hot water and place thermometers in them. Record temperature of water in each can.
5. Place both cans in a shady place. Observe and record the temperature of each can after some time.
 - In which can did the water cool faster?



black-coloured can



silver-coloured can

Activity 8.7

Which one is the good absorber of heat?

You will need: • an electric heater • two marbles • wax
• a metal plate with rough, dark coloured surface
• a metal plate with shiny, smooth, light coloured surface

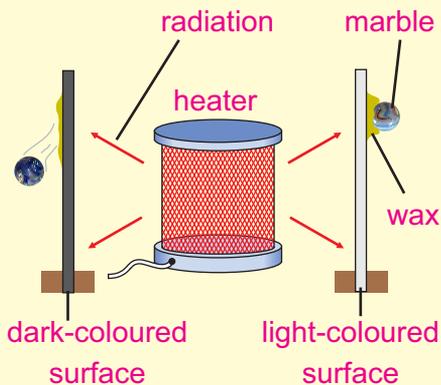
Procedure

1. Stick a marble on each plate with the help of wax.
2. Place the heater between the two metal plates so that each plate receives the same amount of heat from the heater.
3. Switch on the heater.

Observe the marbles stuck on the plates.

Things to think

Why did the marble stuck on the plate with rough, dark coloured surface drop first?



Science, Technology and Society

In hot countries, houses are painted with light-coloured paints. The light colour of the paint absorbs little heat and reflects most of the radiation from the Sun. What colour of paint would you suggest for the houses in very cold countries?

8.10: Good and Bad Radiators and Absorbers of Heat

Experiments have proved that good absorbers of heat are also good radiators of heat. Black surfaces are good absorbers and good radiators of heat, while shiny surfaces are bad absorbers and bad radiators of heat (Fig.8.11, 8.12).

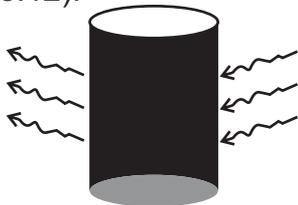


Fig. 8.11: A black, dull surface

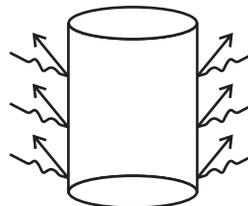


Fig. 8.12: A white, shiny surface

Tidbit

Since shiny surfaces are bad emitters of radiation, shiny teapots and utensils can keep food or tea warm for a longer time than black ones. In addition, shiny containers can keep cold liquids cool for a longer time than black containers.



Shiny teapot



Black teapot

8.11: Everyday Applications of Radiation of Heat

Every object emits or radiates some amount of heat. Knowledge of radiation can help us in many ways.

1. When we sit beside a fire, the heat of fire reaches us by radiation.
2. The cooling fins at the back of our refrigerator need to radiate its heat quickly to the surroundings. Its surface is made rough and painted black (Fig. 8.13).
3. During hot summer days, it is advised to wear white or light-coloured clothes. White colour absorbs less heat than dark colours.
4. In cold areas, a greenhouse is used for better growth of plants. Radiation from the Sun passes through the glass or plastic and warms up the soil and plants. Plants and soil absorb and emit radiation and increase the temperature in the greenhouse. Plants grow well in increased temperature of the greenhouse (Fig. 8.14).

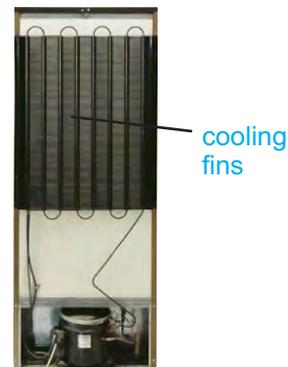


Fig. 8.13: Black cooling fins at the back of this refrigerator radiate heat quickly.



Fig. 8.14: A greenhouse

8.12: The Vacuum Flask

The vacuum flask is a container which can keep hot things hot and cold things cold. The vacuum flask reduces the rate of transfer of heat by all the three ways, i.e. conduction, convection and radiation.

The vacuum flask (thermos flask) is actually two thin glass or metal bottles, one inside the other (Fig. 8.15). Air between the glass walls is removed to create vacuum. The vacuum prevents the transfer of heat by **conduction** and **convection**. The walls of both bottles are coated with aluminium on the vacuum side. These silvered (like a mirror) and smooth glass walls prevent transfer of heat by **radiation**. The lid of the flask is made from a bad conductor such as cork or plastic only a little amount of heat is lost by conduction through the lid. The thin walled glass bottle is protected by fixing it in a metal or plastic container.

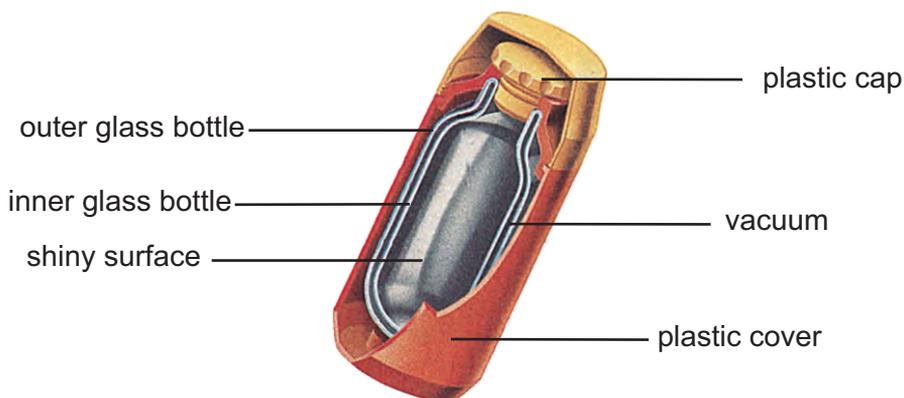


Fig. 8.15: A vacuum flask slows the transfer of heat by conduction (plastic), convection (vacuum) and radiation (shiny surface).



Extend Your Thinking

How conduction, convection and radiation are alike and how they are different?

Tidbit

A blacksmith experiences all three ways of heat transfer, i.e. **conduction**, **convection** and **radiation**.

1. The iron in the blacksmith's furnace glows red as heat is transferred to the metal from the furnace. (conduction)
2. The heat of the furnace warms the air in the blacksmith's shop. (convection)
3. The blacksmith feels the glow of heat from the forge. (radiation)



Key Points

- ⊙ Heat is a form of energy. Heat always flows from an object at higher temperature to an object at lower temperature.
- ⊙ Conduction is the transfer of heat through matter without the actual movement of particles from their positions.
- ⊙ Convection is the transfer of heat in which molecules of a medium actually move to the source of heat energy to absorb heat and then move away from it.
- ⊙ Radiation is the transfer of heat from a hot body to a cold body directly, without heating the space in between the two bodies.
- ⊙ Conduction occurs in solids, liquids and gases. But metals are better heat conductors.
- ⊙ Convection occurs only in liquids and gases.
- ⊙ Radiation needs no material medium to transfer heat energy.
- ⊙ Good and bad conductors of heat play very important role in our lives.
- ⊙ Convection causes wind and ocean currents.
- ⊙ Heat from the Sun reaches us by radiation.
- ⊙ Some birds take advantage of convection currents and glide in the air for hours.
- ⊙ A good radiator of heat is also a good absorber of heat.
- ⊙ A vacuum flask reduces the transfer of heat by conduction, convection and radiation to keep things hot or cold.

Questions

1. **Complete each of the following sentences by writing the correct term.**
 - i. The transfer of heat by movement of molecules from place to place _____
 - ii. It can maintain the temperature of drinks _____
 - iii. The transfer of heat by direct contact of molecules _____
 - iv. The surface which absorbs and radiates heat better _____
2. **Encircle the correct answers in the following.**
 - i. When we sit in the sun we are heated by:
(a) convection (b) conduction
(c) radiation (d) convection current
 - ii. Warm air rises because of:
(a) light (b) convection
(c) conduction (d) radiation
 - iii. A metal spoon is placed in a cup of hot water. The spoon gets warm by:
(a) conduction (b) convection current
(c) radiation (d) convection
 - iv. In a vacuum flask, the vacuum prevents the transfer of heat by:
(a) conduction (b) convection
(c) radiation (d) air

- v. What is happening when warm water rises in a lake and cold water sinks?
 (a) conduction (b) convection
 (c) radiation (d) mixing
- vi. Heat energy can be transferred well by conduction from one material to another only if both are:
 (a) solids (b) liquids
 (c) gases (d) all the three
- vii. Wind blows due to:
 (a) conduction of heat (b) convection of heat
 (c) radiation of heat (d) emission of heat
- viii. Which colour is a good reflector of heat?
 (a) red (b) black
 (c) blue (d) white
- ix. What happens if two objects at different temperatures are touching?
 (a) Heat energy transfers from the warmer object.
 (b) Heat energy transfers from the colder object.
 (c) Heat energy transfers to the warmer object.
 (d) No heat energy transfer takes place.

3. Give short answers.

- i. Why do we use cooking pots made of metals?
 ii. What is a convection current?
 iii. Which surfaces do absorb maximum heat?
 iv. Why do we use woollen clothes and blankets during winter days?
 v. What is the advantage of gliding flight for a bird?

4. What is convection? How does it occur?

5. Write a few everyday applications of conduction of heat.

6. Write a note on a vacuum flask.

7. Write brief notes on:

i. Ocean currents and winds

ii. Gliding flight of birds

**Computer
Links**

For more information visit:

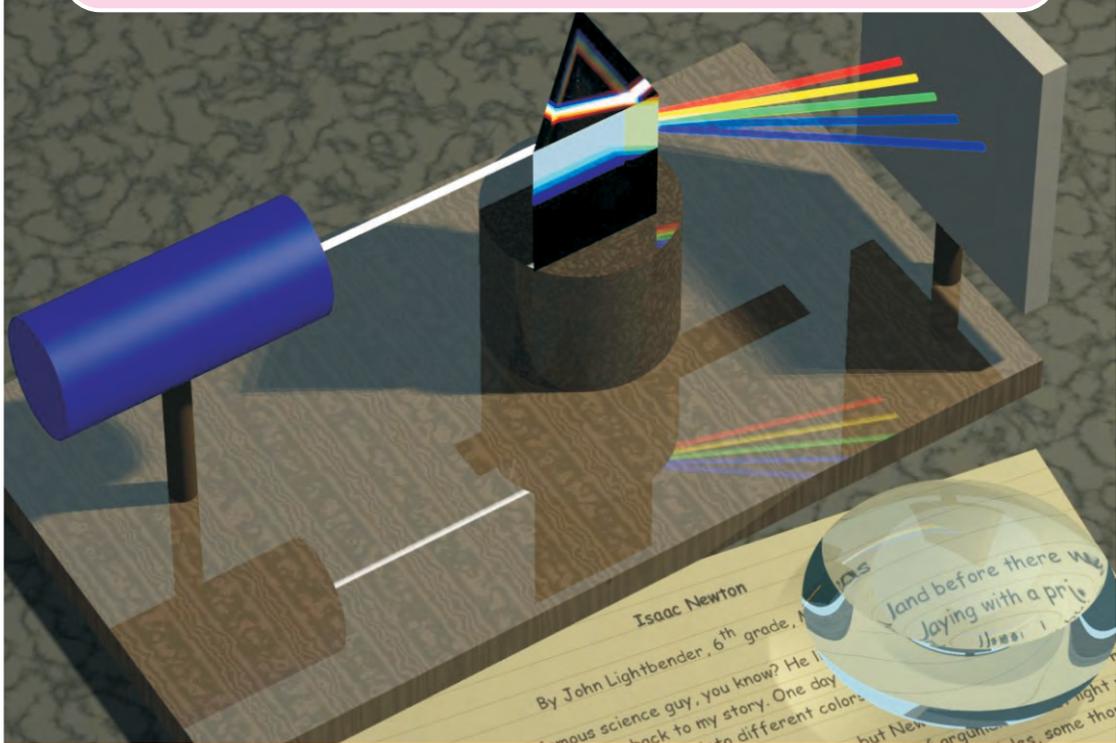
- <http://www.wisc-online.com/Objects/ViewObject.aspx?ID=sce304>
- <http://www.vtaide.com/png/heat2.htm>

Dispersion of Light

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain refraction of light and its causes.
- ▶ discuss the effects of refraction with examples.
- ▶ list the colours of light using a prism.
- ▶ describe the dispersion of light by a prism.
- ▶ identify different uses of light of different colours at home, school and country and explain the relationship of choice of colours to their purpose.
- ▶ define spectrum of light.
- ▶ identify primary colours and show how they are combined to form secondary colours.
- ▶ identify a device in their surroundings that uses different combinations of colours.
- ▶ demonstrate how spinning of a rainbow disc results in the appearance of white disc.
- ▶ explain why an opaque or non-luminous object appears to be of certain colour.



Light passing through a prism can be split into exciting colours.

We have learnt a few properties of light in class VI. In this chapter we shall discuss some more properties of light. You may have seen some of these scenes around you:

- the shallow bottom of a water tub which is actually deep
- a puddle of water on the road on a hot, sunny day
- a beautiful rainbow in the sky after rain
- different colours in an oily film on the surface of water

All these phenomena are the result of a property of light, called refraction.

9.1: Refraction

We know that light does not need a material medium to travel. Light travels at different speeds in different mediums. Light travels the fastest through the vacuum.

When light passes from one transparent medium to another, it changes its speed and direction (or bends). This bending of light is called **refraction**. But, when light falls perpendicular to the surface of the medium, it does not change its direction.



Fig. 9.1: The pencil in the glass of water looks as it has been broken at the water line. It is because of refraction of light.

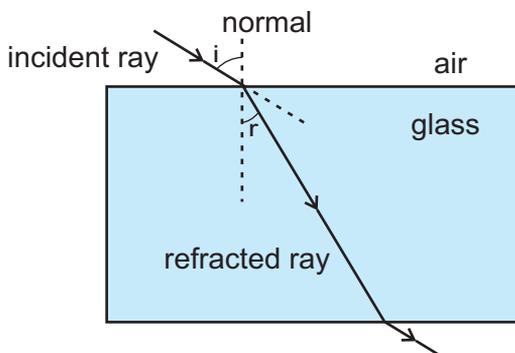


Fig. 9.2: A light beam bends as it travels from air into glass and also from glass into air.

Important Terms

We can understand the term refraction with the help of the following terms:

Incident Ray: The ray of light that travels in one medium and falls on the surface of the second medium.

Refracted Ray: The ray of light that changes its direction in the second medium.

Normal: An imaginary line, drawn perpendicularly on the surface of the medium at the point where incident ray falls (point of incidence).

Angle of Incidence: The angle between the normal and the incident ray. It is denoted by ' i '.

Angle of Refraction: The angle between the normal and the refracted ray. It is denoted by ' r '.

Activity 9.1

Effect of Refraction

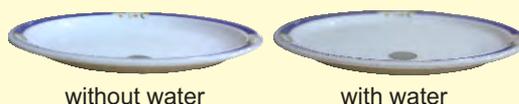
You will need: • a plate • water • a coin

Procedure

1. Take a short, opaque plate and place a coin at its bottom.
2. Position yourself in such a way that the coin is just not visible to you.
3. Ask your partner to pour water into the plate until you can see the coin clearly.

What happens?

When the coin is not visible to you, the rays of light travelling from the coin in a straight line are not able to enter your eyes. These rays are blocked by the edge of the plate. As soon as water is poured in the plate, the change of medium occurs. Now light has to travel from water into air. Due to refraction of light it bends and enters your eyes. The coin is now visible to you due to refraction.



9.2: Refraction in Different Mediums (Glass and Water)

When light passes from air into water or glass, it bends towards the normal. The angle of incidence is greater than the angle of refraction (Fig:9.3a).

$$\angle i > \angle r$$

When light passes from water or glass into air, it bends away from the normal. The angle of refraction is greater than the angle of incidence (Fig:9.3b).

$$\angle r > \angle i$$

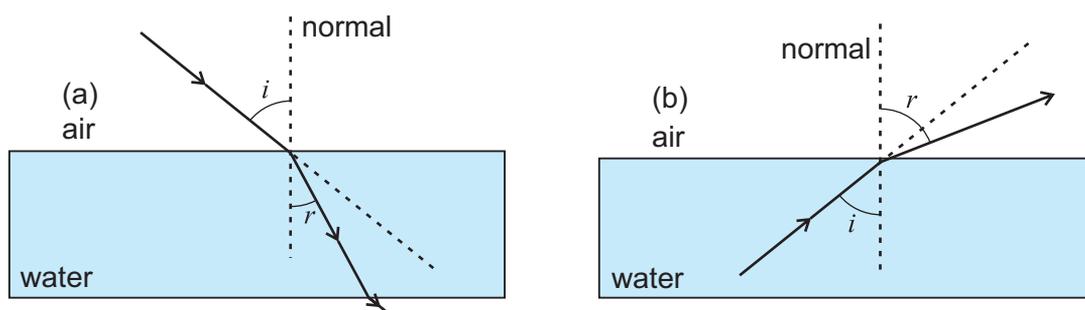


Fig. 9.3: (a) Light bends towards the normal when passes from air into water or glass. (b) It bends away from the normal when passes from water or glass into air.



Extend Your Thinking

A light wave is bent more as it travels from air to glass than in traveling from air to water. Is the speed of light greater in water or glass?

9.3: Laws of Refraction

There are two laws of refraction.

1. The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.
2. The ratio of the speed of light in vacuum to its speed in another medium is always constant.

Activity 9.2

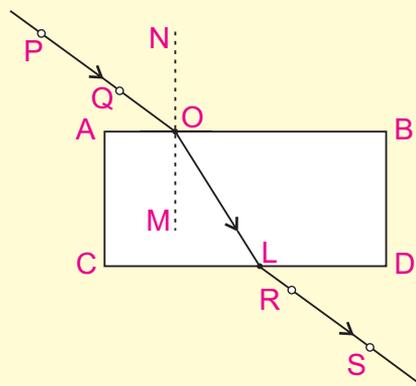
You will need

- a glass slab
- a drawing board
- drawing pins
- white sheet of paper
- common pins
- geometry box

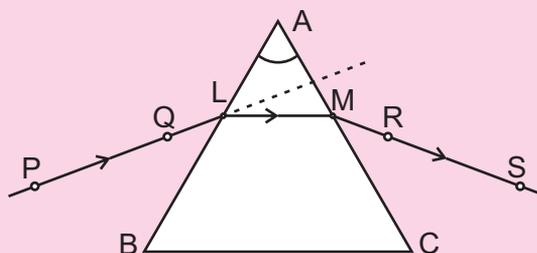
Procedure

1. Fix a white sheet of paper on a drawing board.
2. Put a glass slab in the centre of the paper. Draw the boundary of the slab as ABCD.
3. Fix two pins P and Q on the paper in such a way that they make an angle with the slab.
4. Look for the image of the pins from the other side through the slab. Fix two more pins R and S in line with the images of P and Q.
5. Remove the slab and the pins. Mark the position of the pins.
6. Join P and Q as the incident ray to AB at point O.
7. Join R and S as the refracted ray to CD at point L.
8. Join O and L.
9. Draw a normal NOM at point O.
10. Fix P and Q pins at different positions and place R and S pins on the other side of the slab accordingly.

You can see that the incident ray, the refracted ray and normal at the point of incidence, all lie in the plane of paper.



Using the knowledge from the above activity study the refraction of light through a prism.



9.3.1: Refractive Index

The speed of light varies in different mediums. Some mediums cause light to bend more than others when it passes through them. The degree to which a medium can bend light is given by its refractive index.

In terms of speed of light, we can define refractive index as, “**refractive index** is the ratio of the speed of light in vacuum to its speed in the medium”.

$$\text{Refractive Index of the medium} = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}}$$



Fig.9.4: Willebrord Snell (1580–1626) was a Dutch astronomer and mathematician. In 1621, he presented the law of refraction.

9.4: Real and Apparent Depth

Sometimes refraction of light gives us a false impression of the depth and position of objects in water or glass. For example, we have noticed that clear swimming pool looks shallower than their actual depth. It is because of refraction of light.

Light travels faster in air than in water. When light passes from a denser medium (water) to a rare medium (air), it bends away from the normal. When this refracted light enters our eyes, the bottom of the pool and objects lying on the bottom appear close to us than they really are (Fig.9.5).

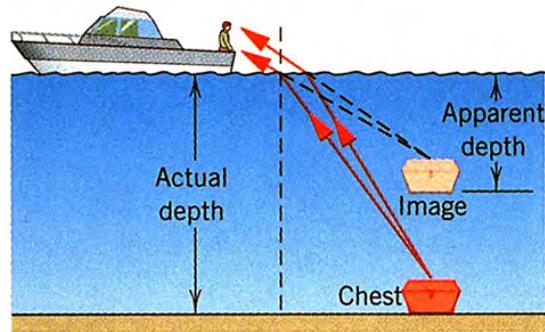


Fig:9.5. It is because of the refraction of light that the chest (box) appears higher in the water than it actually is.

9.5: Critical Angle

When light rays pass from a denser medium (water or glass) to a rare medium (air), they bend away from the normal. The angle of refraction is greater than the angle of incidence. If the angle of incidence is gradually increased, a stage will come when maximum refraction occurs and the angle of refraction becomes 90° (Fig.9.6). Here the refracted ray becomes parallel to the surface of the refracting medium. The angle of incidence for which the angle of refraction is 90° is called the **critical angle**. It is denoted by ‘C’. Critical angle for water is about 49° while for glass is 42° .

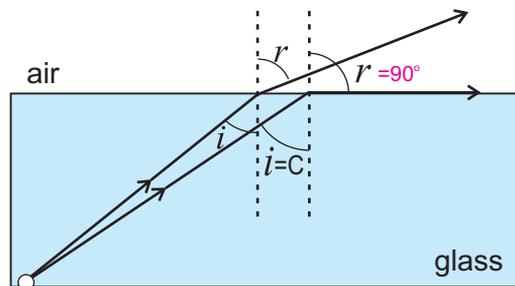


Fig. 9.6: C is the critical angle of glass.

9.6: Total Internal Reflection

When light passes from glass or water into air (denser to rarer medium), it bends away from the normal. But when angle of incidence (\hat{i}) is greater than the critical angle 'C', the light rays reflect back into the same denser medium. This phenomenon is called **total internal reflection** (Fig.9.7).

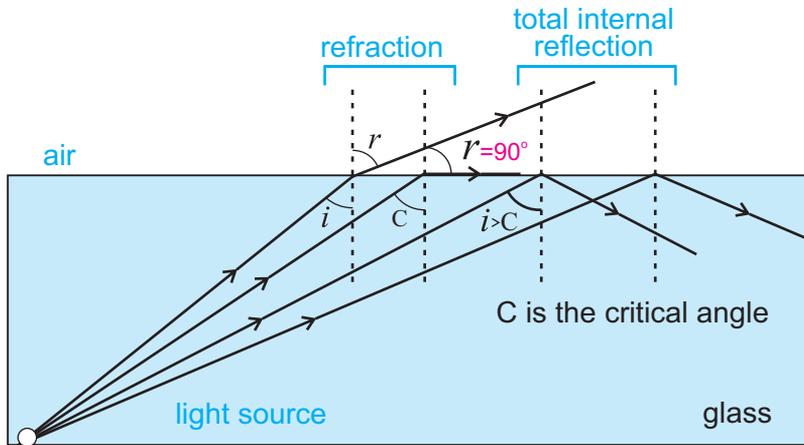


Fig. 9.7: Total internal reflection

Total internal reflection takes place only when:

1. Light passes from a denser medium (water or glass) to a rare medium (air).
2. The angle of incidence of all rays must be greater than the critical angle of that denser medium.

$$\angle i > \angle C$$



Fig. 9.8: The underwater reflection of the turtle is the result of total internal reflection.

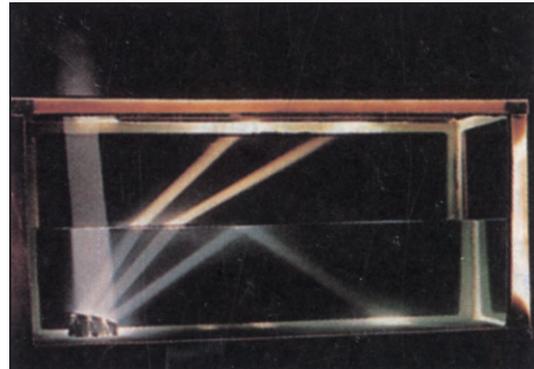


Fig. 9.9: Once the angle of light beam becomes greater than the critical angle, it is totally reflected at the surface of the water.

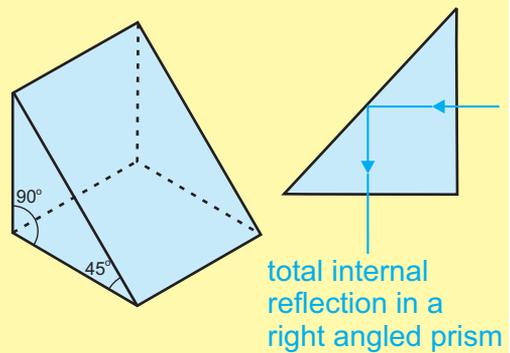
9.7: Applications of Total Internal Reflection

Many optical instruments use the principle of total internal reflection for their working.

Prisms

A **prism** is a block of glass with three rectangular and two triangular surfaces.

A **right angled prism** has one 90° and two 45° angles. The critical angle for glass is about 42° . When light enters the prism, it will undergo total internal reflection.



Binocular

The critical angle for glass is around 42° . When light enters a right-angled prism, it makes an angle greater than the critical angle. It causes total internal reflection to take place. A binocular uses reflecting prisms to see distant objects (Fig.9.10).

Periscope

We can see objects which are higher than our eyes with the help of a periscope. A simple periscope consists of a tube, at the ends of which are fitted two right angled prisms. The first prism turns light coming from the object towards the second. The second prism turns it to our eyes. The prisms use the principle of total internal reflection (Fig.9.11). Periscopes are used in submarines, tanks, etc.

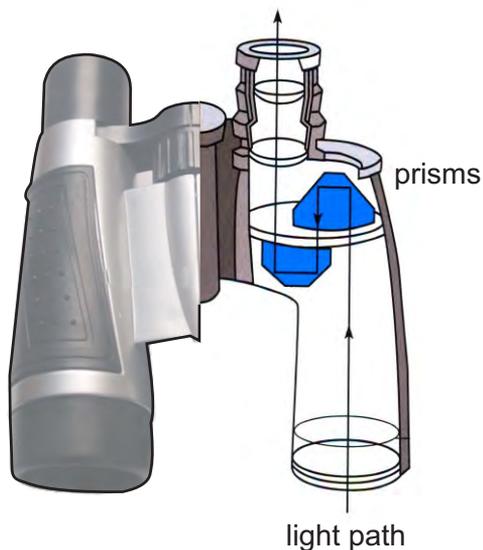


Fig: 9.10: A binocular uses reflecting prisms to see distant objects.

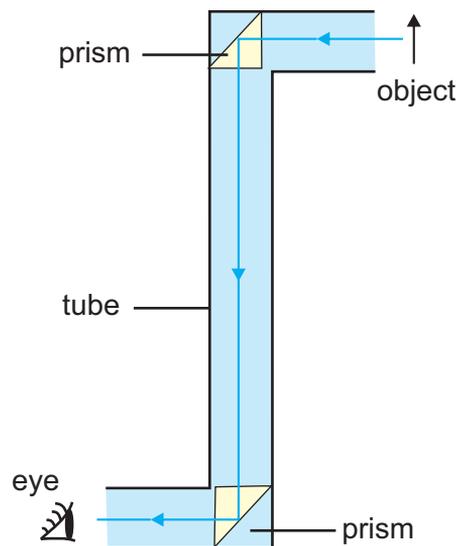


Fig:9.11: Prisms in a periscope help to see objects which are higher than eyes.

Mirages

Have you ever seen water on the road ahead while travelling on a hot, sunny afternoon? But when you get there the road is perfectly dry (Fig.9.12). The water was never there. What you saw was a mirage.

A **Mirage** is an image of some distant object which appears to us due to the refraction and total internal reflection of light.

The air higher up is cooler than the air near the road. Light travels faster when it reaches the warmer air. The light rays bend as they travel downward due to refraction. Near the ground where air is even more warm, the light rays travel almost parallel to the ground but continue to bend in other direction (total internal reflection). When we see these bending light rays, our brain assumes that the rays have travelled in a straight line. These rays seem to us as reflecting from water. As a result, we see a mirage. Desert travelers often observe mirages.



Fig. 9.12: We see a mirage due to the refraction and total internal reflection of light.

Fish Eye View

We have studied that when light travels from one medium into another, its speed changes, which causes the light to refract at the boundary. As light travels from water to air, it will bend away from the perpendicular to the surface. When the angle of incidence is greater than 48 degrees, all the light is reflected back into the water (total internal reflection). When fish looks up, it will see reflected view of the sides and bottom of the pond, while directly above, it sees a compressed view of outside world due to refraction.

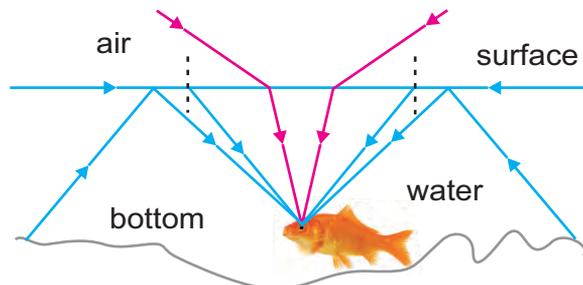


Fig. 9.13: A fish looks at water above as a mirror due to total internal reflection.

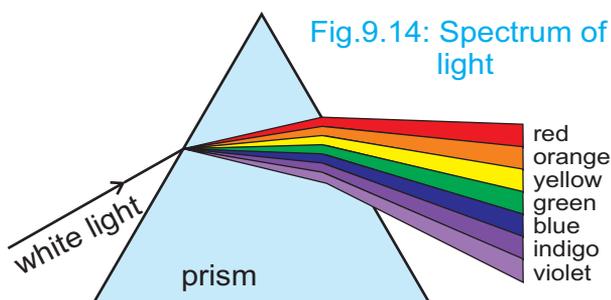
The critical angle of glass is 42° . Total internal reflection makes light transmission over long distances possible in optical fibres. **Optical fibres** are thin transparent glass fibres in which light travels due to total internal reflection. These fibres are commonly used in communication, e.g. in telephone transmissions, TV programs and computers. An optical fibre can carry thousands of phone calls at the same time. Find other uses of optical fibres in medicines and industries.



9.8: Dispersion of Light

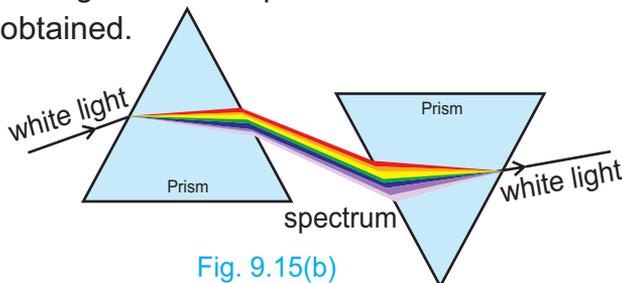
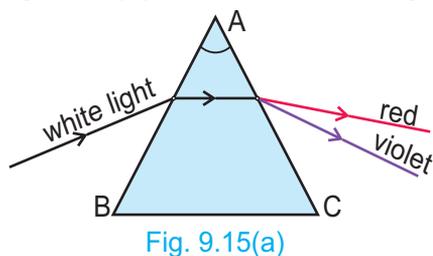
Sunlight is often called white light, although it is a combination of different colours. We can see these colours in a rainbow. These colours are red, orange, yellow, green, blue, indigo and violet.

We can also split white light into its colours by passing it through the prism. The band of seven colours obtained is called **spectrum** of white light. The splitting of white light into its component colours is called **dispersion of light** (Fig.9.14).



9.8.1: Why does White Light get Dispersed?

When a beam of light enters a prism, all the colours of white light refract at different angles— it causes the white light to split into its component colours. Red light bends the least. Violet light bends the most and refracts by the largest angle. In this way, white light disperses into its component colours {Fig.9.15(a)}. When this spectrum is again passed through another prism as shown in the Fig. 9.15(b), a beam of white light is obtained.



Activity 9.3

Obtaining a Spectrum of Colours

You will need: • a prism • a white cardboard

Procedure

Shine a narrow beam of sunlight on one rectangular surface of a prism in such a way that a spectrum of colours forms on a white cardboard screen on the other side of the prism.

Identify the colours of light, seen by you. Which colour is at the top and which one is at the bottom?

Activity 9.4

White light is a combination of seven colours.

You will need: • a cardboard • a string

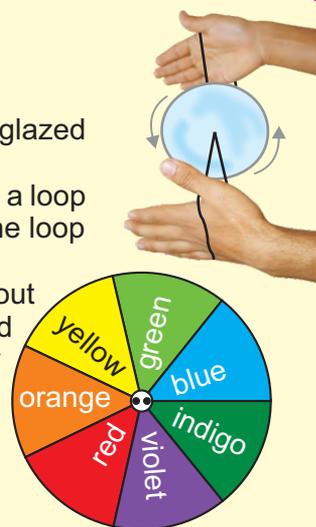
• glazed papers of different colours

Procedure

1. Take a round cardboard. Paste equal-sized pieces of glazed papers of seven colours of light.
2. Make two holes near the centre of the cardboard. Make a loop of a string through these holes. Hold the two ends of the loop into your hands and also twist the string strongly.
3. Let loose the string and stretch your hands in and out alternately. Repeat this again and again. The cardboard will start revolving as shown in figure. Watch carefully the revolving cardboard.

Things to think

- i. Can you still see the different colours on the cardboard?
- ii. Which colour can you see in the revolving cardboard?



Rainbow Formation

A rainbow is a natural demonstration of refraction, dispersion and total internal reflection of light. When white light of the Sun passes through tiny rain drops suspended after rainfall, a rainbow may appear. Raindrops in the air act like tiny prisms. They refract and reflect the sunlight and then separate it into different colours. The colour scheme of rainbow is the same as in the spectrum made by the prism. Since red colour bends the least and violet colour bends the most from its original path, so in the rainbow, the red colour appears at the top and the violet colour appears at the bottom. The other colours appear in between these two colours (Fig.9.16).

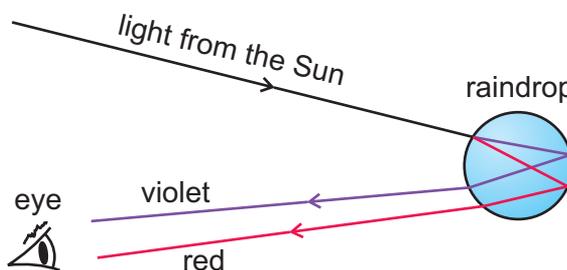


Fig. 9.16: A rainbow forms when sunlight is refracted and totally reflected by tiny water droplets.

Do You Know?

- We can only see a rainbow in front of us when the Sun is shining behind us.
- A rainbow usually shows all the seven colours of white light.



Extend Your Thinking

Why don't we see a rainbow during most rainstorms?

Activity 9.5

Seeing a Rainbow

You will need: • a sunny day • a running hose pipe

Procedure

1. Stand with your back to the Sun.
 2. Spray water from the hose pipe. (Place your thumb over the hole at the end of the hose to get a spraying effect.)
 3. Watch the spray against a dark background (grass or wall).
- Can you see a rainbow in the water droplets of the sprinkling water?
 - What is the order of these colours from bottom to the top?



9.9: Colours of Light

An understanding of colours is very useful in photography and theater lightings. People who work with lights of different colours must know how to produce lights of various colours from a few basic colours. The colours that can be used to make any other colour are called **primary colours**. These are red, blue and green. We can mix the light of three primary colours to produce white light.

Red + Blue + Green = White

When two primary colours mix, they produce a **secondary colour**. Cyan, yellow and magenta are secondary colours. A colour television uses different combinations of colours.

Red + Green = Yellow

Red + Blue = Cyan

Blue + Green = Magenta

We can obtain other colours of light by mixing lights of primary and secondary colours.

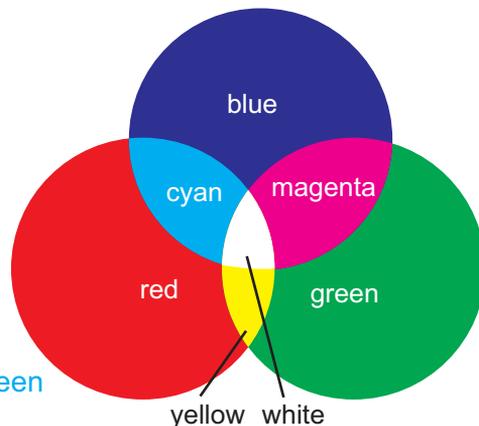


Fig. 9.17: Red, blue and green are primary colours of light.

Activity 9.6

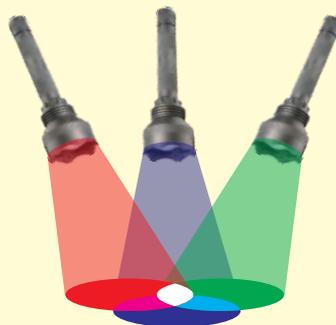
Mixing the Colours of Light

You will need:

- three torches
- red, blue and green cellophane papers

Procedure:

1. Take three torches. Paste a green cellophane paper on the glass of one of the torches, red cellophane filter on the second and a blue cellophane paper on the third torch.
2. Throw lights of different colours on a white screen in such a way that light of one colour falls on the light of the other colour.



Observe mixing of colours and fill the table.

Colours of the light thrown on the screen	Colour which appears on the screen
Red + Blue	
Green + Blue	
Green + Red	
Red + Green + Blue	

9.10: Colours of Objects

When white light shines on non-luminous objects they reflect some colours and absorb all the others. The **colour of an object** is the colour of light it reflects.

A red object appears red because it reflects red colour of light and absorbs all the other colours (Fig. 9.18). The grass of our lawn appears green as it reflects green light into our eyes. Why does a blue car appear blue?

When all the colours of light are reflected into our eyes, the object appears white. And, when all the colours of light are absorbed by the object, it appears black. Black objects do not reflect any light. Objects of colours other than primary colours reflect mixture of colours.



Fig. 9.18: The petals of this rose appear red because they reflect red light. The leaves appear green because they reflect green light.



Extend Your Thinking

What colours are reflected by an object that appears black?

Key Points

- ⦿ When light passes from a transparent medium to another, it changes speed and bends. This bending of light is called refraction.
- ⦿ Refraction causes images to form in our eyes.
- ⦿ When light passes through a prism, it refracts and bends at an angle. A prism can split white light into its component colours.
- ⦿ Red, orange, yellow, green, blue, indigo and violet are the component colours of white light.
- ⦿ The band of seven colours of light is called the spectrum of light.
- ⦿ A rainbow disc has all the seven colours of light. When it is spinned, white disc is seen.
- ⦿ Red, blue and green are three primary colours of light. Primary colours combine to make secondary colours of light.
- ⦿ The colour of an object is the colour of light it reflects. A red flower reflects red colour and appears red. A white surface reflects all the colours of light and appears white. A black surface reflects no colour.

Questions

1. Complete each of the following sentences by writing the correct term.

- i. They can carry thousands of phone conversations at the same time _____
- ii. The bending of light, when it enters from one medium to another _____
- iii. The angle of incidence at which maximum refraction occurs _____
- iv. The ratio of the speed of light in vacuum to its speed in another medium _____
- v. The splitting of white light into its component colours _____

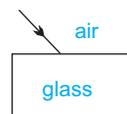
2. Encircle the correct answers in the following.

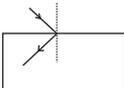
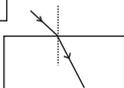
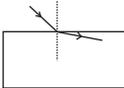
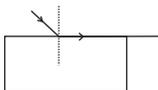
- i. When a light ray passes from one medium to another at an angle:

(a) reflection occurs	(b) refraction occurs
(c) refraction does not occur	(d) reflection does not occur
- ii. Which of the following objects does not refract light?

(a) a microscope	(b) a magnifier
(c) a camera	(d) a mirror
- iii. The splitting of white light into its component colours is called:

(a) dispersion of light	(b) reflection of light
(c) total internal reflection	(d) mirage
- iv. A ray of light strikes at an angle on one side of a rectangular glass block. Which diagram shows the right path of the light ray?



- | | |
|---|--|
| <p>(a) </p> <p>(c) </p> | <p>(b) </p> <p>(d) </p> |
|---|--|

- v. We see a mirage due to the:
- (a) reflection of light (b) total internal reflection
 (c) dispersion of light (d) refraction of light
- vi. A coin in the bowl becomes visible when water is added. It is because of:
- (a) reflection of light (b) refraction of light
 (c) total internal reflection (d) dispersion of light

3. Give short answers.

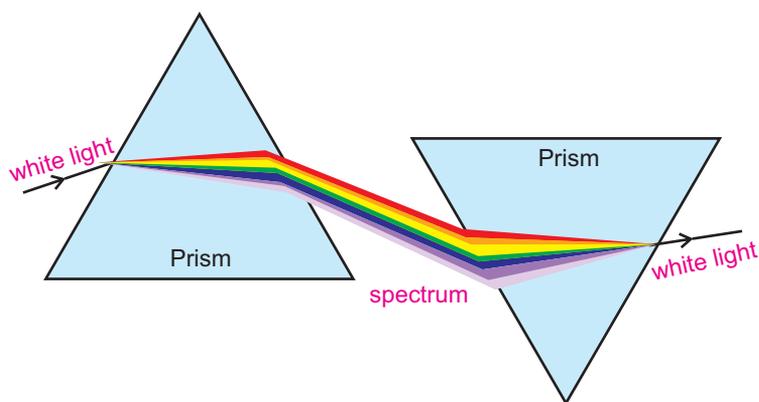
- i. What happens, when light travels from glass into air at an angle?
 ii. What is refractive index?
 iii. How can you calculate the refractive index of water?
 iv. What happens when the primary colours of light are mixed in equal proportions?
 v. Why do we see colours of different objects?
 vi. Define critical angle.
 vii. State the laws of refraction.

4. Define refraction of light. Discuss the effects of refraction with examples.

5. Define total internal reflection. Explain the phenomenon of mirage.

6. What is dispersion of light? Why does white light get dispersed?

7. Explain the phenomenon in the following diagram.



Computer Links	<p>For more information visit:</p> <ul style="list-style-type: none"> • www.school-for-champion.com/science/light_dispersion.html • http://www.slideshare.net/Sciencetutors/light-dispersion-spectrumrefraction-reflection-presentation
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Sound Waves

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain the wavelength, frequency and amplitude of sound waves and give their units.
- ▶ state factors on which sound depends.
- ▶ investigate objects in home and surroundings that are designed and made to produce different sounds.
- ▶ compare audible frequency range of humans and different animals.
- ▶ design a musical instrument to explain the relation between its sound and shape.
- ▶ identify the application of different sounds in daily life.



Water waves are one kind of wave. Other examples of waves are sound, light, radio and microwaves.

When we throw a stone in a pool of water, waves are produced in water (Fig.10.1). A **wave** is a disturbance that transfers energy from one place to the other. Waves can be produced in liquids, gases and solids. Many waves require some material to travel through. This material thing is called a medium. Gases (air), liquids (water), and solids(rope or a metal) all act as mediums.

What Causes Waves?

Hold one end of a rope and move it up and down, you will produce waves in it. We see that vibrating movements of some substance can create waves. A **vibration** is a repeated to-and-fro or up-and-down motion of some substance.



Fig. 10.1: Waves in a pool of water



Fig. 10.2: We can create waves in water by dipping our finger again and again.

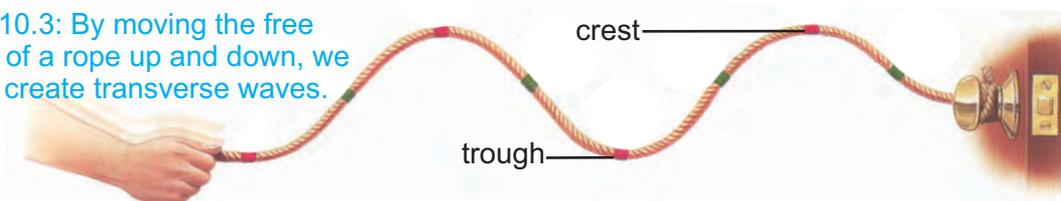
10.1: Transverse and Longitudinal Waves

There are two types of waves, i.e. transverse waves and longitudinal waves.

10.1.1: Transverse Waves

A wave in which particles of the medium move up and down perpendicularly to the direction of the wave is called a **transverse wave**. Waves that are produced in water are transverse waves. Observe transverse waves produced by the up and down movement of a rope in Fig.10.3. The highest point of a transverse wave is called a **crest**, and the lowest point between two crests is called **trough**.

Fig.10.3: By moving the free end of a rope up and down, we can create transverse waves.



Extend Your Thinking

Suppose a wave moves from one side of a lake to the other. Does the water move across the lake? Explain.

10.1.2: Longitudinal Waves

A wave in which particles of a medium move back and forth, parallel to the direction of the wave is called a **longitudinal** wave. Take a slinky spring as shown in Fig.10.4. If we pull and push one end of the slinky spring continuously, we can produce a longitudinal wave (Fig.10.4).

The parts of a longitudinal wave, where particles of the medium are compressed together, are called **compressions**. The parts of a longitudinal wave, where particles of the medium are spread out, are called **rarefactions**. As the wave moves, compressions and rarefactions are produced due to the back and forth motion of particles of the medium. Sound from a vibrating body produces longitudinal waves in air. These waves reach our ear and affect the ear drum.

One Complete Wave

A compression and a rarefaction is combined to form a longitudinal wave. What about a transverse wave?

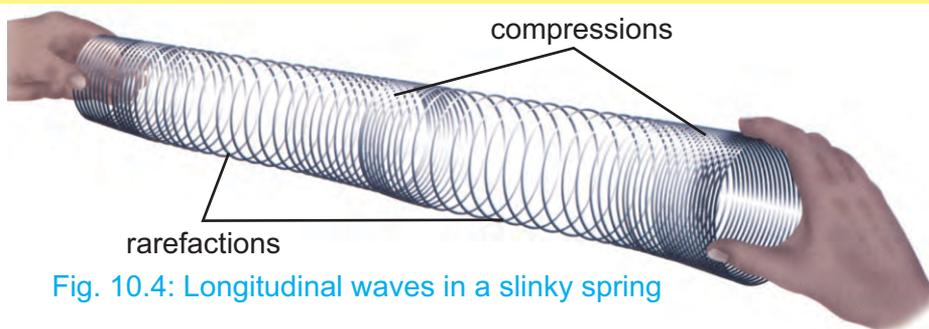
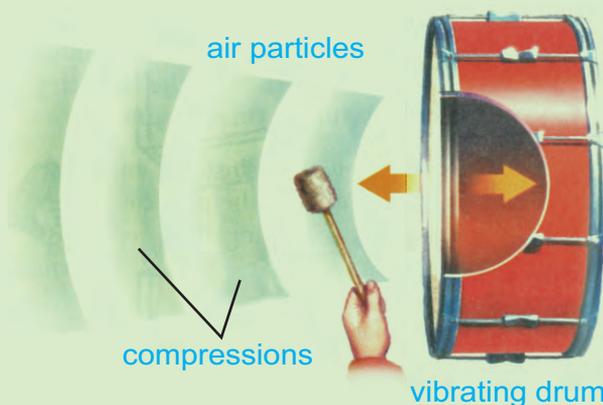


Fig. 10.4: Longitudinal waves in a slinky spring

Sound waves are longitudinal waves.

A sound wave traveling through air is an example of a longitudinal wave. When a drummer beats a drum, the surface of the drum vibrates and creates a disturbance in the air beside it.

When the drumhead moves to the left, it compresses the particles of air and creates a compression. When the drumhead moves to the right, the particles of the air on the right move farther apart, creating a rarefaction. These compressions and rarefactions travel through the air as longitudinal waves. When the disturbance in the air reaches our ears, we hear the sound of the drum.



10.2: Wavelength, Speed, Amplitude and Frequency

The basic terms to understand waves are amplitude, wavelength, frequency and speed.

Wavelength

A **wavelength** is the shortest distance between two adjacent crests or troughs of a transverse wave. For longitudinal waves, it is the distance between two adjacent compressions or rarefactions (Fig.10.5). Wavelength is measured in metres (m).

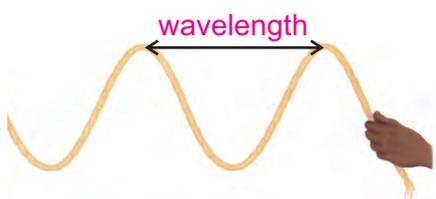


Fig. 10.5: Distance between two adjacent crests or compressions is the wavelength.

Amplitude

Amplitude of a wave is the maximum distance of the particles of the medium from the rest position. We can also say that it is the height of a crest or depth of a trough (transverse wave) measured from the rest position (Fig.10.6). Amplitude is measured in metres (m).

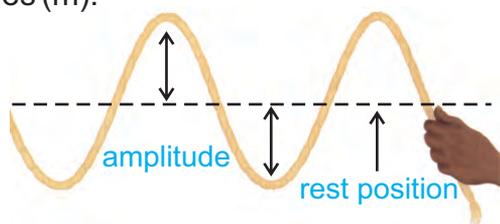


Fig. 10.6: Amplitude of a transverse wave

Frequency

The number of vibrations produced by a vibrating body in one second is called **frequency** (Fig.10.7). Frequency is measured in units called hertz (Hz). When one wave passes through a point in one second the frequency is 1 wave per second or 1 hertz.

$$\text{Frequency} = \frac{\text{no. of waves}}{\text{time (in seconds)}}$$

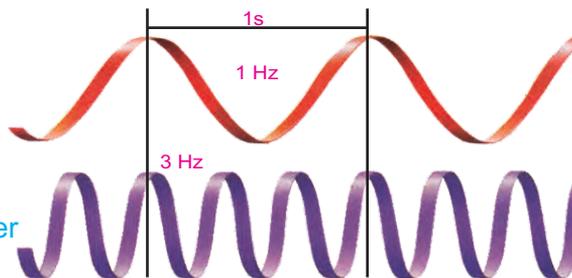


Fig. 10.7: The wave on the bottom has a frequency three times greater than the wave on the top.

Speed

Imagine watching a flash of lightning and thundering of cloud. First we see the flash of lightning. A few seconds later we hear thunder. This happens because sound and light travel at different speeds. Light travels much faster than sound. Different waves travel at different speeds. The distance a wave covers in unit time is called its **speed**. Speed is measured in metre per second. Sound travels at different speeds in different mediums.



Fig.10.8. Thunder is always heard after we see lightning. It shows that light travels much faster than sound.

Table: 10.1: Speed of Sound in Different Mediums

Medium	State of matter	Speed (m/sec)
air	gas	330
water	liquid	1,500
brick	solid	3,600
wood	solid	3,800
steel	solid	6,000

Extend Your Thinking
When sound waves travel from air to water what will happen to the speed at which they are moving?

10.2.1: Relationship of Speed, Wavelength and Frequency

The speed, wavelength and frequency of a wave are related to each other by a mathematical formula.

$$\text{Speed} = \text{wavelength} \times \text{frequency}$$

We can calculate any one of the three values if we know the other two.

Science, Technology and Society



Jet-powered car

On October 14, 1947, Captain Chuck Yeager of USA became the first person to fly a plane faster than the speed of sound. Fifty years later on October 15, 1997, Andy Green drove his jet-powered car at 339 meters per second. His speed was faster than the speed of sound.

10.3: Audible Frequency Range

The word audible means 'able to be heard'. Our ears cannot hear sounds of all frequencies. The range of frequencies which a person can hear is known as **audible frequency range**.

A healthy human ear can hear sounds of frequencies from about 20 Hz to 20,000 Hz. It is the audible frequency range for humans. Different animals have different audible frequency ranges.



Fig.10.9. The audible frequency range reduces in most old people.

Table 10.2: Audible Frequency Ranges of Different Animals

Animals	Frequency range(Hz)	Animals	Frequency range(Hz)
dog	20 — 45,000	dolphin	150 — 150,000
cat	45 — 64,000	rat	200 — 76,000
cow	23 — 35,000	bat	2,000 — 110,000
horse	55 — 33,500	elephant	1 — 20,000

Extend Your Thinking



When a little boy blows a dog whistle, his dog comes, even though the boy can't hear the whistle. Explain why the boy can't hear the whistle, but his dog can.

10.4: Pitch and Loudness

Everyday, we hear a great variety of sounds. We enjoy some sounds. Some sounds are undesirable. Sounds produced by radio, television and musical instruments are pleasant. Sounds produced by machines, traffic on a road, etc. are undesirable. How can we distinguish between the sounds? Pitch and loudness are the characteristics that help us to decide whether a sound is pleasant or not.

Pitch

The voice of a girl is more shrill than the voice of a boy. This difference is due to the pitch. A shrill sound is called a high pitch sound, whereas a less shrill sound is called a low pitch sound. **Pitch** is the shrillness or graveness of a sound. Pitch

of the sound depends on the frequency of the sound wave. The higher the frequency, the higher the pitch is.

Activity 10.1 Frequency and Pitch

- Rotate the wheel of your bicycle as shown in the figure.
- Touch a piece of cardboard to the spokes of the rotating wheel and listen to the sound produced.
- Now increase the speed of rotating wheel and again listen to the sound produced.

We observe that on increasing the speed of the wheel, the sound becomes more shrill due to increase in its frequency. In other words we can say that the **pitch** of the sound has increased.



Activity 10.2 Making High and Low Pitched Sounds

You will need: • 5 empty glasses • metal spoon • water

Procedure

1. Put different amounts of water in each glass.
2. Carefully tap each glass with the spoon. Observe what you hear.
3. Arrange the glasses from the lowest to the highest sound.

Questions

- i. Which glass has the lowest pitch?
- ii. Which glass has the highest pitch?



Loudness

Sometimes, we need to shout in a louder voice. We have to use an extra energy. **Loudness** is related to the amplitude of a sound. The larger the amplitude, the louder the sound. Loudness helps us to distinguish a soft sound from a loud sound of the same frequency.

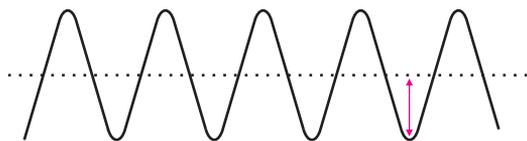


Fig.10.10: Waves of a loud sound have large amplitudes.



Fig.10.11: Waves of a soft sound have small amplitudes.

Making Sounds

It is not difficult to make sounds but it is sometimes difficult to see what is happening when sounds are made.

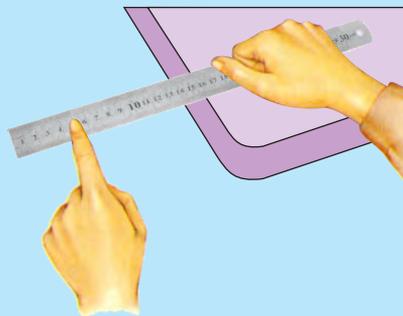
Spoon Sounds

Hit a spoon on the edge of an empty bowl, listen to the sound produced. Try it on different objects.



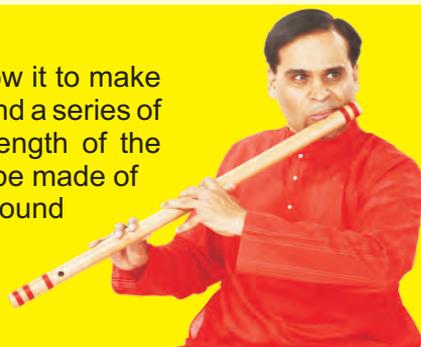
Ruler Sounds

Hold one end of a steel ruler on the edge of a table. Push down the other edge of the ruler. Let it go and try to hear sound.



Wind Instrument — Flute

A flute is a wind instrument. The flautist has to blow it to make music. Flutes are hollow tubes with a mouthpiece and a series of holes. The holes can be closed to control the length of the vibrating column of air inside the tube. A flute can be made of wood, metal and plastic. The flautist changes the sound by opening and closing the holes in the flute.



Activity 10.3

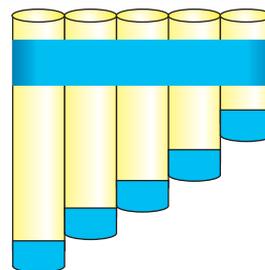
Making High and Low Sounds

You will need

- 2 feet of $\frac{1}{2}$ -inch PVC sprinkler water pipe
- 5 coins of the size of the diameter of the pipe
- 2-inch wide tape

Procedure

1. Cut the PVC pipe into five sections of different lengths.
2. Place a coin over one end of each pipe and cover each coin with the tape.
3. Wrap the tape around the set of pipes as shown in the figure.
4. Blow across the top of each pipe — it is just blowing on a soda bottle.



Questions

- i. What happens to the sound as you go from longest pipe to the shortest pipe?
- ii. Which pipe makes the lowest pitch of sound?
- iii. Which pipe makes the highest pitch of sound?

10.5: Applications of Different Sounds

Sounds are very important in our lives. We use many devices which produce different sounds.



Doorbell

Sound of a doorbell indicates that someone is at the door.



Telephone

Sound of a telephone attracts our attention to attend to the person on line.



Security System Alarm

Some buildings are fitted with security system alarm. The alarm produces sound to alert people to the danger.



Siren

A siren warns us about danger.



Radio

We listen to music, news, etc. on a radio.

Smoke detector

A smoke detector produces alarming beeps on detecting smoke of fire.



Stereo Player

Listen to your favourite singer using a stereo player.



Extend Your Thinking

Sound waves need a material medium to travel. In a science fiction movie, a nearby spaceship explodes. You hear the explosion. Is this realistic?

Science, Technology and Society



Sound waves with frequencies above the normal human range (20,000Hz) of hearing are called **ultrasound**. The sound waves which have frequencies below 20Hz are called **infrasound**.

- Doctors use ultrasound to examine a patient internally.
- Manufacturers of concrete slabs use ultrasound waves to check the cracks or cavities in concrete slabs.

Key Points

- ⦿ In transverse waves particles of the medium vibrate at right angle to the path of the wave. In a longitudinal wave, particles of the medium vibrate back and forth, parallel to the path of the wave.
- ⦿ Sound waves are longitudinal waves.
- ⦿ Wavelength of a sound wave is the distance between two adjacent compressions or rarefactions. It is measured in metres (m).
- ⦿ Frequency is the number of vibrations produced by a vibrating body in one second. It is measured in hertz (Hz).
- ⦿ Amplitude of a wave is the maximum distance the wave vibrates from its rest position. It is also measured in metres (m).
- ⦿ Pitch and loudness are the characteristics on which sound depends.
- ⦿ A healthy human ear can hear sounds of frequencies from about 20Hz to 20,000Hz. Different animals have different audible frequency ranges.
- ⦿ We use doorbells, sirens, telephones, alarms, stereo players, etc. that produce different sounds.

Questions

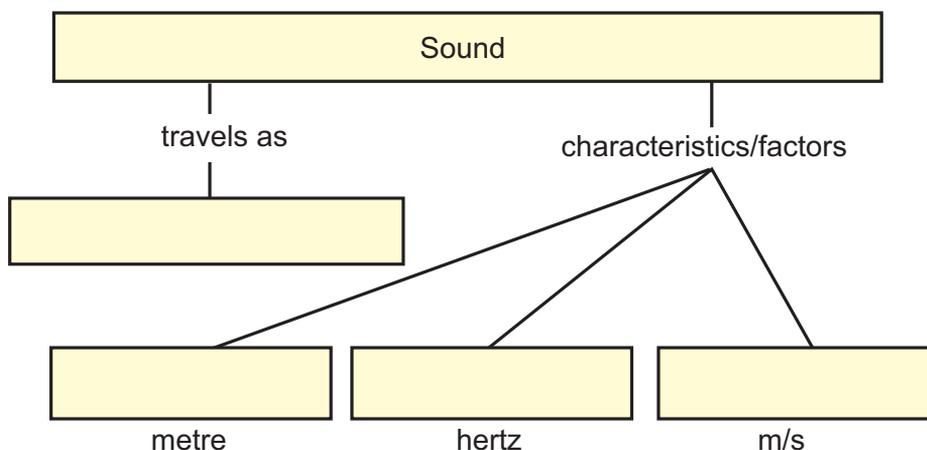
1. Complete each of the following sentences by writing the correct term.

- i. The lower portion of a transverse wave _____
- ii. The shrillness or graveness of a sound _____
- iii. The distance a wave covers in one second _____
- iv. A compression and a rarefaction combine to form _____
- v. A material thing through which a wave travels _____

2. Encircle the correct answers in the following.

- i. When a wave travels through a medium:
 - (a) particles are transferred from one place to the other
 - (b) energy is transferred from one place to the other
 - (c) particles and energy both are transferred from one place to the other
 - (d) nothing happens
- ii. The speed of sound in air is:
 - (a) greater than that of light
 - (b) 100 kilometres per hour
 - (c) 100 metres per hour
 - (d) 330 metres per second
- iii. A sound wave is a:
 - (a) transverse wave
 - (b) longitudinal wave
 - (c) standing wave
 - (d) sometimes transverse and sometimes longitudinal
- iv. Objects that vibrate slowly have a pitch that is:
 - (a) high
 - (b) loud
 - (c) soft
 - (d) low

- v. Sound waves travel more quickly through:
 (a) solids (b) gases
 (c) space (d) liquids
3. **Give short answers.**
- i. Sketch a transverse wave and label a crest, a trough, a wavelength, and amplitude.
- ii. Define the wavelength of a longitudinal wave.
- iii. Name a few devices that use different sounds in our everyday life.
- iv. What makes some sounds louder than others?
- v. What is the relationship between frequency and pitch?
- vi. How does sound travel?
4. **Compare transverse waves and longitudinal waves.**
5. **What type of waves are sound waves, and how do they transfer sound energy?**
6. **Describe loudness and pitch of the sound.**
7. **Write brief notes on:**
 (a) Audible frequency range (b) Speed of sound
8. **Complete the concept map given below.**



Computer Links

For more information visit:

- www.bowlesphysics.com/image/AP_Physics_B_waves_and_sound.pdf
- www.fi-edu/fellows/fellow2/apr99/soundvib.html

Circuits and Electric Current

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ define current.
- ▶ make parallel and series circuits.
- ▶ investigate about types of circuits used for different purposes.
- ▶ identify a disadvantage of a series circuit.
- ▶ differentiate between current and energy.
- ▶ explain the effects of electric current in daily use appliances.
- ▶ describe voltage.
- ▶ explain the resistance as an opposition to the flow of current.
- ▶ describe the relationship between voltage and resistance.
- ▶ measure current by using different devices.
- ▶ list the major uses of electricity in homes.
- ▶ list electrical hazards and precautionary measures to ensure the safe use of electricity at home.
- ▶ describe why electricity is dangerous to humans.



You are familiar with electricity as many appliances/devices operate on it.

We have learnt in class VI that electricity supplies energy. Electricity can produce light, heat, sound, etc. Electrical energy can help make our lives easier. There are two kinds of electricity.

i. static electricity **ii. electric current**

We have learnt about static electricity in the previous classes. Here we shall discuss electric current, its effects and measurement.

11.1: Flow of Current (Direction)

The flow of charges through a conductor is called **electric current**. Charges travel from one pole to the other pole of an electrical source (battery) as shown in the Fig. 11.1.

It has been proved that only negatively charged electrons move from one place to the other. Positively charged protons do not move. In early days, before the discovery of electrons, scientists guessed wrongly that electric current was the flow of positive charges from the positive pole of the battery to the negative pole. Scientists still adopt this idea and they have called it as **conventional current**.

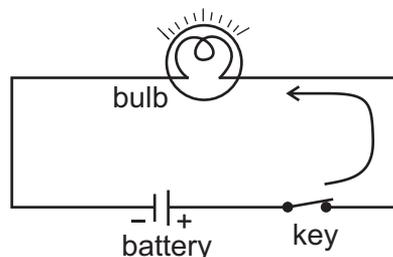


Fig. 11.1: Electric current flows from one pole to the other of an electrical source.

The unit for electric current is **ampere (A)**. Other smaller units are milliampere (mA) and micro ampere (μA). Electric current is measured by an **ammeter**.

An **electric circuit** is a complete path along which charges flow. A key (switch) can open or close a circuit. Electric current only flows through a closed circuit.



Fig. 11.2: These and many other appliances in our homes use electric current.

Conductors and Insulators

The materials which allow electric current to pass through them are called **conductors**. Metals, such as copper, silver, iron and aluminium are good conductors.

The materials which do not conduct electricity are called **insulators**. Rubber, glass, sand, plastic and wood are insulators.



11.2: Types of Electric Circuits

There are several kinds of circuits. But here we shall discuss its two main types, i.e. **series circuits** and **parallel circuits**.

Series Circuits

If all the components are connected one after another in a single loop, then it is a series circuit. In a **series circuit**, there is only one path for the current to flow (Fig. 11.3). The amount of current which flows through each component (bulb) of the circuit is the same.

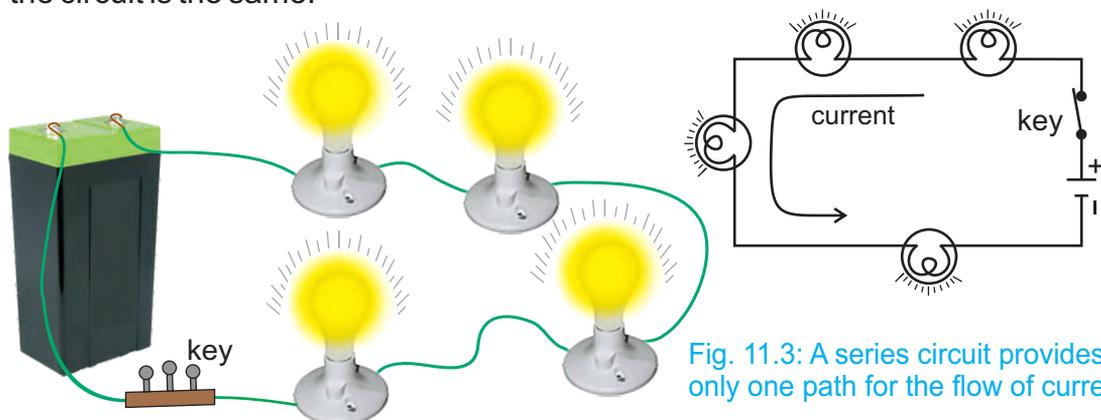


Fig. 11.3: A series circuit provides only one path for the flow of current.

Disadvantage of the Series Circuits

There is a disadvantage of the series circuit:

- There is only one path for the current to flow. A break at any part of the circuit stops the flow of current in the whole circuit.

Activity 11.1

Making a Series Circuit

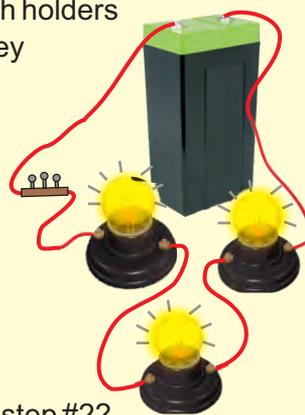
You will need: • a battery • three 1.5 volt bulbs with holders
• 1 burned-out bulb • connecting wires • key

Procedure

1. Connect a battery, a key and two 1.5V bulbs in a series circuit. Draw a picture of your circuit in your notebook.
2. Switch off the key. Add another bulb in the series with the other two bulbs. Switch on the key.
3. Replace one of the light bulbs with a burned-out light bulb.

Things to think

- i. How does the brightness of the light bulbs change in step #2?
- ii. What happens to the other lights in the circuit in step #3?



Parallel Circuits

If the components are connected in two or more loops, then it is a parallel circuit. In a **parallel circuit**, there are more than one paths for the current to flow (Fig. 11.4). The current flowing through different branches of a parallel circuit may be the same or different. But the current in each branch is less than the total current flowing out from the electrical source (battery).

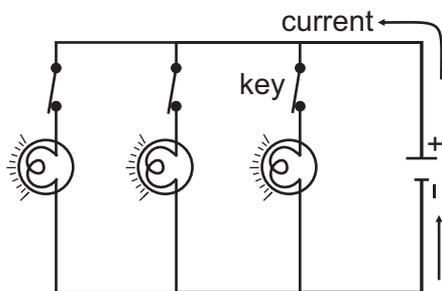
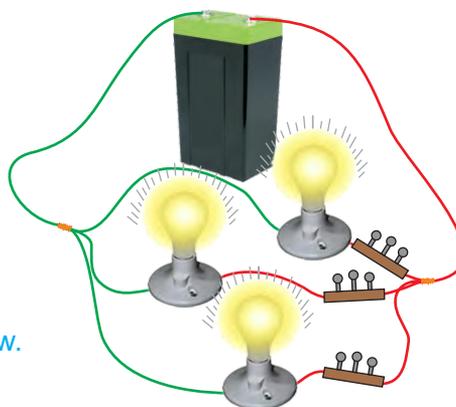


Fig. 11.4: In a parallel circuit, there are more than one path for the current to flow.



Advantage of a Parallel Circuit Over a Series Circuit

A parallel circuit has an advantage over a series circuit.

- There are more than one path for the current to flow. A break in any branch of the circuit stops the current flowing through that branch only.



Extend Your Thinking

Why electrical wiring in our houses is parallel rather than in series circuits?

Activity 11.2

Making a Parallel Circuit

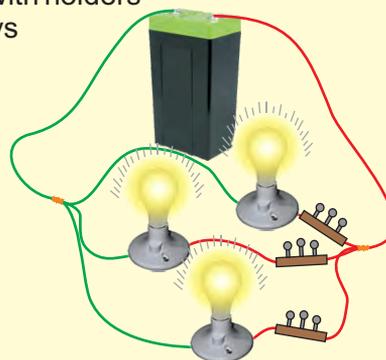
You will need: • a battery • three 1.5 volt bulbs with holders
• 1 burned-out bulb • connecting wires • 3 keys

Procedure

1. Connect a battery, keys and two 1.5V bulbs in a parallel circuit. Draw a picture of your circuit in your science notebook.
2. Switch off the keys. Add another bulb and key in parallel with the other two bulbs. Switch on the keys.
3. Replace one of the light bulbs with a burned-out light bulb.

Things to think

- i. How does the brightness of the light bulbs change in step #2?
- ii. What happens to the other lights in the circuit in step #3?



Tidbit

- The lights of this ship are connected in a parallel circuit. If one light goes out, the rest keep glowing.



11.3: Energy Transfer in an Electrical Circuit

Electricity brings energy to our homes from a power station (Fig.11.5). The energy of moving electric charges within a circuit is called electrical energy. As charges flow in a circuit, some electrical energy always changes to heat energy.

A light bulb transforms electrical energy to light energy. Electric bells and stereo players transform electrical energy to sound energy. A heater gives us heat by using electrical energy. A fan converts electrical energy into mechanical energy (Fig.11.6).



Fig. 11.6: A fan uses electrical energy to work.



Fig. 11.5: Electrical energy comes from a power station through electric cables.

11.3.1: How Do Charges Flow?

The flow of electrons through a conductor (wire) can be compared to the flow of water in a pipe. Connect two cans of water, one on the floor and other on the table (Fig. 11.7). The water flows from higher level to the lower level. The potential energy of water in the can at a higher level causes the water to flow. Similarly, current flows from higher electric potential to lower electric potential.

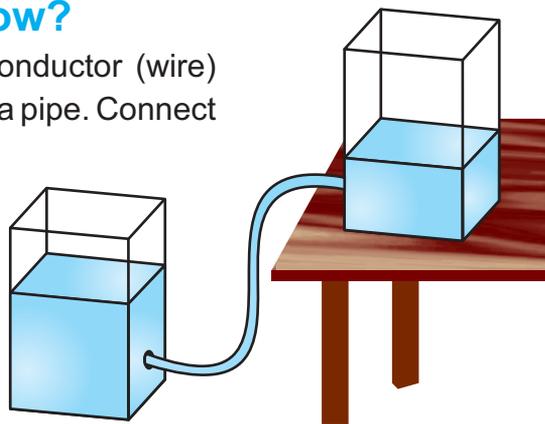


Fig. 11.7: The flow of current in a wire can be compared to the flow of water in a pipe.

The difference of potential between two points in a circuit or battery is called **potential difference** or **voltage**. Potential difference causes the charges to move through the conductor. Potential difference is measured in **volts** (V). Charges will flow as long as there is a potential difference between the two points. Every battery has its potential difference printed on it. For example, a dry cell carries 1.5V. Other units of volt are millivolts (mV) and kilovolts (kV). A **voltmeter** is used to measure potential difference.

11.3.2: Resistance

Electric current flows through some objects better than others. The measurement of how well something conducts electricity is its resistance.

Resistance is the hindrance to the flow of current. During its journey through an electric circuit, the charges collide countless times with atoms within the conductor (wire). These collisions result in the hindrance to the flow of the current (resistance). The unit of resistance is ohm.

The resistance of a wire depends on **length of the wire** and **thickness of the wire**.

Recall the flow of water in a pipe! A long pipe resists the flow of water more than a short pipe and a thin pipe resists the flow of water more than a wide pipe. Long wires have more resistance than short wires. Thin wires have more resistance than thick wires.



Fig.11.8: Water flows more easily through a short, wide pipe than through a long, narrow pipe. Similarly, electrons flow more easily through short and thick wires.



Extend Your Thinking

How is pressure of water created in a service station?

11.3.3: Relationship between Voltage and Resistance

A mathematical equation shows the relationship between voltage and resistance.

$$\text{Resistance} = \frac{\text{voltage}}{\text{current}}$$

The above equation shows that resistance is equal to the voltage divided by the current. It is called **Ohm's Law**.

In 1827, a German scientist George Simon Ohm discovered the relationship between the voltage and resistance in an electric circuit.

Tidbit

An electric eel can create a voltage of more than 600V.



Do You Know?

When electric current flows through the tungsten filament of a bulb, the resistance makes the filament very hot. It is because of the high resistance of tungsten filament that it glows.



11.4: Measuring Current, Voltage and Resistance

Following meters are used to measure current, voltage and resistance of an electric circuit:

An **ammeter** is the device to measure the amount of current in an electric circuit (Fig.11.9). It is connected to the circuit in series so that the full current passes through it. An ammeter does not change the amount of the current in a circuit because it has very low resistance.



Fig. 11.10:
Voltmeter

Fig. 11.9:
Ammeter

A **voltmeter** is the device to measure the voltage (potential difference) in a circuit (Fig. 11.10). It is connected in parallel with the circuit. The current does not flow through a voltmeter because it has very high resistance.



Fig.11.11: Multimeter

A **multimeter** can measure resistance, voltage and small currents.

11.4.1: Electrical Power

All electrical devices such as fans, blenders, computers, etc. convert electrical energy into other forms of energy. **Electrical power** is the rate at which a device converts electrical energy into another form of energy. Its unit is watt (W).

Kilowatt-hour (kWh)

Our electricity bill shows the amount of energy we use during one month. It is taken as kilowatt-hour. One kilowatt-hour is 1 unit on the electricity meter.

One **kilowatt-hour (kWh)** is the amount of energy used up when an electrical appliance of 1,000 watt works for 1 hour.



11.5: Effects of an Electric Current

We cannot see the electrical energy flowing in the circuit. But if any of the following three things happen, we say that electricity is flowing.

Heating Effect of Current

When electric current flows through a metal wire, it makes it hot. Light is also produced when a wire becomes very hot. We use many appliances in our homes that convert electric current into heat.



Fig. 11.12: A toaster and an electric iron convert electrical energy into heat.

Chemical Effect of Current

An electric current can chemically affect the materials particularly in molten or solution form. When a current flows through a solution, it can break up the solution into its components. This process is called **electrolysis**. Electricity is also used to coat a metal object with a thin layer of another metal. This process is called **electroplating**. The rims of bicycles are nickel-plated.



Fig. 11.13: Electricity is used to coat this rim with nickel.

Magnetic Effect of Current

An electric current can also produce magnetic effect in a metal wire. A coil of wire around a piece of iron behaves like a bar magnet when an electric current is passed through it. Such magnets are called **electromagnets**. An electromagnet loses its magnetism when the current stops flowing through it. Electromagnets present in the earpieces of your telephone convert electric signals into sound. Electromagnets are also used in electric motors.

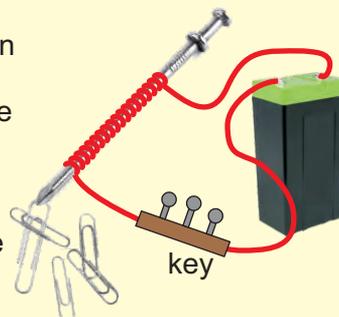
Activity 11.3

How to Make an Electromagnet

You will need: • a battery • an iron nail • insulated wire • paper clips • key

Procedure

1. Wrap the wire around a nail at least 15 turns as shown in the figure.
2. To make the electromagnet, connect the ends of the coiled wire to each end of the battery through key.
3. Try to pick paper clips with your electromagnet.
4. Switch off the key.
5. Can the electromagnet pick up paperclips when the current is off?



11.6: Why is Electricity Dangerous

Electricity is a part of our everyday life, but sometimes it can be dangerous. An electric shock is a lot painful and dangerous. If we follow these safety rules, we would be safe and sound:

- Don't touch an electric wire which has fallen from power lines.
- Never touch electrical appliances with wet hands.
- Don't enter any metal object into electric sockets.
- Don't overload power sockets. Overloaded sockets can cause fire (Fig. 11.14).
- If a person has been electrocuted, don't touch the body of that person. Use a non-metallic object to move the victim away from the electric wire.



Fig. 11.14: An overloaded power socket

Short Circuit

Damaged insulation of wires may cause a short circuit. A large current passes through the wires which causes the wires to overheat quickly. A fire may start as a result of short circuit.



11.7: Electricity and Safety

By taking precautionary measures we can use electricity quite safely.

Fuses

A **fuse** is a piece of thin conducting wire connected in the path of a live wire. It gets heated up and melts on passing of a very large amount of current. Fuses are used to protect houses against short circuits and overloading.

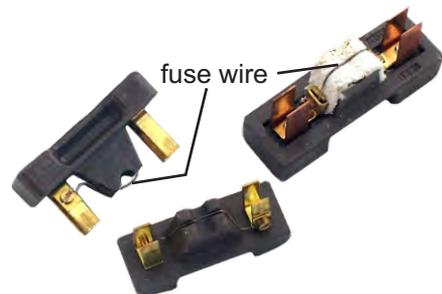


Fig. 11.15: Fuses

MCBs (Miniature Circuit Breakers)

Replacing the fuse again and again is not a pleasant experience. So, engineers have

developed the alternatives of fuses, i.e. miniature circuit breakers (MCBs) (Fig.11.16). An **MCB** is a small electromagnet switch that works like a fuse but it does not blow out. It just breaks the circuit by tripping when a current more than its rating passes through it.



Fig. 11.16: MCBs

Earth Wires

Additional Earth wires protect us from electric shocks. If a short circuiting occurs in a device, current will flow directly into the Earth through a low-resistance Earth wire. In this way, a person who touches a faulty device will be protected. An Earth wire is buried in the ground.

Three-pin Plug

In three pin plug, two pins connect the appliance to the main supply while the third pin connects the metal cover of an electric appliance to the Earth wire. In case of short circuiting, this third pin helps in sending the large amount of current into the ground.



Fig. 11.17: Three pin plug

ELCB (Earth Leakage Circuit Breaker)

An earth leakage circuit breaker (ELCB) is a safety device used in electrical installations to prevent a shock.

An ELCB is an electromagnetic switch. It quickly turns off the power when the current flowing through the Earth wire exceeds the limit. If some one tries to use a faulty electric appliance, an ELCB breaks the circuit at once.



Fig. 11.18: ELCB



Extend Your Thinking

Why the third pin of a three-pin plug should not be removed?

Science, Technology and Society

Everyone in Pakistan is facing the widespread electricity load-shedding. People have to pass sleepless nights, and their daily routine is also disturbed. Besides many factors, the habits of consumers are also not good. Suggest some ways to stop the wastage of electricity in our homes.

Key Points

- ⦿ The flow of charges through a conductor is called electric current.
- ⦿ The path along which charges can flow is called an electric circuit.
- ⦿ In a series circuit, all the components are connected one after the other in a single loop. In a parallel circuit, the components are connected in two or more loops.
- ⦿ As there is only one path for the current to flow in a series circuit, a break at any part of the circuit stops the flow of current in the whole circuit
- ⦿ We use many appliances which use heating, chemical and magnetic effects of the electric current.
- ⦿ Voltage is the difference of potential between two points in a circuit or battery.
- ⦿ Resistance is the hindrance to the flow of current. The resistance of a wire depends on length of the wire and thickness of the wire.
- ⦿ An ammeter is used to measure the amount of electric current in an electric circuit.
- ⦿ Electricity is very important for us, but it can also be dangerous. An electric shock can be fatal for a person.
- ⦿ We use fuses, MCBs, Earth wires and ELCB's for the safe use of electricity.

Questions

1. Complete each of the following sentences by writing the correct term.

- i. The circuit provides only one path for the current _____
- ii. One unit on our electricity meter _____
- iii. The unit of potential difference _____
- iv. The unit of electric current _____

2. Encircle the correct answers in the following.

- i. Electric current is the:
(a) flow of atoms (b) flow of protons
(c) flow of electrons (d) flow of neutrons
- ii. The potential difference in a circuit between two points is measured in:
(a) volts (b) amperes
(c) watts (d) coulombs
- iii. Which one is an insulator?
(a) copper (b) glass
(c) iron (d) aluminium
- iv. Resistance of a conductor depends on:
(a) thickness of the wire (b) length of the pipe
(c) voltage of the electrical source (d) speed of the flow of charges
- v. The device to measure potential difference in a circuit is called:
(a) ammeter (b) voltmeter
(c) barometer (d) thermometer

- vi. When there are more than one path for a current to flow, the circuit is called:
(a) series circuit (b) parallel circuit
(c) open circuit (d) closed circuit

3. Give short answers.

- i. What is an electric current?
ii. What causes the current to flow in an electrical circuit?
iii. What are the functions of an ELCB?
iv. Compare fuses and circuit breakers. Which one is easier to use?
v. What is the main difference between a series circuit and a parallel circuit?
vi. How does increasing the potential difference affect the current?

4. Describe series and parallel circuits in detail.

5. Explain heating and chemical effects of the current.

6. Write notes on:

- i. Resistance ii. Electrical Power
iii. MCBs (Miniature Circuit Breakers)

What a Speed!

Japan has made a high speed train. It can reach a speed more than 450 km/h. This train is moved by strong electromagnets instead of wheels. It is called a magnetically levitating train, or maglev train. Some people call it a bullet train.



Computer Links

For more information visit:

- <http://www.physicsclassroom.com/class/circuits/u9l2c.cfm>
- http://groups.physics.northwestern.edu/lab/ec_c.pdf

Investigating the Space

Students' Learning Outcomes

After completing this chapter, the students will be able to:

- ▶ explain the big bang theory of the origin of the universe.
- ▶ evaluate the evidence that supports scientific theories of the origin of the universe.
- ▶ describe a star using properties such as brightness and colour.
- ▶ identify bodies in space that emit and reflect light.
- ▶ suggest safety methods to use when observing the Sun.
- ▶ define the terms star, galaxy, milky way and the black holes.
- ▶ explain the types of galaxies.
- ▶ explain the birth and death of our Sun.
- ▶ identify major constellations visible at night in the sky.
- ▶ describe the formation of black holes.
- ▶ explain the working of a telescope.



This photograph shows only a small portion of billions of stars in the universe.

In a clear night we see thousands of stars and other heavenly bodies twinkling in the sky. In this chapter we shall learn about stars, constellations, galaxies and other astronomical bodies.

12.1: What's Beyond Our Solar System

We know that our solar system is a part of the universe. The universe is immensely vast. According to the space scientists the universe **is expanding**. They also tell that there are more than **200,000,000,000 billion stars** in the universe.

Many questions may arise in our mind as: what is the universe? How did it begin? Let us try to find the answers to these questions about the universe. The universe is all of space and everything in it. Most of the universe is empty space. Our solar system is an extremely small part of the universe. Many theories are given to explain the origin of the universe. These theories are results of human efforts in understanding the nature and origin of the universe.

12.1.1: The Big Bang Theory

According to Islam and other Ibrahimic religions, universe was created by Allah (Almighty). According to the Holy Quran, Allah (Almighty) said **كُنْ** and the universe was created (**فَيَكُونُ**). Scientists have been presenting different theories of creation of the universe from time to time. One of these theories is “**The Big Bang Theory**”. According to this theory:

About 10 to 20 billion years ago, the universe was packed into one giant fireball. Then a tremendous explosion started the expansion of the universe. This extraordinary explosion is known as the **Big Bang**. This explosion hurled matter and energy in all directions (Fig.12.1). After the Big Bang, the universe assumed the form of huge clouds of extremely hot, expanding and contracting gases. With the passage of time, the matter cooled: the force of gravity pulled together the particles of matter to form stars and galaxies.

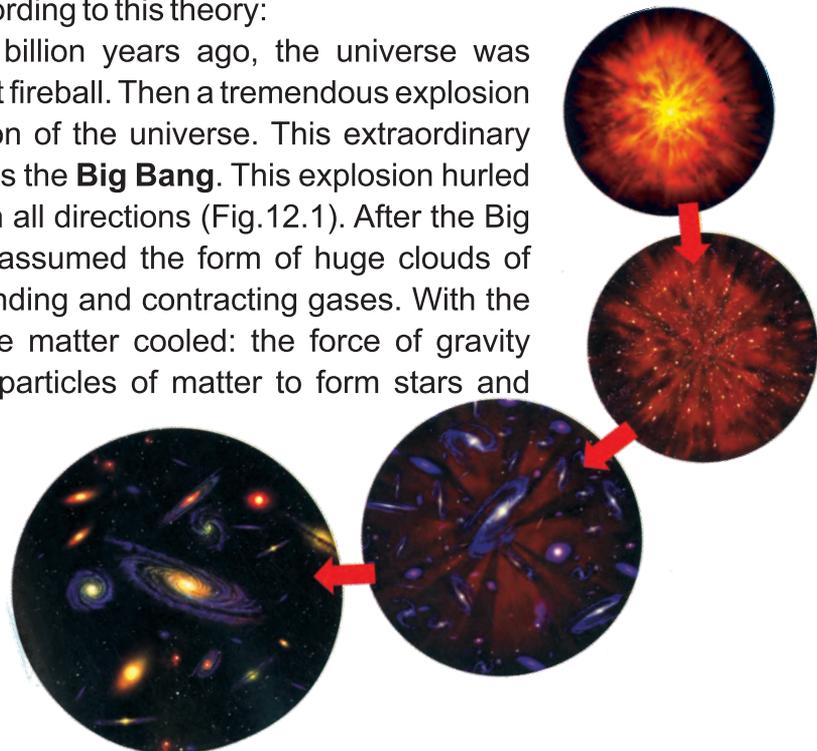


Fig. 12.1: The origin of the universe according to the 'Big Bang Theory'.

The Big Bang theory was first proposed in 1927 by a priest, George Lamaitre of Belgium. This theory was supported by the discoveries of Edwin Hubble and Nobel Prize-winning scientists Arno Penzias and Robert Wilson (Fig. 12.2).

1. Edwin Hubble found experimental evidence to support The Big Bang Theory. He found that distant galaxies in every direction are going away from us with a very high speed. This observation is acceptable if the universe began in a huge explosion.
2. The Big Bang Theory also predicts the existence of cosmic background radiation (the glow left over from the explosion itself). This radiation was discovered in 1964 by Arno Penzias and Robert Wilson. They later won the Nobel Prize for this discovery.

Although the Big Bang Theory is widely accepted, it probably will never be proved. It cannot answer many questions about the occurrence of the Big Bang.

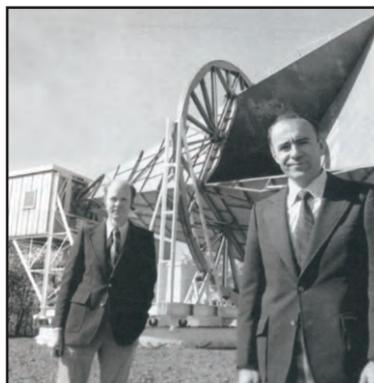


Fig. 12.2: Robert Wilson (left) and Arno Penzias (right) discovered cosmic background radiation in 1964.

Tidbit

The study of the Sun, Moon, stars and other objects in space is **astronomy**. An astronomer studies the space objects.

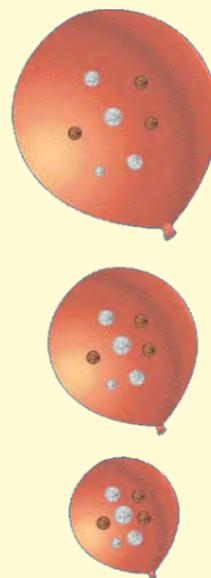
Activity 12.1

Model of an Expanding Universe

1. Cut out small circles from sticky labels. The circles will be the galaxies in your model.
2. Slowly blow up a balloon. Stop as soon as the balloon appears round. Hold the end of the balloon to keep the air from escaping.
3. Have a classmate place the galaxies at various positions on the balloon. The balloon now represents the universe and its galaxies.
4. Blow up the balloon until it is completely inflated. As you do, observe what happens to the galaxies.

Things to think

- i. Do the galaxies get any bigger as the universe expands?
- ii. What relationship can you find between the speed of the galaxies moving apart and their initial distances from one another?



12.2: Stars, Galaxies, Milky Way and Star Distances

On a clear night we can see a cloudy band that stretches North to South across the sky. In fact we are seeing part of our own galaxy, the Milky Way. There are countless stars in our galaxy. We cannot see our galaxy as a whole, but scientists can see many other galaxies in the sky.

12.2.1: Stars

We see many twinkling lights in the night sky. Some of these lights come from objects in space called stars. The Sun is also a star. Beyond the solar system, billions and billions of stars are present in space. Every **star** is a ball of glowing gases which emits energy in the form of heat and light. Astronomers say that our Sun is a medium-sized star. Some stars are much larger and some are smaller than our Sun.

Colours of Stars

We know that stars emit heat and light in different amounts, so stars have different temperatures. The colour of a star is related to its temperature (Fig.12.3). The coolest stars have about 2800°C temperature at their surfaces and appear red. The hottest stars have 28000°C or higher temperatures and look blue. The stars with in-between temperatures have orange, yellow and white colours.

The Sun is a yellow star. It has a temperature of 5,500 to 6000°C at its surface. Stars that are a little colder than the Sun look orange. Stars that are a little hotter than the Sun appear white. See the table 12.1.



Fig. 12.3: Blue stars are hotter than red stars.

Table 12.1: Colour and Temperature of Some Stars

	Name of Star	Colour	Temperature
★	Betelgeuse	red	2,800°C
★	Arcturus	orange	4,100°C
★	Sun	yellow	6,000°C
★	Polaris	yellow	5,800°C
☆	Vega	white	9,700°C
★	Algol	blue	11,700°C
★	Beta	blue	28,000°C



Extend Your Thinking

When viewed from the Earth, a red star and a blue star appear to be equally bright. What could you infer about these two stars?

Brightness of Stars

The brightness of a star depends on two factors:

1. distance of the star from the Earth
2. amount of energy the star emits

Imagine that you are looking at two stars that are exactly the same distance from the Earth. The star which emits greater amount of energy will seem brighter than the other.

Now imagine two stars that emit equal amount of energy. One is near to the Earth and other is very far away from the Earth. Which star will look brighter? The near one or the farther one?



Fig. 12.4: We can estimate how far away each street light is by looking at its apparent brightness. Does this work with stars?

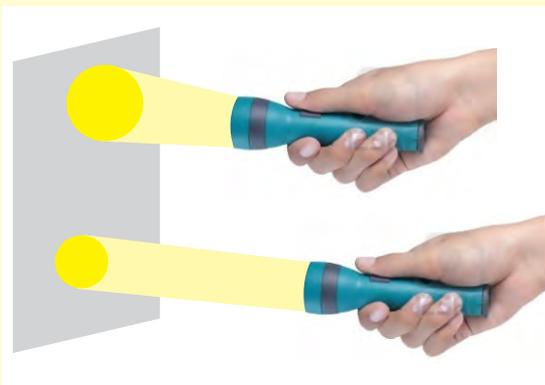
Activity 12.2

Star Light, Star Bright

You will need: ● 2 flashlights of the same size ● transparent tape
● a white chart ● a meter rod ● measuring tape

Procedure

1. Label one flashlight A and another flashlight B.
2. Attach a large sheet of white paper to a wall at about shoulder height. Make the room dark.
3. Ask one student to stand at least 1 metre away from the white chart. Ask this student to shine flashlight A on the paper.
4. Ask the second student to stand at least two metre away from the white chart. Ask this student to shine flashlight B on the same chart, to the right of the light from flashlight A.
5. Ask a third student to use a meter rod to measure the diameters of the central spots of light from flashlight A and flashlight B.
6. Measure the distances of flashlights A and B from the wall with measuring tape. Record your information in your science note book.



Things to think

- i. Which circle is brighter and which is dimmer?
- ii. What can you conclude from this activity about the apparent brightness of stars at different distances from the Earth.

12.2.2: Star Distances

The stars are very far away from us. They are also at great distances from each other. Distances between stars are so great that these cannot be measured in kilometres. Instead, we use light-years to express the distance in the universe.

A **light-year** is a measure of distance that light covers in one year with a speed of 300,000 kilometres per second. It seems that a light-year is a very long distance. The Sun is our closest star in our galaxy. The next closest star Proxima Centauri is 4.2 light-years away from us. We can also say that light of this star will take 4.2 years to reach the Earth.

Do You Know?

There are many stars in the universe whose light does not reach us. They are invisible to us.



Extend Your Thinking

Why is the light-year a useful unit for measuring distance to stars as compared to the kilometres?

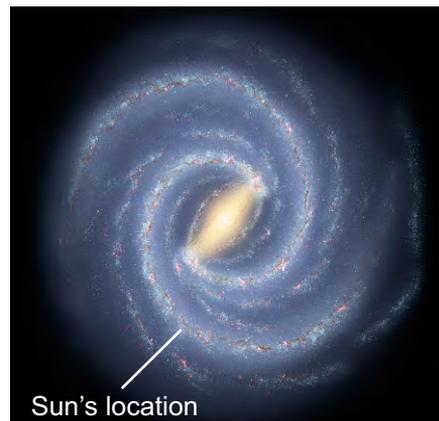
12.2.3: Galaxies

We have learnt that after the Big Bang the universe assumed the form of huge clouds. These clouds of gases and dust formed stars. A **galaxy** is a very large group of stars, nebulae, gases, dust and planets. A galaxy may contain billions of stars. Astronomers have used special instruments to identify about one billion galaxies. Our solar system is the part of the **Milky Way** galaxy.

There are many types of galaxies in the universe. Scientists classify galaxies in three main types on the basis of shape.

Spiral Galaxies

A galaxy that has a flat disklike shape with a bulge in the centre is called a spiral galaxy. Spiral galaxies may have a few or many spiral or curved arms. A large amount of dust and gases is present in these galaxies. The Milky Way and Andromeda are spiral galaxies. The Milky Way galaxy contains 100 to 200 billion stars. The Sun is about 30,000 light-years away from its centre. The Milky Way galaxy is moving with a speed of 2200,000 kilometres per hour in space.



12.5: Milky Way is a spiral galaxy.

Tidbit

Andromeda is about 2,250,000 light-years away from the Milky Way galaxy. It is our neighbouring galaxy.

Elliptical Galaxies

These are oval shaped galaxies (Fig.12.6). These galaxies do not rotate as spiral galaxies around their axis. An elliptical galaxy contains less amounts of dust and gases as compared to a spiral galaxy. Trillions of stars may be present in an elliptical galaxy. New stars cannot form in most elliptical galaxies. Most of them contain only old stars.



Fig. 12.6: An Elliptical Galaxy

Irregular Galaxies

These galaxies have no definite shape (Fig.12.7). The stars in an irregular galaxy do not appear to be grouped in any set shape. These galaxies have many shapes and sizes. The Clouds of Magellan, is an irregular galaxy. It is a very small galaxy near the Milky Way. These galaxies are not very common.



Fig. 12.7: An Irregular Galaxy

Activity 12.3

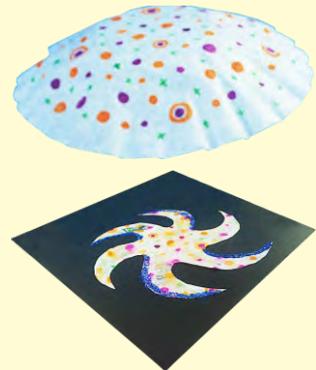
Making a Model of a Spiral Galaxy

You will need

- paper plate
- paper chart
- coloured markers
- water
- straw
- glue stick
- glitters
- construction paper

Procedure

1. Using water-colour markers, draw colourful designs of stars, planets, moons, and comets on the back of the paper plate.
2. Use a straw to dribble a few drops of water on the paper plate. The water will make the colours run together in lovely ways. Let the colours dry.
3. When the colours are dry, cut the paper plate into spiral galaxy shape as shown in the figure.
4. Use a glue stick to add some blue glitter highlights to your galaxy.
5. Glue a piece of construction paper on the back of the plate to make a two-sided border.
6. Paste your spiral galaxy on the paper chart. Display your galaxy.



12.2.4: Constellations

If we look at the sky in a night full of stars, we may see certain patterns of stars. These star patterns are constellations.

A **constellation** is a group of stars with a definite pattern or arrangement. Each constellation has a different pattern. Each constellation is found in a certain place in the sky.

Constellations were very important to people long ago. Those people used the night sky to tell time and seasons. Crop planting, festivals and other events were planned according to the movement of the stars in constellations.

People long ago named the star patterns they saw for objects, animals or famous people. People also made strange stories about constellations. We can observe many constellations in the night sky.

The **Big Dipper** is a famous constellation. There are seven visible stars in the Big Dipper. Four stars make the bowl of the Big Dipper while three stars form the handle. The two bright stars on the end of the Big Dipper's bowl point to the **Pole Star**. This star helps in finding directions (Fig.12.8).



Fig.12.8: Big Dipper

Cassiopeia is a constellation that seems to move around the Pole Star all the year. Cassiopeia is on the opposite side of Pole Star from the Big Dipper and about the same distance away. The five brightest stars in Cassiopeia form the shape of capital letter M or W. People long ago thought this star pattern looked like a queen sitting on her throne (Fig.12.9).



Fig.12.9: Cassiopeia

Leo, the Lion is also a famous constellation seen in the months of March, April and May. Stars in this constellation are arranged in the shape of backward question mark and a triangle. We can also find this constellation with the help of two bright stars in the bowl of the Big Dipper. If we look North, these two stars indicate Pole Star. If we look South, these two stars point to Leo Constellation (Fig.12.10).

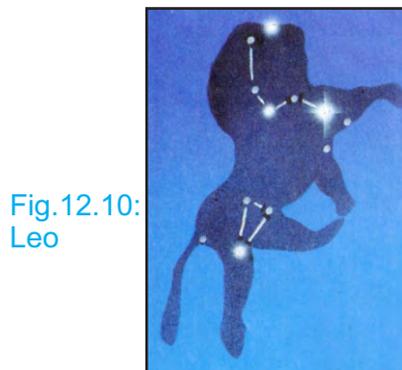


Fig.12.10:
Leo

Activity 12.4

Constellation in a Can

You will need: • a tin can • constellation patterns • nail
• flashlight • permanent marker • scissors • hammer

Procedure

1. Take a tin can. Open its one end.
2. Each student to select one of the constellation patterns. Use a black marker to trace inside the circle on the paper.
3. Put the paper on the close end of the can.
4. Using a nail and hammer, make holes on the close end of the can according to the constellation pattern.
5. Label the can with the name of the constellation using a permanent marker.
6. In a dark room, place your flashlight in the open end of the can and turn it on. The light will shine through the holes creating a constellation on the wall or ceiling. You may rotate the can to have your constellation at different times of the night.

Things to think

- i. How turning the can affects the way the constellations appear ?



12.3: The Life of Stars

Science has told us that the universe is finite, with a beginning, a middle and a future. Stars have life cycles too. A star is also born, changes, and then dies. The lifespan of a star is measured in billions of years.

Birth of a Star

We have studied that great clouds of gasses and dust are present in galaxies. Each of these clouds is called a **nebula**. Stars are born in nebulae (singular nebula). A nebula collects more dust and gas during its travel through space (Fig. 12.11). The gas and dust particles are packed into a hot spinning ball of matter. Such a ball of hot matter is called a **protostar**. With the passage of time, a protostar becomes hot enough to produce great amount of energy. At this stage a protostar is called a **star**. A star like the Sun emits light and heat all the time.



Fig. 12.11: Scientists have observed protostars and young stars within the Horsehead nebula.



Extend Your Thinking

The matter that makes up a star today may have been part of another star that died billions of years ago. How is it possible?

Death of a Star

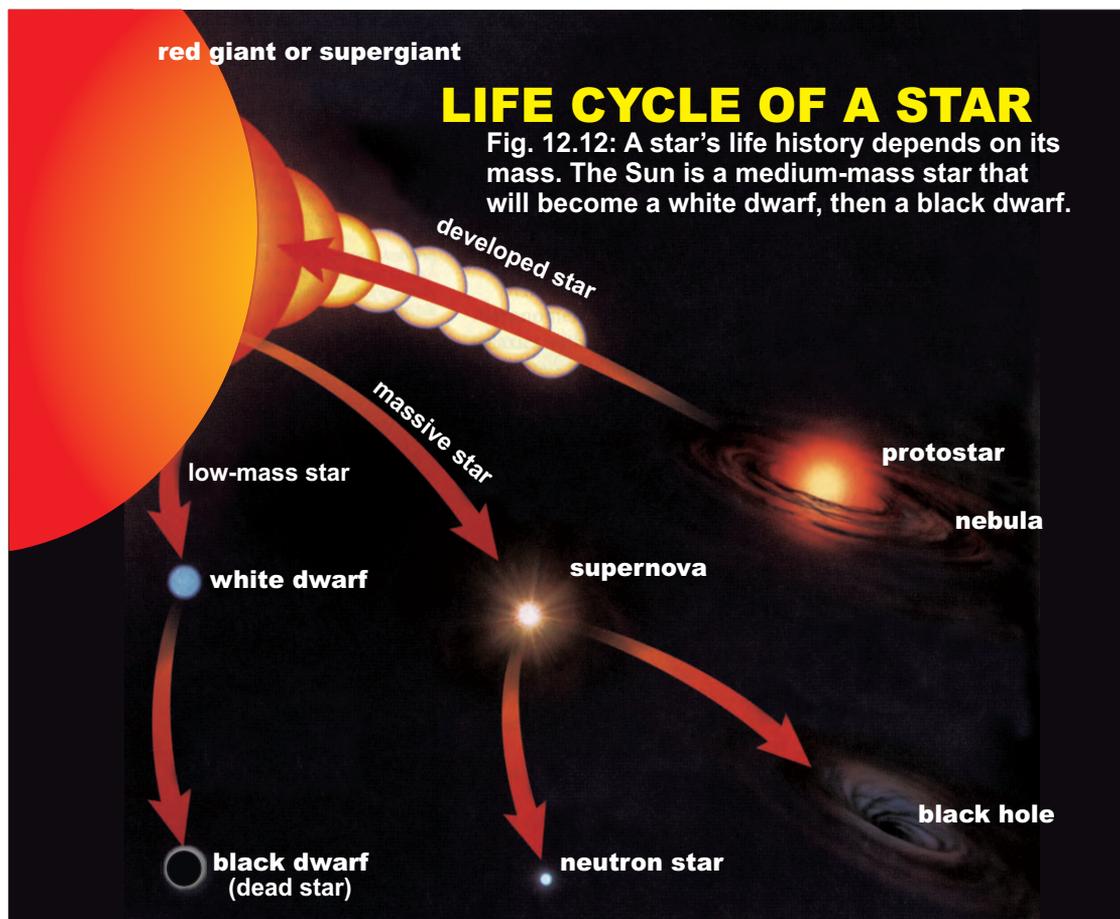
The matter of a star is converting into energy. This radiant energy is released into space. Our star (the Sun) is dying (Fig. 12.12). Let us see, how.

Red Giant Stage

Our star (the Sun) has passed five billion years while emitting energy. After the next five billion years, the hydrogen in the core of the Sun may be used up. The Sun will start to collapse. Its core will become denser and hotter and the Sun will swell in size. It will become a **red giant**. The Sun will be a red giant for only about 500 million years.

Dwarf Stage

By and by the Sun in the form of red giant will cool and gravity will make it collapse inward. Our star will become a **white dwarf** at this stage. Eventually, the Sun will become a burn-out black chunk of very dense matter. It will not emit light any more. This last stage of a star's life is called a **black dwarf**.



Formation of Black Holes (Life of a Massive Star)

Stars more than six times as massive as our Sun are called **massive stars**. A massive star has short lifespan than the Sun or other low-mass stars. Hydrogen in the core of a massive star is used up with a much fast speed. After only 50 to 100 million years, no hydrogen is left in the core of a massive star. At this time, the core collapses and the star becomes 1000 times greater than its original size. It is now called a **supergiant** (Fig. 12.12).

With the passage of time the supergiant becomes so dense that it cannot bear the pressure of outer layers. The outer layers crash inward with a tremendous explosion, called **supernova**. At the time of supernova, the light of the star becomes much more than all other stars of the galaxy. Great shells of gases fly off the star. Only the tiny core of the star remains left. This core contains only neutrons, so it is called a **neutron star**. It is extremely dense. Some times after the supernova explosion the massive star becomes a black hole.

A **black hole** is so dense that nothing can escape from it due to its very strong gravity. Even light cannot escape from a black hole and it is no more glowing. In fact the black hole is the last stage of the life cycle of a massive star.

 **Extend Your Thinking** Given that there are more low-mass stars than high-mass stars in the universe, do you think there are more dwarfs or more black holes? Explain.

12.4: Looking at Stars

People have looked at the stars for thousands of years. A **telescope** is a device that makes a far away object appear very close (Fig. 12.13). Many more stars can be seen with the telescope than with the unaided eye. A simple telescope has two lenses.

The **objective lens** collects light from a distant object and brings that light, or image, to a point or focus.

An **eyepiece lens** takes the light from the objective lens and magnifies it.

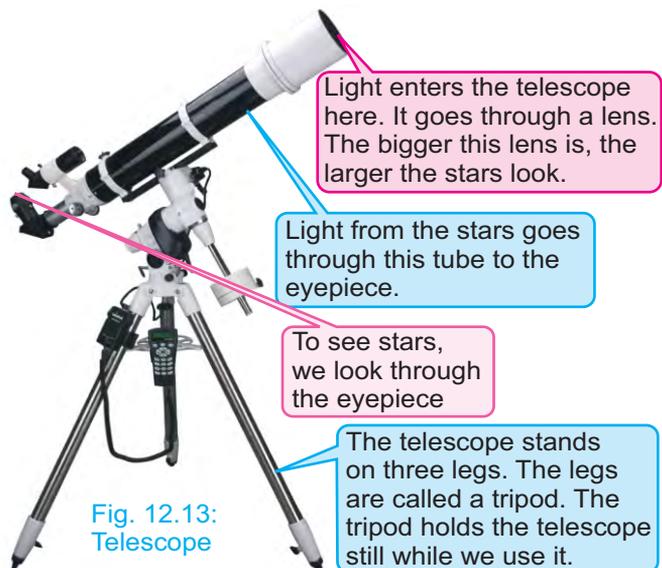


Fig. 12.13: Telescope

Activity 12.5

How to make a Telescope

You will need

- scotch tape
- 1 thin lens (objective)
- 1 thick lens (eyepiece)
- small-diameter cardboard tube
- large-diameter cardboard tube

Procedure

1. Join the thin lens on one end of the small tube with the help of scotch tape.
2. Now join the thick lens on one end of the large tube with the help of scotch tape.
3. Slide the open end of the small tube into the large tube to make a telescope (see the picture).
4. Hold your telescope, and look at an object through one lens. Then turn the telescope around, and look through the other lens. Slide the small tube in and out of the large tube to focus the object.

Things to think

- i. What did you observe as you looked through thin lens and thick lens?
- ii. Using your observations, tell which lens you should look through to observe the stars.



12.4.1: Safety Tips for Observing the Sun

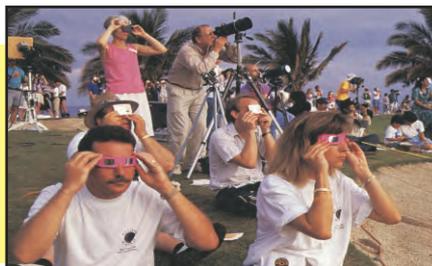
The Sun emits dangerous radiation. Viewing directly into the Sun can damage our eye sight. Make sure the safety of your eye before viewing the Sun.

1. A pinhole or small opening is used to view the image of the Sun on a screen placed a half metre or more beyond the opening.
2. Use two or three sheets of X-Rays film for viewing the Sun.

Remember! No filter is safe for use with any optical device, i.e. telescope, binoculars, etc.

Tidbit

Some people use special Mylar glasses to safely observe an eclipsed Sun.



Science, Technology and Society

Cities have many street lights and other lights from buildings and homes. Because of this, we may not see many stars. Light from street lights and advertising signs also make it difficult to see astronomical objects. Artificial light that makes it difficult to see the night sky clearly is known as **light pollution**. If light pollution increases, how will we see glittering stars and other astronomical objects?

Key Points

- ⦿ According to scientists, the starting point of the universe was the Big Bang. According to the Big Bang Theory, once the universe was packed into one giant fireball. Then a tremendous explosion, the Big Bang scattered the matter of the universe into all directions.
- ⦿ Stars are huge balls of glowing gases. Stars are very far away from us.
- ⦿ The colour of a star is related to its temperature. Blue-coloured stars have higher temperatures than yellow and red-coloured stars.
- ⦿ Stars emit energy in the form of light and heat. The stars which emit greater amount of energy look brighter than other stars.
- ⦿ A galaxy is a large group of stars, nebulae, gases, dust and planets. Our solar system is the part of Milky Way galaxy.
- ⦿ A black hole is the last stage in the life of a massive star. A black hole is so dense that nothing can escape from it.
- ⦿ Scientists classify galaxies in three main types on the basis of shape. These are spiral galaxies, elliptical galaxies and irregular galaxies.
- ⦿ A star (the Sun) starts its life as a protostar in a nebula. Then it changes to a star. After releasing its energy the star becomes a red giant and in the end a dwarf.
- ⦿ A telescope is a device that is able to make a far away object appear very close. We can see many more stars in the night sky with the help of a telescope.
- ⦿ The Sun emits dangerous radiation. We must observe safety measures before viewing the Sun.

Questions

1. Complete each of the following sentence by writing the correct term.

- i. An oval-shaped galaxy is called _____
- ii. A cluster of stars with a definite pattern _____
- iii. A large group of stars, gas, and dust _____
- iv. The last stage of a low-mass star's life _____
- v. A device that is able to make far away objects appear close _____

2. Encircle the correct answer in the following.

- i. Star distances are usually measured in:
 - (a) metres
 - (b) kilometres
 - (c) light-years
 - (d) yards
- ii. Bright stars may appear dimmer than others because they are:
 - (a) older
 - (b) farther away
 - (c) younger
 - (d) closer to the Earth
- iii. The last stage in the life of a massive star is:
 - (a) black hole
 - (b) black dwarf
 - (c) white dwarf
 - (d) red giant

- iv. When great amount of energy is produced in a protostar, then a protostar is called:
 (a) a supergiant (b) a star
 (c) a neutron star (d) a black hole
- v. A cluster of stars present in a nebula includes red stars, blue stars, yellow stars and white stars. Which stars are most like the Sun?
 (a) red (b) yellow
 (c) blue (d) white
- vi. Our neighbouring galaxy is named as:
 (a) Cepheus (b) Andromeda
 (c) Canis Major (d) Taurus

3. Give short answers.

- i. Are blue stars young or old? How can you tell?
 ii. Name one observation that supports the Big Bang Theory.
 iii. List in order, the four stages in the life cycle of a low-mass star.
 iv. How do constellations differ from galaxies?
 v. How do scientists think the universe began?
 vi. What type of star ends its life cycle as a black hole?
 vii. For how many years will the Sun be a red giant?
 viii. On which factors does the brightness of a star depend?
 ix. What is a light-year?
 x. What galaxy our Sun belongs to?

4. Explain the Big Bang Theory of the origin of the universe.

5. Describe the life cycle of a low-mass star.

6. Describe the three main types of galaxies.

7. Write notes on:

- i. Star Distances
 ii. Safety methods to use when observing the Sun

End of Life

When our Sun will become a red giant, it may become so large that it will absorb Mercury and Venus planets. The Earth would become extremely hot. All life on the Earth would be wiped off.

Computer Links

For more information visit:

- <http://www.ugcs.caltech.edu/~yukimoon/BigBang/BigBang.htm>
- <http://www.telescope.org/pparc/res8.html>

Glossary

Ammeter: the device to measure the amount of current in an electric circuit

Atom: the smallest particle of an element

Atomic number: the number of protons in the nucleus of an atom

Audible frequency range: the range of sound frequencies that can be heard by an animal or human

Big Bang Theory: the theory which states that universe began with a tremendous explosion

Black hole: an object in space whose gravity is so strong that not even light can escape. Last stage of the life cycle of a massive star.

Blood circulation: the movement of blood throughout the body

Blood vessels: tube like parts that carry blood

Chemical change: a change in which state and composition of a thing changes

Chemical formula: a short hand notation for a compound using symbols and valencies

Chlorination: the method of killing germs by dissolving an appropriate amount of chlorine in water

Circuit: a complete path along which charges flow

Circuit breaker: an automatically-operated electric switch that protects an electric circuit from damage caused by overload or short circuit

Colour of object: the colour of light an object reflects

Compound: a pure substance composed of two or more elements that are chemically combined

Conductor: a material that allows heat or current to pass through it

Consumers: organisms that cannot make their own food

Convection: the transfer of heat by direct contact of particles in matter

Cosmic background radiation: radiation left over from the big bang that fills all of space

Critical angle: the angle of incidence at which maximum refraction occurs

Decomposers: organisms that breakdown dead animals and plants bodies into simpler substances

Diabetes: disease that results if insulin is not present or not used in the body.

Diaphragm: a muscle beneath the lungs that helps move air in and out of the body

Diarrhoea: excessive discharge of stool whether watery or frequent

Digestion: the process that breaks down food into simple substances so that they can move into the blood.

Dispersal of light: the splitting of white light into its component colours

Ecosystem: a community interacting with the non-living (abiotic) parts of its environment

Electric circuit: a complete path through which electrons can flow

Electric current: the flow of electrons through a material

Electrical power: the rate at which a device converts electrical energy into another form of energy

Electricity: a way to move electrical energy from one place to another

Embryo: young plant that begins developing after fertilization

Fertilization: the process of fusion of an egg and a sperm

Fertilizers: chemicals that farmers add to the soil to increase the amount of food that will grow

Filtration: the removal of suspended solid particles present in water with the help of a filter paper

Flower: reproductive part of a flowering plant

Food web: a network of many food chains in an ecosystem that overlap each other

Frequency: the number of sound waves that pass a given point in one second

Fruit: a ripened ovary that may contain seeds

Fuse: a piece of thin conducting wire connected in the path of a live wire in the electrical circuit

Galaxy: large grouping of stars in space

Glacier: a large mass of slow-moving ice

Ground water: the water found beneath earth's surface

Habitat: a place where an organism lives

Hard water: water which gives less lather with soap and forms curds

Heart: a pumping organ which pushes blood into the vessels

Heat conduction: the transfer of thermal energy from one piece of matter to another

Hydrocarbons: compounds that are composed of only carbon and hydrogen atoms

Hydrogenation: the process in which hydrogen chemically combines with vegetable oil to change it into fat

Insulator: a material that does not allow heat or current to pass through it easily

Ion: a charged atom or group of atoms formed when one or more electrons transfer from one atom to another

Isotopes: atoms that have the same number of protons but have different numbers of neutrons

Longitudinal wave: a wave in which particles of the medium move back and forth, parallel to the path of the wave

Lungs: balloon-like structures present in the chest cavity that help in breathing process

Mass number: the sum of the protons and neutrons in an atom

Milky way: our home galaxy

Nebula: a large cloud of dust and particles in which stars form

Non-reversible change: a change in which the product formed cannot be sent back to its original form

Nucleus: the tiny, positively charged region in the centre of an atom, made up of protons and neutrons

Nutrient: a substance in food that produces energy and materials for life activities

Ovary: female sex organ that produces eggs

Parasitism: a relationship that benefits the parasite but harms its partner

Phloem: tube-like cells that carry food in the plant

Physical change: a change that makes matter look different without becoming a new substance

Pitch: the highness or lowness of a sound

Plastic: polymer-based material that can be easily moulded

Pollen grain: male reproductive part of a flower that contains sperm.

Pollination: the transfer of pollen grains from stamen to the sticky style

Potential difference: the difference in electric potential between two places; measured in volts

Predation: the feeding of one animal on another animal

Primary colours: the colours of light that can be used to make any other colour

Producers: green plants that make their own food by photosynthesis

Radiation: the transfer of heat through empty space

Radiator: a material that emits heat

Refraction: bending of light when it changes speed while moving from one material to another

Refractive index: the ratio of the speed of light in a vacuum to its speed in another medium

Resistance: the opposition to the movement of electrons following through a material

Respiration: the process by which organisms break down food to release energy.

Reversible change: a change in which the product formed can be sent back to its original form

Saliva: a watery substance produced in the mouth to help digest carbohydrates.

Seed: part formed in the flower that contains a new plant and stored food

Spectrum: the band of coloured lights from a device that disperses light

Spiral galaxy: a galaxy with a bulge in the centre and spiral arms

Stars: balls of hot, glowing gases

Supernova: the death of a large star by explosion

Surface water: fresh water in lakes, streams and rivers

Total internal reflection: when angle of incidence is greater than the critical angle, the light rays reflect in the same medium

Translocation: the movement of food from leaves to the other parts of plant

Transpiration: removal of water from the leaves of a plant

Transplantation: shifting of body parts, organs or tissues from one person to the other

Transverse wave: a wave in which particles of the medium move at right angle to the path of the wave

Valency: the number of electrons that an atom loses or gains in the outermost shell to become stable

Vibration: a repeated to-and-fro or up-and-down motion

Voltmeter: the device to measure voltage (potential difference) in an electrical circuit

Water pollution: addition of harmful or unwanted substances in water

Wave: a disturbance that transfers energy from place to place

Wavelength: distance between two adjacent compressions or two adjacent rarefactions of the same wave

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