Science and Technology

Grade 10

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Preface

School education is the foundation for preparing the citizen who are loyal to the nation and nationality, committed to the norms and values of federal democratic republic, self-reliant and respecting the social and cultural diversity. It is also remarkable for developing a good moral character with the practical know-how of the use of ICT along with the application of scientific concept and positive thinking. It is also expected to prepare the citizens who are moral and ethical, disciplined, social and human value sensitive with the consciousness about the environmental conversation and sustainable development. Moreover, it should be helpful for developing the skills for solving the real life problems. This textbook 'Science and Technology, Grade 10' is fully aligned with the intent carried out by the National Curriculum Framework for School Education, 2076 and is developed fully in accordance with the new Secondary Level Curriculum, Grade 9-10, 2078.

This textbook is initially written by Dr. Indra Raj Upadhaya, Mrs. Mina Shrestha, Mr. Janak Raj Pant, Mr. Yubraj Aadhikari and Lav Dev Bhatta . It has been translated by Mrs. Rajani Maharjan, Mr. Narayan Acharaya and Mr. Suraj Babu Ghimere. The contribution made by Director General Mr. Baikuntha Prasad Aryal, Prof. Dr. Krishna Bhakta Maharjan, Dr. Kamal Prasad Acharya, Mr. Uma Nath Lamsal, Mr. Hedemba Raj Kandal, Mr Keshar Bahadur Khulal, Mr. Shailesh Bahadur Pradhan, Mr Pashupati Shrestha, Mr. Krishna prasad Bhusal, Mr. Bishnu Poudel and Mrs. Pramila Bhakati is remarkable in bringing the book in this form. The language of the book has been edited by Mrs. Kunti Adhikari. Art editing of this book was done by Mr. Shreehari Shrestha by making it four colour. The Curriculum Development Centre extends sincere gratitude to all of them.

The textbook is a primary resource for classroom teaching. Considerable efforts have been made to make the book helpful in achieving the expected competencies of the curriculum. Curriculum Development Centre always welcomes constructive feedback for further betterment of its publications.

2080 BS

Curriculum Development Centre
Sanothimi, Bhaktapur

Contents

1 Scientific Study

The scientific study includes scientific facts, theories, models, experiments and physical situations. It studies various objects in nature in a planned and organized way. It also logically investigates the various phenomena based on the scientific method and empirical or measurable evidence. Various causative factors have a role in different events and phenomena that have occurred in nature. The causative factor, characteristic, or trait that has a direct or indirect relationship with an event or a phenom-enonis known as a variable.

1.1 Variables of scientific research

When we see a phenomenon or change, we are curious to know why it happens, what factors areinvolved, and how they have affected that event or phenomenon. Such curiosity helps us to predict the result of an action correctly. For instance, if we see a wilted potted plant in the garden, we want to know why is it wilted.Is it because of lack of water, overexposure to bright sun, or someother reasons? To find out the answer, we try to find the effects of keeping the plant in theshade or watering it or doingsome other things. With the help of knowledge and experience obtained fromsuch curiosity or interest, we can easily guess what could be the condition of the plant if we forget to water it or keep it in the shade on a hot day.Then we can take the necessary measures to save it.

For each incident or change, there is always cause and effect. In the aforementioned example, either lack of water or excessive heat of the sun is the causative factor whereas wilting is the effect. The effect depends on the causal factors. For example, the rigidity of the stem of a plant depends on the amount of water in it. Therefore, for the right estimation, it is essential to know the relationship between the magnitude of the causative factor and the magnitude of the effect.

This relation can be established through experiments. The task of a scientist is to set up a relationship between various physical quantities and ultimately find out how nature works.

Activity 1.1

Title: Making catapult from a rubber band

Materials required: rubber band (about 5 cm long), a 15 cm long ruler, small pieces of paper (about 2cm length and 2 cm breadth) and measuring tape

Method

1. Wrap the pieces of paper into a cylinder-like form and fold them in the middle. It functions as a projectile or bullet for a catapult.
2. Hook the rubber band into two fingers of one hand (e.g., thumb and forefinger), as shown in the figure.

Figure 1.1

3. Hold the paper bullet within two segments of the rubber band and stretch the rubber band.
4. Ask your friend to measure the extension of the rubber band (distance from the fingers to the paper bullet). Make the distance 4 cm.
5. Release the paper bullet. It will fly away from the catapult. Measure the distance covered by the paper bullet.
6. Note down the extension of the rubber band and the distance travelled by the paper bullet.

7. Now, stretch the rubber band 6 cm and launch the paper bullet. Measure the distance travelled by the bullet. Repeat this for the extension of 8 cm and 10 cm.

S.N.	**Extension of rubber band(cm)**	**Distance travelled by the paper bullet (cm)**
1.	4	
2.	6	
3.	8	
4.	10	

Scientific research involves changing the magnitude of one physical quantity and observing how this change brings changes in another physical quantity. For example: in the above experiment, we studied how the extension (stretch) of the rubber band affects the distance travelled by the paper bullet. Here, the extension of the rubber band and the distance covered by the bullet are both physical quantities and their magnitude are different in each experiment. Such physical quantities are called variables because their value or magnitude varies each time. The elements (physical quantities) that change or may change in an experiment are called variables of the experiment or research. In the above experiment stretching of the rubber band and the distance covered by the paper bullet are the variables of that experiment. The thickness of the rubber band and the size of the paper bullet could also have been changed in that experiment. Therefore, these are also the variable of the research.

Each variable has a name and is represented by a symbol for ease of writing. The relation between variables is expressed interms of a mathematical formula. For example: If the extension or stretch of rubber is denoted by 'e'and the distance travelled by the paper piece is denoted by 'x', the relation between them is $x \propto e$.

Types of variables

Usually, variables are classified into three types: independent variable, dependent variable and controlled variable.

a. Independent variable

During a scientific experiment or research, the researcher manipulates or changes a variable in a particular amount and measures the changes in another variable. The change made by the experimenter or researcher is the causative factor and subsequent change in another variable is the effect.

In the experiment above, stretched rubber band throws the paper bullet. The extension of the rubber band is the causative factor and the distance travelled by the paper is the effect. The researcher or experimenter is free to decide the degree of extension of the rubber band. The variable which can be manipulated by a researcher is called the independent variable. In activity 1.1, the extensionof the rubber band is the independent variable.

Causative factors related to the experiment are independent variables. For example, the amount of fertilizer, sunlight and water can be the independent variables for the growth of a plant.

b. Dependent variable

In experiment 1.1, the researcher cannot tell the distance covered by the piece of paper directly because it depends on the amount of stretching of the rubber band. Such a variable is called a dependent variable. So dependent variable is the variable whose value depends upon the value of anothervariable and the experimenter cannot predict or determine its value directly.For example,in activity 1.1 the distance covered by the paper bullet is the dependent variable. Similarly, while observing the effect of sunlight on the growth and development of the plant, the amount of sunlight is the independent variable and the height or growth of the plant is the dependent variable.

c. Controlled variable

In some experiments or research, there may be more than two variables. Each variable influences the result of an experiment or research. Thus, it isnot possible to determine which variable is responsible for the change in the results or findings. In such a situation, it is difficult to draw conclusion. The conclusion might even not be valid or reliable. Therefore, to make the finding of the experiment valid, reliable and accurate, variables other than the specified independent variable and dependent variable should be controlled so that they do not affect the result. Such variables which are taken into control throughout the experiment or research are known as the controlled variables.

In activity 1.1, the thickness of the rubber band and the size of the paper bullet should be kept the same throughout the experiment.

If different rubber band sare used at each activity, the result will not be valid. Hence, for this experiment, the thickness of the rubber band and the size of the paper bullet are the controlled variables. Similarly, while we are observing the effect of light on plant growth, all plants should be of uniform size at the beginning of the experiment. Air, water and manure supplied to these plants should also be kept uniform throughout the experiment. So,the initial size of plants, air, water, and manure supplied to them are the controlled variables. In the same way, if we are studying the rate of a chemical reaction between the surface area of limestone and acid, the acid used each time should have the same concentration and the quantity and weight of limestone should also be kept the same. In this experiment, surface area is the independent variable, the rate of reaction is the dependent variable and the concentration of acid, quantity and weight of limestone are the controlled variables. Controlling such variables requires special arrangements while formulating the design of the experiment.

In Activity 1.1

Independent variable : ***extensionof rubber band***

Dependent variable : ***distance travelled by paper bullet***

Controlled variable : ***thickness of rubber band and size of the paper bullet***

Other examples of thevariable types mentioned above are listed in the table below:

S.N.	Subject of research	Independent variable (what I can change)	Dependent variable (What I observe)	Controlled variable (what I keep the same
1.	Relation of a rotating knob of a tap and the rate of flow of the water	Magnitude of rotation of knob (in degree)	Amount of the water flow per minute (in litre)	water pressure
2.	Relation of electricity and magnetism in a solenoid	Amount of electric current (in ampere)	Number of pinsattracted by the electromagnet	Number of turns in the solenoid, size of the pin
3.	Effect of heat on the solubility of sugar	Temperature of water (in degree celsius)	Amount of completely dissolved sugar in water (in grams)	Amount of water (always 100 grams)
4.	The immediate effect of physical exercise on the heartbeat	Duration of physical exercise (in minutes)	Number of heartbeats	Type of physical exercise, the interval between the end of exercise, and count of heartbeats

Things to be considered about variables

1. There should be only one independent variable in research or an experiment.
2. There should be only one dependent variable in research or an experiment.
3. Except for the specified independent variable and dependent variable, other variables should be controlled.

4. While expressing the relation between variables in an equation, usually, the dependent variable is written on the left side of the equation and the independent variable is written on the right side. Hence, the independent variable is sometimes called a right variable and the dependent variable is called the left variable. For example,if we study how the distance covered by a moving object varies with time, then the mathematical equation of their relationship will be s =vt. Where distance travelled (s) is the dependent variable, time (t) is the independent variable and speed (v) is the controlled variable.

5. While plotting the relationship of variables in a graph, the dependent variable is always plotted on the y-axis or the vertical line and the independent variable is plotted on the horizontal line or the x-axis.Therefore, the dependent variable is sometimes called the vertical variable or the y-variable and the independent variable is called the horizontal variable or the x-variable. Graph presentation always depicts how the change in the independent variable brings the change in the dependent variable.

1.2 Types of units

Physical quantities are measured in units. The units of all physical quantities can be divided into two types:

1. Fundamental unit
2. Derived unit

Fundamental unit

The unit of measurement which has its independent existence or does not depend upon the other units and cannot be resolved into any simpler forms is called the fundamental unit. For example, the fundamental unit of mass is kilogram, the fundamental unit of time is second, and the fundamental unit of length is metre. In the SI system, there are 7 fundamental units and they are listed below:

S.N.	Physical quantity	Fundamental unit	Symbol
1.	length	meter	m
2.	mass	kilogram	kg
3.	time	second	s
4.	temperature	kelvin	K
5.	luminous intensity	candela	cd
6.	electric current	ampere	A
7.	amount of substance	mole	mol

Derived unit

The unit of measurement which has no independent existence and is composed of two or more fundamental units is called a derived unit. For example, the unit of density is kg/m^3. It consists of two fundamental units; kilogram and meter. Similarly, the unit of force is $kgms^{-2}$, where kilogram (kg), metre (m) and second (s) are the three fundamental units involved in it. It is difficult to say $kgms^{-2}$ in daily use andhence, this combined form of units is given a simpler name, newton (N). Therefore, $N = Kgms^{-2}$. Likewise, the unit of pressure is pascal (Pa). This unit is equal to $kgm^{-1}s^{-2}$. In this way, units of many derived quantities are given a specific name.But in the case of some physical quantities, the combination of fundamental units in itself is in use, for example, unit of density is kgm^{-3}.There is no simpler name for it.

Quantity	Formula	Combination of base units according to the formula	Fundamental Units involved	Derived Unit)
area	$l \times b$	meter × meter	m^2	m^2
volume	$l \times b \times h$	meter × meter × meter	m^3	m^3
density	$\frac{\text{mass}}{\text{volume}}$	$\frac{\text{kilogram}}{\text{meter}^3}$	kg/m^3	kg/m^3
velocity	$\frac{\text{displacement}}{\text{time}}$	$\frac{\text{meter}}{\text{second}}$	m/s	m/s

accelera-tion	$\frac{\text{velocity}}{\text{time}}$	$\frac{\text{meter}}{\text{second} \times \text{second}}$	m/s^2	m/s^2
force	mass × accelera-tion	$\frac{\text{kilogram} \times \text{meter}}{\text{second} \times \text{second}}$	kgm/s^2	Newton (N)
pressure	$\frac{\text{force}}{\text{area}}$	$(kgm/s^2)/meter^2$	kg/ms^2	Pascal (Pa)
work	force × distance	$kgm/s^2 \times$ meter	kgm^2/s^2	joule (J)
power	$\frac{\text{work}}{\text{time}}$	$\frac{kgm^2/s^2}{\text{second}}$	kgm^2/s^3	watt (W)
moment	force × distance	$(kgm/s^2) \times$ meter	kgm^2/s^2	Nm
frequency	$\frac{1}{\text{time}}$	$\frac{1}{s}$	s^{-1}	Hz

To find out the composition of derived unit which includes the fundamental units, analysis can be done based on the definition of the physical quantity. For example:

a) The unit of area is square metre

Analysis: Area = length × breadth

$$= m \times m$$

$$= m^2$$

Therefore, the unit of area is m^2. This unit is formed from two fundamental units.

b) The unit of force is Newton (N)

Analysis: According to the definition of force, $F = ma$

The unit of mass (m) is kg and the unit of acceleration (a) is ms^{-2}.

Therefore, $N = kgms^{-2}$. Hence kilogram, meter and second are the fundamental units and they are combined to form the unit of force which is called newton.

Activity 1.2

Find out the various units used to measure different kinds of physical quantities in your daily life. Classify these units into two groups; fundamental and derived units and fill up the table as given below in your note copy.

Fundamental units	Derived units

The difference between the fundamental unit and the derived unit is mentioned below:

Fundamental unit		Derived unit	
a)	It doesnot depend upon other units.	a)	It depends upon the fundamental units.
b)	There are seven fundamental units used till now.	b)	Many derived units are formed from seven fundamental units.

Analysis of unitwise equation

Various formulae and equations are obtained from the conclusion of scientific studies. The validity and uniformity of such formulae and equations can be checked by the analysis of units involved in such physical quantities. For the validation of an equation, units on both sides of an equation must be the same. Example: While performing the unit analysis of the equation: $s=v\times t$, the fundamental unit of the quantity onthe left-hand side of the equation is m and the fundamental unit of the quantity on the right-hand side of the equation is also $ms^{-1} \times s = m$. Therefore, this equation is valid.

But, if someone claims $s = v/t$, then by performing the unit analysis, the fundamental unit of the quantity on the left-hand side is m but the fundamental unit of the quantity on the right-hand side is ms^{-1}/s or ms^{-2}. Hence the unit of physical quantity on the left-hand side of the equation is not equal with the unit of physical quantity on the right-hand side. So, the equation s = v/t is invalid or wrong.

Addition and subtraction of physical quantities are possible if they have the same composition of fundamental units. Example: u+v is possible because both of them have the same unit, ms^{-1}. Similarly, s - at^2 is also possible because the fundamental unit of s is m and the fundamental unit of at^2 is also m; when simplified. But, s+at is not possible because the unit of s (distance covered) is m and the fundamental unit of atis ms^{-1}. Thus, they cannot be added due to dissimilarity in the composition of fundamental units.

Example: Test the validity of the equation given below by unit analysis.

(i) $v^2 = u^2+2as$

(i) $s = ut+ \frac{1}{2} a^2t$

Now,

(i) $v^2 = u^2+2as$

$$m^2s^{-2} = m^2s^{-2} + m^2s^{-2}$$

In the above equation, there is uniformity in the unit of physical quantity oneither side. So, this is a valid equation.

(ii) $s = ut+ \frac{1}{2} a^2t$

$$m = ms^{-1} \times s + (ms^{-2})^2 \times s$$

$$m = m + m^2s^{-3}$$

In the equation given above, there is no similarity in the base units of the physical quantities on either side. So, this equation is not valid.

Analysis of units is required to prove the accuracy of an equation, to find out the inter-relation of physical quantities and for the conversion of units of various measurement systems.

Exercise

1. Choose the correct options for the following questions.

a. Which of the following is a fundamental unit?

i. newton	ii. pascal
iii. kilogram	iv. joule

b. Which of the following physical quantities has the unit ms^{-1}?

i. acceleration	ii. velocity
iii. force	iv. density

c. Which of the following is a derived unit?

i. candela	ii. ampere
iii. joule	iv. kelvin

d. Which of the following units denote newton?

i. $kgms^{-2}$	ii. $kgm^{2}s^{-2}$
iii. $kgm^{-2}s^{-2}$	iv. $kgms^{-1}$

2. Give reason:

a. Joule is the derived unit of work.

b. Some variables should be controlled while performing an experiment.

c. $v^2 = ut$ is not a valid relation.

3. Differentiate between:

a. Independent variable and dependent variable

b. Fundamental unit and derived unit

4. Answer the following questions:

a. What is a unit?

b. Write the SI units of mass, temperature, energy, and density.

c. How is the validity of an equation checked? Write an example.

d. Mention the fundamental units involved in the unit of pressure.

e. Find out the fundamental units involved in the given derived unit.

   i. newton (N) ii. watt (W)

   iii. joule (J) iv. pascal (Pa)

f. Niva claimed that an alternative formula for power is $P=mv^2$ and the formula of pressure; $P=mv/A$. Check the validity of given formulae by the analysis of units.

g. Describe the independent variable, dependent variable and controlled variable with a suitable example of each.

h. Karma connected a dry cell to a bulb using a few pieces of wire and lit the bulb. He was curious to know how the thickness of the used wire affects the life span of a dry cell. In this test or experiment, find out the independent variable, dependent variable and controlled variable.

i. Chandani wanted to investigate the effects of substances mixed with the soil on plant growth. She decided to mix lime, urea fertilizer, common salt, and compost manure in the soil. Then she brought a bucket of soil from a nearby field and sieved it. She put that soil equally into 12 uniform-sized pots. Then she mixed two spoons of salt in every three pots, two spoons of urea fertilizer in each of the next three pots, two spoons of table salt in each of the next three pots, and finally, two spoons of compost fertilizer in each of the remaining three pots.She then planted similar seeds of the same plant in every pot and placed them all in a sunny place in the house. She watered all the pots every day. After the plants grew, she measured the height of each plant daily and kept a record.

i. Identify the independent variable, dependent variable and controlled variable in Chandani's experiment.

ii. Why did Chandani use 3 pots for each experiment?

j. Subodh wanted to find out how the colour of an object affects its ability to hold heat. For that, he took four conical flasks and coated the first flask with black coloured enamel, the second with white enamel, the third with green enamel and the fourth with red enamel. Then, he filled all the flasks with water, closed the mouth of each flask tightly with cork and then kept them in the sun. After some time he measured the temperature of water in each flask with the help of a thermometer and noted the readings.

Identify the independent variable and dependent variable in Subodh's experiment. Which variables should be controlled by Subodh?

k. Manisha wanted to test the eating habits of her dog. She decided to study how the amount of food and the time of giving food affects the speed at which the dog ate. What is wrong with the design of Manisha's experiment and how can she correct it?

l. Prove that: Unit of electric resistance ohm (Ω) = $kgm^2s^{-3}A^{-2}$

2 Classification of Living Beings

Look at the picture below and discuss the following questions:

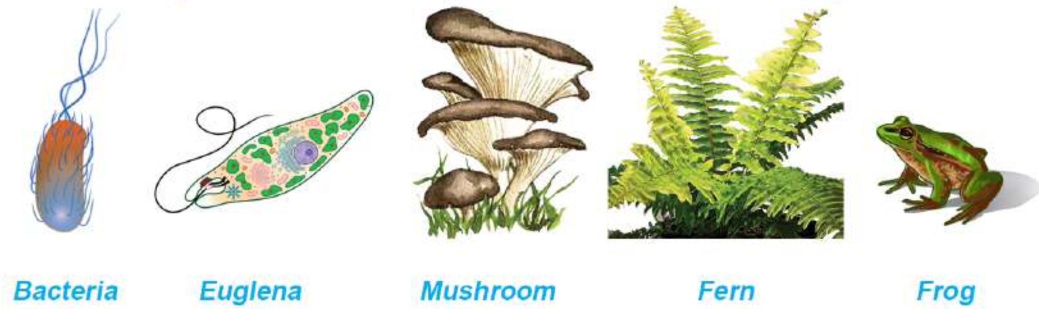


fig 2.1

i. According to five kingdom classification, which kingdom do these organisms belong to?

ii. How are bacteria and Euglena different from each other?

iii. What could bethe similarities and dissimilarities between a mushroom and a fern?

iv. On what basis, are ferns and frogs placed in plant and animal kingdom, respectively?

Environment is a home for microscopic organisms to giant organisms like bluewhale, elephant, banyan, peepal, etc. On the basis of structure of cell, body structure, mode of nutrition, presence or absence of cell wall etc., Robert Harding Whittaker classified these organisms into the five kingdoms. Among them, we already discussed about kingdoms monera, protista and fungi in grade nine. Here, lets recall the main characteristics of the organisms that belong to those three kingdoms.

All the organisms that belong to monera have prokaryotic cell. Protista includes unicellular organisms whereas fungus consists of saprotrophic organisms that have cell wall but no chlorophyll.

Among the organisms given above, bacteria have prokaryotic cell. Euglena is a unicellular organism. Mushroom does not have chlorophyll. And it decomposes dead and decaying plants to derive its food. Fern is an autotroph because of the presence of chlorophyll but frogs are heterotrophs because they lack chlorophyll.

Organism

- **Prokaryotes**
  - **Unicellular**
    - **i Monera**
- **Eukaryotes**
  - **Unicellular**
    - **ii Protista**
  - **Multicellular**
    - **with cell wall**
      - **Heterotrophic Nutrition**
        - **iii Fungi**
      - **Autotrophic Nutrition**
        - **iv Plantae**
    - **without cell wall**
      - **v Animalia**

Figure 2.2 Five kingdom classification system

2.1 Plantae Kingdom

Look at the picture below and discuss the following questions:

Moss *Fern* *Chlamydomonas* *Pea* *Maize* *Pinus*

Figure 2.3

i. What are the similarities in the organisms shown in the picture?

ii. In which kingdom do they belong?

iii. What are the main features ofthe kingdom they belong to?

iv. What are the differences between moss and fern?

Chlamydomonas, moss, fern, pine, pea, maize have green pigments called chlorophyll in their body. They belong to kingdom plantae that includes unicellular as well as multicellular green plants. Their cell wall is made up of cellulose. They are autotrophs. Some of these plants are flowering and some are non-flowering. On the basis of their structure, these plants are classified into three divisions: Algae, Bryophyta and Trachaeophyta.

1. Algae

Activity 2.1 The study of Algae

Objective: To identify the characteristics of algae

Materials required: Bottle, dropper, glass slide, cover slips, and compound microscope

Method

i. Collect water with algae in a bottle from a nearby pond or a damp marshy place.

ii. Put a drop of water along with algae on the slide with the help of dropper.

iii. Cover the algae with a cover slip.

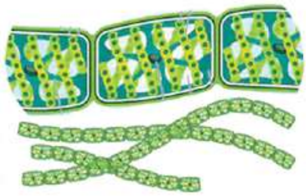
iv. Observe the slide undermicroscope.

v. After observing, draw a diagram to show the structure of the algae.

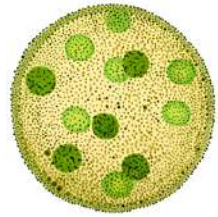
vi. Based on the observation, discuss the characteristics of the algae.

Conclusion

Observe the given picture and identify their characteristics.



Spirogyra



Volvox

Fucus

Figure 2.4

In plants -Spirogyra, Volvox, Fucus etc. shown in the picture, root stem and leaf cannot be differentiated. Their plant body is called thallus. Their cells contain cell wall and chlorophyll. These plants belong to division algae. Characteristics of the plants under this division are as follow:

a. They are either unicellular or multicellular.

b. They are autotrophs due to the presence of chlorophyll. They prepare and store food in the form of starch.

c. Their cell wall is composed of cellulose.

d. They reproduce both sexually and asexually.

e. These plants are found in pond, river, sea and marshy places.

Example: Chlamydomonas, Volvox, Spirogyra, Ulothrix, Fucus etc.

2. Bryophyta

Activity 2.2 Observation of the moss

Objective: To identify the characteristics of bryophyta.

Materials required: moss, needle, chart paper

Method

i. Take a moss plant.

ii. Observe its various parts and identify them.

iii. Note its features based on the observation.

iv. Draw its neat diagram on a chart paper based on observation.

v. Browse the internet and find out its other characteristics.

vi. Present the characteristics of bryophyta in your class on the basis of internet research and direct observation of the moss.

vii. Based on the discussion, make a list of characteristics of bryophyta.

Conclusion

Look at the picture below and identify their characteristics.

Marchantia

Moss

Riccia

Figure 2.5

Plants such as Marchantia, moss, Riccia shown in the picture are more developed than algae. They are green plants. Plant body of Marchantia is thallus but plant body of moss is differentiated into rhizoid, stem, and simple leaf. These plants are found in moist and shady places. Plants under bryophyta need water for fertilization. So, they are also called amphibian plants. General characteristics of plants under bryophyta are as follows:

a. They are multicellular plants.

b. They are autotrophs.

c. Plant body is either thallus or differentiated into rhizoid, stem and simple leaf.

d. They are found in moist and shady places.

e. These plants are dioecious and plant body is gametophyte. Male plant produces male gamete in antheridium. Female plant produces female gamete in archegonium. Hence, this phase is called gametophyte. The male gamete is released from antheridium andreaches thearchegonium through water, where it fuses with the ovum to form a zygote. Then, zygote germinates and develops into as porophyte. In this phase, the spore mother cell divides by meiosis to form haploid spores. This phase is called the sporophyte phase because spores are produced here.

f. The phenomenon in which sporophytic and gametophytic generation come one after another to complete life cycle of a plant is called alternation of generation. The gametophytic generation is dominant and independent in the life cycle of these plants.

g. They have no vascular tissue. So they grow upto few centimetres high or are found attached and spread on substratum.

Example: Marchantia, moss, Riccia, etc.

3. Tracheophyta

Observe the picture below and discuss their structure and characteristics

Figure 2.6

Plant body of fern, Cycas, banana, peepal etc. shown in the picture is differentiated into root, stem and leaf. They have xylem and phloem as vascular tissue which perform transportation of substances throughout the body.

So these plants are under the division tracheophyta. Division tracheophyta includes non-flowering fern plant, small herbs, shrubs to huge and developed plants. On the basis of structure, plants in division tracheophyta are classified into three subdivisions: pteridophyta, gymnosperm and angiosperm.

A. Pteridophyta

Activity 2.3 Observation of the fern

Objective: To identify the characteristics of fern

Materials required: fern plant, chart paper, gum, etc.

Method

i. Bring a rooted fern plant.
ii. Observe its root, stem and leaves thoroughly.
iii. Note down its characteristics based on observation.
iv. Draw a neat diagram of fern plant on chart paper on the basis of your observation.
v. Paste the chart paper on aboard and discuss its feature in the class.
vi. Based on the discussion, prepare a list of characteristics of fern plant

Conclusion

Fern

horse tail

clubmoss

Figure 2.7

Root, stem and leaves are prominent in the plants like fern, clubmoss, horse tail and these plants donot bear flower. They have feather like leaves. Generally, their stem is in the form of rhizome which lies horizontally under the soil. General characteristics of the plants under the subdivision pteridophyta are mentioned below:

a. They are found in moist and shady places.

b. They have no seed but plant body is differentiated into root stem and leaf. Leaf is feather like; stem is under-developed in the form of rhizome and root is developed.

c. They have developed vascular tissue like xylem and phloem.

d. These plants have numerous brown spots on the lower surface of leaves which are called sori (singular: sorus). Inside the sorus lies sporangium (plural:sporangia) that produces spores. Some leaves may not contain sori. Leaf with sori is called sporophyll and that without sori is called tropophyll. Plant body is called sporophyte because it produce shaploid spores.

e. Spores fall on the ground by the rupture of sporangia which germinate into gametophytes named prothalli (sing., prothallus) under suitable condition. Gametophyte produces both male and female gametes.

f. Their life cycle also shows alternation of generation. Sporophytic phase is dominant and lasts longer.

Plants like Fern, fiddlehead fern, Ground gooseberry, Lycopodium, Selaginaella, Pteris etc.fall under this division.

B. Gymnosperm

Look at the pictures given below and discuss.

Pinus

Juniper

Cycas

Figure 2.8

i. Do these plants bear flower?

ii. Where can we find their seeds and what do they look like?

iii. How are their leaves different from leaves of other plants?

Plants such as Cycas, Juniper, Pinus etc. are kept under flowering plants but they bear cones instead of flowers. They have naked seeds without fruits. So these plants are kept in the sub-division gymnosperm. Following are the characteristics of the plants under the sub-division gymnosperm:

a. Incourse of evolution of plants, gymnosperms are the first plant to produce seed.

b. They bear cones instead of flowers. Male and female cones are separate. So they are unisexual. Pollination takes place through wind.

c. There is no ovary in cone and hence no fruits. Seed is naked.

d. Their leaves are elongated and needle like.

e. Stem is enclosed within thick bark.

f. Shape of these plants is inverted cone like and hence they are called coniferous plants.

g. The roots of these plants are spread far into the ground.

Example: Cycas, Pinus, Juniper, Himalayan yew, Himalayan cedar

C. Angiosperm

bamboo

soybean

figure 2.9

Plants such as soybean, bamboo, etc. are real flowering plants. They have seeds enclosed in fruit. Sothese plants are placed under subdivision angiosperm. General characteristics of plants kept under angiosperm are given below:

a. They are most advanced plants of kingdom plantae.

b. These plants are found everywhere in land and water.

c. They have well developed root, stem, leaf, flower and fruit.

d. They bear real flower and flower contains both ovary and ovule.

e. Some plants are bisexual and some are unisexual.

f. Pollination takes place through various medium such as wind, water, insects, animal.

g. These plants contain seeds inside the fruit.

Orange, maize, banana, paddy, soybean, water hyacinth, Lemna, Pistia, etc. belong to this subdivision.

On the basis of number of cotyledons present in their seeds, angiosperms are grouped into two classes- monocotyledon and dicotyledon.

a. Monocotyledon

Activity 2.4 **Observation of the maize plant**

Objective: To identify the characteristics of monocotyledonous plant

Materials required: maize plant, chart paper, gum

Method

i. Obtaina rooted maize plant.

ii. Observe theroot, stem, leaf, flower, fruit, and seed of the plant thoroughly.

iii. Based on your observations, notedown the arrangement of veins in the leaf, the type of root, parts of the flower, and the characteristics of the seed.

iv. Draw a neat diagram of maize plant on chart paper.

v. Paste the chart paper on the board and discuss the plant'scharacteristics in class.

vi. On the basis of maize plant, you have studied, prepare a list of characteristics of monocotyledonous plant.

Conclusion

Paddy

Bamboo

Turmeric

Barley

Banana

Figure 2.10

The leaves of the plants shown in the picture are slender and elongated. Veins are arranged in parallel. The roots of the plants are all equal and arise from the same place. So these plants are kept in the monocotyledon class. General characteristics of plants under this class are mentioned below:

a. They have parallel venation in leaves.

b. They have fibrous root.

c. Usually, they have hollow stem. Nodes are prominent, at equal interval. From the node arise branch and leaf. The leaf base expands into a sheath covering the stem.

d. Vascular tissues are xylem and phloem scattered within the stem.

e. Floral parts are three or multiples of three in number.

f. They have seeds enclosed in fruit. Seed consists of only one cotyledon.

g. They are found both in land and water. Wheat, sugarcane, banana, barley, bamboo etc. belong to this class.

b. Dicotyledon

Activity 2.5 Observation of the gram

Objective: To identify the characteristics of dicotyledonous plant

Materials required: gram plant, soaked gram seed, chart paper, glue

Method

i. Takea few soaked gram seeds in a bowl.

ii. Take out a seed, remove its outer covering, and observe and note down the number of cotyledons in the seed.

iii. Bring a rooted gram plant. If you do not find one, look for a gram plant on the internet.

iv. Observe its roots, stems, leaves, flowers, fruits, and seeds.

v. Based on your observations, note the arrangement of veins in leaves, the type of roots, parts of the flower, and characteristics of the seeds.

vi. Draw a neat picture ofgram plant on a chart paper based on your observations.

vii. Paste the chart paper on the board and discuss the characteristics of the gram plant in your class.

viii. On the basis of gram plant you have discussed, prepare a list of characteristics of dicotyledonous plants.

Conclusion

Figure 2.11

Plants shown in the picture, such as mustard, pea, orange, soybean, and bean, have broad and flat leaves. There is a mid-rib from which many veins and veinlets arise forming a network throughout the leaf blade. They have a prominent main rootfrom which small root branches arise. Their seeds contain two cotyledons. So they are placed in the class dicotyledon. Dicotyledonous plants have following characteristics:

a. These plants range from small shrubs to very large trees.

b. They have a taproot system.

c. The stem is solid, strong, and mostly woody. Nodes are present at unequal intervals.

d. Vascular bundles are arranged in a ring-like form within the stem.

e. Reticulate venation is found in the leaf. The stem is petiolated and leaf is either simple or compound.

f. Seeds are enclosed within fruit. The seed consists of two cotyledons.

Soybean, mustard, pea, orange, mango, gram, beans, pumpkin, etc.,belong to this class.

Activity 2.6 Classification of plants

Objectives: To classify plants

Materials required: Plants found in your locality, chart paper, glue

Method

i. Collect small rooted plants from your locality.

ii. Collect leaves of larger plants.

iii. Observe the plants collected in student groups in the classroom.

iv. Comparethe roots, stems, and leaves of the collected plants and discuss in groups which plant falls into which division and class.

v. Draw the classification chart of plant kingdom on chart paper and paste the plants properly according to their group on chart paper.

vi. Now, paste the chart paper on the wall of the classroom.

Project work 2.1

Prepare herbarium by collecting various plants with their roots, stems, leaves, and flowers found in your locality.

2.2 Kingdom Animalia

Look at the picture of animals given below and discuss.

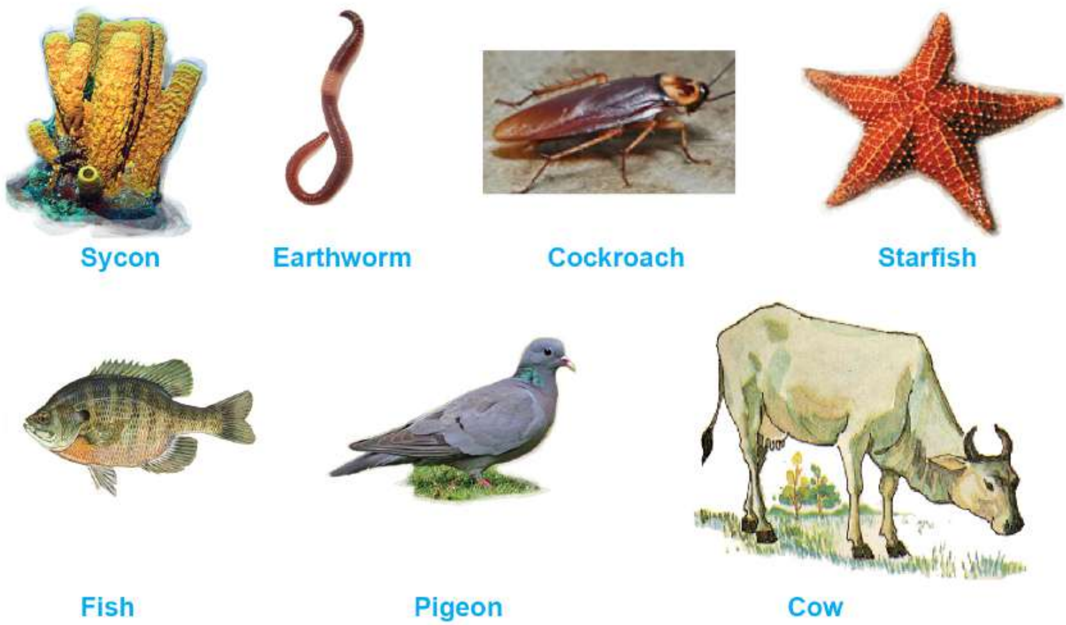


Figure 2.12

i. Which kingdom do these animals belong to?

ii. Do they have cell wall in their cells?

iii. Which animals have a vertebral column?

iv. What differences are found in starfish and fish?

v. What is the reason for placing all these animals in one kingdom?

All these animals have body made up of eukaryotic cells without cell walls. These animals are heterotrophs. Sycon, earthworms, cockroaches and starfishes have no vertebral column or backbone.But fish,pigeons, and cows have a vertebral column in their body. Various types of animals are found in this kingdom. These animals differ in their body structure, shape, forms, etc. Some animals possess an endoskeleton, while some animals' bodies are covered by hard exoskeletons.

Body structure is simple in some animals while all the systems are developed in the body of some animals. Some animals under this kingdom have no vertebral column in their body. They are called invertebrates. Animals having vertebral column are called vertebrates. According to the five kingdom system, among the animals in kingdom Animalia, the animals withouta vertebral column are classified into eight phyla: Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Annelida, Arthropoda, Mollusca, and Echinodermata. Animals with a notochord and vertebral column are classified under the phylum Chordata. Hence, there are altogether nine phyla in the kingdom Animalia.

Porifera

Look at the pictures of animals given below and discuss:

Spongilla

Sycon

Euspongia

Figure 2.13

i. Where can these organisms be found?

ii. How can they perform nutrition and excretion?

iii. How do they move from one place to another place?

Spongilla, Sycon, and Euspongia in the figure are multicellular organisms. They are found in marine water (sea). They have pores in their body. Water enters and exits the body through these pores. So these animals are kept in phylum Porifera. These animals are also called poriferans or sponges. They are found attached on the substratum.

General characteristics of animals under this phylum are given below:

a. They are the first multicellular organisms.

b. Tissue is not developed in these organisms.

c. Their body develops from two germ layers in the embryonic stage and hence, they are called diploblastic animals.

d. They have pores in their body in which a larger pore is called osculum and smaller pores are called ostia. Water enters the body through ostia and exits through osculum which is called water canal system.

e. They respire through the general body surface.

f. Their adult forms are found attached to substratum.

g. They have high regeneration capacity. When their body splits accidentally into pieces, each piece give rise to a new individual.

h. They reproduce both asexually and sexually. Asexual reproduction takes place by budding and regeneration, and sexual reproduction takes place by the formation of gametes.

i. Their bodiesare radially symmetrical in some forms i.e. body is divisible into equal halves by any one of many longitudinal planes. They are mostly asymmetrical.

Animals such as Sponge, Leucosolenia, Hylonema, Cliona, etc., are grouped under this phylum.

Coelenterata

Look at the pictures of animals given below and make discussions:

fig 2.14

i. What may be the function of appendages or outgrowths arising from the body of these animals?

ii. How do these animals obtain their food?

iii. What is the structure of the body of these animals?

The appendages or outgrowths arising from the body of Hydra, Coral, and Jellyfish shown in the picture are called tentacles. Tentacles help in feeding and movement. They have an internal hollow cavity in their body which is called coelenterons, and hence they are kept in the phylum coelenterata. General characteristics of the organisms under this phylum are given below:

a. Animals in this phylum are multicellular and diploblastic.

b. They are the first tissue graded animals.They have an empty vessel-like hollow cavity inside the body called coelenteron. Coelenteron is also called gastrovascular cavity since it performs the functions of both digestion and transportation.

c. They have a single opening of the alimentary canal, which is called the mouth. The mouth is surrounded by tentacles. Their feeding and locomotion take place by tentacles. Tentacles contain stinging cells or nematocysts which help to sting/kill and capture the prey.

d. They respire through the general body surface.

e. They reproduce both sexually and asexually. Asexual reproduction takes place by budding and regeneration method.

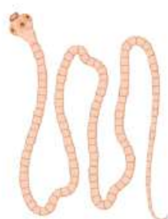
f. They are found in ponds, lakes, and seas.

g. Their bodies show radial symmetry.

Example: Hydra, Coral, Jellyfish, etc.

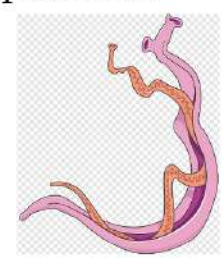
Platyhelminthes

Observe the picture given below. If possible, Search the internet about these animals and discuss the following questions:



Tapeworm

Liverfluke



Bloodfluke

Figure 2.15

i. What is the structure of the body of these animals?

ii. Do they have a developed organ system?

iii. Where are these organisms found?

iv. What is their mode of nutrition?

The body of animals such as tapeworms, liverflukes, blood flukes shown in the picture is like the tape or flat leaf. Animals belonging to this group are mostly parasites. They get shelter in the bodies of other animals. These animals are classified under the phylum platyhelminthes. 'Platy' means flat and 'helminthes' means worms. Their general characteristics are:

a. Shape of their body is flat leaf-like or long ribbon-like and hence they are called flatworms.

b. Their body is developed from three germ layers in the embryonic stage. So, they are triploblastic animals.

c. At the anterior and ventral surface of their body lies mouth, but these animals are without anus. The mouth is surrounded by hooks thathelp them to attach to the host.

d. A sucker is found around the mouth that helps to attach and absorb blood and nutrients from the host.

e. They do not have well-developed organ system.

f. The space between the body wall and internal organs is filled up with parenchyma tissue. It helps in transportation. There is no circulatory system.

g. They respire through their general body surface.

h. They have male and female reproductive organs in the same body, and hence they are called hermaphrodite or bisexual animals. Fertilization is internal.

i. They reproduce both sexually and asexually. Asexual reproduction takes place by fragmentation and regeneration.

j. They are mostly parasites and a few are free-living.

Examples: Liverfluke, Tapeworm, Diplozoon, Otoplana, Blood fluke, Planaria etc.

Nemathelminthes

Look at the picture given below and discuss the following questions.

Round worm *Hook worm* *Pinworm*

Figure 2.16

i. Have you ever had roundworm (Ascaris) in your abdomen?

ii. Whatis the structure of roundworm like?

iii. Where are hookworms and pinworms found?

iv. Do these animals harm the human body?

Ascaris, hookworms, and pinworms are parasites. They suck blood from humans and other animals. Their bodiesare long, cylindrical and wormlike. They belong to Nemathelminthes. The characteristics of animals in this phylum are as follow:

a. Animals under this phylum have elongated and cylindrical body with tapering ends.

b. Their bodies can be divided into two equal halves which is called bilaterally symmetrical.

c. They are triploblastic.

d. They have a developed digestive system with mouth, anus, and sucker.

e. Their respiratory system and circulatory systems are absent.

f. They respire though theirgeneral body surface.

g. They are unisexual.

h. They reproduce by sexual methods only. Fertilization is internal.

i. They are mostly parasites. Few are free-living organisms. Parasites cause disease in the body of other animals.

Example: Ascaris, Hook worm, Pinworm, etc.

Annelida

Activity 2.7

Objective: To identify the characteristics of phylum Annelida

Materials required: Earthworm, needle, forceps

Method

i. Take an earthworm. Observe its structure thoroughly.

ii. Note its characteristics.

iii. For more information, search about earthworm inthe internet and note the features.

iv. Draw a neat diagram of earthworm on chart paper.

v. Paste the chartpaper on the board and discuss characteristics of earthworm.

vi. After the discussion, prepare a list of characteristics of phylum Annelida based on the study of earthworm.

Observe the picture of animals below and discuss their features.

Figure 2.17

Animals such as earthworm, leech and Nereis are found in swampy or moist lands. Their bodies are elongated, cylindrical, and metamerically segmented. Earthwormsare free-living and are found in moist soil. Leeches are ectoparasites, that are found in swamps. They suck blood from vertebrates. All these animals belong to the phylum Annelida. Characteristics of animals of this phylum are given below:

a. Their body is elongated, cylindrical and segmented both externally and internally.

b. The body is bilaterally symmetrical and triploblastic.

c. They have moist skin.

d. They respire through their outer body surface.

e. Excretion takes place through nephridia.

f. The circulatory system is well-developed. Haemoglobin is found in their blood.

g. The nervous system consists of a nerve ring and nerve cord with nerves.

h. The digestive system is well-developed.

i. Some of them are hermaphrodite and some are unisexual.

j. They have a high regeneration capacity.

k. They are found in moist lands, water, and some of them are ectoparasites.

Examples: earthworms, leeches, Nereis, etc.

Arthropoda

Look at the animals shown in figure or if possible, observe the specimens and discuss.

Butterfly *Crab* *Prawn* *Spider* *Centipede*

Figure 2.18

i. What are the similarities in the body structure of these animals?

ii. Where are these animals found?

iii. What is the outer covering of their body made up of?

iv. Why are these animals kept in phylum Arthropoda?

Butterflies fly from a flower to another with the help wings. Centipedes have many legs, prawns and crabs live in water. They have jointed legs. So, these animals belong to phylum arthropoda. This phylum is the largest one in the animal kingdom. Animals in this phylum have following characteristics:

a. Their body is externally covered by a hard covering called exoskeleton which is made up of chitin.

b. The body is bilaterally symmetrical, triploblastic, and segmented.

c. Their body is divisible into the head, thorax, and abdomen. In some forms, the head and thorax arefused and called cephalothorax. The head bears a pair of compound eyes, paired antennae and mouth parts.

d. Legs are jointed and arising from thorax.

e. Generally, insects have two pairs of wings. But one pair of wings is present in some arthropods or sometimes wings are absent.

f. Male and female are separate. They perform sexual reproduction.

g. They breathe through their body surface,gills, or trachea. They are found in all types habitats like air water and land.

Examples: butterfly, bee, centipede, millipede, crab, spider, prawn, housefly, etc.

Mollusca

Look at the animals shown in figure or if possible, observe the specimens and discuss.

Slug *Snail* *Cuttle fish* *Octopus*

fig 2.19

i. What is the function of the hard cover in the bodies of these animals?

ii. How do these animals sense the presence of anenemy and hide themselves inside the covering?

iii. How do they move?

iv. Can their body be divided into two equal halves?

Slug and snail are found in damp soil. Octopus and cuttlefish are found in marine water. They have tentacles in their head. Tentacles are sensory in function and are used to detect surrounding stimuli. They also have muscular feet which are used for locomotion. So, these animals are grouped under the phylum Mollusca.

Following are the characteristics of this phylum:

a. They are soft-bodied animals.

b. Their body is divided into head, visceral mass, muscular feet, and mantle.

c. Most of their body is covered with an exoskeleton made of calcium. They hide their body inside the hard exoskeleton when they touch an object.

d. The head bears tentacles and eyes.

e. Their body is asymmetrical which means body cannot be divided into equal halves by any means.

f. Muscular feet help in swimming in water or gliding on the surface.

g. They respire through the body surface, gills or pulmonary sac.

h. The digestive system, circulatory system, and nervous system are developed.

i. They are usually unisexual, but few are hermaphrodite or bisexual.

They are found in both land and water. Examples: slug, snail, octopus, cuttlefish, unio, etc.

Echinodermata

Starfish *Sea cucumber* *Sea urchin*

Figure 2.20

Animals shown in the picture are spiny skinned. They belong to the phylum echinodermata. Following are the characteristics of animals under this phylum:

a. Their body is externally covered by hard calcareous (made ofcalcium carbonate) spines.

b. Animals are of various shapes like globular, star-like, elongated and spherical.

c. They do not have distinct head.

d. They are triploblastic and radially symmetrical animals.

e. They move with the help of tube feet.

f. The digestive system is developed.

g. They respire through gills.

h. They are unisexual.

i. These animals reproduce sexually.

j. Regeneration is common in them.

k. All the animals in this phylum are found in marine water or sea water.

Example: Starfish, Sea urchin, Sea cucumber, etc.

Project work 2.2 Collection and classification of animals

With the help of your teacher, form groups of students and collect small animals found around your school. Adopt precautions while collecting the animals. Follow the teacher's instructions. Carefully observe the collected animals. Classify them on the basis of external feature into different phyla. Prepare a report on it and present in the class room.

Phylum: Chordata

This phylum consists of the most advanced animals of animal kingdom. All animals bearing a notochord are classified in the Chordata phylum. Animals belonging to this phylum have the following characteristics:

a. They have a developed, elastic, rod-like notochord between the nerve cord and alimentary canal at any stage of life.

b. Paired lateral gill openings are situated on both sides of pharynx in the embryonic stage.

c. A hollow, tubular nervous tissue is found in the vertebral canal.

d. The skeleton is covered with muscles.

e. They have a closed circulatory system.

Phylum Chordata is divided into four sub-phyla. They are Hemichordata, Urochordata, Cephalochordata, and Vertebrata. The first three subphyla arecollectively called Protochordata since animals belonging to these subphyla are more primitive than the animals in Vertebrata. Here, we are going to discuss sub-phylum Vertebrata only.

Sub-phylum vertebrata

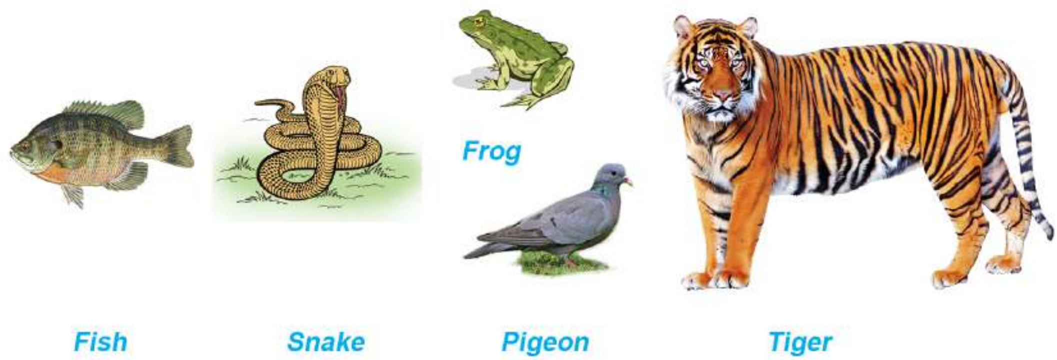


Figure 2.21

All the animals shown in picture have backbone or vertebral column. Animals having vertebral column are called vertebrates. Notochord developed in the embryonic stage of these animals is later replaced by vertebral column.

Fish, frog, snake, pigeon, whale, Bat, etc. are under the subphylum vertebrata. They have mostly similar features, however very few features are not common. Animals belonging to this sub-phylum have the following features:

a. Their body is bilaterally symmetrical.

b. The respiration takes place through gills or moist skin or lungs.

c. The body temperature of some animals which are called poikilothermic or cold blooded animals, changes according to the surrounding environment.

d. The body temperature of some animals which are called homeothermic or warm blooded animals does not change according to the surrounding environment. They maintain their body temperature slightly higher than that of environment.

e. They have well developed circulatory system. Number of heart chambers range from two to four.

f. Some animals called oviparous give birth to their young ones by laying eggs while some animals called viviparous directly give birth to their young ones.

Based on their physical structure and development, animals in sub-phylum vertebrata are divided into five classes: pisces, amphibian, reptilia, aves, and mammalia.

Pisces

Activity 2.8: Observation of the fish

Objective:To identify the characteristics of Pisces

Materials required: fish, chart paper

Method

i. Take a fish.

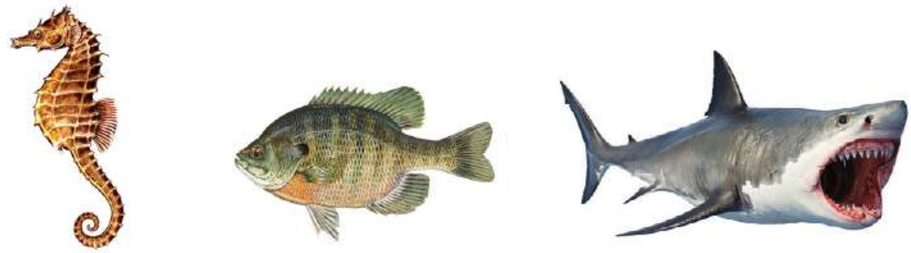
ii. Observe its structure in detail.

iii. With the help of your teacher, identifyit's all organs.

iv. Note its characteristics based on your observation.

v. Draw a neat and labelled diagram of fish on chart paper.

vi. On the basis of thestudy of fish, discuss the characteristics of pisces.



Sea horse Fish Shark

Figure 2.22

Animals shown in the picture belong to the class pisces. General characteristics of these animals are given follow:

a. Their body is elongated, flat, and streamlined. Their bodies are covered by scales.

b. Their body is divisible into head, trunk, and tail. The neck is absent.

c. Gills are found on the lateral side of head. They help in respiration.

d. They have paired and unpaired fins for locomotion.

e. They have air sacs in their body.

f. Their heart is two-chambered.

g. These animals are poikilothermic.

h. They are unisexual animals.

i. They are mostly oviparous but few are viviparous.

j. Most fishes perform external fertilization but internal fertilization is found in some fishes like sharks.

i. They live in water. All fishes, sea horse, etc.belong tothis class.

Amphibia

Activity 2.9 Observation of the frog

Objective: To identify the characteristics of amphibians

Material: Frog

Method

i. Take a frog.

ii. Observe its external structure thoroughly.

iii. With the help of the teacher, identify it's all organs.

iv. Note its characteristics based on your observation.

v. On the basis of observation of the frog, discuss the characteristics ofamphibia.

Conclusion

Toad

Frog

Salamander

Fig.2.23

Toads, salamanders, and frogs live on land and water both. They belong to the class Amphibia. The characteristics of animals in this class are given below:

a. Their body is covered by moist skin.

b. Their body is divided into head and trunk. Tail is found in some amphibians.

c. They have two pairs of limbs.

d. They are poikilothermic.

e. Their young ones are tadpoles that respire through gills. Adult forms respire through lungs and moist skin.

f. They have a three-chambered heart.

g. They are unisexual.

h. These are oviparous and lay eggs in water. Fertilization is external.

i. They need water for reproduction. Examples: frogs, toads, and salamanders,etc.

Reptilia

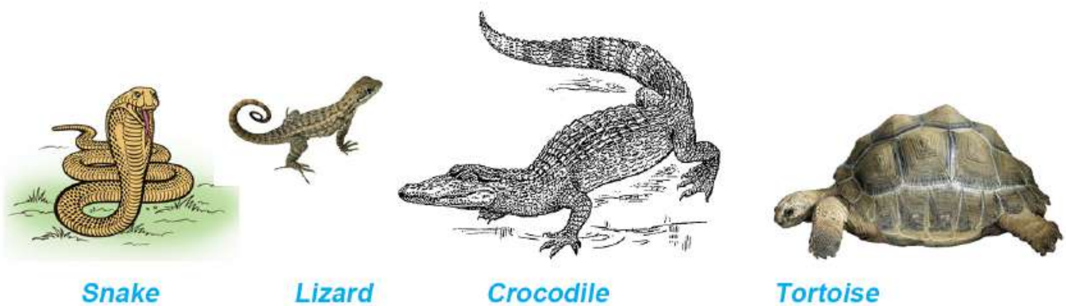


Figure 2.24

Animals such as snake, lizard, crocodile, tortoise, etc. crawl on the ground. So they are grouped in the class reptilia. Animals in this class have following characteristics:

a. Their bodies are covered with dry and horny scales.

b. Their bodiesare divided into four parts: head, neck, trunk, and tail.

c. They have two pairs of limbs which crawl on the ground for locomotion.

d. These animals are poikilothermic.

e. They respire through lungs.

f. They have a three-chambered heart. But crocodiles havea four-chambered heart.

g. They are unisexual. Fertilization is internal and they are oviparous.

h. They are mostly found on land although some of them live in both land and water. The aquatic ones come to the surface of water for respiration.

Example: snake, garden-lizard, wall-lizard, crocodile, tortoise, etc.

Aves

Figure 2.25

Fore limbs are modified into wings in parrot, lophophorus, peacock,duck, hen, etc. They have a beak. Their bodies are covered with feathers. So, these animals are grouped under the class aves. Their general features are given below:

i. Their body is covered with feathers.

ii. Body is divisible into head, neck, trunk, and tail.

iii. They have two pairs of limbs in which the forelimb is modified into wings and the hind limbs are used for walking.

iv. They have hollow pneumatic bones in their bodies which make their bodies lighter for flying.

v. These animals are homoeothermic.

vi. They breathe through lungs.

vii. They have a four-chambered heart.

viii. They are unisexual. Fertilization is internal and they are oviparous.

ix. These animals have air sacs inside their bodies. They live on land, and they can fly. Example: parrot, lophophorus, peacock, duck, hen, etc.

Mammalia

Whale *bat* *rat* *Lion*

Figure 2.26

Animals shown in the picture such as rat, bat, lion etc., have body covered with hair. They give birth directly to young ones and suckle milk to their babies. All of them belong to the class mammalia. Animals under this class have following characteristics:

a. Their body is covered with hair.

b. Generally, their body is divided into head, neck, trunk, and tail.

c. They have developed mammary glands.

d. They breathe through lungs.

e. These are homeothermic.

f. They have a four-chambered heart.

g. They are unisexual. Fertilization is internal. They are viviparous.

Human, horse, whale, cow, etc., belong to this class.

Activity 2.10: Study of museum specimen of animals

Objective: To classify and identify the characteristics of animals

Material required: Specimens of animals in the science laboratory

Method

i. Observe various animal specimen in the science laboratory.

ii. Study their features.

iii. Classify these animals on the basis of their features.

iv. Prepare an animal classification chart on a chart paper. Fill in the chart with the name of the animals you observed.

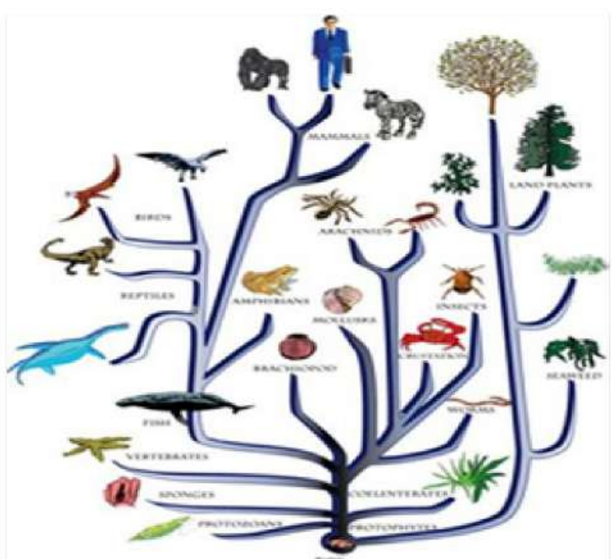


Fig. 2.27 Evolution of organism and classification

Relation of classification of living beings and evolution

Look at the given picture and discuss the following questions.

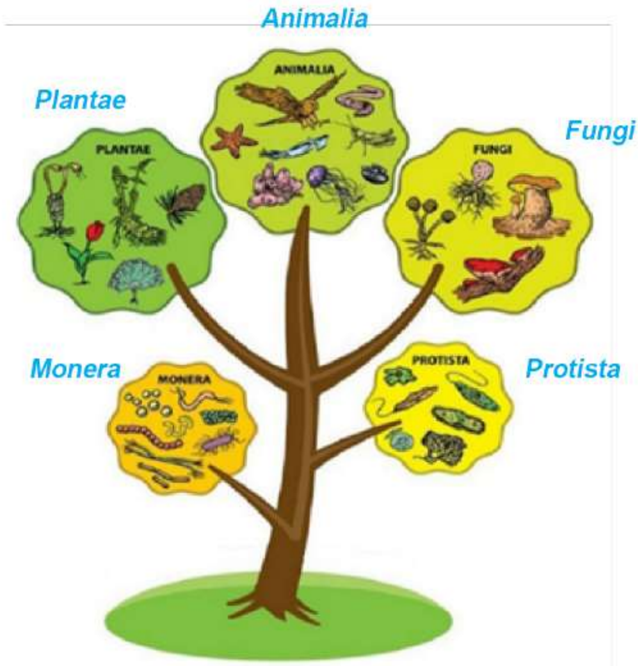


Figure 2.28 Classification of living being

i. Which organisms do you think evolved earlier among the organisms under the protists and the organisms under the monerans?

ii. The five kingdoms are shown in the tree diagram. Discus the relationship between the evolution and classification of living beings based on the given diagram.

When we study the basis of five kingdom classification, some kingdoms have many common features but a few of them have less common features. It indicates that all livings beings have a common ancestry. Here, the common characteristics of all living beings is that their body is developed from a living cell.

Classification of living beings shows that prokaryotic organisms evolved first on the Earth, which are now in the kingdom Monera. Then, eukaryotic organisms evolved slowly, which are now in the Protista kingdom. During the courseof evolution, other multicellular organisms like fungi, plants, and animals developed gradually.

Classification of living beings and evolution are separate disciplines of biology. Classification of living beings is the process of grouping them on the basis of their similarities and differences. Similarly, evolution is the process of gradual change of living beings from a simpler to a more complex form. Those animals which have many common features are kept in the same group in the classification of living beings.When we compare the animals of class Mammalia and Aves, they have a few common features. When we compare the animals of class Mammalia and Pisces, they have very few common features. It indicates that animals belonging to mammals under went speciation from the same ancestor some years ago.

When we observe the animals within group vertebrata, pisces have two-chambered heart. Reptiles have three-chambered heart but aves and mammals have a four-chambered heart. It also indicates that advanced animals developed from less developed animals. Classification of living beings is possible because of such differences in the organisms.

What we know from the common features in pisces, aves and mammals is that the organisms belonging to these three classes evolved from the same ancestor many years ago. During the course of evolution, they developed new characteristics and, in this way, new organisms were formed. Here, aves arecloser to mammalia than pisces. This means thataves and mammals appear to have diverged from a common ancestor only a few years earlier than pisces. Common features of pisces, mammalia and aves indicate that they were developed from a distant common ancestor. In this way, if we study the characteristics of various phyla in the animal kingdom, we can find some similarities among them. It proves that all the organisms of the animal kingdom have common ancestry. In course of evolution, they advanced into various new forms.

Project work 2.3 Study the relationship between classification of living beings and evolution

Take a classification chart of living beings. Study the basis of classification in detail. Discuss with your friends the characteristics of animals of different groups in the chart. Identify their similarities and differences. Take the help of teacher and internet, if required. Based on your findings, prepare a short report on the relation between classification of living beings and evolution. If possible, prepare a powerpoint presentation of the report and present it to the class.

Exercise

1. Choose the correct options for the questions below.

a. What are the main features of organisms under kingdom plantae?

   i. Eukaryotic cell, cell with cell wall, heterotrophs

   ii. Eukaryotic cell, cell without cell wall, heterotrophs

   iii. Eukaryotic cell, cell with cell wall, autotrophs

   iv. Eukaryotic cell, cell with cell wall, saprotrophs

b. Why is Cycas kept in gymnosperm?

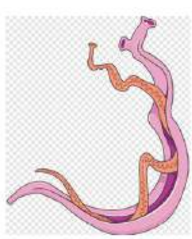
   i. Bears flowers, produces seed.

   ii. Bears flowers, leaves are needle-like.

   iii. Bears cones instead of flowers, seeds are naked without fruit.

   iv. Bears cones instead of flowers, seedsare enclosed in fruit.

c. Two animals are shown here in figure. They belong to the same kingdom. Look at the figure and write the main reason for grouping them under the same kingdom.



   i. Multicellular and have various organ systems

   ii. Multicellular and heterotrophic

   iii. Multicellular and parasitic

   iv. Multicellular and oviparous

d. Based on evolution, which of the following groups of organisms are closely related?

   i. Porifera, Annelida, Chordata
   ii. Porifera, Arthropoda, Chordata
   iii. Coelenterata, Arthropoda, Chordata
   iv. Platyhelminthes, Nemathelminthes, Annelida

e. What is the main reason for classifying whales in the class mammalia?

   i. Respires through lungs
   ii. Vertebral column is found in the body
   iii. Viviparous
   iv. Gives birth and suckle milk to young ones

f. Why are club mosses more advanced than the mosses?

   i. Clubmoss grows on the land.
   ii. Clubmoss is sporophyte.
   iii. Xylem and phloem tissue are found in clubmoss.
   iv. Sporophyte is dominant in alternation of generation.

g. To which kingdom do organisms having cell walls belong?

   i. monera, fungi, animalia
   ii. fungi, plantae, protista
   iii. fungi, plantae, animalia
   iv. fungi, plantae, monera

h. To which class do egg-laying animals with a four-chambered heart and body covered with feather belong?

   i. Mammalia
   ii. Reptilia
   iii. Aves
   iv. Amphibia

i. Which of the following group of plants belong to angiosperm?

    i. pinus, fern, pea
    ii. juniper, maize, gram
    iii. moss, maize,bean
    iv. paddy, banana, mango

j. Which division do the plants having vascular tissue belong to?

    i. Sporophyta
    ii. Gametophyta
    iii. Tracheophyta
    iv. Spermatophyta

2. Differentiate:

a. Plant kingdom and animal kingdom
b. Fish and star fish
c. Jelly fish and cuttle fish
d. Moss and club moss
e. Pinus and peepal
f. Fish and whale
g. Dove and Bat

3. Give reason:

a. Living beings need to be classified.

b. Fucus and Marchantia look alike, but Fucus is classified as algae while Marchantia is classified as bryophyta.

c. Gymnosperms do not bear fruit.

d. Although a crocodile has a four-chambered heart, it belongs to the reptilian class.

e. Although bats and whales have dissimilar characteristics, they belong to the same class.

f. Riccia is an amphibian plant.

g. Fern is not a flowering plant; Cycas bears flower like cone but no fruit; banana bears flower and fruit. However, all these plants are kept in the same division.

4. Answer the following questions.

a. Into how many divisions are the organisms in plant kingdom divided?

b. Write the main features of kingdom plantae.

c. Write the similarities of plants which belong to gymnosperm and angiosperm.

d. If you are given only the leaves of some plants in tracheophyta and asked to distinguish their subdivisions using the taxonomic knowledge you have acquired in class. Is it possible to do so? Give your arguments.

e. What are the main characteristics of pteridophyta?

f. Roshni observed only the flowers of new plant in her garden and concluded that the plant belongs to monocotyledon. Is observation of only the flowers a right way to identify monocotyledon? Give reasons.

g. Two plants are shown in the picture. Observe both pictures and answer the following questions:

i. Compare and write their similarities and differences.

ii. Mention their subdivisions. Also write the reason for placing them in these subdivisions.

iii. Which one of them is more advanced? Clarify with reasons.

h. Following chart shows the group of four animals. In which group does fish belong to?

	terestrial	*aquatic*
invertebrates	A	B
vertebrates	C	D

i. Digestive system is not developed in the animals of phylum porifera. How do they digest food? Write.

j. Rakesh saw an animal while he was playing in the ground. How can he identify the phylum of that animal by using taxonomic knowledge of kingdom Animalia? Explain.

k. Shark and whale both live in water. Based on their features, which is more developed animal? Explain with reasons.

l. Pictures of two animals are shown below, compare them and answer the following questions:

i. In which phylum and class do they belong ?

ii. Write any two similarities and dissimilarities between them.

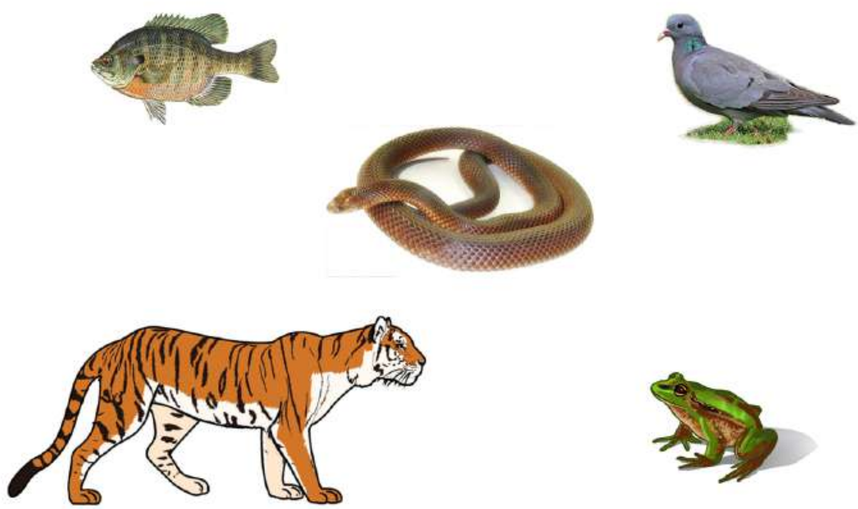
iii. How does the study of these animals clarify the concept of evolution?

m. Explain the relation between classification of living beings and evolution.

n. Draw a chart to show classification of kingdom plantae according to five kingdom system.

o. Draw a chart to show classification of kingdom animalia according to five kingdom system.

p. Look at the picture below and answer the following questions:



i. Which animal has a two-chambered heart?

ii. Which animal suckles milk to its young?

iii. Write any two similarities between frogs and snakes.

iv. Which of these animals have air sacs in their bodies?

3

Honey Bee

Observe the picture given below and discuss:

Figure 3.1 Bee hive

i. What type of hive is shown in the picture?

ii. Should humans make hives for bees?

iii. What type of animal is a bee?

Let's study the event

Sanumaya was watering the flowers in her garden. At that time, her attention was drawn to the buzzing sound of some insects. She began to look carefully to see why those insects had been buzzing. Then, she noticed that those insects were honey bees. They were flying and sucking nectar from flowers. Sanumaya looked the bees attentively for some time. She saw that the bees were sitting on flowers for a while before flying away. She tried to find out where they were going, and after following, She saw the bees were sitting in a hive made in a nearby tree. Although from a little distance, she also observed the hive and saw various types of bees there.

Have you ever seen a beehive in your home or locality? Based on your experience or the aforementioned event, discuss the following questions:

i. What do honeybees feed on to survive?

ii. Are all the bees of same type in a beehive?

iii. What lessons can be learned from bees?

iv. Do bees help humans only by producing honey, or do they help in other ways too?

A bee is an insect that lives freely in a special type of hive that has made for itself. It belongs to the phylum Arthropoda. While farming honeybees, farmers construct artificial hives for them. Honey beesare social insects living in large colony. There are three types of honey bees called queen, worker, and drone, living in a hive. There is a high level of understanding and discipline among the members of the bee colony. A high degree of division of labour is also found among them. Every member of the bee colony is very disciplined and hardworking, and they keep themselves busy all the time. Honeybees collect pollen and nectar to make honey.

Human beings have been adopting traditional methods of farming bees since ancient times. Since the 20th century, beekeeping has been done not only for the production of honey but also for pollination and for producing wax. Nowadays, modern hives are used for beekeeping as an agricultural business, from which more honey can be produced. Commercial rearing of bees is called apiculture. A separate study of bees is done for farming bees from a business point of view. The science that studies bees is called melittology or apicology which is a branch of entomology (the science of insects).

Activity 3.1 Observation and study of the bee

Objective: Study the physical structure of the bee

Material required: If possible, all types of bees, if not, a video or picture showing the external structure of all bees.

Method

i. Make three groups of students in the classroom.

ii. Take a picture of a bee or watch a video and study its body structure.

iii. Now draw a neat diagram of the bee you observed and note its characteristics.

iv. Present and discuss the findings of each group turn by turn.

Conclusion: Conclude the structure of honey bee based on discussion.

Queen bee

Drone bee

Worker bee

Figure3.2 Types of bee

Generally, the size of a bee ranges from 9 mm to 20 mm in length. Like other insects, their body is divided into head, thorax, and abdomen. They have paired compound eyes, paired antennae and mouth parts in their head. They detect surroundings stimuli by the help of antennae. Compound eyes can see without rotating the head. Thorax consists of three segments. From each segment arise a pair of legs. Legs are jointed, so they are kept in the phylum Arthropoda. The first two segments of the thorax give rise to a pair of wings which help them to fly a far distance. The abdomen consists of 9 segments, but 6 segments are prominent in adult females and 7 segments in adult males.

In a hive, three types of bees are present: queen bee, drone bee and worker bee. Each member has their own characteristics, which is studied here:

Queen bee

The queen bee is the largest sized and elongated bee in the beehive. Its head is smaller and rounded than others. Its proboscis is short and covered with hairs. Sting is present at the end of abdomen. Generally, there is only one queen in the hive. Its main function is to lay eggs. It controls activities of all bees in the hive according to the situation. Its body produces a special scented substance called pheromone. With the help of this, it attracts males for mating. Similarly, pheromones are also used for the communication and to find out the location of hive. A queen bee lives the longest in the hive, about 2-5 years. Worker bees form a new queen by feeding royal jelly to the larva.

Drone bee

The drone bee is smaller than the queen but larger, blackish and hairy than the worker bee. It does not have sting, pollen basket, and wax-producing glands. It is the laziest bee in the hive. It is even fed by worker bees. Its function is to fertilizethe queen bee. Drones are haploid. They have only 16 chromosomes, but the queen and worker are diploid, having 32 chromosomes. Drones are developed from unfertilized eggs. This process is called parthenogenesis. They only survive for about two months.

Worker bee

They are the smallest size bee in the hive. They have a special body structure. Mouthparts are chewing and lapping type.

Worker bees are extremely hardworking. Their legs are densely covered withhair. Legs also possess pollen baskets. They collect pollen in the pollen basket and transport to the hive. The function of worker bees includes collecting nectar, constructing the hive, nursing young ones,protecting the hive, etc. About 20,000-80,000 worker bees can be found in a hive. Life span of worker bees is about 6 weeks to 6 months.

Question to think: Why do bee stings cause swelling?

Life cycle of honey bee

Activity 3.2 Observation and study of the life cycle of the honey bee

Materials required: Video or picture showing life cycle of the honey bee, clay, metacard, etc.

Method

i. Divide the class into four groups.

ii. Watch the video of honey bee.

iii. Study thoroughly and each group discuss one of the stages (egg, larva, pupa and adult) of life cycle of bee. Draw a picture on the metacard and note the characteristics. Also prepare a model of the life cycle of the honey bee using clay.

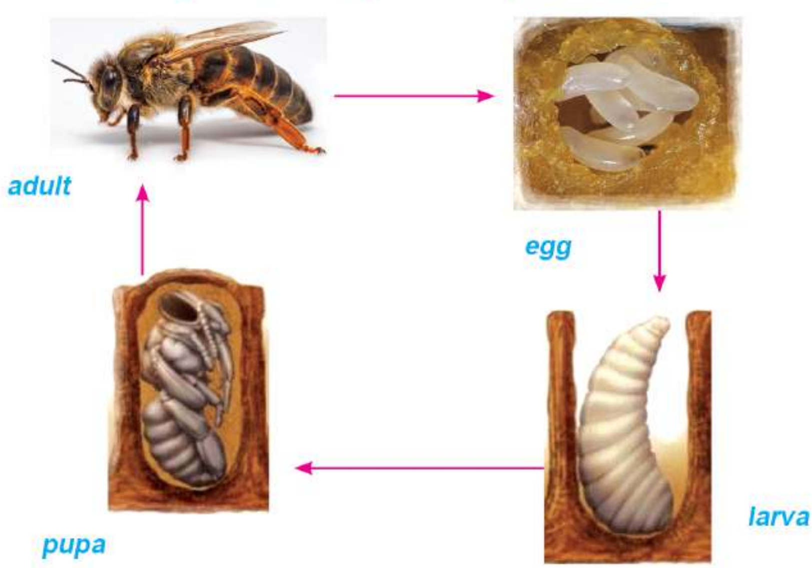
iv. Paste the metacard and model prepared by each group on the board in sequential order. Present and discuss each stage in turn.

Conclusion: Conclude the discussion on life cycle of the honey bee based on the presentation.

All bees complete their life cycle in four stages- egg, larva, pupa, and adult. The duration of these stages varies according to the types of bees. To complete the life cycle, there occur two events- histolysis (degeneration of old tissues) and histogenesis (the formation of new tissues) in the larva and pupa. Because of these events, there is transformation of egg into larva, larva into pupa, and pupa into adult. This process is called complete metamorphosis.

When there is an excess number of worker bees in a hive, the queen bee forms a new colony with a number of worker bees and eventually leaves the hive. Worker bees construct new hive. The worker bees in the old hive prepare a new queen by feeding a larva developed from a fertilized egg only with royal jelly. When the queen bee becomes adult, she leaves for the nuptial flight or mating flight. Usually, the queen bee leaves for the mating flight in the evening. When the queen bee leaves hive then she is followed by a group of drones. Queen bee mates with many drones. After mating, drones die. Queen bees receive sperms from drones which are used to fertilize millions of eggs. The structures used to store sperm in the body of the queen are called spermathecae. Drones die after mating because their genital organs are forcibly pulled during mating. After 2-3 days of mating, the queen bee starts laying eggs in the brood cell.

Figure 3.3 Life cycle of honey bee



Egg

The eggs of honey bee are white and elongated. Each egg lies erect within the brood cell on the first day, slanted on the second day, and horizontal on the third day. The queen bee lays eggs in drone cells to make drones, queen cells to make queens and worker cells to make workers. She can lay eggs up to 3,000 per day under favourable conditions. The number of eggs varies with the types of bees. The duration of an egg for all bees is three days. The size of an egg ranges from 1 mm to 1.5 mm. There are two types of eggs: fertilized and unfertilized. From fertilized eggs develop queen and worker bees. Drones develop from unfertilized eggs.

Larva

After three days of laying eggs, the eggs hatch into larvae.The larval stage lasts for about 5.5 days for queens, about 6 days for workers,and about 7 days for drones. The larva actively feeds in this stage. The larvae of future queens and drones are larger than the larvae of future workers. Queen and worker bees are both females developed from fertilized eggs. Whether a larva will be developed into a queen bee or a worker bee depends upon the type of food fed to the larvae. All larvae are fed royal jelly for three days. After that, the food type is changed according to the types of bee. The larvae that will become queen bees in the future continuously feed on nutritious royal jelly, but the larvae of future workers and drones feed on beebread after three days. Honey bread or bee bread is the mixture of honey and pollen. The larva moults for five times. As the food fed to the larvae is different, the duration of their developmental stage is also different.

Pupa

The pupa is an inactive phase in the life cycle of the bee in which it does not feed or move, but its structural changes are going on. In this phase, three pairs of legs, wings, and mouthparts are developed. The pupal stage lasts for 8 days, 12 days,and 14 days for the queen, the worker, and the drone respectively.

Adult

After many changes, the pupa is transformed into an adult. The mandibles in the mouth of the newly formed adult bee chew the layer of wax sealed to the brood cell and emerge out. After they emerge, worker bees start helping others immediately. They have important tasks in the hive, such ascaring for brood cell, feeding larvae, and protecting the hive.

Figure 3.4 Various stages of bees

Generally, it takes different time period to reach adulthood from an egg. This is given in the following table.

Bee	Egg	Larva	Pupa	Total
Queen bee	3	5.5	7.5	16 day
Worker bee	3	6	12	21 day
drone	3	7	14	24 day

Newly born worker bees work within the hive for about three weeks. Then, the workers are assigned to work outside the hive. Work division of the bee according to their types and age:

S.N.	Type	Age	function
1.	Drone	Throughout the life	Fertilize queen bee and make hive warm.
2.	Queen bee	Throughout the life	Lays eggs and regulates the activities of hive by secreting pheromones.
3.	Worker	1-3 day	Clean the hive and cling to the honey comb to provide warmth to egg larva and pupa
		4-6 days	Feed honey bread to larvae.
		7-11 days	Royal gland is developed in their head to produce royal jelly which is fed to larva and queen.
		12-17 days	Four pair of wax glands are developed in their body, used for making honey comband to seal larval cell and honey cell.
		18-20 days	Sting glands are developed to protect hive.
		After 21 days	Collect nectar, pollen, water, etc.

Let us know

Honey production

Like royal jelly, honey is not produced from a particular gland in the body of a bee. Honey is a combination of monosaccharide sugars, especially fructose and glucose, which is prepared by evaporating as much water as possible from a mixture of different types of flower juice or nectar with the help of natural wind and the wind that blows when the worker bees flap their wings. It is composed of 80-85% carbohydrates, 15-17% water, 0.3% protein, 0.2% amino acids, vitamins, and other constituents. The colour, smell, and effectiveness of honey depend on the type of flowers from which the nectar is collected.

Use of honey bee

Honey bees are beneficial insects for the ecosystem, including human beings. Their benefits can be mentioned in the following points:

a. Human beings are encouraged in various social behaviours by the hardworking nature, division of work, and high level of disciple among honey bees.

b. Highly nutritious honey is produced by bees, which is used in Ayurvedic medicine, candy, cake, bread, etc.

c. While sucking nectar from flowers, pollination is carried out in plants. So honey bees have a role in the production of more crops in agriculture.

d. Beeswax is widely used in cosmetics; for the manufacture of cream, lipstick, candles, etc.

e. Beekeepers can earn a large sum of money if they get knowledge on extraction of royal jelly from the bees.

f. Farmers can earn a lot of money from apiculture which can promote the economy of anation.

Project work: Visit the beekeeping area

Visit the bee keeping area near the school, observe, and inquire about the structure of bees, the life cycle of bees, bee farming, and its importance. Based on this, prepare a short report and discuss it in the class.

Exercise

1. Choose the correct options for the questions below.

a. Which bee contains only 16 chromosomes?

i. Queen bee ii. Worker bee

iii. Drone bee iv. Queen and worker bee

b. From where is royal jelly produced?

i. from the gland at the head of queen bee

ii. from the gland at the head of drone

iii. from the gland at the head of worker bee

iv. from the salivary gland of worker

c. Which bee is formed when the larva is fed royal jelly continuously?

i. queen ii. drone

iii. workers iv. queen and worker bee

d. Which stage of the bee is shown in the given diagram?

i. egg ii. larva

iii. pupa iv. adult

e. Why is honey bee called a social insect?

i. It produces honey.

ii. It helps in pollination in plants.

iii. It lives in colony

iv. It is domesticated insect.

f. When the pollen baskets in the legs of worker bees are broken by certain means, which of the following functions cannot be performedby them?

i. collecting nectar

ii. constructing brood cell

iii. feeding royal jelly tolarva

iv. collecting pollen from flower

g. Which of the following is the characteristic of the drone bee?

i. haploid, sterile, medium sized, hairy

ii. haploid, fertile, medium sized, hairy

iii. diploid, sterile, medium sized, smooth

iv. diploid, fertile, medium sized, hairy

h. Where does the queen bee store the sperms received from the drone bee after the nuptial flight?

i. pollen sac ii. ovary

iii. sperm sac iv. egg sac

2. Differentiate:

a. Drone and worker bee b.Queen bee and worker bee

c. Queen bee and drone

3. Give reason:

a. Honey bee is called social insect.

b. Pasture land is required for bee farming.

c. Drone dies after mating.

d. Bees are multipurpose insects.

4. Answer the following questions:

a. Write the various types of bee found in the hive.

b. What is the function of the drone bee?

c. If the queen bee dies for some reason, who will control the hive?

d. How does the queen bee control other members of the hive?

e. Write the uses of honey.

f. Describe the structure of the queen bee.

g. Mention the functions of the worker bee.

h. Explain how the division of labour occurs in bees.

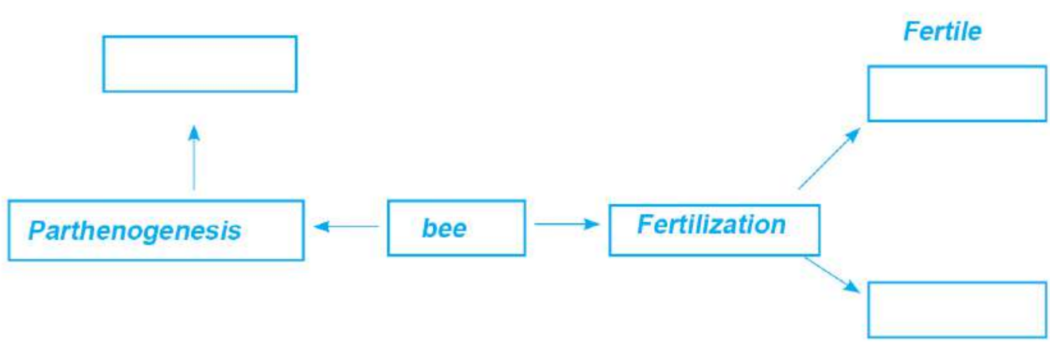
i. Explain the life cycle ofhoney bee with diagram.

j. What is the process called in which a drone is developed froman unfertilized egg?

k. When a farmer practises bee farming, then income of other farmers in that locality also increases. Justify your reason.

l. Due to the problem of pasture land in the beekeeping area, beekeepers shifted the bees from there. After that, there was areduction in the yield of mustard crops of nearby farmers. Based on this, explain the relationship between beekeeping and agricultural production.

m. Look at the concept map and complete it.



4 Heredity

Observe the picture given below and answer the following questions.

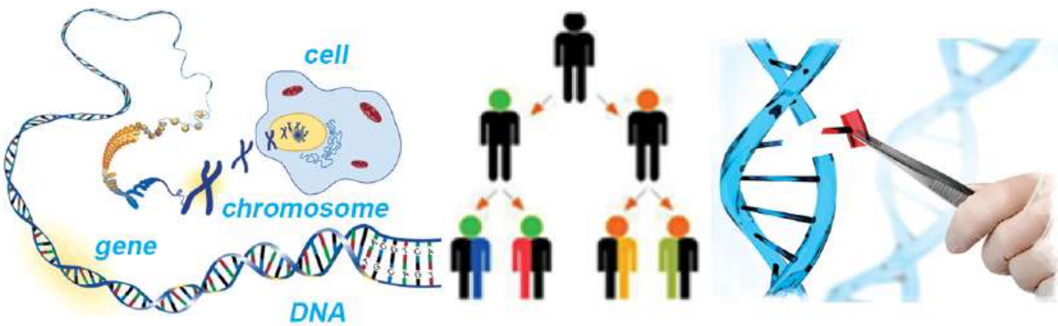


Figure 4.1 Gene, Sex determination, Genetic Technology

i. What are the lines in the nucleus of the cell in the picture above?
ii. What is the secret behind the offspring of living beings resembling their parents?
iii. How does the transmission of parental characters from one generation to another take place in organisms?
iv. How is the number of cells increased in an organism?
v. In the picture above, why is a small fragment of DNA being removed and another piece added?

All living things do not live forever. When organisms become mature, they produce offspring like themselves. In all organisms, characters are passed on from the previous generation to the next generation, so the offspring of all organisms resemble their parents. Chromosomes found in the nucleus of the organism are responsible for this. During cell division, chromosomes replicate and divide to pass into daughter cells. Parental characteristics are transmitted to offspring, and the influence of several other factors, including the environment contributes to the variation in organisms of the same species. Chromosomes determine the characteristics of living beings. The characteristics of living beings depend upon the number of chromosomes and millions of genes present in the chromosomes in an organism. Sex chromosomes have the main role in the determination of sex. Genes present in the chromosome determine the physical characteristics of a living being and also help in the transmission of such characteristics to the next generation. The branch of biology that deals with the study of genes is called genetics.

Mendel founded various laws regarding genetics which made it easier to perform various experiments in this field. Nowadays, various technologies have been developed in genetics. These are proven to be effective in various research works and the daily lives of human beings. The development of genetic engineering has made the reproduction of various animals through artificial means and the development of various hybrid animals possible.

4.1 Cell division

Observe the picture given below and discuss:

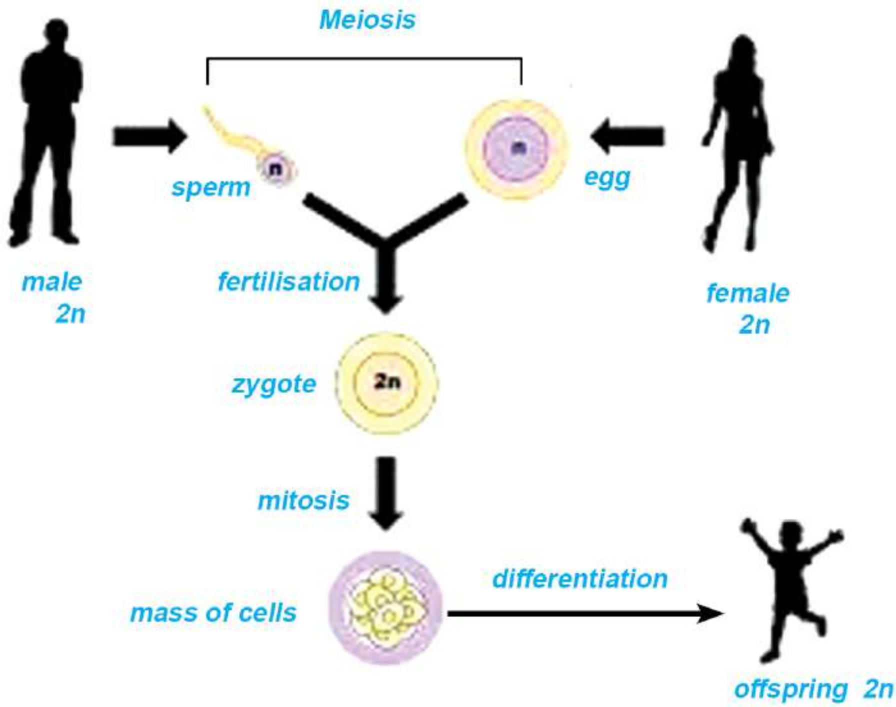


Figure 4.2 Cell division for the growth and development of living beings

Questions for discussion

i. How does the body heal wounds when abody part is injured?

ii. How does a single-cell zygote develop into a giant body?

iii. Are new somatic cells and gametes produced in our body in the same way?

iv. What is the difference between gametes and somatic cells?

It is assumed that prokaryotic cells evolved into eukaryotic cells and unicellular eukaryotic cells slowly evolved into multicellular organisms over time. At the time of sexual reproduction, cells in the male and female reproductive organs undergo meiosis cell division to form gametes. Male and female gametes formed in this way, fuse during mating or copulation to form a zygote. Zygote is single-celled. It gets divided by repeated mitosis cell division to develop into a complete body, which is the combined form of numerous cells. Both mitosis and meiosis cell division are complete in two phases; karyokinesis and cytokinesis. The division of the nucleus is called karyokinesis, followed by the division of cytoplasm along with the cell membrane, which is called cytokinesis. Two daughter cells are formed from a mother cell in a mitosis cell division and four daughter cells are formed in a meiosis cell division. Daughter cells formed at the end of meiosis are gametes, whereas cells formed at the end of mitosis are somatic or vegetative cells.

A. Mitosis cell division

Activity 4.1 The study of mitotic cell division

Objective: To prepare and study the model of mitotic cell division

Materials required: Clay of various colours, woolen thread pieces of different colours, cardboard

Method

i. Take cardboard. Make a shape of a cell on it by using any coloured clay.

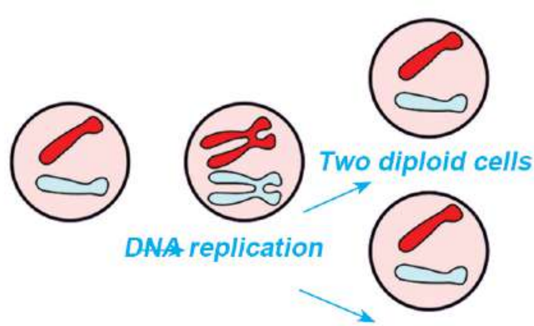


Figure 4.3 Model of mitotic cell division

ii. Use two different coloured threads to represent chromosomes.

iii. Make another cell and show DNA replication as shown in the figure.

iv. Now, show that two separate cells have an equal number of chromosomes, as given in the figure.

v. Paste the prepared mitotic cell division model on the board and discuss it in class. Take the number of cells, number of chromosomes, etc. into consideration while discussing.

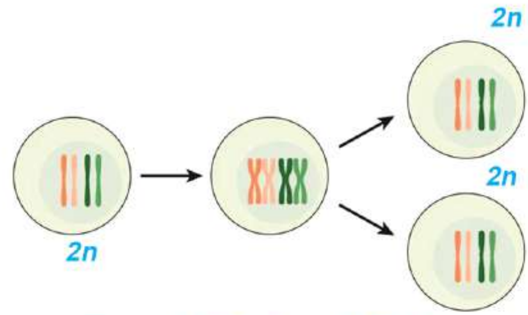


Figure 4.4 Mitotic cell division

Mitotic cell division occurs in all cells of the body except reproductive cells. A cell divides into two daughter cells during mitotic cell division. This type of cell division mainly occurs for the growth, development, and repairing of the tissue of the body. In our body, except for gamete, each cell is diploid containing two sets of chromosomes in which one set is paternal and another set is maternal. Such cells are represented by 2n. Before cell division, DNA in the chromosomes of the nucleus of a cell is replicated and forms two identical copies. At the end of cell division, two identical daughtercells are formed, each havinga copy of the DNA. This is how genetic characteristics found in mother cell are established in daughter cells. So, there is no change in the number of chromosomes in the daughter cells formed by mitotic cell division. Hence, this type of cell division is also called equational division.

Significance of mitotic cell division

a. Mitosis plays a key role in physical growth, as the number of cells with the same genetic makeup increases during cell division.

b. It helps regenerate cells in injured areas, returning them to their original state.

c. It helps in the asexual reproduction of some plants and invertebrates.

d. It maintains genetic stability.

B. Meiotic cell division

Activity 4.2 The study of meiotic cell division

Objective: To prepare and study a model of meiosis cell division.

Material required: Different coloured clay, gum, chart paper, or thermocol sheet.

Method

i. Take a cardboard or thermocol sheet. Make a shape of a cell on it using any coloured clay.

ii. Use different coloured clay to make chromosomes.

iii. Make another cell and show DNA replication as shown in the figure.

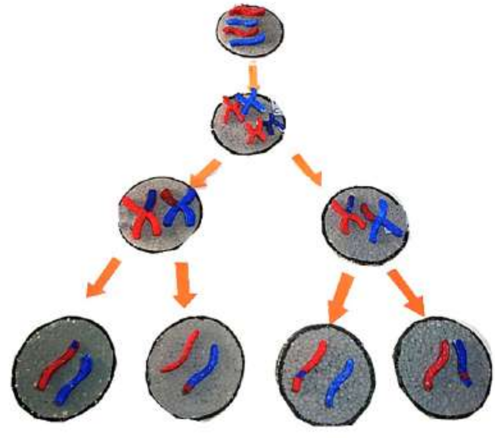


Figure 4.5 Model of meiosis cell division

iv. Make two separate cells with halfof the number of chromosomes and paste them.

v. Now make four cells and make an equal number of chromosomes in each cell as shown in the picture.

vi. Paste the prepared meiotic cell division model on the board and discuss it in class. Consider new numbers of cells, changes in chromosome numbers, etc. while discussing it.

This type of cell division is only confined to the mother cells of major reproductive organs, i.e., the testis and ovary. In this cell division, one diploid mother cell divides to form four haploid daughter cells or gametes. A haploid cell is a cell in which the chromosome number is reduced to half that of the mother cell. In meiosis, there is a slight variation in the genetic makeup of the daughter cells produced from the mother cell. This cell division completes in two phases.

During the first phase, an exchange of genetic materials occurs between two non-sister chromosomes through crossing over,and due to this phenomenon; the genetic makeup of each chromosome changes. Afterward, they become separate and get organized into two haploid nuclei. So, karyokinesis is the division of a nucleus into two. Then, it is followed by cytokinesis to form two haploid cells. In the second phase, mitotic cell division of these haploid cells occurs, first through karyokinesis and then cytokinesis. Finally, four cells are formed at the end of meiotic cell division. Variation in the genetic makeupof these cells is found due to crossing over in the first phase of meiosis. This division is also called reductional cell division because chromosome number is reduced to half in the daughter cells. Meiotic cell division occurs in the testes of adult males and ovaries of adult females to form gametes needed for sexual reproduction. During sexual reproduction, the male gamete fuses with the female gamete to form a diploid zygote.The mitosis cell division of the zygote forms the whole body of an organism.

Question to think

Why are the face, body structure, and behaviours of the children born from the same parents not exactly the same?

Significance of meiotic cell division

1. Meiotic cell division plays amain role in the sexual reproduction of organisms.
2. It helps in evolution by bringing variation.
3. It helps to repair chromosomal disorders.

Activity 4.3

Make a list of differences between mitosis and meiosis on a chart paper or prepare Power Point slides and present them in the class.

Objective: To study the differences between mitotic and meiotic cell divisions

Materials required: Chart paper, different colours

Based on the information obtained above and by observing the activity 4.2 and 4.1, write the differences between mitosis and meiosis. Also, you can prepare Power Point slides for presentation.

4.2 Deoxyribonucleic acid (DNA)

DNA is a long thread-like structure found inside the cell, carrying genetic information. DNA is found in the cytoplasm of prokaryotic cells and the chromosome of the nucleus of eukaryotic cells. DNA of viruses is covered by a capsid, a protein coat. In DNA, a single unit formed by the combination of a nitrogen base, and deoxyribose sugar is called a nucleoside, while a single unit formed by the combination of a nitrogen base, deoxyribose sugar, and phosphate ion is called a nucleotide. Such nucleotides are the structural unit of DNA. The sequence of nucleotides is different among individuals. So, qualities are also different among them. DNA consists of two antiparallel strands. Four types of nitrogen bases found in DNA are adenine, guanine, cytosine, and thymine. Adenine is linked with thymine by making a double bond, but guanine is linked with cytosine by making a triple bond. DNA carries hereditary information or characters in an organism. A small segment of DNA that represents/codes the particular character of an organism is called a gene. Millions of such genes are found in a chromosome. During cell division, hereditary information is transmitted by DNA from the mother cell to daughter cells, which helps in the transmission of characters from one generation to another. Transcription occurs in DNA to form RNA, which helps to synthesize protein.

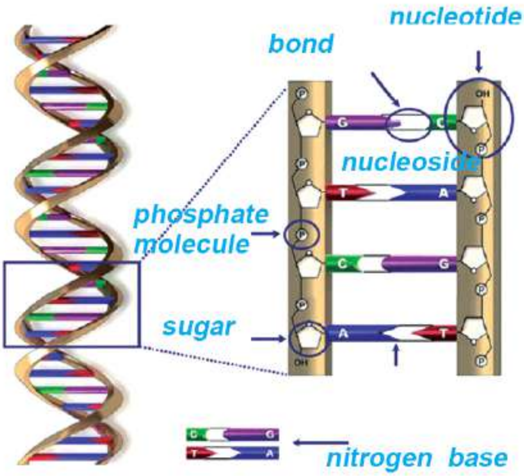


Figure 4.6 Structure of DNA

Project work: Formation of a DNA model

Construct a DNA model with the help of materials found in your locality and present it to the class.

4.3 Ribonucleic acid (RNA)

RNA is a polynucleotide where each nucleotide is formed by the combination of a nitrogen base, ribose sugar, and phosphate. RNA is single-stranded. It is generally found in the cytoplasm and also found in chromosomes in some amount. RNA is enclosed within a capsid in viruses. It serves as genetic material in them. Four types of nitrogen bases found in RNA are adenine, guanine, cytosine, and uracil. Adenine is linked with uracil by a double bond, but guanine is linked with cytosine by a triple bond. There are three types of RNA which are Messenger RNA (m-RNA), transfer RNA (t-RNA), and ribosomal RNA (r-RNA). The main function of RNA is to synthesize proteins.

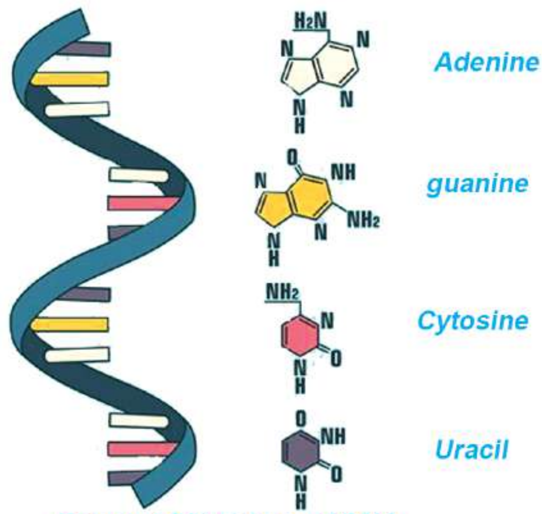


Figure 4.7Structure of RNA

Activity 4.4

Objective: To differentiate DNA and RNA

Materials required:

Models or pictures of DNA and RNA

Method:

i. Thoroughly observe the model of DNA and RNA.

ii. Identify nitrogen bases and sugar molecules found in DNA and RNA both and fill up the given table.

Basis of difference	DNA	RNA
Nitrogen bases		
Sugar		
Function		
location		

4.4 Chromosome

Observe the picture given below and discuss the following question.

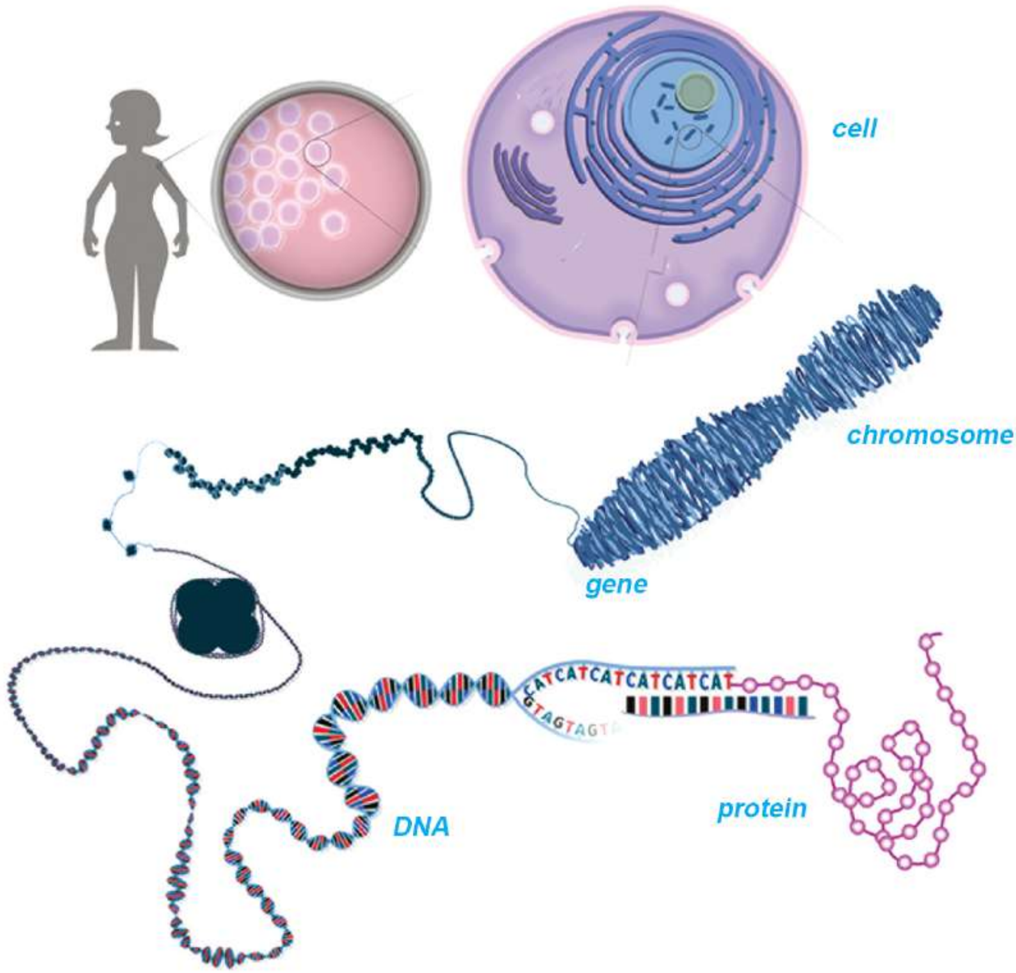


Figure 4.8 Cells, Chromosome, and Gene location

i. Where are chromosomes found in the body?

ii. What is a chromosome made of up?

iii. What is the role of genes in a living being's body?

iv. Do all living beings possess chromosomes?

When we observe the plant cell and animal cell through a powerful microscope, we can see a network of minute fibers inside the nucleus. These fibres are called chromatin fibres. During cell division, these fibres become short and thickened and also prominent, which are called a chromosome. Each Chromosome is made up of DNA and histone protein, and numerous genes are found in a chromosome. Each gene represents a particular character of an individual. A small fragment of DNA in the chromosome is a gene. The chromosome has mainly two parts: chromatid and centromere. Chromatids are the two arms of the chromosome. Sister chromatids are the identical copies found in the replicated chromosome. The knot-like structure of the chromosome where two chromatids are connected is called the centromere.

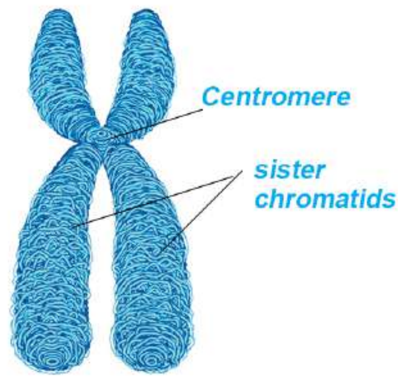


Figure 4.9 Structure of chromosome

Gene

The smallest fragment of DNA in a chromosome which codes or represents a specific character of an organism is called a gene. There are millions of genes in a chromosome. Genes help in the transmission of hereditary characteristics from parents to offspring. Genes also help in evolution by processes like mutation and genetic recombination.

Types of chromosomes

Chromosomes are of two types based on their function. They are somatic chromosomes or autosomes and sex chromosomes.

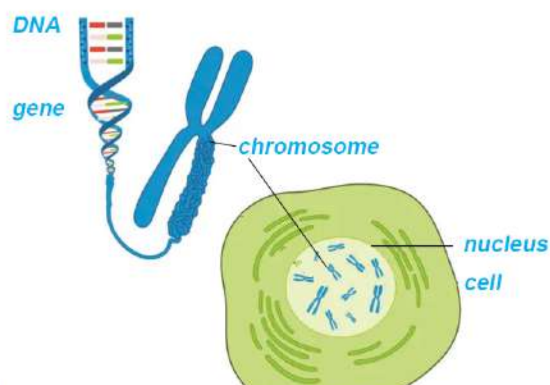


Figure 4.10 Location of gene

Project work 4.1 Construction of human karyotype model

Materials required: Different coloured clay, cardboard or thermocol, gum, chart or picture of human karyotype

Method

i. Make a model of 22 pairs of somatic chromosomes and the single paired sex chromosome found in either males or females by using different coloured clay, after observing the chart or picture of the human karyotype.

ii. Now, paste these chromosome models serially on the cardboard or thermocol.

iii. Present the karyotype model that you prepared in class and discuss the somatic chromosomes and sex chromosomes.

a. Somatic chromosomes

The chromosomes that determine the physical characteristics of an individual are called somatic chromosomes. In a pair of somatic chromosomes, each member has the same morphology. So, these chromosomes are also called autosomes.

b. Sex chromosomes

The chromosomes that determine the sex of an individual are called sex chromosomes. The structure of each member of a pair of sex chromosomes is different. So, these chromosomes are called heterosomes.

Number of chromosomes

In a particular organism, the number of chromosomes is constant. But the chromosome number varies from species to species. For example,human beings have 46 chromosomes, but gorillas have 48 chromosomes in a cell of their body. The number of chromosomes is generally expressed in pairs. For example, human beings have 23 pairs of chromosomes

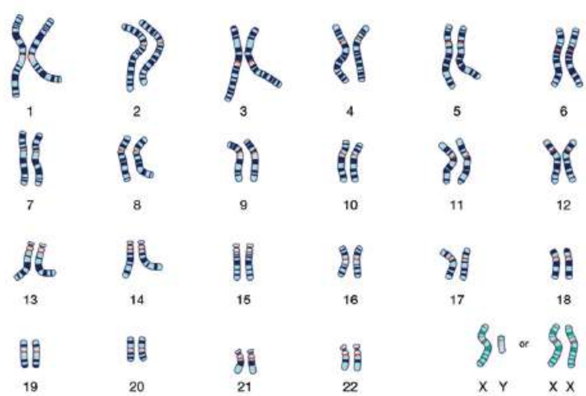


Figure 4.11 Number of chromosomes in humans

in a cell. The purpose of mentioning it like this is that among the 23 pairs, one set of 23 chromosomes belongs to the father, and the remaining set of 23 chromosomes belongs to the mother.

Generally, two sets of chromosomes are found in a somatic cell called diploid (2n). One set of chromosomes is found in a gamete called haploid (n). For example, a human somatic cell contains 46 (2×23) chromosomes, which is diploid. Human gametes, either sperm or ovum, contain 23(1×23) chromosomes, which is haploid.

Role of sex chromosomes in the determination of sex in humans

Project work 4.2 Constructing Modelof sex determination in humans

Materials required: Clay of various colours, cardboard or thermocol, gum, chart, or picture showing the process of sex determination

Method

i. Observe the human sex determination chart or picture and use different coloured clay to make X chromosome and Y chromosome.

ii. Paste the X and Y chromosomes on the cardboard or thermocol sheet according to the required number of sex determination processes and name them.

iii. Present the prepared model in class and discuss the role of sex chromosomes in determiningthe sex of an organism.

Genes present in the chromosome determine the characteristics of living beings. Similarly, the process of separation of male and female sexes due to the genes present in the sex chromosomes of an organism is called sex determination. Sex chromosomes determine the sex of the fetus.

There are a total of 23 pairsof chromosomes in the body cells of humans. Among them, 22 pairs are autosomes, and one pair is a sex chromosome or heterosome. The cell of a male individual contains one pair of sex chromosomes called XY, but the cell of a female individual contains XX sex chromosomes. During the reproductive phase, meiotic cell division takes place in the diploid ($2n=2\times23$) germ cells (found in testes and ovaries) of males and females to produce haploid gametes ($n=23$) respectively. The mother cell of the male reproductive organ (testis) consists of 44+XY chromosomes. This cell gets divided through meiosis to form sperm having either 22+X or 22+Y chromosomes. Similarly, the mother cell of the female reproductive organ (ovary) consists of 44+XX chromosomes. This cell also gets divided through meiosis to form an ovum having only 22+X chromosomes. During sexual intercourse or copulation, if a sperm having 22+X chromosomes fuses with the ovum with 22+X chromosomes, then the future child will be a female or daughter (44+XX). Similarly, if a sperm having 22+Y chromosomes fuses with the ovum with 22+X chromosomes, then the future child will be a male or son (44+XY). The probability of getting a son or daughter is 50% in fertilization since 50% of male sperm have X-sex chromosomes, and 50 % have Y-sex chromosomes.

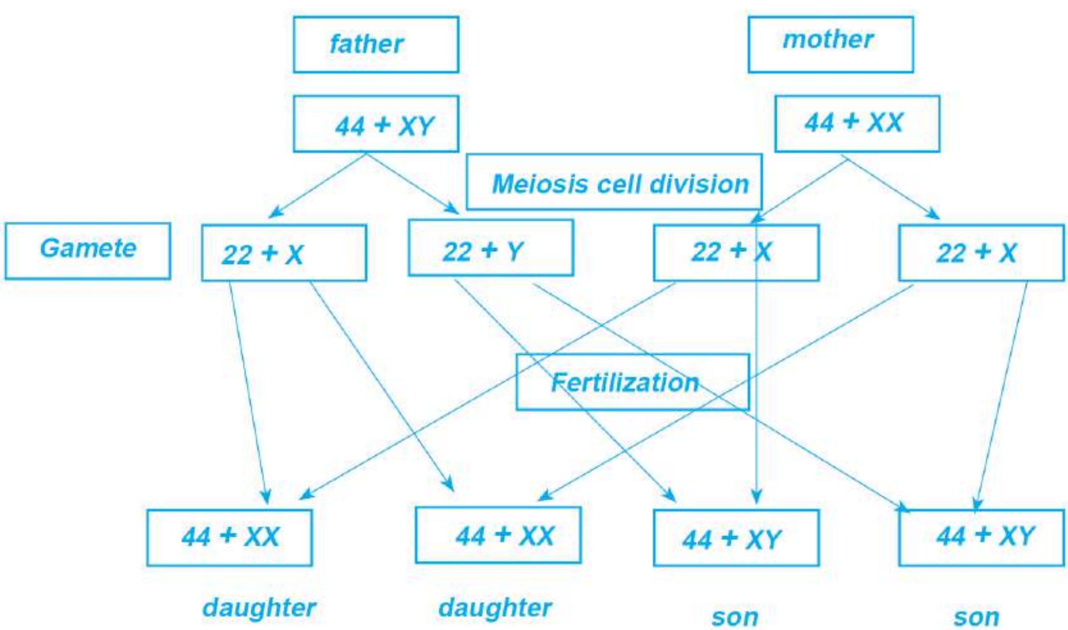


Figure 4.13 Sex determination chart

Exercise

1. Choose the correct option for the given questions.

a. How many pairs of sex chromosomes are found in the human cell?

i.	1 pair	ii.	22 pairs
iii.	23 pairs	iv.	46 pairs

b. What is a chromosome made up of?

i.	DNA and RNA	ii.	DNA and carbohydrate
iii.	DNA and protein	iv.	RNA and protein

c. What is the main function of sex chromosomes?

i. To determine physical characteristics

ii. To determine sex

iii. To increase immunity

iv. To determine the structure of the eye

d. What is the smallest unit of the chromosome that helps in the transmission of hereditary characteristics?

i.	DNA	ii.	Chromatid
iii.	Centromere	iv.	Gene

e. Which of the following statements is correct for mitotic cell division?

i. Four cells are formed at the time of cell division.

ii. Haploid cells are formed at the end of cell division.

iii. It has the main role to form gametes.

iv. This cell division helps to repair tissue.

f. A technician working in a radiotherapy laboratory was tested after a long time of marriage when there was no childbirth. After the test, it was found that his child production capacity was reduced because he worked in high-intensity radiation for a long time. Which part of the cell is affected in this case?

i. DNA ii. RNA

iii. Cytoplasm iv. Nucleus

g. If there is no DNA transcription in a cell, which process is affected?

i. Photosynthesis ii. Protein synthesis

iii. Sexual reproduction iv. Cell division

h. If a nucleotide is destructed during DNA replication, what happens to the organism?

i. Genetic disorder occurs

ii. It brings a problem in cell division

iii. It brings a problem in reproduction.

iv. The chromosome doesnot function.

i. Which of the following indicates the set of chromosomes in a cell of a woman?

i. 44+XY ii. 44+XX

iii. 22+XY iv. 22+XY

j. Which of the following statements is true?

i. Ovum contains only a Y chromosome and sperm contains an X chromosome.

ii. Ovum contains only an X chromosome and sperm contains a Y chromosome.

iii. Ovum contains only an X chromosome and sperm contains either an X or Y chromosome.

iv. Ovum and sperm both contain X and Y-chromosomes.

2. Write differences:

a. Autosome and sex chromosome

b. Mitosis and meiosis

c. DNA and RNA

d. Haploid and Diploid

3. Give reason:

a. Offspring have the same characteristics as their parents.

b. The male has a main role in the determination of sex.

c. Though males have both X and Y sex chromosomes, some of them have only male or only female kids.

d. Meiotic cell division is also called reductional cell division.

e. Mitotic cell division is also called equational cell division.

f. Sexual reproduction is impossible without meiotic cell division.

g. Meiotic cell division brings variation.

4. Answer the following question.

a. What is a gene?

b. What is a chromosome? Clarify the role of chromosomes in the body of living beings.

c. Explain the importance of mitotic cell division in the growth and development of the body.

d. Explain the role of mitosis and meiosis in the reproduction of organisms.

e. What will happen if meiotic cell division doesnot occur in the reproductive cell of an organism? Explain.

f. Clearly explain the role of genes in the transmission of hereditary characteristics in organisms.

g. How is sex determined in humans? Explain with a chart.

h. A woman is pregnant. What is her probability of giving birth to a daughter? Write in percent.

i. A couple gave birth to only a son. Does it mean that the testes of those male-produced spermshave Y-chromosomes only?

j. Complete the concept maps 'a' and 'b'. Write the differences between these processes.

Reproductive cell → ………………… **cell division** → **gamete**

A

Somatic cell → ………………… **cell division** → …………………

B

4.8 Genetics and genetic technology

Heredity and Mendelism

All living beings can produce offspring like themselves. Due to this reason, they continue their generation by giving birth to their young ones. Offspring inherit the characters of the previous generations. Although the organisms may look the same, they have some qualities that differ from each other. Parental characteristics are transmitted to the offspring in both sexual and asexual reproduction. These traits are transmitted from one generation to another because of the genes present in the chromosomes of the nucleus of a cell. Each gene carries a specific characteristic of an organism and hence it is responsible for transmitting the qualities of the father and mother to their children. The phenomenon in which parental characters are transferred to their young ones is called heredity, and such characters are called hereditary characters.

Activity 4.5 The study of various types of peas

Material required: Various types of pea seeds, a chart showing dominant and recessive characters based on Mendel's experiment, chart paper, gum

Method:

i. Collect various types of pea seeds found in your locality. Sort them into different groups on the basis of their characters like shape, size, and colour.
ii. Discuss these characteristics on the basis of Mendel's experiment chart. Based on the discussion, differentiate these characters into dominant and recessive characters.
iii. Paste these seeds on the chart paper and also mention characters to present in the class.

Conclusion:

The branch of biology that deals with the study of genes, heredity, and variation is called genetics. Genetic engineering, medical genetics, etc., are sub-branches of genetics. Gregor Johann Mendel was the first scientist to propose the laws of genetics through various researches.

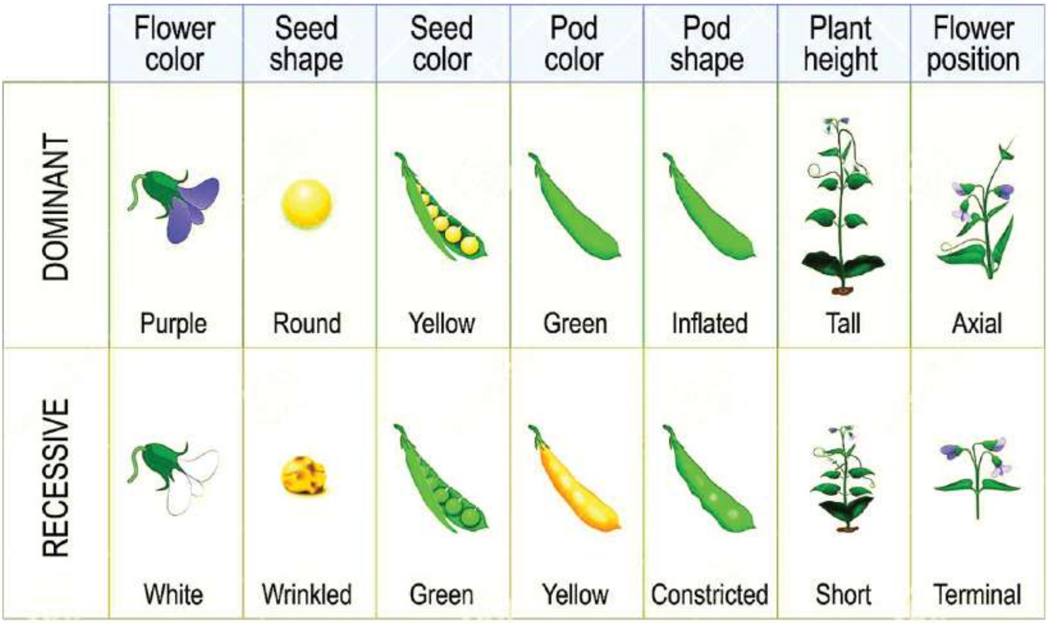


Figure 4.13 Dominant and recessive characters in pea plant

Mendel was born on 22 July 1822 in Austria and is also called the father of genetics. He carried out many experiments on the pea plants grown in his garden to prove that hereditary characters transmit from parents to offspring. While doing experiments, he considered seven pairs of contrasting characters in the pea plant, which are:

- Height of plant: Tall (TT) and dwarf (tt)
- Position of flower: Axial (AA) and terminal (aa)
- Colour of pod: Green (GG) and yellow (gg)
- Shape of pod: Inflated (II) and constricted (ii)
- Shape of seed: Round (RR) and wrinkled (rr)
- Colour of flower: purple (RR) and white (rr)
- Colour of seed: yellow (YY) and green (yy)

Mendel selected pea plants for his research due to the following reasons:

1. Pea plants are bisexual and their flowers are closed, making them naturally self-pollinating plants.
2. Cross-pollination can be done if necessary.
3. Their life cycle is short, and offspring can be produced faster.
4. They have many pairs of contrasting characters.
5. Many seeds can be produced at once, and due to this, many offspring can be produced.
6. They are easy to cultivate.

Method of Mendel experiment

Mendel studied seven pairs of pure and hybrid traits found in pea plants separately and classified each offspring according to the trait. He selected pure tall pea plants and pure dwarf pea plants and carried out pollination between them to study the heredity. Seeds obtained from that pollination were grown, which were called first filial generation. All the plants of first filial generation were tall. He performed experiments using the remaining pairs of contrasting characters too. He found similar type of results, i.e., only one character was expressed in each of the first filial generations. When two pea plants, each having a pair of contrasting characters, were pollinated, the character expressed in the first filial generation was called the dominant character. The character which was hidden in first filial generation was termed recessive character.

Mendel carried out self-pollination between the hybrids produced in first filial generation. After self-pollination, the offspring obtained in the second filial generation were both tall and dwarf. Among them, 75% were tall and 25% were dwarf. Furthermore, while self-pollinating the pure tall progeny of the second filial generation, all the offspring were pure tall pea plants. Self-pollination between pure dwarf plants of the second generation produced only pure dwarf offspring. Similarly, self-pollination of hybrid offspring of the second filial generation yielded 75% tall and 25% dwarf pea plants, which is presented in the chart given below:

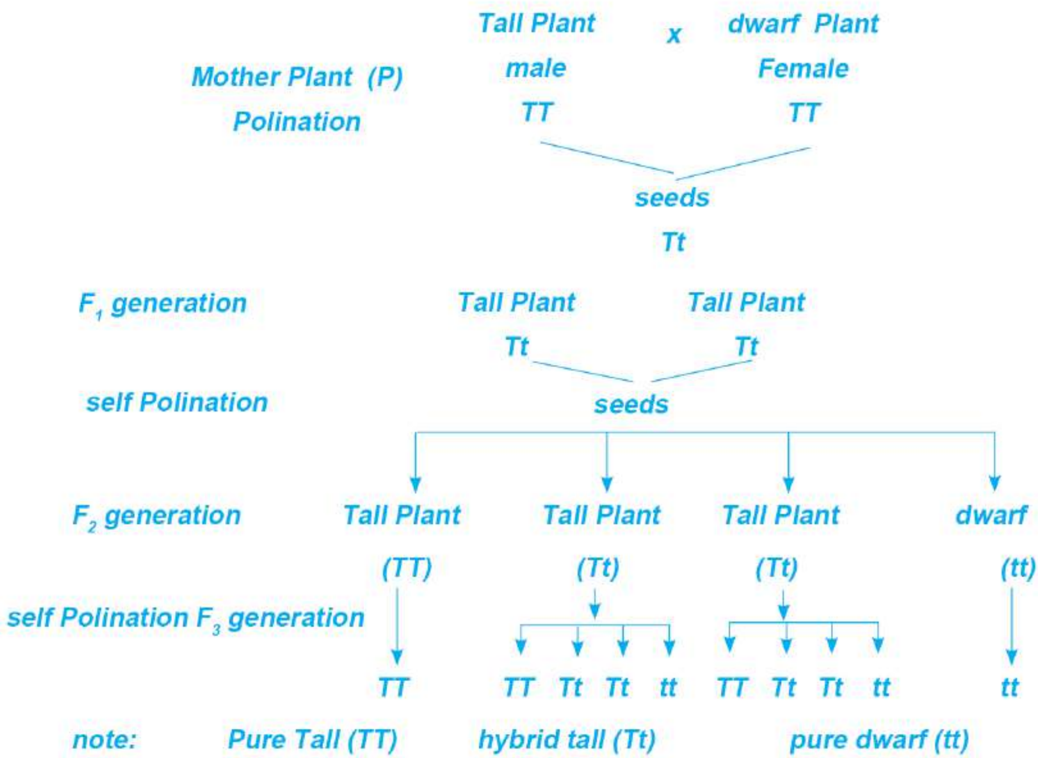


Figure 4.14

Monohybrid cross between tall plant and dwarf pea plant (upto F3 generation)

Results of Mendel's experiment

a. Tall plants were produced from pure tall plants.

b. Tall and dwarf plants were produced in a ratio 3:1 from hybrid tall plants.

c. Dwarf plants were produced from pure dwarf plants.

Phenotypic ratio and genotypic ratios in Mendel's experiment

Phenotypic characters are the character seen externally in an organism. Similarly, Genetic constitution or genetic makeup of an organism is called genotypic character.

Phenotypic ratio is Tall: dwarf = 3:1

Genotypic ratio is pure tall: hybrid tall: pure dwarf = 1:2:1

Monohybrid cross and dihybrid cross

When a cross is made between two pure plants or organisms considering a pair of contrasting characters, then it is called a monohybrid cross. Example: 100% hybrid plants were produced in a cross pollination between a pure tall pea plant and a pure dwarf pea plant in first filial generation.

Similarly, when a cross is made between two pure plants or organisms considering two pairs of contrasting characters, this cross is called dihybrid cross.

Activities 4.6 Prepare a chart of monohybrid cross according to Mendel's experiment up to F2 generation and discuss it in the class.

Laws of Mendel

1. Law of dominance
2. Law of purity of gametes or law of segregation
3. Law of independent assortment

Law of dominance

According to Mendel's law of dominance, when a cross is made between two pure individuals having a pair of contrasting characters, only one character is expressed externally in F1 generation which is called the dominant character. Hence, the character or trait which is expressed externally in F1 generation is called the dominant character and the character which remains hidden in F1 generation is called the recessive character.

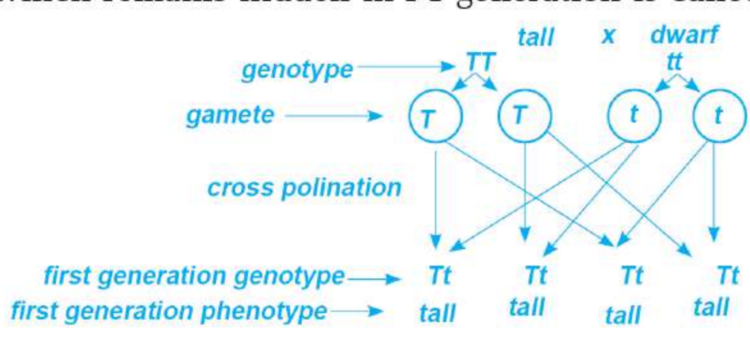


Figure 4.15 Chart showing Mendel's law of dominance

In Mendel's experiment, a cross pollination between pure tall pea plant and pure dwarf pea plant produces all the hybrid offspring in F1 generation in which all are externally tall indicating tall character is dominant and dwarf as a recessive character.

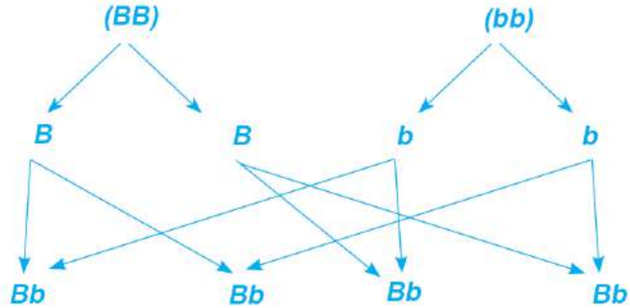


Figure 4.16 Cross breeding of pure black guinea pig and pure white guinea pig

Mendel's law of dominance can also be studied by crossing guinea pigs. When black guinea pigs (BB) are crossed with white guinea pig (bb), then hybrid black guinea pigs are produced in the F1 generation. Here, black colour is the dominant character, and white is the recessive character.

Law of purity of Gametes

Although two different characters coexist in the hybrid of the first generation, they remain pure without losing their originality. In the formation of gametes in the hybrid, during meiosis cell division, the genes of the pure or hybrid allele in the mother cell are separated and only pure characters enter each gamete. It means gametes formed are pure. This law is called the purity of gametes.

For example, when self-pollination is performed among the progeny obtained in the first filial generation, the genes of the hybrid alleles separate, and hence tall and dwarf plants are produced in the second generation. The ratio of tall and dwarf plants is 3:1.

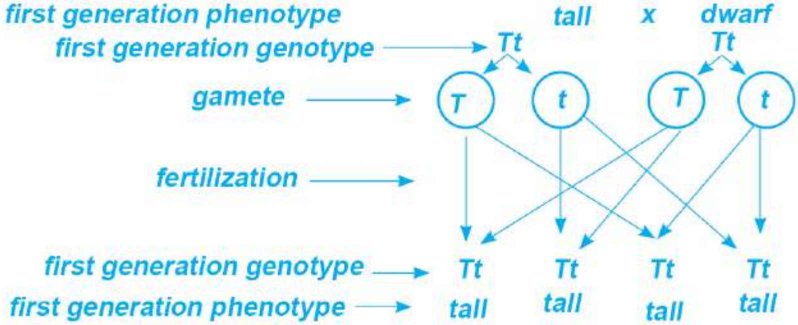


Figure 4.17: Second generation produced from self-pollination between hybrids of first generation

hybrid cross in guinea pig

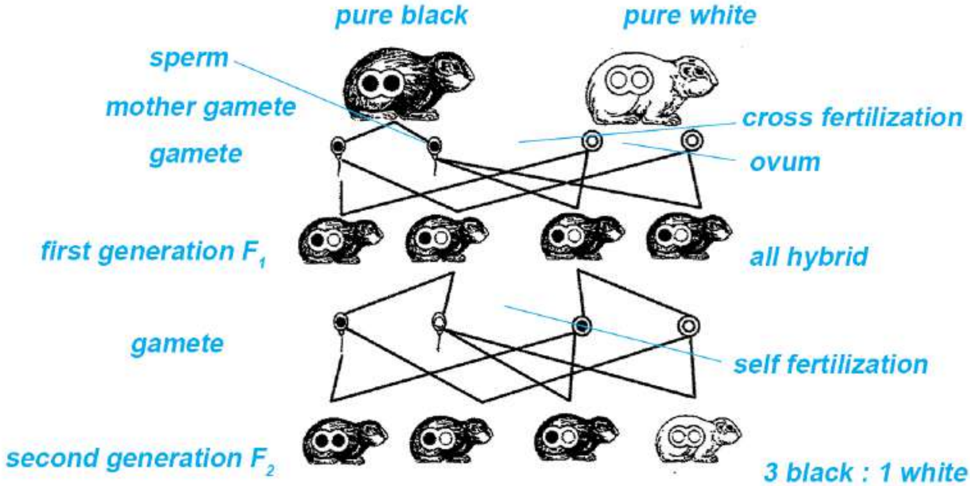


Figure 4.18 Second generation produced by self-breeding of hybrid black guinea pig

Similarly, when the hybrids offspring obtained by crossing the pure black guinea pig and pure white guinea pig were crossed together, 75% black and 25% white guinea pigs were produced. In this case, phenotypic ratio of black and white was 3:1, and the genotypic ratio was 1:2:1 (pure black: hybrid black: pure white).

Genetic technology

Figure 4.19 A fragment of DNA of an organism is added to the DNA of another organism

Currently, the world has advanced a lot in the field of technology, and genetic technology is one of them. This technology helps to develop new qualities by making various changes in DNA easily and quickly. In this technology, modification in the genetic material or gene is carried out. Nowadays scientists have been able to find out: what genes are, their function, and how they can be altered by adding, deleting, and substituting DNA. Genes are found in all organisms, and they are transferred from one generation to another. Genes have coded instructions that are used to synthesize proteins and to transmit hereditary characters.

Genetic technology is the process of modifying genes by understanding genetic expression, taking advantage of natural genetic variation, and transferring genes to new organisms. Among the various technologies, genetic engineering is the process that alters the DNA structure of an organism using laboratory-based techniques. It is also called genetic modification. In this process, a new trait is developed by changing a single nitrogen base pair (A-T or C-G), deleting or adding a gene in the DNA. Gene variants created through genetic engineering can be passed from one generation to the next. Identifying genes and their functions is an important application of genetic technology. Genetic technology has an important place in biotechnology and molecular biology. It has made it possible to change and regulate plant characteristics by using DNA sequencing information in its structure, function, process, etc. At present, genetic technology based on molecular markers, transgenic technology and gene expression has been widely used in agricultural production, which has shown great potential to improve agricultural yield and quality, reduce losses caused by various biotic and abiotic factors, and improve the reproductive capacity of organisms. These modern DNA technologies with high potential and need are the important ways to guarantee the sustainable development of agriculture. Nowadays, DNA technology is mostly used in the field of forensic science. This technology is used to investigate various criminal cases called DNA test.

Role of DNA testing in various investigations

The use of DNA testing technology has made it easier to investigate various criminal cases and identify the guilty. DNA testing is mostly used for criminal investigations and paternity testing. As a scientific method, it is effective in establishing facts, but DNA testing is a complex and highly sensitive task. Even a simple error can lead to significant inaccuracies. Therefore, to make DNA testing reliable, fair, and effective, special attention is required during the collection and transportation of samples. Samples should also be protected from contamination.

Project work

Use the internet to find out the application of DNA testing in various fields and prepare a Power Point slide. Present it in the class and discuss.

Selective breeding

Since ancient times, people have been selecting and breeding plants and animals with good qualities for agricultural products they want. In this way, selective breeding is the process of selecting animals and plants with the best qualities and interbreeding them to produce offspring with desired characters. The main purpose of selective breeding is to introduce the desired traits in an organism and establish those traits in the future offspring. This method involves selecting and breeding the mother and father, or both, to produce desired plants and animals. Selective breeding emphasizes natural reproduction using the gene variation occurring naturally in organisms. However, some people criticize it because, during selective breeding, some natural qualities may disappear, or it can mutate and undesirable qualities may appear in animals. For example, if we reject dwarf animals and breed only tall animals, the offspring inherits the gene for tall. If this process is repeated for many generations, the tallness trait will be established in future generations while the quality of being dwarf or short will disappear.

Project work

Use the internet or inquire your elders about selective breeding in various organisms and make a short report on it. Then discuss it in class.

Disadvantages of selective breeding

1. Usually, selective breeding increases the population of plants and animals having similar genetic traits.
2. There is a chance of spreading infectious diseases genetically.
3. In this method, breeding between very closely related species is done, so offspring are more likely to suffer congenital genetic problems.
4. Selective breeding is also called artificial selection because it involves human interferences.
5. Selective breeding inhibits some naturally occurring genetic traits and can affect biodiversity, making it possible for species to become extinct in the future due to some bad traits.

Method of selective breeding

Various techniques can be adopted in selective breeding. Some techniques are mentioned below:

Inbreeding

Inbreeding is done to establish the population of organisms with predictable traits. In this method, closely related animals are allowed to interbreed. If inbreeding is done continuously, genetically alike offspring will be produced. Organisms produced in this way are described as purebred or inbred. Examples of purebred animals are Siamese cat and Labrador Retriever dogs.

Figure 4.20 Siamese cat and Labrador Retriever dog

Line breeding

It is also a type of inbreeding. In this method, breeding is done between more distant relatives to get animals with desired characteristics. This reduces the rate of becoming purebred. It also reduces the risk of ill health that can sometimes be seen on purebred animals.

Self-pollination

Most plants have both male and female reproductive organs in the same body. They are able to self-pollinate. Only some qualities of plants grown from the seeds produced from self-pollination are identical to mother plant, but not all. This is because of gene reshuffle during sexual reproduction. This method helps to produce genetically identical plants.

Cross breeding

This method involves breeding two unrelated individuals. Generally, this type of breeding is done between two different species of same genus. This is often used to produce progeny with desired traits from two different individuals. This method is suitable to produce offspring which display the characteristics of interest by crossing two purebred organisms. Offspring produced by cross breeding are called hybrids.

The main purpose of cross breeding is to enhance the quality of the hybrid. Qualities of the hybrid are not transferred to all subsequent generations.

Some organisms produced from cross breeding

Liger

The hybrid animal obtained by crossing the male lion and female tiger is called liger. It is a most known hybrid animal. It is larger than its parents. It generally behaves like the lion.

Tigon

The hybrid animal obtained by crossing the male tiger and female lion is called Tigon.

Tigon is smaller than the Liger, and it is smaller than either of its parents. It resembles tiger but most qualities such as roaring and socialization are like that of a lion.

Figure 4.21 Liger

Tigon

Beefalo

Beefalo is a hybrid produced by the cross between a buffalo (American Bison) and a bull. They are different from other hybrids and they can reproduce.

Figure 4.22 Beefalo

Zebroid

The hybrid animal obtained by crossing the zebra and horse is called zebroid. They cannot reproduce.

Figure 4.23 Zebroid

Mule

The hybrid animal produced by cross breeding of a donkey and a horse is called mule. It can carry load like the donkey and run like the horse. It is also sterile.

Figure 4.24 Mule

Pomato

Pomato is the plant produced by crossing potato and tomato. In this plant, tomato is produced in stem above the soil and potato is produced underground.

Figure 4.25 Pomato

Activity 4.7

In addition to the examples mentioned above, prepare a list of animals produced by selective breeding that you have seen or heard, or search on the internet and discuss in the class.

Advantage of cross breeding

Cross breeding can be carried out in both the plants and animals. By this method new varieties of an organism can be produced. Farmers are benefitted by this technique. Some advantages of cross breeding are given below:

1. This method combines the desirable qualities of two organisms from different breeds, varieties, or species.
2. Human beings can produce organisms with desired characters.
3. Cross breeding provides the opportunity to make full use of a wide range of genetic material.
4. Animals that exhibit better quality than the parent animal can be developed.
5. Immunity, strength, age, vigour, etc.of an organism can be improved by this method.

6. Crop production can be increased from plants produced throught his method.

Disadvantages of cross breeding

1. If there is no proper understanding and management of cross breeding techniques, problems may arise in breeding policy in the future.
2. The price of products obtained from cross breeding is lower compared to that of the products obtained from purebred. So, farmers cannot earn as much as expected.
3. There is a limitation in the sale of animals produced by cross breeding in the export market.
4. As the external and genetic characteristics of the hybrid go on changing, the chance of extinction of purebreds increases.
5. In this breeding, natural traits of parent are not completely transferred to their progeny; hence such traits may disappear gradually.

Artificial insemination

Nowadays, because of the development of various technologies, fertilization is possible without mating between male and female organisms. The practice of producing offspring of advanced variety has greatly increased nowadays which is by collecting semen from the male located at far distant and inseminating into the body of the female organisms. Thus, artificial insemination (AI) is the technique of collecting semen from advanced breeds of male and allowing them to enter the female reproductive tract at the right time through the use of equipment. Offspring produced by this technique are found to be as normal as those produced by natural mating. In this process, healthy sperm is collected from the male and allowed to pass into the uterus of a healthy female for fertilization at the appropriate time using artificial means.

The first scientific research on artificial insemination of domestic animals was carried out in dogs in 1784 by the Italian scientist Lazzaro spallanzani.

His experiment confirmed that fertility resides in the microscopic sperms that float in semen, not in the liquid part of the semen. The main objective of artificial insemination is to produce a large number of advanced offspring by transmitting the sperm of an advanced breed of male to a female ready for conception.With this technique, the farmers in animal husbandry can avoid the trouble of rearing expensive males with special qualities. This also helps to strengthen farmers' economic status. Currently, artificial insemination is in practice instead of natural mating in many animals, such as cows, buffaloes, goats, sheep, etc. This is a subsidiary method of reproduction that is now practiced worldwide. This type of breeding is a useful technique to improve genetic quality in animal husbandry.

Advantage of artificial insemination

Artificial insemination has many advantages compared to natural mating. Some of them are listed below:

1. There is no need of rearing male for breeding, which saves expenses of rearing.
2. It helps to control the infection and spread of disease during mating.
3. After collecting semen from the male, it is tested and fertility is checked to ensure the fertility of the male.
4. Collected special semen can be used even after the death of the male.
5. Collected semen can be easily transported over long distances for fertilization.
6. This method helps to prevent injury to the female or male at the time of fertilization.
7. This method increases the rate of fertilization.
8. It helps to keep a good record of reproduction.

Disadvantage of artificial insemination

1. It needs well-trained manpower and special equipment.

2. It requires more time than natural breeding.
3. Reproduction may nottake place, or there might be a chance of infection if the equipment isnot properly sanitized during artificial insemination.

In vitro fertilization (IVF)

A case study:

A 38-years-old woman and her 42-years-old husband have been trying to conceive for the past five years. Test of infertility did not show any cause for this. Regular ovulation cycle is normal in her body. Her reproductive tract is also normal, as shown by Hysterosalpingography (a special X-ray of internal female reproductive organ). Her husband's sperm count is also normal. They are disappointed because they still donot have a child. In this situation, the doctor advised them to adopt invitro fertilization (IVF) method. Do you know about invitro fertilization? Search on the internet or inquire with elders about it and discuss in class.

Let us know

Lesle Brown, a woman who lived in Manchester, England, had suffered for many years due to the blockage in her fallopian tubes. To solve it, she underwent the experimental IVF procedure in November 1977. For this, a matured ovum was taken out from her ovary and fused in a dish in the laboratory with her husband's sperm to form an embryo. Then, the embryo was transplanted into her uterus after a few days. British gynaecologist Patrick Steptoe and scientist Robert Edwards had been doing research on IVF a decade earlier. When the media found out about Brown's conception, she faced intense investigation. Then, Lesle Brown gave birth to her daughter by caesarean section on 25th July 1978. Her daughter's name is Louise Joy Brown, who is the first child in the world to be borne by invitro fertilization.

In Nepal, IVF technology began in 2004 in Om hospital through the establishment of an IVF centre. On March 3, 2005, Rajendra Tamang and Sandhya Tamang gave birth to a baby named Om Mani Tamang as Nepal' s first test-tube baby through this process.

IVF is the most effective method of assisted reproductive technology. This method is a complex series of procedures to help couples with reduced fertility and genetic problems. IVF is a method of conception that differs from normal sexual intercourse. The child born through the process of IVF is physically and mentally normal. The characteristics of the child born from IVF may or may not match those of his parents, as this procedure can be done using a couple's own ovum and sperm, or if a couple has problems with ovum and sperm production, an egg and sperm from a known or unknown donor can also be used. In IVF, a mature ovum from the ovary of female is taken and stored in a petridish and fused with the sperm of the male in a sophisticated laboratory. The fertilized ovum is then transferred to the female's womb (uterus) after a few days. It takes about three weeks for a complete cycle. But it may take more time depending upon the nature of the problem. The embryo grows in woman's uterus as in normal pregnancy.

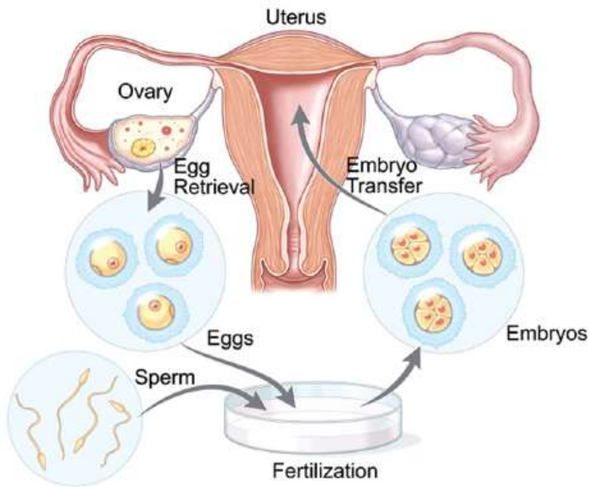


Figure 4.26 Method of In Vitro fertilization

Advantage of IVF

1. IVF is the best method of conception for those couples who are unable to conceive due to various problems related to conception.
2. It allows conception by using a couple's own sperm and ovum or by the use of donor's sperm and ovum.
3. It is more successful than other assisted reproductive techniques.
4. It is helpful to solve the problem related to various chromo-

somal disordersin the child.

5. Infertility and genetic problems can besolved by this technique.
6. It increases fertility and reduces the risk of miscarriage.
7. It increases the chance of having a healthy child.

Disadvantage of IVF

1. There is no guarantee of a successful IVF cycle. It may not be successful and may take more than one cycle.
2. There may be various side effects associated withthe use of IVF.
3. The problem of multiple births at the same time can also occur.
4. Adopting this technique may cause emotional stress in the couple.
5. There is a chance that the embryo might be implanted outside the uterus.
6. It is an expensive method.
7. There is also a chance of pre-mature birth of a baby with low weight.

Exercise

1. Choose the correct option for the following questions.

a. What plant did Mendel use for his experiment?

i. Pea
ii. Gram
iii. Maize
iv. Bean

b. Which of the following is the genotypic ratio for Monohybrid cross?

i. 1:2
ii. 3:1
iii. 1:2:1
iv. 9:2:3:1

c. What is the term for a characteristic that is passed down from generation to generation?

i. Dominant character
ii. Recessive character
iii. Hereditary character
iv. Imported character

d. A white-skinned child was born to a dark-skinned parent. What is the reason for this?

i. The parent was hybrid
ii. Both the father and mother have pure black characters
iii. White colour is dominant
iv. Black colour is recessive

e. In order to produce good meat, farmers look for Boer goats and cross them with local goats. What kind of breeding method is this?

i. Artificial insemination
ii. Selective breeding
iii. IVF
iv. Natural selection

f. Ramit has produced a new plant by crossing an orange plant and a lemon plant.What type of plant is this?

i. Advanced variety plant   ii. Pure plant

iii. Hybrid plant   iv. Artificial plant

g. Roshani is a student from Himalayan region. A mule is reared in her home for transportation of the goods. But the mule is getting older, and her family members are considering getting a new mule. In this situation, she asked her father how amule gives birth to a child. Which of the following is the correct answer given by her father?

i. Mules produce offspring naturally

ii. There is inbreeding in mule.

iii. Mule cannot produce offspring naturally

iv. Mules produce offspring by AI.

2. Differentiate:

i. Dominant and recessive characters

ii. Phenotype and genotype

iii. Inbreeding and crossbreeding

iv. Artificial insemination and invitro fertilization

v. Tigon and Liger

3. Give reason:

a. Children look like their parents, but not exactly the same.

b. Mendel selected pea plants for his experiment.

c. When tall pea plants and dwarf pea plants are cross-pollinated, tall plants are produced in the first filial generation.

d. When self-breeding is done between hybrids, different types of offspring are produced.

e. DNA testing is a reliable technique for criminal investigation.

f. Genetic engineering involves the detailed study of DNA.

g. Offspring produced by cross-breeding may be sterile.

h. Special attention should be given while collecting samples for DNA testing.

4. Answer the following question:

a. What is genetics?

b. What is DNA testing? For what purposes is it used?

c. Give some examples of genetic technology.

d. Mention the importance of DNA in genetic technology.

e. Explain the importance of genetic engineering.

f. What is monohybrid cross? Show in the filial chart, the result obtained by cross pollinating first and then self-pollinating of a red flowering pea plant and white flowering pea plant.

g. Explain with an example that Mendel's experiment can be done not only in plants but also in animals.

h. Explain the Mendel's law of dominance and purity of gametes.

i. Round seeded pea plant and wrinkle seeded pea plant arecross-pollinated first and then the offspring obtained were self-pollinated again. The result of the second filial generation is shown in the table below. Now answer the following questions:

	R	r
R	RR	Rr
R	Rr	rr

i. What is the ratio of plants showing dominant and recessive characters?

ii. Write the genotypic and phenotypic ratio of this generation.

iii. Among them, which plant is purely round-seeded? Why?

j. When a cross is made between a black guinea pig and a white guinea pig, the offspring of first filial generation were all black. Explain why white guinea pigs did not appear in this generation?

k. A teenage girl who has lost her mental balance became the victim of rape and gave birth to a child. How can the father of the child be detected?

l. The district animal development centre conducted a camp to fertilize many cows at once. Which technique did that organization adopt at that time? Explain this technique in brief.

m. Is genetic engineering a boon or a bane for the present era? Give your arguments.

n. How has AI technology helped to bring happiness to the farmer? Explain.

o. IVF is proved to be a boon for childless couples. Justify this statement.

5

Physiological Structure and Life Process

Blood circulation in human body

Roshani's grandfather was suffering from knee pain. When he consulted the doctor and started taking medicine, the problem was reduced. Based on this context, discuss the following questions in class:

i. How does the medicine taken orally reach the knees?
ii. Which body system is involved in this process?
iii. What is the main organ of this system?

Observe the picture and discuss:

i. What happened to the man in the picture?
ii. How can this patient be helped in this situation?

Figure 5.1

There are various organ systems in the human body. Each system performs function of its own. In digestive system, food is digested and converted to simpler and soluble forms. These simplest forms, such as glucose, are transported to every cell of the body by the help of circulatory system. In the same way, oxygen, medicine, and hormones are transported from one part of the body to another. Blood circulation has main role in the transportation of substances in the human body. Blood is composed of blood corpuscles and plasma and it flows in the single direction in our body due to the pressure created by the pumping action of heart. Such a pressure created by heart is blood pressure which can be felt in the artery. Sometimes, blood pressure may behigh than the normal due to various factors. Various problems in the heart are because of high blood pressure and by the deposition of cholesterol on the wall of artery and the heart. There are various modern technologies for the treatment of heart problems. For example, Angioplasty, open heart bypass surgery, etc. There are four blood groups in human body which include A, B, AB, and O, and each group can be either Rh positive or

Rh negative, hence there are altogether eight blood group including Rh positive and Rh negative.

5.1 Human blood circulatory system

The blood circulatory system is one of the nine systems in the human body. This system also connects with other systems. The chief organ of the blood circulatory system is the heart which pumps the blood collected from various parts of the body. The blood pumped by the heart flows through blood vessels and it reaches all cells of our body. It transports nutrients and inhaled oxygen to all the cells of the human body. Similarly, blood carries carbon dioxide produced in the cells to the lungs and other wastes to excretory organs. Heart, blood vessels, and blood are the main parts of the circulatory system.

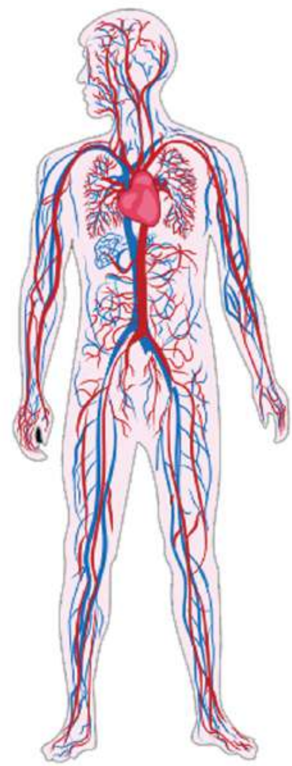


Figure 5.2 Human blood circulatory system

5.2 Blood

About 5.5 litres of blood is present in the body of a healthy adult person. Blood transports essential nutrients, oxygen, hormones, etc. to all the cells of the body. It also transports unnecessary harmful wastes to the excretory organs. Blood is alkaline in nature, and its pH value ranges from 7.35-7.45.

Structure of blood

Activity 5.1

Objective: To study the components of blood

Material required: Compound microscope, permanent slide of blood smear

Method

i. Observe the permanent slide of blood smear under a compound microscope.

ii. Observe in high power to identify all the components of blood.

iii. Draw a neat diagram of all the components of blood that you have seen.

iv. Based on observation, discuss the structure of blood inside the class.

Blood is the red-coloured connective tissue that is a thick fluid. It consists of 55% plasma and 45% blood cells. Blood contains three types of blood corpuscles or blood cells. They are Red blood cells, White blood cells, and Platelets.

Plasma

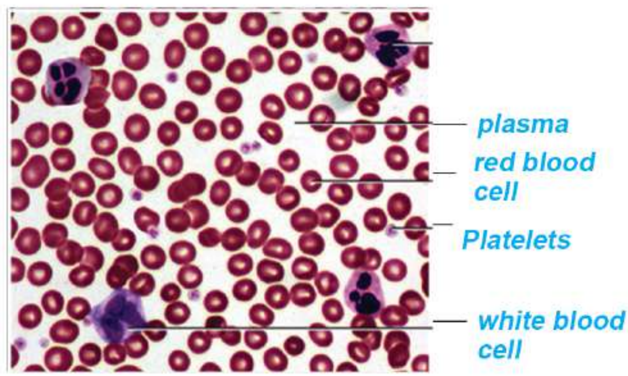


Figure 5.3 Composition of blood

Have you ever seen blood being collected after a goat is cut? After some time, the collected blood coagulates and is separated into a water-like liquid. This liquid part is known as plasma. It comprises 55% of total blood volume. Plasma is pale yellow coloured transparent liquid. It is composed of 80%-90% water and 10-20% dissolved substances such as carbohydrates, proteins, fats, and salts. Additionally, three types of proteins, namely albumen, globulin, and fibrinogen are also found in plasma.

Functions of plasma

1. It regulates the amount of water in the blood.
2. It transports nutrients and unnecessary wastes from one place to another.
3. Plasma also transports enzymes and hormones secreted by glands to various parts of the body.
4. Fibrinogen present in plasma helps in the clotting of blood.
5. Plasma regulates the temperature of our body.

6. It also maintains the chemical composition of blood and its pH.
7. When fibrinogen is removed from plasma, it is called serum. Serum is used to diagnose various diseases.

Blood corpuscles

a. Red Blood Cell

Red blood cells are red coloured, biconcave, round shaped and without nucleus. They are also called erythrocytes. These cells containa pigment called haemoglobin, which makes blood red. Haemoglobin is made up of iron and a protein called globin. Iron present in haemoglobin is responsible for the transportation of abundant oxygen to the cells. Haemoglobin also transports carbondioxide produced by the cells to the lungs. Haemoglobin combines with oxygen to form oxy-haemoglobin, and with carbon dioxide to form carboxy-haemoglobin.


Figure 5.4 Red blood cells

Number of red blood cells ranges from about 45 lakhs to 50 lakhs per cubic millimetre of blood. Their life span is 90-120 days. About 20 lakhs red blood cells are formed per second and the same number are destroyed. Red blood cells are formed in the bone marrow of spongy bone and are destroyed in the liver and spleen. A deficiency of red blood cells in the blood leads to a disease called anaemia. An anaemic person feels tired even after a short walk. Similarly, excess red blood cells in the blood causes a disease called polycythemia. The process of formation and destruction of red blood cells occurs in the body throughout life. Iron produced after the breakdown of old red blood cell is reused.

b. White Blood Cell

White Blood Cells have no definite shape but they are larger than red blood cells. They possess nucleus and other cellular components, but they do not have haemoglobin. They are also called leucocytes. White blood cells are of two types: granular and non-granular. White blood cells that contain granules (non-living particles) in their cytoplasm are called granular leucocytes. Neutrophil, eosinophil, and basophil are granular leucocytes. White blood cells that do not contain granules (non-living particles) in their cytoplasm are called non-granular leucocyte. Lymphocytes and monocytes are non-granular leucocytes.

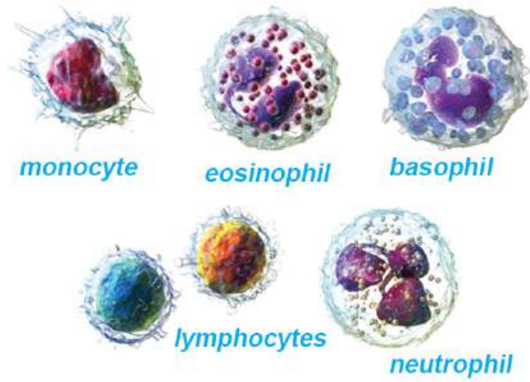


Figure 5.5 White blood cells

The lifespan of white blood cells is about two weeks. Number of white blood cells ranges from about 4 thousand to 11 thousand per cubic millimetre of blood. They are formed in bone marrow and are destroyed in the spleen. When there is an abnormal increase in the number of white blood cells in the blood, then they destroy other blood cells, resulting in a disease called leukemia or blood cancer.

White blood cells fight against disease-causing germs that enter the body from outside and destroy them. So, these cells are referred to as the soldiers of the human body. These cells increase the immunity of our body. An abnormal decrease of white blood cells leads to a disease called leukopenia.

c. Platelet

Platelets are the smallest-sized, round, and non-nucleated blood cells in the human body. They are microscopic blood cells. Per cubic millimetre of blood contains about 2 to 4 lakhs platelets.

They are formed in the red bone marrow. Their life span is about 2 to 3 days, and they are also destroyed in the spleen. Platelets combine with fibrinogen to clot blood during cut and injuries. Blood willnot clot even in small wounds or cuts if the platelet count becomes low. This is called haemophilia. An abnormal increase of platelets in blood results in thrombocytosis, which causes heart attack and stroke.

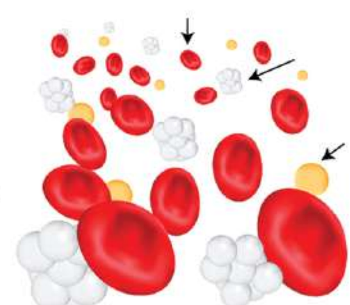


Figure 5.6 Platelets

Functions of blood

1. Transportation

Blood transports carbon dioxide and oxygen to the required sites. It also transports nutrients, enzymes, hormones and other essential substances from one part of the body to the other parts.

2. Regulation

Blood regulates the temperature of the human body. It also controls the amount of water, salts, etc. in the body in a constant amount.

3. Protection

White blood cells in blood protect us from various infectious diseases by fighting against germs. Similarly, platelets in blood help to stop bleeding at injuries and cuts. Antibodies, which maintain the immunity of our body, are produced in the blood.

5.3 Blood group

Activity 5.2 Keeping the record of human blood group

Objectives: To make a record of the blood group of students of class ten

Materials required: Chart paper, pencil and marker

Method

1. Take a chart paper.
2. Make a table in the chart paper as shown below.
3. Fill the information of the blood group of each student of your class in tabulated form and paste it on the board.

S.N.	Name of students	Blood group
1.		
2.		
3.		

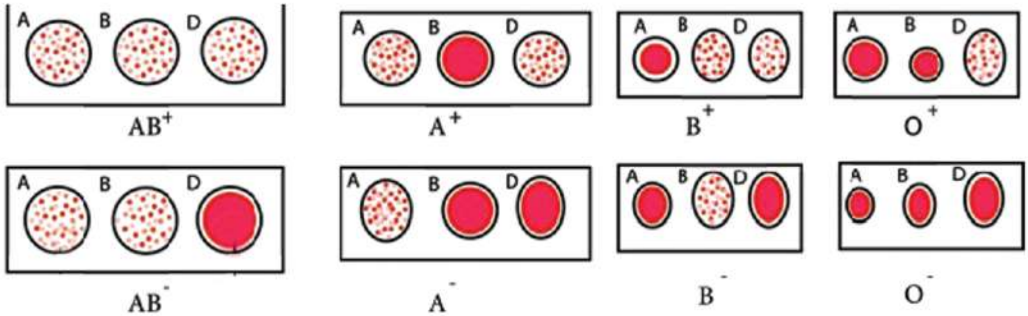


Figure 5.7 Test of human blood group

In the red blood cell (RBC) of human blood, various types of antigens are present. Antigen A and antigen B are found on the surface of RBC of blood. Human blood grouping is based on the inheritance of these red blood cells. On the basis of presence or absence of antigen on the red blood cell, blood is distinguished into different blood groups, such as A, B, AB and O. So, a human blood group may be type A, type B, type AB or type O. Blood which contains antigen A on the surface of red blood cell is called type A blood group. Type B blood group is the blood which contains antigen B. If the surface of RBC contains both antigen A and antigen B, it is called type AB blood group. If the surface of RBC does not contain any antigen, antigen A or antigen B, then it is called type O blood group. Blood group O is the most common blood group in the world. Apart from antigen A and Antigen B, blood may also contain D antigen or Rhesus factor (Rh factor).

Blood group is either positive or negative on the basis of presence or absence of D-antigen or Rh factor. If Rh factor is present, it is positive and if Rh factor is absent, it is negative blood group. If a person has blood group A+ve, his/her blood contains both the antigen A and Rh factor on the RBC. For example, if a person's blood does not contain any antigens, it is O–ve blood group. Blood group should be confirmed before blood transfusion. If a patient is given blood that does not match their blood type, intra-venous clumping can occur in the patient's blood which is fatal. Therefore, before donating blood to the patient, it is important to check whether the patient's own blood and donor's blood are compatible or not.

Project work

Organize a visit to the health post near your school with the help of your science teacher to collect materials related to blood and blood circulation system. If you are unknown of your blood group, then test your blood there. Based on the collected materials, prepare a report on human blood and blood circulation. Take help from the internet if required. Present the report in the classroom and discuss.

5.4 Heart

Activity 5.3 Observation of heart

Objective: To observe the heart and draw it.

Materials required: Heart of a goat or buffalo, dissection tray, dissection box, chart paper, etc.

Method

i. Take a heart of goat or buffalo from a butcher's shop.

ii. Wear gloves and observe the structure of the heart thoroughly.

iii. Identify all its external parts with the help of your teacher.

iv. Draw its external structure on the chart paper.

v. Now put that heart on a dissection tray.

vi. Take a vertical section of it by cutting in a vertical plane.

vii. Observe and identify the internal parts of it with your teacher.

viii. Draw its internal structure on the chart paper.

ix. Discuss the structure of the heart in the classroom. Take the help of your teacher if required.

The heart is the central organ of the circulatory system. It pumps blood to each cell and tissue of our body. The heart is made up of cardiac muscle and is situated inside the thoracic cavity, between two lungs. It is slightly tilted towards the left side. The heart is enclosed within a double-layered protective membrane called pericardium. The space between these two layers is filled with fluid, called pericardial fluid. It protects the heart from external shocks and injuries. The size of the human heart is the size of the owner's closed fist, and it weighs about 300 grams on average.

The heart is a triangular or conical muscular organ composed of cardiac muscles. It contracts and expands regularly to pump blood throughout the body. Blood is pumped through blood vessels and reaches each cell and tissues of body. About two-thirds of the heart lies to the left of thoracic cavity. A hair–like, very fine network of capillaries surrounds the heart. The coronary artery supplies oxygenated blood to the heart, while the coronary sinus vein transports deoxygenated blood to the right auricle of heart.

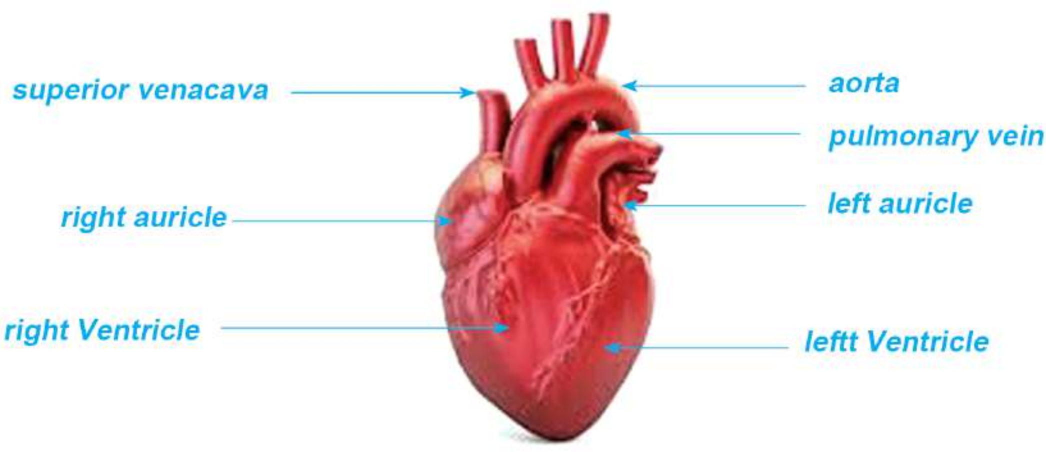


Figure 5.8 External structure of human heart

Internal structure of the heart and blood circulation

The human heart is four-chambered. The upper two chambers are called auricles or atria, while the lower two are called ventricles. There is a thick muscular septum in the middle of the heart that divides the heart into left and right parts and also prevents the mixing of oxygenated and deoxygenated blood in the heart. The four chambers in the heart are named right auricle, right ventricle, left auricle, and left ventricle. Blood vessels are connected to these chambers through which the heart supplies and receives blood. The auricles receive blood from various parts of the body, but the ventricles send blood to various body parts. The heart pumps blood to different part of the body with great pressure. To withstand such pressure, the walls of the ventricles are thicker than those of auricles. The right ventricle pumps blood only up to the lungs, but the left ventricle pumps blood to various organs with great pressure. Therefore, the wall of the left ventricle is thicker than the wall of the right ventricle.

The blood vessels that bring deoxygenated or impure blood to the right auricle of the heart are the superior vena cava and inferior vena cava. The superior vena cava brings impure blood from the upper parts of the body, while the inferior vena cava brings impure blood from the lower parts of the body. When the auricles contract, impure blood from the right auricle is passed to the right ventricle, and pure blood from the left auricle to the left ventricle. The pulmonary artery transports deoxygenated blood to the lungs for oxygenation, while the pulmonary vein transports oxygenated blood to the left auricle of the heart. The only artery that transports oxygenated blood in the human body is the pulmonary artery, and the vein that transports oxygenated blood is the pulmonary vein. After the pure blood is passed from the left auricle to the left ventricle, blood from the left ventricle is pumped to various parts of the body through the aorta.

There are four valves in the heart. The valve situated between the right auricle and right ventricle of the heart is called the tricuspid valve. By opening this valve, blood passes from the right auricle to the right ventricle. The valve situated between the left auricle and left ventricle of the heart is called the bicuspid valve or mitral valve.

Pure blood from the left auricle flows to the left ventricle by opening this valve. Both valves open simultaneously when the auricles contract together, and the contraction of the auricles is followed by the contraction of both ventricles. When the right ventricle contracts, the tricuspid valve is closed, and the pulmonic valve between the right ventricle and pulmonary artery opens, and deoxygenated blood is pumped to the lungs through the pulmonary artery for oxygenation.

Similarly, when the left ventricle contracts, the bicuspid valve is closed, and the aortic valve between the aorta and left ventricle opens, and oxygenated blood is pumped to the various organs of the body through the aorta.

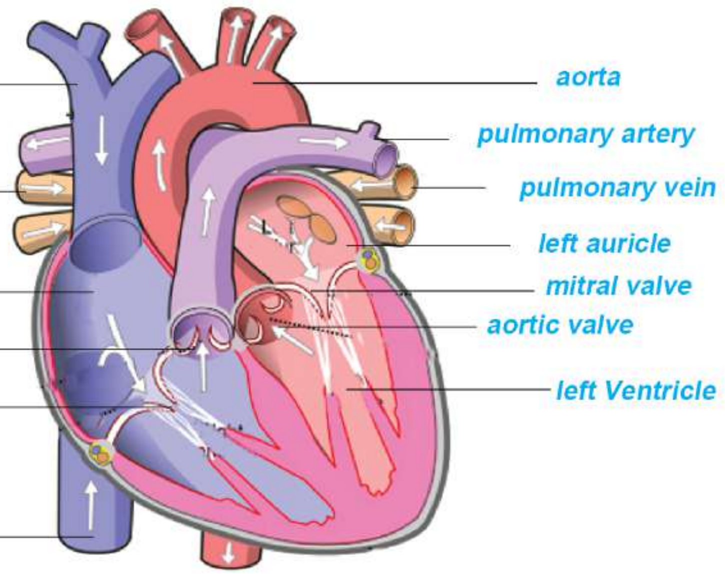


Figure 5.9 Internal structure of the human heart

5.5 Heart attack

In general, the process that continues in the heart is blood coming to the heart from various parts of the body, and blood going to various organs from the heart. But sometimes, the flow of blood to the heart tissues is suddenly reduced or blocked, and in this situation, the heart cannot do its work properly, and the person feels extreme difficulty. This condition is called heart attack. This is a serious and emergency condition.

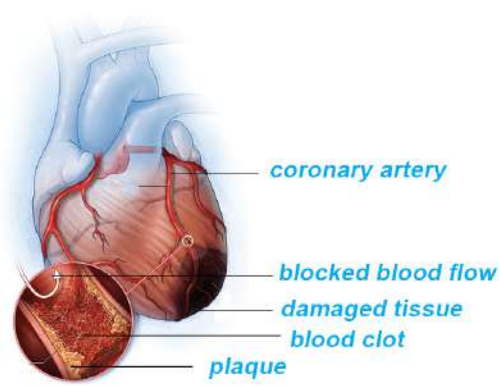


Figure 5.10 Condition of a heart attack

This problem may arise when the coronary artery that supplies pure blood to the heart becomes narrower due to the excess deposition of fat or cholesterols on the inner wall of the artery. Such a deposit of fat or cholesterol on the inner wall of the artery is called plaque. Sometimes, these plaques break down and form thrombi, which may also block capillaries, damaging certain tissues of the heart. A heart attack is also called myocardial infarction, and immediate treatment is required to save the life of a person suffering from a heart attack.

Risk factors of heart attack

Age

Male above 45 years and female above 55 years of age are at the risk of heart attack than the youths.

Consumption of tobacco products

Chewing tobacco and its products and smoking cigarettes are also the causes of heart attack.

High blood pressure or hypertension

A person whose blood pressure is high for a long time is also at the risk of heart attack.

High cholesterol and triglycerides

Arteries become narrower due to the deposition of high level of bad cholesterol on their inner wall. Such cholesterol resists the flow of blood through the artery and increases the chance of a heart attack. Similarly, high levels of triglycerides in the blood also increase the risk of heart attack.

Diabetes

Diabetes is a disorder in which blood sugar level increases in the body. This condition also increases the risk of heart attack.

Family history

If someone has a family history of heart attack, s/he is also at risk of heart attacks.

Lack of regular exercise and unhealthy diet

Consumption of foodstuffs containing more trans-fat, salt, and sugar, animal fat, and processed foods and lack of regular exercise also increases the risk of a heart attack.

Stressful life

Emotional stress, like excessive anger or excessive negative thinking, etc. also increases the risk of a heart attack.

Consumption of illegal drugs

Habits such as taking drugs like cocaine and amphetamines as stimulants affect the coronary artery and increase the chance of a heart attack.

Symptoms of a heart attack

Symptoms of a heart attack vary among people. General symptoms of a heart attack are given below:

a. Sudden pain and discomfort in the centre of the chest which slowly spreads to shoulder, hand, neck, jaw, and sometimes the stomach

b. Cold sweat, fatigue, shortness of breath

c. Headache or sudden dizziness, nausea

d. Some people have sudden heart attacks. But most people experience warning signs of a heart attack a few hours, days, or weeks earlier, such as: regular discomfort or pressure in the chest region that does not get reduced even after taking a rest. These are the initial symptoms and insufficient blood flow to the heart tissues may be the cause of discomfort in the heart.

Preventive measures

a. Maintain healthy lifestyle.

b. Do not consume alcohol and give up smoking.

c. Keep a healthy body weight.

d. Consume a healthy and balanced diet.

e. Exercise regularly.

f. Manage the stress.

g. High blood pressure and diabetes increases the risk of heart attack. So, these conditions should be treated and managed.

h. Go for regular health check-ups.

Diagnosis of heart attack and treatment

For the diagnosis of a heart attack, the blood pressure, pulse, and temperature are checked. Diagnosis also involves overall tests related to the heart, heartbeat, etc.

A heart attack is tested using various techniques, including Electrocardiogram, blood test, Echo, Angiography, CT Coronary Angiogram, and MRI.

Angiography

Angiography is a type of fluoroscopy X-ray used to test blockages in blood vessels. In general, X-ray images of blood vessels are not viewed clearly. However, in this process, a special dye called contrast medium is injected into the blood. This process highlights blood flow and provides a clear view of problems in blood vessels. The X-ray image formed in angiography is called angiogram.

During a heart attack, many tissues of the heart are destroyed per minute. So, immediate treatment is essential to restore blood flow and oxygen levels. For this, immediate supply of oxygen to the patient is required. Especially, the treatment of a heart attack depends on whether there is a partial or complete blockage of blood flow. The patient should be immediately taken to the hospital for treatment, where doctors' instructions are followed. In general, when angiogram and angioplasty equipment are not available, doctors start treatment by using blood thinners. In places where angiogram and angioplasty are available, a surgical procedure is required to open the blocked artery.

Medical procedures such as Coronary angioplasty and stenting, coronary artery bypass surgery, etc., are used to open blocked arteries.

Coronary angioplasty and stenting

This medical procedure is used to open the clogged coronary artery of the heart, also called percutaneous coronary intervention (PCI). During angioplasty, a cardiologist puts a long, thin, flexible tube called a catheter into a blood vessel of the hand or leg and guides it to the narrowed artery of the heart. A stent (a small metal mesh tube) is often placed during angioplasty. The stent helps to open narrowed or blocked blood vessels and n ow. The stent widens the blood vessels and e it is coated with a medicine.

Coronary artery bypass surgery

This is also called open-heart surgery and is the emergency surgical procedure adopted during a heart attack. This method involves surgery by taking a healthy blood vessel from the leg area and making a new pathway to improve blood flow to the heart muscle. Then, heart tissues get nutrient and oxygen-rich blood through a new pathway.

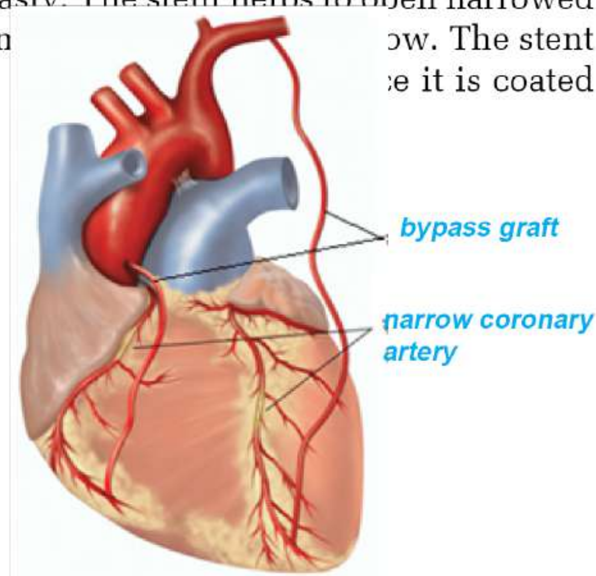


Figure 5.11 Coronary artery bypass surgery

Project work

Use the internet to learn about angiography and open-heart surgery and prepare PowerPoint slides for a presentation in class and discuss.

5.6 Heart beat, pulse rate or heart rate

A heartbeat is the sound of the heart due to the regular and rhythmic contraction and relaxation of the heart muscle. Heartbeat varies with the physical condition of the body. A stethoscope is the device used to measure heartbeat. At resting condition, heartbeat of a healthy adult person is 60-100 times per minute. This is called the heart rate. A slow heartbeat, which is less than 60 times per minute, is called bradycardia or slow heart. A fast heartbeat, which is more than 100 times per minute, is called tachycardia or fast heart.

Because of the regular and rhythmic contraction and relaxation of the heart muscle, blood is pumped to various cells and tissues through arteries. While blood is flowing through the artery, the pressure exerted by blood on arteries can be felt from the outside. This is called the pulse. In general, heart rate and pulse rate are equal. So, these terms are used synonymously. In a healthy adult person, the normal pulse rate ranges from 60 to 100 times per minute. With the help of the fingers placed on the throat or arm, pulse rate of a person can be felt.

Activity 5.4 Measurement of the pulse rate

Objective: To measure pulse rate

1. Sit in a normal posture.
2. Place two fingers on the thumb side of your arm where radial artery is situated between radius bone and tendon. Feel pulse of this artery carefully. Count the number of beat or pulse for one minute. Record the pulse rates of your classmates in the same manner. Compare the data and discuss.
3. Similarly, place your finger on the carotid artery located beneath your lower jaw and measure your pulse rate.

Figure 5.12

Blood vessel

Blood vessels are the flexible, muscular tubes which transport blood to various cells and tissues of the body. Arteries, veins, and capillaries are the three types of blood vessels.

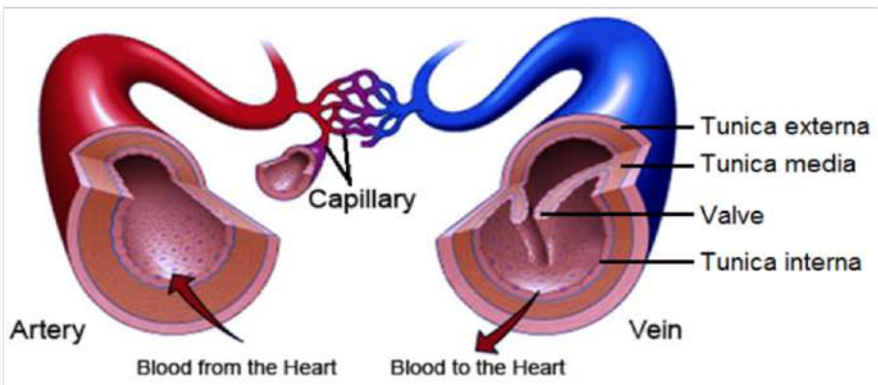


Figure 5.13 Types of blood vessels

Artery

The blood vessel that transports blood from heart to the various parts of the body is called an artery. Arteries are highly muscular blood vessels. Such muscular wall helps to withstand the pressure of blood. There are no valves in arteries. The aorta is the largest artery in the human body, and it divides to give off numerous small arteries. Arteries, in turn, divide to give off arterioles. Each arteriole, again, divides to form a fine network of blood capillaries.

Capillaries

Arterioles divide to form a network of fine, thread-like or hair-like blood vessels called capillaries. Blood capillaries supply nutrients, oxygen, hormones, enzymes, etc. dissolved in blood to the cells and receives the wastes like carbon dioxide, urea and other unnecessary substances produced in the cells to transport them up to excretory organs. After receiving wastes from the cell, capillaries unite subsequently to form venules and veins.

Vein

The blood vessel which transports blood from various organs of the body to the heart is called vein. Their wall is composed of three layers as found in artery but they have a thinner layer of smooth muscles. So veins are thin-walled blood vessels. Veins carry carbon dioxide and waste-rich blood collected by venules to the heart, so there is less speed and pressure of blood in veins and also the probability of blood flow in reverse direction. To prevent the blood flow in the opposite direction, veins have valves at frequent intervals. Venules, veins, and venacava have the same function, but their size differs and numbers.

5.7 Blood circulation

The process by which blood is transported from the heart to various body parts and from the various body parts to the heart is called blood circulation. The heart pumps about 5-6 litres of blood per minute in an adult human. The circulation of blood in the human body can be divided into two ways:

1. Systemic blood circulation
2. Pulmonary blood circulation

Systemic blood circulation

The process of blood circulation in which oxygenated blood from the left ventricle flows through the aorta and its branches (arteries) to various parts of the body, and the deoxygenated blood from these organs returns to the heart through veins is called systemic circulation.

When the left ventricle contracts, pure blood flows from the heart into the aorta. From the aorta to the small arteries and arterioles, blood reaches to the cells through capillaries. In this way, nutrients, oxygen and other essential substances are supplied to each cell of the body. When these substances are utilized in the cells, carbon dioxide gas and other wastes are produced, which are then transported by blood through veins. These veins, in turn, unite to form the venacava, and hence blood rich in carbon dioxide (impure blood) is transported to the right auricle through the venacava. In this way, the process in which blood from the left ventricle goes to various parts through arteries and then returns to the right auricle through veins is called systemic blood circulation.

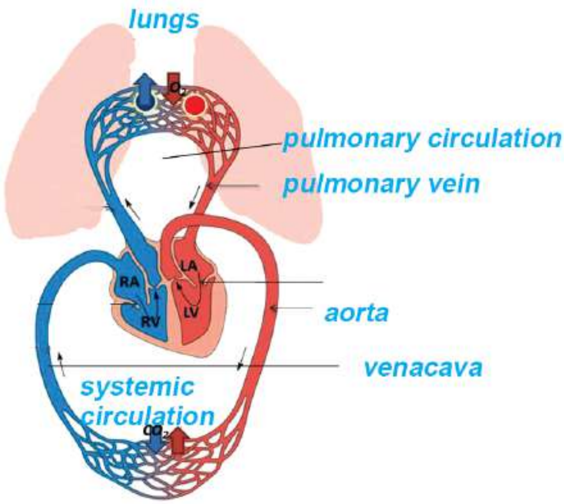


Figure 5.14 Blood circulation

left Ventricle $\xrightarrow{\textbf{artery}}$ **different parts of body** $\xrightarrow{\textbf{vein}}$ **right auricle**

Pulmonary blood circulation

The circulation of blood between the heart and lungs through the pulmonary artery and pulmonary veins is called pulmonary circulation. When the right ventricle contracts, the pulmonic valve opens and deoxygenated blood (carbon dioxide-rich blood) flows through the pulmonary artery and finally through the capillaries network surrounding the millions of alveoli of the lungs. Then, carbon dioxide is left in the alveoli where oxygen is picked up by the blood, which becomes pure or oxygenated. The pure blood is carried to the left auricle through the pulmonary veins. Therefore, the process in which impure blood flows from the right ventricle to the lungs and pure blood flows from the lungs to the left auricle of the heart is called pulmonary blood circulation.

right Ventricle $\xrightarrow{\textbf{pulmonary artery}}$ **lungs** $\xrightarrow{\textbf{pulmonary vein}}$ **left auricle**

5.8 Blood pressure

When the left ventricle contracts and pumps pure blood into arteries, pressure is exerted on the inner walls of the arteries. Such pressure created by the blood on the wall of blood vessels, especially arteries, is called blood pressure. Blood pressure depends on the size of the blood vessel, blood flow, the amount of blood, and the force created during ventricular contraction. Blood pressure is measured in the unit 'mmHg'. Blood pressure is expressed in two values or readings. The upper reading or value is systolic blood pressure, which is created due to the ventricular contraction. The lower value or reading is diastolic blood pressure, which is created due to ventricular relaxation or when the ventricle comes to its original position. Systolic blood pressure in an adult is 90mmHg to 130 mmHg. Similarly, diastolic pressure in an adult person is 60mmHg to 90mmHg. Nowadays, blood pressure is also measured by digital methods.

The device used to measure the blood pressure of a human is called a sphygmomanometer. Blood pressure depends on the mental state, age, sex, and physical state of an individual. The normal blood pressure of an adult person is 120/80 mmHg, where 120 mmHg is systolic blood pressure and 80 mmHg is diastolic blood pressure.

High blood pressure or hypertension

If the blood pressure of an individual exceeds 140/90 mmHg, such a condition is called high blood pressure or hypertension. Symptoms of high blood pressure are given below:

a. Headache, shortness of breath

b. Nose bleeding

c. Sweating, fatigue

d. Face becomes red

e. Sleeplessness, anxiety

Causes of high blood pressure

Blood pressure is caused due to various reasons. Some are mentioned below:

a. Lack of regular physical exercise

b. Hereditary occurrence of high blood pressure

c. Smoking and drinking alcohol regularly

d. Excessive body weight

e. Physically and mentally stressful life

f. Excess consumption of salty and fatty food items

Preventive measures of blood pressure

High blood pressure leads to various physical and mental problems. Therefore, high blood pressure can be avoided by paying attention on time. Following are the ways to avoid blood pressure:

a. Pay attention to the kind of daily meal that you consume. Consume less salty and oily food items.

b. Avoid smoking and drinking alcohol.

c. Take balanced diet in food.

d. Daily physical exercise is essential.

e. Do yoga, meditation and pranayama.

f. Take precautions by checking blood pressure frequently.

g. Live a stress-free life.

h. Participate in various recreational activities.

Diabetes

Due to various causes, the insulin hormone that helps in the management and utilization of glucose obtained from our food becomes low, and blood sugar level rises. A condition in which the amount of glucose in the blood is more than required is called diabetes. It is also called hyperglycemia.

Symptoms of high glucose level in blood

a. Excessive thirst and hunger

b. Frequent dizziness and unconsciousness

c. Frequent urination

d. Blurred vision

e. Person becomes thin and fatigued

f. Muscular spasms and numbness in the hands and legs

g. Slow healing of wounds, etc.

Reasons for high glucose levels in blood:

a. Insufficient secretion of insulin hormone

b. Obesity and inactive lifestyle

c. Imbalanced diet

d. Excessive consumption of fat- and carbohydrate-rich food

e. Heredity

Preventive measures of high blood glucose level

a. Consume green vegetables and fruits abundantly.

b. Regular physical exercise.

c. Maintain proper weight.

d. Maintain an active lifestyle.

e. Live a stress-free life.

f. Go for morning walk daily.

g. Eat balanced diet.

Uric acid

When purine-containing foods are consumed in excess amounts and during the metabolism of purine within the body cells and digestion, they break down and form a type of acid called uric acid. Uric acid is mainly produced in the intestine and liver and, for its excretion, reaches the kidney through the blood. In its way, it helps remove other toxic substances, including plaque deposited on the walls of blood vessels, and makes the blood circulation smooth.

Purine is the source of uric acid, which the body continuously requires for the synthesis of DNA and RNA. Excessive consumption of purine-rich foods leads to the rise of uric acid levels in the blood and brings serious health problems. The problem caused due to the increase of uric acid levels in the blood is called hyperuricemia. Following are the problems of hyperuricemia:

Symptoms of high uric acid

a. Pain in joints

b. Deep pain in muscles

c. Increased chance of kidney stones

d. Reddening, swelling, and burning sensation in skin

e. Excessive pain in the joints of toes

f. Difficulty in walking and movements

Reasons for high uric acid levels in the blood

a. Due to diabetes or any other disease, the kidneys are unable to function perfectly and cannot excrete uric acid.

b. Excess consumption of purine-rich food

c. Habit of drinking less water

Control and preventive measures of high uric acid

a. Exercise regularly.

b. Drink sufficient water, multiple times a day in small amounts.

c. Avoid drinking alcohol and smoking.

d. Consume baking soda.

e. Eat cherries (they contain anthocyanin, an antioxidant which helps to reduce uric acid in blood)

f. Reduce the consumption of fatty red meat, sea foods, pulses, etc.

g. Consume fewer amount of purine-rich food.

Project work

a. Visit a nearby hospital and inquire about high blood pressure, diabetes, and uric acid with the doctors and other health workers there. Prepare a short report and discuss it in class.

b. Inquire about the condition, causes, and measures taken for high blood pressure, diabetes, and high uric acid in your family members, and present a report prepared for class discussion.

Exercise

1. Choose the correct option for the following questions.

a. Which of the following sets of organs belong to the circulatory system?

   i. heart, blood, and lung

   ii. heart, blood, and blood vessel

   iii. heart, liver, and lung

   iv. heart, blood vessel, and liver

b. Which of the following blood cells is without a nucleus?

   i. neutrophil   ii. lymphocyte

   iii. monocyte   iv. platelet

c. Which disease is caused due to the deficiency of haemoglobin?

   i. diabetes   ii. haemophilia

   iii. anaemia   iv. leukemia

d. How many chambers are there in the human heart?

   i. 2   ii. 3

   iii. 4   iv. 5

e. What is the cause of systolic pressure on the wall of the artery during the contraction phase of the ventricle?

   i. Excessive pressure is created inside the heart.

   ii. Pressure produced in the left ventricle of the heart is transmitted to the artery.

   iii. The artery also contracts at the time of contraction of the left ventricle.

iv. Blood becomes thicker at the time of contraction of the left ventricle.

f. The results of Rohit's blood test for blood group identification are shown in the table below.

Antigen	A	B	O	D
Blood clot	Seen	Seen	not seen	not seen

What is his blood group?

i. A positive ii. O positive

iii. AB positive iv. B positive

g. A person feels thirstier, hungrier, dizzy, and sometimes faints, has frequent urination, blurred vision, etc. What is his/her problem?

i. high blood pressure ii. high blood sugar in blood

iii. problem of uric acid iv. anaemia

h. Which of the following tests is appropriate to identify the blockage in a coronary artery during the pain in the heart?

i. test of blood pressure of heart ii. angiogram

iii. ECG iv. measuring heart beat

i. Saambhawi hurt on her leg when she hit a stone while playing in school. Despite various efforts, her bleeding did not stop. What is the reason for this?

i. lack of haemoglobin in blood

ii. lack of white blood cells in blood

iii. lack of platelets in blood

iv. lack of red blood cells in blood

j. Rasmila's grandfather has a problem of swelling of the joints and pain in the body when he eats red meat, legumes and fried foods. What is his problem?

i. high blood pressure   ii. high blood glucose level

iii. problem of uric acid   iv. anaemia

2. Write differences:

a. Red blood cell and White blood cell

b. Auricle and ventricle

c. Artery and veins

d. Pulmonary blood circulation and systemic blood circulation

e. Systolic blood pressure and diastolic blood pressure

f. Anaemia and haemophilia

g. Angiogram and open heart surgery

h. Platelets and white blood cell

3. Give reason

a. Blood is red.

b. WBCs are like the soldiers of body.

c. Wall of ventricle is highly muscular or thicker than the wall of auricle.

d. Wall of left ventricle is thicker than the wall of right ventricle.

e. Arteries do not have valve but veins have valves.

f. A person with anaemia feels tired after a short walk.

g. Arteries are deeply seated inside the muscles but veins are superficial.

h. Blood group should be tested before transfusion.

i. Blood coagulates slower or does not coagulate in haemophilic person.

4. Answer the following questions.

a. Describe the main parts of the human circulatory system.

b. Write the main function of blood.

c. When any part of the body is injured, the bleeding stops after a while. Why?

d. Ramila gets tired even after walking a short distance and also feels difficult to breathe? What is the reason for this? Explain.

e. A person has blood pressure 130/90 mmHg. What does this mean?

f. Which device is used to measure blood pressure?

g. Before the transfusion of blood to a patient, blood group of donor and receiver patient is checked by the doctor. Why?

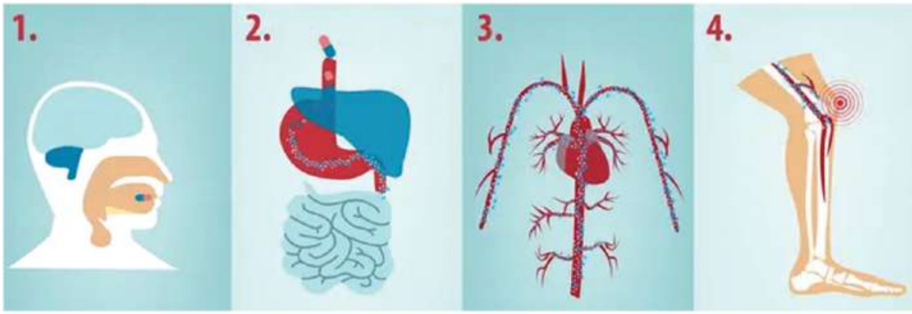
h. Sarita's grandmother shows the symptoms like frequent urination, tiredness, muscular spasm and numbness in hands and legs, and thirst. What is the problem with her?

i. Mention the effect and preventive measures of high blood pressure.

j. Respiratory system, digestive system and circulatory system in human body are interrelated. Explain this statement with reasons.

k. How is high or low blood pressure detected?

l. What process in the body is represented by the given figure? Which systems are involved in this process? If the organ system shown in figure 3 were absent, how would the medicine ingested in figure 2 still be able to reach the knee? Explain with reasons.



m. Answer the following questions on the basis of the information given on the table.

Name of blood cell	Shape	Nucleus	Area of production	Area of destruction
X	Biconcave	absent	Bone marrow	Liver and spleen
Y	Irregular	present	Bone marrow and lymph node	Liver, spleen and at the site of infection
Z	Round and spherical	absent	Bone marrow	Spleen

i. Which blood cell deficiency causes anaemia in a person?

ii. What will be the problem when the number of Y blood cells increases beyond normal?

iii. If blood coagulates slower or does not coagulate in the injured or cut part of a person, which blood cells are below the normal count in that person? What is this condition called?

n. While Sarita was walking on the road, she saw an old man suffering from chest pain. She rushed him to the hospital.

The initial examination suggested that he might have a heart problem. Which test would be appropriate to identify his heart condition? Explain with reason.

o. Explain the blood circulation in the human body with a diagram.

p. Write the preventive measures for hyperuricemia.

q. Explain the internal structure of the human heart with a neat and labelled diagram.

r. Explain the main causes of a heart attack.

s. Introduce angiogram and its importance.

t. Give a brief introduction to open-heart surgery.

u. When Samip's blood was tested, the number of white blood cells was found to be more than 3000. Which symptoms may appear in his body in this situation? Give a reason.

v. The level of fibrinogen was found to be high in the plasma of Harish at the time of the blood test. Does this affect his blood circulation or not? Explain with a reason.

w. Study the given table and answer the following questions.

Person	injury	Flow of blood from injured part
X	Superficial	Bleeding continuously, it was not stopped by general treatment
Y	Deep	Bleeding with high pressure, it was stopped by general treatment
Z	superficial	Bleeding for a while and stopped.

i. Which person suffers from haemophilia?

ii. In which person is the artery injured?

iii. Which injury, Y or Z is more dangerous? Give a reason.

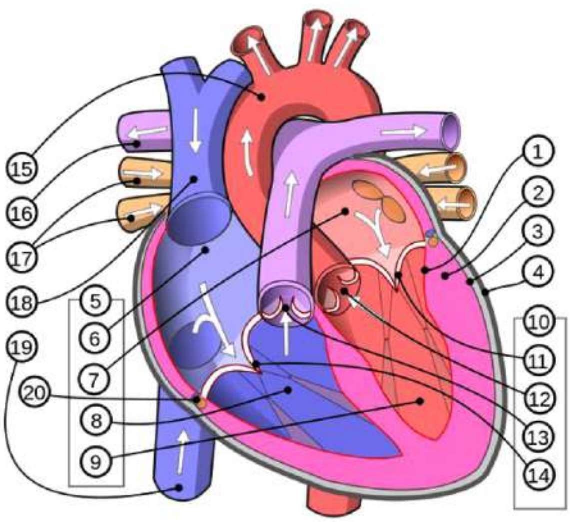
x. Study the concept map given below and answer the following questions.

Left Ventricle	**Kidney**	**Left Auricle**

i. What type of blood circulation is shown in the concept map?

ii. In which parts of the concept map do arteries and veins play a role in blood circulation?

y. Look at the diagram given below and answer the following questions.



i. Differentiate the blood vessel 15 and 18.

ii. Write the function of valves 11 and 13?

iii. What happens in the absence of part 4?

iv. Label the part 6, 7, 8 and 9.

z. Draw neat and labelled diagram of:

i. External structure of the human heart

ii. Internal structure of the human heart

iii. Arteries, veins, and capillaries

iv. Pulmonary blood circulation

v. Systemic blood circulation

6

Nature and Environment

Observe the given picture and discuss.

Figure 6.1

i. What could be the number of the animals shown in above picture, in Nepal?

ii. How will human existence be affected if measures are not taken to conserve these animals?

iii. What could be the reason behind the increment of temperature of the Earth's surface day by day?

iv. As shown in the picture, are the mountains becoming bare or naked due to the melting of snow? How can this be prevented?

v. How relevant is the use of traditional herbal medicine in this modern age?

There are various types of plants and animals around us. In order to preserve the existence of such organisms, it is necessary to maintain the good condition of the environment and habitats. Due to various human activities in the name of modernization and industrialization, the atmospheric conditions of Earth's surface are changing which is causing changes in climate. Climate change has affected the shelter and existence of organisms found on Earth, both directly and indirectly. Due to various natural causes and human activities, many animals and plants are decreasing in number and some have reached extinction. These organisms are rare, and many species of rare plants and animals are found in Nepal. It is our responsibility to protect them so that future generations can also learn about these plants and animals and utilize them. Since some plants have medicinal properties, they have been used as medicine since ancient times to solve various physical complications of the body. These plants are called medicinal plants.

6.1 Climate Change

Activity 6.1 Study of the effect of climate change

Fill in the table below by identifying possible environmental changes and their effects that occur in your locality or school due to climate change, and discuss them in class.

S.N.	Climate change	Effects of environmental changes

Climate

Climate is the average weather pattern for long time, typically about 30 years, in a certain geographical area. Generally, the climate of a place remains similar. Very small natural changes on Earth do not change climate. However, due to the emission of different types of greenhouse gases by human activities, the climate of the world has changed. As a result, the weather patterns of various regions have changed a lot.

Climate change

Climate change is a serious global problem, and developing countries are more affected by it than developed ones. Nepal's contribution to greenhouse gas emission is negligible, yet it is at a high risk of adverse effects of climate change. In addition to the natural up and down of the climate over a long period of time, there has been a gradual change in the Earth's climate due to changes in the composition of the atmosphere caused by direct or indirect human activities. The process of change in climate in the particular place in the long interval of time due to unstable nature and various human activities is called climate change. During climate change, the regular cycle of weather of a place is disturbed. Overall, climate change refers to a change in the statistical magnitude of the weather over a long period of time. Scientists around the world have studied climate change and its effects by analysing various sources such as weather data, satellite images, and research reports of the places affected by climate change. Climate change is also experienced in Nepal. Since the past, the temperature of Nepal is increasing at the rate of 0.06°C every year. Various water sources, like rivers, lakes, and fountains, are drying up every year, and the volume of water in rivers is decreasing. There is an equal chance of flooding due to glacial lake outbursts. Heights of mountains are decreasing due to the melting of snow. Based on all these facts, it can be said that climate change has a negative impact in Nepal as well.

Causes of climate change

The causes of climate change include both natural factors and human-induced activities. Due to poverty, illiteracy, and social inequality, the livelihoods of communities that depend on natural resources are considered more sensitive to the impact of climate change. Causes of climate change can be classified into two: natural and human-induced.

Natural cause

Various natural phenomena influence the environment. The emission of greenhouse gases takes place because of such natural events, and consequently, climate change occurs. Some natural activities are given below:

a. Solar activities

Energy is produced in the sun because of thermonuclear fusion reactions. When the rate of this reaction changes, the energy produced in the sun also changes. This also affects the intensity of solar radiations that come on the surface of the earth. Such changes affect the weather. So, such variations in solar activities have a role in climate change.

b. Change in the reflectivity of the earth

The amount of solar radiation reflected from the earth depends on the nature of the earth's surface and atmosphere. About 70% of the solar radiation that reaches the earth is absorbed. It contributes to the natural changes on the surface of the earth like melting of ice due to climate changes. Greenhouse gases include water vapour too, which is formed due to the evaporation from seas, rivers, and other water sources. Fluctuation in the amount of light and heat radiations of the sun on the earth's surface results in a change in the rate of evaporation.

c. Volcanic eruption

Volcanoes have played a noticeable role in the climate. During volcanic eruptions, various gases, including carbon dioxide and aerosols, are emitted. Such gases and aerosols spread high up to the upper layer of the atmosphere and block solar radiation for some time, making the earth's surface cold. In addition, emitted greenhouse gases in such cases remain in the atmosphere for a long time trapping the solar radiations and increasing the temperature of the earth.

Figure 6.2 Volcano

Human-induced cause

Various activities done by human beings are also the cause of climate change. Greenhouse gases are abundantly produced due to human-induced activities, which form a thick layer above the earth's surface and trap solar heat, leading to a rise in temperature on the earth. Some causes are given below:

a. Production of greenhouse gases

While burning fossil fuels like coal, mineral oil, natural gases to produce heat energy and electrical energy, a tremendous amount of harmful gases, including greenhouse gases, are produced. This process also contributes to the increase in the temperature of the earth's surface.

Figure 6.3 Energy production centre

b. Industrialization

Different types of industries are established to produce cement, steel, electrical appliances, plastic clothes, and other materials. Fossil fuels are used to run such industries. Gases released by the combustion of such fuels pollute the environment and also play role in climate change.

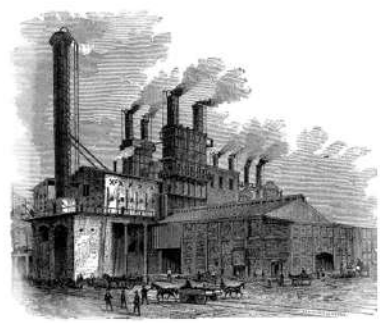


Figure 6.4 Factory

c. Deforestation

Forests are being cut down in an uncontrolled manner during the construction of roads, human settlements, and cultivation. Deforestation reduces the amount of carbon dioxide consumed by plants for preparing food, and consequently, the amount of greenhouse gases in the environment will be increased. This increases global warming. The forest is the main storage site of carbon emitted into the environment.

Figure 6.5 Deforestation

d. Burning of fossil fuels

Fossil fuels are used in most of the vehicles like cars, buses, planes, ships, trucks, etc. While burning such fuels, harmful as well as greenhouse gases, mainly carbon dioxide, are released. These gases pollute the environment and also increase the temperature of the earth.

Figure 6.6 Vehicles

Effects of climate change

Activity 6.2

Divide the students into several groups as per the need, collect photos and details of the effects of climate change on the mountains, hills, and terai by using the internet and newspapers, and then prepare a poster. Display the poster in class and discuss the effects of climate change on the environment and human life.

Over the past few decades, the rise in atmospheric temperature and the resulting climate–related disasters, like either extreme rainfall, no rainfall or drought, have adversely affected the Himalayan range and glaciers of Nepal, as well as the ecosystems dependent on them. Due to the rapid melting of snow caused by the rising temperature of the earth, the size of glacial lakes is increasing, and the risk of glacial lake outburst is also increasing. The negative impacts of climate change have been directly felt in areas related to livelihoods, such as forests and biodiversity, energy sources, human health, tourism, housing, and infrastructure development. Climate-related disasters, such as floods, landslides, and forest fires, have also caused the loss of a large amount of property every year. The effects of climate change are described below:

a. Drought and floods

Climate change brings the changes in the availability or pattern of rainfall in various areas, leading to the possibility of drought in some areas and floods in others due to excess rainfall. Drought and floods affect agricultural production, which increases the risk of food crisis in the future.

b. Increasing sea level

An excess amount of greenhouse gases in the atmosphere results in an increase in the temperature of the atmosphere, leading to changes in the climate. This overall rise in temperature of the earth is called global warming. This rise in temperature also causes an increase in the volume of seawater. Besides, water formed by the melting of snow due to global warming also contributes to the rise of sea level. As a result, water levels reach the top of coasts and islands, destroying flora, fauna, and their habitats, and affecting local communities.

c. Effects on biodiversity

The increment in the earth's temperature caused by climate change brings changes in the life processes of organisms living on land and seas. These changes affect their growth, development, and physiology. Climate change also affects the adaptation of animal and plant species found in land and marine forms. As a result, the risk of extinction of those organisms increases.

d. Negative impact on human health

Climate change adversely affects various environmental components. This also impacts on human health. It causes health hazards in humans, like skin diseases, mental illnesses, nutritional deficiencies, etc.

e. Change in weather

Due to climate change, there has also been a change in the weather. Heavy rainfall occurs in seasons other than rainy season. Sometimes, there is drought during the rainy season. As a result, agricultural farming is affected because sometimes there is heavy rainfall and no rainfall when needed, and often there is too much rainfall for the crops that can easily grow with little water.

Measures to control climate change

Activity 6.3

a. Organize a drawing exhibition on the effects of climate change.

b. Prepare a list on a chart paper by observing the activities going on around you or use the internet to find out the ways to mitigate climate change issues. Also, discuss these measures in the class.

The government of Nepal has formulated policies and programs to manage the adverse effects and risks of climate change. According to the Environmental Protection Act 2076, the government of Nepal, provincial government, local level, and other public bodies and the private sector can issue necessary orders by publishing notices in the Nepal Gazette regarding measures to be adopted to mitigate the adverse effects and risks of climate change. Various negative impacts are seen on the earth due to climate change. To control climate change, it is necessary to adopt measures to minimize it. Some measures are given below:

a. Reducing carbon emission

Global warming is increasing due to the excessive emission of carbon. Climate change can be controlled by reducing the amount of carbon emissions. For this, energy efficiency should be improved and emphasis should be given to the use and conservation of energy resources. Priority should be given to the use of alternative energy sources like solar energy and wind energy in transportation. This can reduce fossil fuel consumption and carbon emissions.

b. Emphasizing in carbon storage

Green plants utilize carbon dioxide to prepare their food and release oxygen into the environment, which is essential for organisms. So, emphasis should be given to the conservation of forest resources through plantation and the conservation of trees. This way more carbon can be stored within plants, helping to minimize the climate change.

c. Public awareness and change in behaviour

If we make our activities more environmentally friendly, we can minimize climate change.

We should make our habits more environmentally friendly and also participate in making the public aware.

Project work 6.1

Prepare a PowerPoint presentation on climate change by researching various newspapers, articles, and the internet, and present it to the class. Discuss your findings with your classmates.

6.2 Endangered plants and animals of Nepal

Identify the animals and plants shown in the picture. In the classroom, discuss the status of these creatures based on the information obtained from various newspapers, radio, television, or other means of communication.

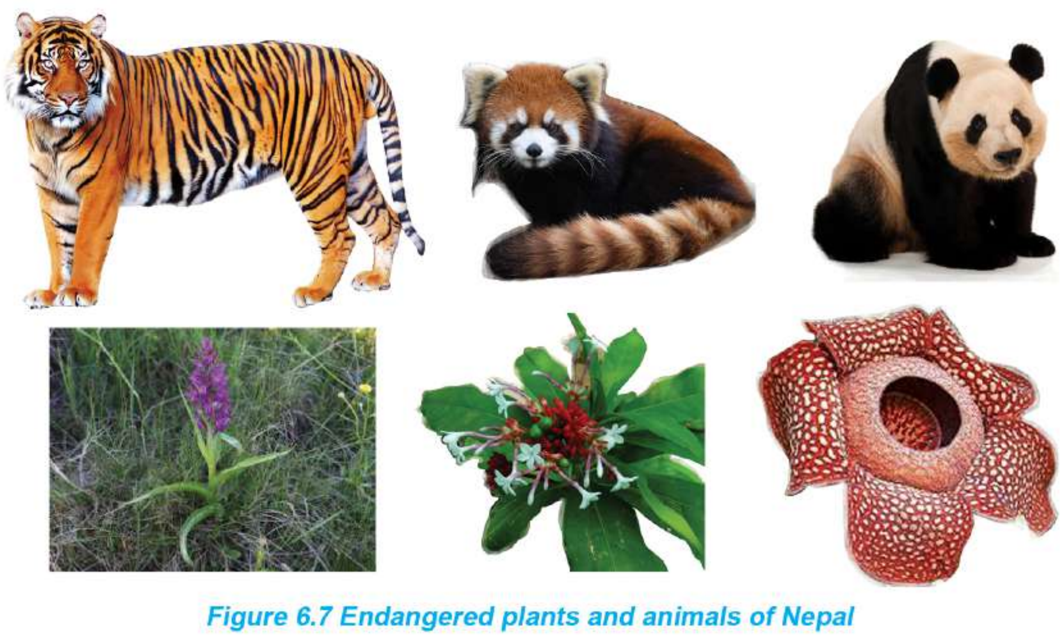


Figure 6.7 Endangered plants and animals of Nepal

The existence of many types of life on the earth is disappearing due to climate change and various other reasons. The number of many animals are decreasing, and some animals have become extinct. The organism that are about to become extinct are called rare organisms, and such rare organisms are found in different parts of our country. The survival of all plants and animals depends on bio-diversity.

Due to human activities and changes in nature in course of modern development, the existence of animals has decreased. There is a chance of extinction of many plants and animals. The main reasons for this are as follow:

a. Due to the adverse effects of weather and climate change, the distribution pattern of plants and animals is affected
b. Uncontrolled use of biological resources is causing a decline in their numbers.
c. Growing new species of plants without any research has affected the indigenous species of plants.
d. Rearing new species of animals without any research has displaced indigenous or prevailing animals of that area.
e. Environmental pollution is increasing.

Project work 6.2

Observe the various plants and animals in your surroundings. Ask the elders in your neighbourhood and make a separate list of the plants and animals which were found there in the past and are not found currently. What are the reasons for their decline? Find out how to protect them, and also, your role in protecting them. Prepare a short report based on the points below, with your analysis, and present it to the class:

a. List of local plants and animals
b. Plants and animals that are declining
c. Reasons for their decline
d. Measures that can be adopted for their conservation
e. Your role in conservation

6.3 Conservation measures for endangered and rare plants

Various species of plants are found in our country. Among them, some important plants are Jatamasi, Champ, Sarpagandha, Panch aule, Lauth Salla, etc., which have been decreasing. These plants are used by human for various purposes, but because they are being used without considering their status, they are going to be extinct in the near future.

Therefore, protection of these plants is a must. Various efforts have been made to protect them. The Government of Nepal has implemented the "Control of International Trade of Endangered Wild Fauna and Flora Act, 2073" for the conservation of rare wild animals and plants. This act includes various rules related to controlled breeding, study research, and sales distribution of rare wild animals and plants. Some conservation measures for protecting rare plants are as follows:

a. Conservation of natural habitat

Collecting firewood, fodder leaves, and grasses from the forest, forest fires, and the extension of pasture land lead to the loss or destruction of natural habitats of wildlife. These activities should be controlled. Rare plants can be conserved by the protection of their natural habitat. Haphazardly grazing of cattle in the forest area should be stopped by humans. Besides, such places should be identified and conserved.

b. Conservation of rare and endangered plants

The varieties of raw materials required for conducting different types of industries and factories are obtained from different types of plants. While collecting such raw materials, the existence and protection of useful plants should be kept in mind. They should not be destroyed in such a way that they cannot be produced again. Their theft and smuggling should be controlled.

c. Increasing the production of saplings through modern methods to expand the number of rare plants

To increase the number of rare plants, their seed should be collected and grown in a nursery. Modern techniques like tissue culture can also be adopted to produce many saplings at a time. After that, afforestation of rare and useful plants can be widely done.

d. Formulation and implementation of appropriate laws

Rules and laws should be made to conserve plants that are about to go extinct and those that are prone to extinction. The information regarding laws should be spread to the public and should be implemented effectively.

e. Medicinal use and conservation of rare plants

It is necessary to make the public aware that most of the rare plants can be used for medicinal purposes. Public awareness raising programs about the rare plants should be organized at the local level. Local people, communities, and organizations should be mobilized for protecting rare plants.

6.4 Measures of conservation of wildlife

Due to various human-induced and natural causes, fauna is endangered, extinct, and becomes rare. Various fauna or animals are at the danger of extinction due to the change in the ecosystem, destruction of habitat, adverse effects on the environment, poaching and illegal trade. To control the illegal hunting and trade of wildlife, the "Control of International Trade of Endangered Wild Fauna and Flora Act, 2073" has been implemented by the government. The following are the conservation measures of rare fauna:

a. Study and research

Extensive study and research work should be carried out to find out the exact status of the nature and the ecosystem available, for the conservation of rare animals and birds.

b. Conservation of natural habitat

All animals and birds flourish in their own natural habitat. Therefore, the natural environment, such as forests, streams, watersheds, pasture lands, etc., should be protected for the conservation of rare flora and fauna.

c. **Strict prohibition of poaching of the conserved wildlife**

The main reason behind the extinction of various fauna is their illegal hunting and trade.Therefore, the rules formulated to control and prevent the hunting of endangered and rare animals and birds should be effectively implemented for their protection.

d. **Managing ex-situ conservation of rare wildlife**

The number of rare animals and birds can be increased by creating a suitable environment for them in the ex-situ conservation area and keeping them in aquariums, botanical gardens, zoos, and similar habitats.

e. **Provision of laws and their effective implementation**

Suitable rules and laws formulated for the conservation of rare wild animals and birds should be effectively implemented. Due to this, illegal activities will be controlled, and rare animals can be protected.

f. **Promoting public awareness**

It is necessary to conduct various programs to increase awareness among the public about the importance of rare animals and birds, the reason for the decline in their number, conservation measures to be adopted and benefits of their conservation, and the participation of local people and public responsibility.

Activity 6.4

Search on the internet about any rare plant and animal you like and prepare a description on chart paper with the title "My favourite rare animal or plant………" which includes its current status, characteristics, reason of extinction, conservation measures, and a picture. Then, present it in the class.

Protected animals and birds

In addition, the following animals and birds are protected in our country: 27 species of mammals, 9 species of birds, and 3 species of reptiles. The list is as follow:

Table: protected animals and birds

Mammals	Birds
1. Pigmy Hog	1. Great hornbill
2. Red Panda	2. Cheer pheasant
3. Black buck	3. White stork
4. Gaur Bison	4. Black stork
5. Wild yak	5. Sarus crane
6. Wild water buffalo	6. Bengal florican
7. Grey Wolf	7. Impeyan pheasant
8. Hispid hare	8. Lesser florican
9. Swamp deer	9. Crimson horned pheasant
10. Asiatic wild elephant	
11. Lynx	**Reptiles**
12. Striped Hyena	1. Gharial
13. Assamese Monkey	2. Asiatic rock Python
14. Indian Pangolin	3. Golden monitor lizard
15. Chinese Pangolin	
16. Himalayan musk deer	
17. Clouded leopard	
18. Great Tibetan sheep	
19. Bengal Tiger	
20. Snow Leopard	
21. Tibetan Antelope	
22. Gangetic Dolphin	
23. Leopard cat	
24. Spotted Linsang	
25. One-horned Rhinoceros	
26. Four-horned Antelope	
27. Brown Bear	

6.5 Medicinal plants of traditional use, found in Nepal

Identify the picture given below and discuss:

Figure 6.8 Medicinal herbs

a. What are the names of the plants given above?

b. For what purpose can these plants be used?

c. What are these plants commonly called?

d. What are the advantages of cultivating these plants on a commercial basis?

The plants shown above are commonly used as home remedies for various ailments. Various parts of these plants are used as raw materials for making different types of medicines. So, they are commonly called medicinal plants. Malabar nut (ASURO), Asiatic pennywort (GHOD TAPRE), aloe vera (GHIU KUMARI), holy basil (TULSI), neem, etc. are common medicinal plants found in various regions of Nepal. According to the Department of Plant Resource, more than 7000 flowering plants are found in Nepal, more than 700 species of plants are identified as medicinal plant and used as medicine. The highest number of medicinal plants is identified in the Karnali region. There is a need for further study and research regarding the correct use of such plants, their market management, proper and sustainable use, and also the utilization of our traditional knowledge and skills.

Activity 6.5

Prepare a list of medicinal plants found in your locality and home, and write their uses in the table given below. Also, discuss them in class.

S.N.	Name of medicinal plants	Part of plant used as medicine	Uses
1.	Amala		
2.			
3.			

In this chapter, we discussed some of the medicinal plants identified in Nepal:

Holy Basil (Tulsi)


Figure 6.9 Tulsi plant

Its scientific name is Ocimum tenuifiorum. It is a multipurpose medicinal plant found everywhere in the world. It produces more oxygen and is important from a religious point of view. Therefore, according to our tradition, people who have reached the end of their life are kept near this plant to compensate for the lack of oxygen. Tulsi is used as a spice in various dishes. It is also used in tea. All parts of the plant, including the leaf, shoot, flower, root, and seeds are important. These parts can be used as medicine. Consuming it stimulates the appetite and promotes active and smooth digestion. The plant also possesses antimicrobial properties and is used to destroy harmful microorganisms that affect animals and humans. It is used for various purposes, such as disinfection, purifying water, and gargling. In rural areas, its leaves are boiled with water and consumed during throat pain or cold and infections.

Neem


Figure 6.10 Neem plant

Its scientific name is Azadirachta indica. It is a tall tree. Its all parts like leaves, root, stem, flower, and fruit are used for making a variety of Ayurvedic medicine. Its parts are extremely bitter in taste, and neem juice is very useful in skin-related health problems.

It is also known to be a natural purifier of blood, destroying and reducing the bad cholesterol in the body. To minimize high blood pressure, neem juice is consumed. But excessive consumption may lead to extreme low blood pressure and complications.

Heart-leaved moonseed (Gurjo)

Its scientific name is Tinospora cordifolia . It is found in most of the nurseries and forests of Nepal.

It is a climbing shrub. It grows by taking the support of other plants and can be propagated from the stem. It is found from the terai region to the Himalayan region of Nepal. It boosts the immunity of the body. So, this helps to prevent infections. It is a multipurpose medicinal plant having anti-oxidant properties. Its optimum consumption does not have negative effect on the body, but its excessive consumption reduces the sugar level in the blood.

Figure 6.11Heart-leaved moonseed (Gurjo)

Asiatic pennywort (Ghod tapre)

Its scientific name is Centella asiatica. It is found in the tropical places. It is a herbaceous plant. This plant has a slightly aromatic smell and is a perennial plant that lives for more than two years. It creeps along the ground and is specially found spreading like a green carpet in swampy and shady places in paddy fields, banks of streams, etc. All of its parts can be used for medicinal purposes.

Figure 6.12 Asiatic penny wort (Ghod tapre)

It also possesses antimicrobial and anti-oxidant properties. Its consumption is beneficial because it is neuroprotective in function. Its regular consumption enhances mental capacity and memory power. It contains anti-stress formula. Its consumption relieves depression and anxiety. From ancient times, this herb has been used as a medicine for the common cold. Its fresh flower is crushed and made a paste to apply on burnt skin and wounds. It is believed that, its paste can treat skin related problems. It is used as raw material for making various medicines. Similarly, Ghod tapre is used to make cosmetics like skin care cream, skin toning, etc.

Turmeric

Figure 6.13 Turmeric

Its scientific name is Curcuma longa. This plant is also a perennial herb. Its stem is modified into underground rhizome. It contains an organic chemical called curcumin, which makes it yellow-coloured. Medicinal property of this plant is the presence of curcumin. Turmeric also contains vitamin A, B, B2, and C abundantly. Other minerals like calcium, phosphorus, and iron are found in it. Turmeric contains antimicrobial property. It makes our diet spicy and attractive and also kills harmful microorganisms found in our food. Consumption of turmeric enhances our body's immunity. It is cultivated in Nepal since ancient times. It helps to destroy the toxins in the body, and is also used for the treatment of leprosy, scabies, etc. Turmeric is beneficial to prevent respiratory diseases, heart-related diseases, etc. It is used to make cosmetics and is also used as a natural dye for colouring various materials.

Malaber nut (Asuro)

Its scientific name is Adhatoda vasica. This plant is a medium-sized shrub. It is found in the range of Chure mountains and up to Mahabharata range. This plant is full of medicinal properties. It contains chemicals like vasicine, vasicinone, hydroxyl vasicine. Because of these chemicals, it is used in the treatment of respiratory ailments. Malabar nut leaves are boiled with water, and this water is used to gargle for the treatment of teeth and gum ailments. Because of the microbial property of this plant, its consumption prevents various infections. Its flower is used as medicine in the burning sensation of the urinary tract. To get relief from common cold, it can be also used in tea. Juice of its flower and leaf helps to clear mucus from lungs and respiratory tract and also helps to widen respiratory pathways. It is cut down to make manure in fields.

Figure 6.14 Asuro

Calamus (Bojo)

Its scientific name is Acorus calamus. It is an erect herb with aromatic parts. It grows on swampy land and on the bank of ponds, ditches, etc. It grows easily without any care from human. Its leaves are like sword-shaped, and its modified root-like structure is called rhizome. Rhizome is used as traditional medicine. It is beneficial for throat-related health disorders. It is used to relieve pain and to treat upset stomach. But its excessive use causes nose bleeding.

Figure 6.15 Bojo

Caterpiller fungus (Yarsagumba or Yarchagumba)

Its scientific name is Cordyceps sinensis. Yarsagumba is found at the height of 3000m-5000m from sea level, in the snow-covered grasslands. It is a long, white, or brown-coloured fungus of about 5-8 cm and grows on the body of a caterpillar. Yarsagumba belongs to fungi group. It reproduces by spores. From the old yarsagumba on the land, many spores spread in the atmosphere. These spores get adhered on the body of a caterpillar of a type of butterfly. These spores germinate in the body of that larva. Then, hyphae of such fungus spread into the body of larva in search of food. The caterpillar can move for some time, but later they become relaxed when the hyphae spread extensively in the body of the larva. Finally, the larva dies under the soil. Then, this fungus receives the nutrients from the dead body of the caterpillar and grows. Therefore, yarsagumba has two parts: upper part is fungus and the lower part is caterpillar. In the winter, yarsagumba seems like an insect in which the fungus is fully developed. In the rainy season, when snow melts, the fungus completely mummifies the dead insect. This fungus has no root, stem, leaf, flower, and fruit. It is used for making medicine in Ayurveda. It is an energy booster when consumed with honey or milk. It is rare, and its collection, use, sales, and export is prohibited by the government.

Figure 6.16 Yarchagumba

Mugwort (Tite paati)

This medicinal plant belongs to the category of herbs. Its scientific name is Artemisia vulgaris and it is found in the mid-hilly region of Nepal. This plant is used for the production of various types of cosmetics, perfumes and organic pesticides. Generally, this herb grows everywhere.

Figure 6.17 Tite pati

Farmers also use it as grass, which is dried to make bedding materials (litter) for cattle. Nowadays, scented oil is extracted from this plant.

Aloe vera (Ghiu kumari)

Its scientific name is Aloe vera. Generally, it grows in dry places. Its leaves are thick, fleshy, and serrated. This plant stores food and water in its leaves and water accumulated in the leaf is gel-like. This gel is used as a remedy for various ailments. In Ayurveda, Ghiu kumari is also considered as "SANJIVANI". Vitamins A and C, which are required for human beings, are found abundantly in Aloe vera. Regular consumption of Aloe vera juice is beneficial for abdomen, bone joint, and skin-related problems. When its gel is applied to the skin, it provides relief from cracking of the skin and sunburn and also helps to maintain moisture in the skin and makes it glow. It does not allow pimples, dandruff, etc. to occur on the skin. Applying its gel to the hair makes the hair shiny and also strengthens the roots. When applied to a burned area, the wound heals faster.

Figure 6.18 Aloe vera

Project work 6.3

Collect different types of medicinal plants/herbs found around your home and school and paste them one by one on each page of a notebook. Also, write their availability and uses on each page. In this way, prepare a handbook of herbs by collecting information about these medicinal plants.

Project work 6.4

Apart from the medicinal herbs mentioned above, inquire about the medicinal plants found in your locality and prepare a short report on their availability, use, and conservation measures. Discuss these plants in the class.

Exercise

1. Choose the correct option for the following questions:

a. Nowadays, sometimes there is low rainfall and sometimes heavy rainfall, which has affected the agricultural production. What may be the reason for this?

i. Volcanic eruption   ii. Climate change

iii. Decline of rare wildlife

iv. Change in atmospheric pressure

b. What is the reason for the increase in the volume of sea level?

i. Heavy rainfall   ii. Low rainfall

iii. Global warming   iv. Deforestation

c. Which of the following groups is a group of endangered animals?

i. Swamp deer, Asiatic wild elephant, stripped hyena

ii. Asiatic wild elephant, stripped hyena, jackal

iii. Antelope, tiger, leopard

iv. Asiatic wild elephant, tiger, bear

d. In which group of plants, does Tulsi belong?

i. Endangered plant

ii. Medicinal plant

iii. Thorny plant

iv. Creepers

e. The union of a type of caterpillar with a specific fungi forms Yarsagumba. In this, what is the relation between caterpillar and fungi?

i. Symbiotic ii. Parasitic

iii. Predator iv. Saprotrophic

f. In chickenpox, neem powder paste is applied to the affected parts, and neem leaves are spread on the bed. It helps to heal chickenpox. What property in neem helps to do so?

i. Anti-inflammatory property

ii. Anti-oxidant property

iii. Anti-microbial property

iv. Anti-pyretic property

g. Which part of Bojo is used for medicinal purposes?

i. Rhizome ii. Leaf

iii. Stem iv. Flower

h. Rama has been coughing for a long time? For this, which medicinal plant helps to get relief from cough?

i. Boiled neem water ii. Aloe vera juice

iii. Boiled tulsi water iv. Yarsagumba powder

i. What is the reason for the natural disaster shown in the given picture?

i. Climate change ii. Deforestation

iii. Heavy rain fall iv. Volcanic eruption

2. Write the differences:

a. Weather change and climate change

b. Endangered plants and medicinal plants

c. Greenhouse effect and climate change

3. Give reason:

a. The main causative factor of non-seasonal rainfall is climate change.

b. Sea level rises due to climate change.

c. Climate change also causes the extinction of animals.

d. Endangered animals can be protected by conserving their natural habitat.

e. The use of medicinal plants is beneficial for human health.

f. Tulsi is called a life-giving plant.

g. Neem is a multipurpose medicinal plant.

h. Yarsagumba is used as an energy-booster herbal medicine.

4. Answer the following question:

a. What is climate change?

b. Write the main reasons for climate change.

c. Describe the effects of climate change.

d. What types of animals are called rare animals?

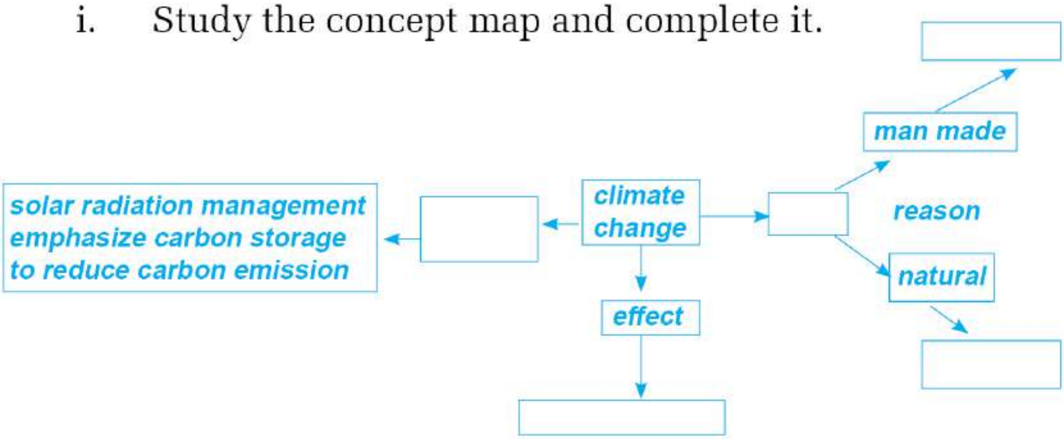
e. What measures can be adopted to protect rare animals?

f. Many plants are being extinct in Nepal due to climate change. What role can you play to protect such plants? Describe in brief.

g. In order to protect and promote the medicinal herbs found in Nepal, it is essential to train the local people on the processing of herbs and their use. Explain your opinions.

h. By protecting Yarsagumba and increasing its production, the economy of the country can also improve. Explain this statement.

i. Study the concept map and complete it.



j. Analyse the differences between part A and part B by observing the given picture.

k. Look at the picture thoroughly and explain its role in climate change.

l. The one-horned rhinoceros is on the verge of extinction. What can be done to protect it? Write in brief.

m. We can find different types of medicinal herbs in our locality. But we depend on others for the treatment of common ailments. Identify the main reason for this and write about what can be done to maximize the use of local medicinal herbs.

7

Motion and Force

		
Figure 7.1 Parachute landing Perseverance Rover sent from Earth to the planet Mars	Figure 7.2 Rocket used to send Perseverance Rover	Figure 7.3 The International Space Station in orbit about 400 km above Earth (ISS)

Stones dropped from our hands, fruits falling from trees, etc. move towards the Earth. The earth attracts various objects toward its center. Moon and Earth are also attracting each other. Figure 7.1 shows the parachute being used for the safe landing of the Perseverance Rover sent from Earth to Mars. That means, Mars also attracts objects toward its center.

Gravitation and Newton's universal law of gravitation

When Sir Isaac Newton, a British mathematician/physicist, saw a fruit falling from a tree to the ground, he began to wonder why the fruit did not fall horizontally but only vertically. After doing much study and thinking, he concluded that the attraction between the apple and the earth caused the fruit to fall towards the centerof the earth. Similarly, he wondered how the planets, moon, sun, stars, etc. are stuck in the sky.

Fig 7.4

After a long study, Newton concluded that there exists a force of attraction between all bodies. He named this force gravitation. In 1687, he propounded the Universal Law of Gravitation.

Activity 7.1

In Figure 7.5, the calculation of gravitational force between two bodies is shown. These values were obtained using the PhET Interactive Simulations on the Internet.To open this activity on your computer, open the internet browser and type https://phet. colorado.edu/sims/html/gravity-force-la latest/gravity-force-lab_en.htmlon the search bar. In the simulation, the mass of the sphere and its distance can be changed through the slider. The two cases of changing the massand changing the distance are presented in the table below. Study them and draw suitable conclusions from thegiven data.

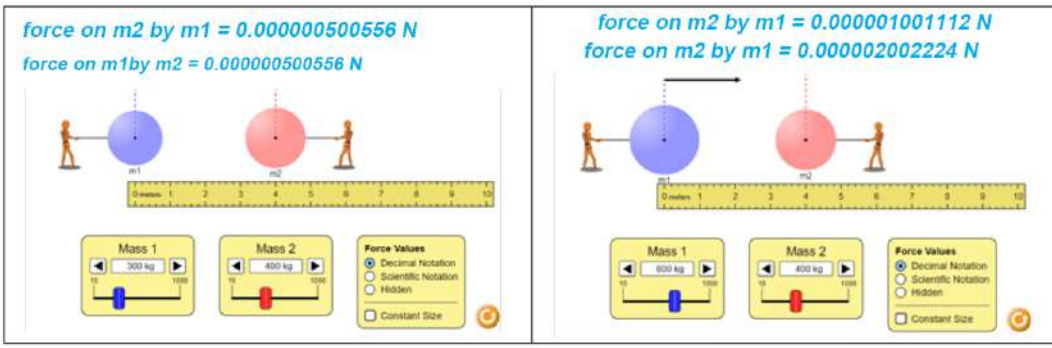


Figure 7.5 Difference in gravitational force between two objects when their mass is changed

(a) First, doubling the mass of the first sphere while keeping the mass of the second sphere and the distance between them the same, and then doubling the mass of both spheres keeping the distance between them constant.

The force between two masses before changing the mass (F_1)	After changing mass		The force between two masses (F_2)	Conclusion
	First mass (m_1)	Second mass (m_2)		
0.000000500556 N	600 kg	400 kg	0.000001001112 N	$F_2 = 2 F_1$
0.000000500556 N	600 kg	800 kg	0.000002002224 N	....

(b) Doubling the distance between two spheres keeping the mass constant.

first mass (m_1)	Second mass (m_2)	Initial distance (d_1)	force (F_1)	Changed distance (d_2)	force (F_2)	Result
300 kg	400 kg	4 m	0.000000500556 N	8 m	0.000000125139 N	

From this activity, when the mass of one sphere and that of both spheres are doubled, the gravitational force is found to be two times and four times the initial force respectively. Here, when the product of two masses increases four times, the gravitational force is also increased by four times. That is, when the distance is kept constant, the gravitational force is directly proportional to the product of the masses of the two objects. Similarly, when the distance between two spheres is doubled, the gravitational force is found to be reduced by four times. That is, when the mass is kept constant, the gravitational force isinversely proportional to the square of the distance between the two objects.

The collective conclusions of activity 7.1 are included in Newton's universal law of gravitation. According to this law, the gravitational force produced between any two objects in the universe is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

As shown in figure 7.6, let the mass of the objects A and B be m^1andm^2 respectively, the distance between the centers of these two objectsbe d, and the gravitational force produced between them be F. According to Newton's law of gravity, the gravitational force (F) is directly proportional to the product of the mass of these objects m_1 and m_2,

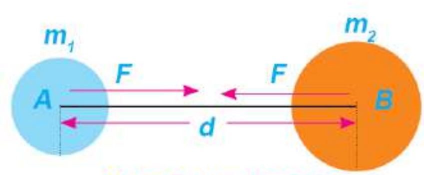


Fig 7.6 two masses

That is, $F \propto m_1 \; m_2$............ (i)

and inversely proportional to the square of the distance d,

That is, $F \propto \frac{1}{d^2}$ .... (ii)

Combining (i) and (ii),

$$F \propto \frac{m_1 m_2}{d^2}$$

$$F = G\frac{m_1 m_2}{d^2} \text{ .... (iii)}$$

Here, G is the proportionality constant and is also known as the universal gravitational constant. Using equation (iii), the gravitational force between any two objects can be calculated.

The gravitational constant G is the magnitude of gravitational force produced between two unit masses that are separated by unit distance.

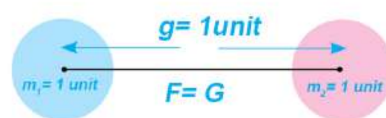


Figure 7.7 Definition of G

As shown in the figure, when $m_1 = m_2 = 1$ kg and $d = 1$ m

$$F = \frac{Gm_1m_2}{d^2} = \frac{Gx1x1}{1^2} = G$$

The value of the gravitational constant was first measured by Henry Cavendish in 1798 using the Cavendish balance. From that experiment, the value of G was found to be 6.67×10^{-11}. Since its value remains the same regardless of the materials and the medium between the bodies, it is called the universal gravitational constant. Its SI unit is $N\,m^2/kg^2$

Example 7.1

The mass of the Earth is 5.97×10^{24} kg and its radius is 6371 km. Calculate the gravitational force between the Earth and a 1 kg iron sphere on its surface.

According to the information given in the question,

Mass of Earth $(m_1) = 5.97 \times 10^{24}$ kg

Mass of sphere on the surface of the earth $(m_2) = 1$ kg

Radius of the earth(R) = 6371 km = 6371 x 1000 m = 6.37×10^6 m

The gravitational force between two spheres, $F = \frac{Gm_1m_2}{d^2}$

On substituting the values,

$$F = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 1}{(6.37 \times 10^{6})^2}$$

$$\text{or } F = \frac{6.67 \times 5.97 \times 10^{-11+24} \times 1}{(6.37 \times 10^{6})^2}$$

$$\text{or } F = \frac{39.82 \times 10^{13} \times 1}{40.58 \times 10^{12}} = 0.986 \times 10^{13-12}$$

$$\text{or } F = 0.981 \times 10 = 9.81\ N$$

$$\therefore F = 9.81\ N$$

The gravitational force between the earth and an iron ball of mass 1 kg on its surface is 9.81N

Example 7.2

The mass of the Moon and the Earth is 5.97×10^{24} kg and 7.34×10^{22} kg respectively. The distance between the Moon and the Earth is 3.84×10^5 km. Calculate the gravitational force between the Moon and the Earth.

According to the information given in the question,

Mass of Earth $(m_1) = 5.97 \times 10^{24}$ kg

Mass of Moon $(m_2) = 7.34 \times 10^{22}$ kg

Distance between the earth and Moon (d) $= 3.84 \times 10^5$ km $= 3.84 \times 10^8$ m

The gravitational force between the earth and moon, $F = \frac{Gm_1m_2}{d^2}$

Substituting the given values,

$$F = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 7.34 \times 10^{22}}{(3.84 \times 10^{8})^2}$$

$$\text{Or } F = \frac{6.67 \times 5.97 \times 7.34 \times 10^{-11+24+22}}{14.75 \times 10^{16}}$$

$$\text{Or } F = \frac{292.28 \times 10^{35} \times 10^{-16}}{14.745} = 19.82 \times 10^{35-16}$$

$$\therefore F = 19.82 \times 10^{19}\ N$$

The gravitational force between the Earth and the Moon is $1.982 \times 10^{20}\ N$.

Question for discussion

As calculated in example 7.1, the gravitational force between the Earth and a sphere of mass 1 kg is 9.8N. This force acts on both objects. However, when the ball is dropped from a certain height, the Earth does not move upwards, but only the ball appears to fall towards the Earth. Why? Using Newton's second laws of motion, calculate the acceleration produced by that force on the sphere with a mass of 1 kg and on the Earth with a mass of 5.97×10^{24} kg.

Variation in gravitational force with mass and distance

The change in gravitational force observed in activity 7.1 can be explained mathematically by using the formula used to calculate the gravitational force. Suppose two objects A and B have masses m_1 and m^2 respectively. If the distance d between those objects is d and the gravitational force in the initial condition is F_1.

then, $F_1 = \frac{Gm_1m_2}{d^2}$ .... (i)

When the mass of an object is made double	When the mass of both objects is made double
Putting, $m_2 = 2\ m_2$ in equation (i) $F_2 = \frac{Gm_1 2m_2}{d^2} = 2\ \frac{Gm_1m_2}{d^2}$ $F_2 = 2F_1$	Putting, $m_1 = 2\ m_1,\ m_2 = 2\ m_2$ in equation (i) $F_2 = \frac{G2m_1 2m_2}{d^2} = 4\ \frac{Gm_1m_2}{d^2}$ $F_2 = 4F_1$

On Keeping the distance between two objects constant, increasing the mass of an object by 2 times, the gravitational force also increases by 2 times. Similarly, by increasing the mass of both objects by 2 times, the gravitational force increases by 4 times.

When the distance between the objects is made half	When the distance between the objects is doubled
Putting, $d = \frac{1}{d^2}$ in equation (i) $F' = \frac{Gm_1m_2}{\left(\frac{d}{2}\right)} = 4\ \frac{Gm_1m_2}{d^2}$ $F' = 4F$	Putting, $d = 2\ d$ in equation (i) $F' = \frac{Gm_1m_2}{(2d)^2} = \frac{1}{4}\ \frac{Gm_1m_2}{d^2}$ $F' = \frac{1}{4}\ F$

If the distance between the two objects is halved, while keeping the mass constant, the gravitational force between the two objects increases by 4 times. Similarly, if the distance between two objects is increased by two times, the gravitational force between those two objects decreases by four times.

Consequences of gravitational force

Some of the consequences of gravitational forces are presented below:

(a) Gravitational force has made the existence of the universe including the solar system possible. The gravitational force between the sun and the planets causes the planets to revolve around the sun.

(b) Since the Moon is closer than the Sun to the Earth, it is important even though it has a very small mass compared to the Sun. The effect of the moon's gravitation is more visible on seawater than on land, due to which tides are created.

(c) Gravitational forces between the earth and the objects on its surface make the objects stick to the surface of the earth. Also, if an object is thrown vertically upwards, the object will fall back on the surface.

Gravity

Earth and other planets and satellites are pulling their nearby objects towards their centers. The force exerted by the planet or satellite on nearby objects is often called the force of gravity. It is also called the weight of the object. According to Newton's universal law of gravitation, the force of gravity decreases with increasing height from the planet and becomes negligible at a certain distance. Therefore, Earth and other planets/satellites have a definite gravitational field.

We observe many effects of Earth's gravity in our daily life. Some of these effects are mentioned below:

(a) All objects have the weight due to gravity.

(b) Earth is surrounded by the atmosphere due to gravity.

(c) Objects dropped from a certain height fall towards the center of the Earth due to its gravity.

(d) Due to the effect of gravity, water in rivers and streams flows downwards.

(e) Force of gravity causes acceleration in a falling object.

Acceleration due to gravity

Activity 7.2 Calculation of acceleration due to gravity

Take a small stone and a stopwatch. Drop the stone from different heights (e.g., first floor, second floor of a building). Drop the stone in such a way that no downward force is applied by the fingers on the stone,i.e.,just release the stone from the hand by loosening the fingers. Tell a friend to record the time taken by the stone to reach the ground using a stop watch.

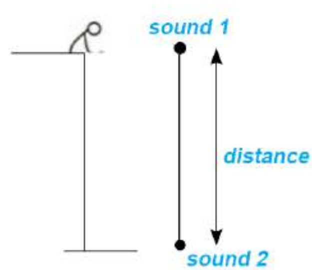


Figure 7.8 Measurement of acceleration due to gravity.

Using the data so obtained and equations of motion ($h=ut+\frac{1}{2}at^2$, $v^2=u^2+2ah$) calculate the acceleration and velocity (final velocity v) of the stone when it hits the ground.While calculating, take the initial velocity of the stone (u) = 0.

A table like the one below can be used for data collection and necessary calculations.

Data collection	h	t	$a=\frac{2h}{t^2}$	Average acceleration	$v=\sqrt{(2ah)}$	Result
First time	...	...	$a_1=\cdots$	$=\frac{a_1+a_2+a_3}{3}$	$v_1=\sqrt{(2ah_1)}$	....
Second time	...	...	$a_2=\ldots.$		$v_2=\sqrt{(2ah_2)}$	
Third time	...	...	....		$v_3=\sqrt{(2ah_3)}$	

In activity 7.2, the object released from the hand is set in motion due to the earth's gravity, and it acts constantly throughout the motion. The more the object falls, the faster its velocity will be. Increasing the velocity of the object means it is accelerating. Thus, acceleration gets produced in the body falling freely towards the earth's surface because of gravity. In activity 7.2, the acceleration of a falling stone is $9.8m/s^2$when the air resistance is negligiblei.e., almost zero. Such acceleration is the acceleration due to the gravity of the earth. The acceleration produced in a freely falling object due to the force of gravity is called acceleration due to gravity. It is denoted by 'g' and its SI unit is meter per second squared (m/s^2).

Question to think

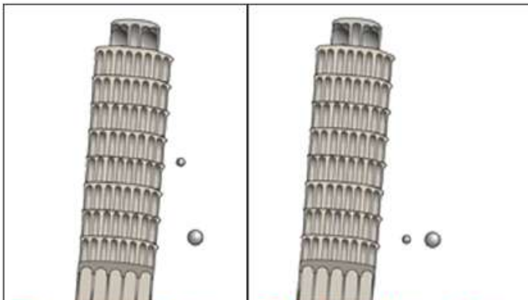
Does the acceleration due to gravity vary according to the mass of the falling object?

Activity 7.3

Take a small stone and a sheet of paper. Tear the sheet of paper into two equal parts. Squeeze one of them tightlyinto a ball shape. Drop the sheet of torn paper, a paper ball and a stone together and observe which one reaches the ground first. Do the sheet of paper,the paper ball and the stone fall at different velocities? If this activity was done on the moon, what would be the result?

In this activity, the sheet of paper and the paper ball having the same mass fall at different velocities, but the paper ball and the stone having different masses fall together. Thus, the rate of change in the velocity of an object falling towards the surface of the earth is not related to its mass. When a sheet of paper falls in the air, the air resistance exerts an upward force on it and the velocity decreases, but in the case of paper ball and stone, the air resistance is negligible and they fall together towards the center of the earth only under the influence of gravity.

Since there is no atmosphere on the surface of the moon, all objects fall freely without obstruction. In such a situation, all objects fall with the same acceleration (acceleration due to gravity). If a sheet of paper and the paper ball, as mentioned in activity 7.3, are dropped together on the surface of the moon, they both fall together



The perception beforeGalileo's experiment	Confirmation after Galileo's experiment

Figure 7.8 Falling of objects with different masses

According to the laws of motion propounded by Aristotle, who was born in Greece in 384 BC, heavier objects fall before lighter ones. This law was disproved by Galileo's experiment in the seventeenth century. Around the year 1590 BC, Galileo dropped two balls together from the Leaning Tower of Pisa in Italy and found that both balls hit the ground together. He concluded that all freely falling bodies fall with the same acceleration due to gravity. This was later proved by the feather- and coin experiment.

Feather and coin experiment

In Figure 7.9, a glass cylinder is connected to a vacuum pump. A feather and a coin are placed at its bottom. When the cylinder is turned upsidedown in the presence ofair inside it, the coin falls faster than the feather.If the air is pumped out using the vacuum pump and the cylinder is turned upside down, the coin and the feather are seen to fall together.

Figure 7.9 Featherand coin experiment

The cause of the coin and feathernot falling together the first time is the presence of air resistance inside the cylinder. Since the surface area of the feather is greater than that of the coin, the air resistance acting on the feather is greater than acting on the coin and acceleration is reduced. So the feather falls slower than the coin. The second time, as there is no air inside the cylinder i.e. there is no air resistance, both the feather and the coin fall together. In the absence of air resistance, the acceleration due to gravity is the same for all objects. That is, the value of 'g' does not depend on the mass of the falling body.

Calculation of acceleration due to gravity

Suppose a body of mass 'm' is on the surface of a planet of mass 'M' and radius 'R'. If the force of gravity of the planet acting on the body is 'F', the gravitational force produced between them is,

$$F = \frac{GMm}{R^2} \text{ .... (i)}$$

If this force produces acceleration 'g' in mass 'm', then from the Second law of motion,

$$F = mg \text{ .... (ii)}$$

From the equations (i) and (ii),

$$mg = \frac{GMm}{R^2}$$

$$g = \frac{GM}{R^2} \text{ .... (iii)}$$

According to equation (iii) the acceleration depends only on the mass 'M' and radius 'R' of the planet.

Since the mass of the falling object is not included in the equation, it confirms the fact that all the masses have the same acceleration when they fall freely, just like the results of Galileo's activity and feather-coin experiment. In non-spherical planets or satellites like Earth, the value of radius 'R' changes depending on location. In equation (iii) both G and M are constants.

In this case, the acceleration due to gravity is inversely proportional to the square of the radius of the planet or satellite. Hence,

$$g \propto \frac{1}{R^2}$$

Acceleration due to gravity depends upon both the mass and the radius of the planet or satellite. For example, the mass of Jupiter is about 319 times the mass of the Earth, but its acceleration value is only 2.6 times the acceleration due to the gravity of the Earth. The radius of Jupiter has a main role to play in this. The radius of Jupiter is 11 times the radius of the Earth. Since the acceleration due to gravity is inversely proportional to the square of the radius, even though the mass of Jupiter is very large, the net effect on the acceleration due to gravity will be only $\frac{319}{121} = 2.6$ times greater.

On substituting the mass of the earth as 5.972×10^{24} and the radius as 6371 km in equation (iii),

$$g = \frac{6.67 \times 10^{-11} \times 5.972 \times 10^{24}}{(6.371 \times 10^{6})^2} = \frac{39.8332 \times 10^{13}}{40.5896 \times 10^{12}} = 9.81 m/s^2$$

Since the value of R changes in different places on the earth, the value of acceleration due to gravity is also found to be different.

Variation in acceleration due to gravity of the earth

The earth is not perfectly round. It is slightly flattened at the poles and bulged in the equatorial region. Hence, as shown in Figure 7.10, the radius of the Earth is less towards the poles and more towards the equator. Since the value of the acceleration due to gravity is inversely proportional to the square of the radius of the earth, its value is more at the poles than at the equator. The value of 'g' in the equatorial region is 9.78 m/s^2 and 9.83 m/s^2 in the polar region. As the value of 'g' is higher in the polar region, objects fall faster in the polar region than in the equatorial region.

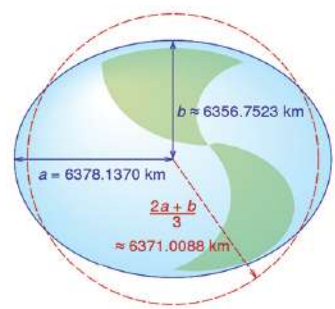
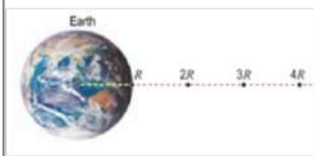


Figure 7.10 Earth's radius

The average value of 'g' on earth is considered to be 9.81m/s^2. This means that the velocity of a freely falling body toward the surface of the earth increases by 9.81 meter per second. In contrast, the velocity of a body projected vertically upwards decreases by 9.81meter per second. The velocity becomes zero at the maximum height that it covers, and then,it returns to the earth.

Height and acceleration due to gravity

Activity 7.4 Comparison of the acceleration due to gravity with increasing distance from the center of the earth

	Distance from the center of the earth (d)	d = 2R	d = 3R	d = 4R
Different distances from center of the Earth	Acceleration due to gravity $g_1=\frac{GM}{d^2}$	$g=\frac{319}{121}=\frac{319}{121}$ $=\frac{1}{4}\times 9.8=2.45\ m/s^2$	....	....

As shown in Figure 7.11, when d = R is the distance from the center of the earth, the value of the acceleration due to gravity, $g_1=\frac{GM}{d^2}$ $= 9.8\ m/s^2$ Other distance d = 2R, 3R, 4R from the center of the earth are also shown in the same figure. In the table along with the figure, the value of acceleration due to gravity at a distance d = 2R is calculated. Likewise, calculate andcompare the values of acceleration due to gravity that occurs as the distance from the center of the earth goes on increasing.

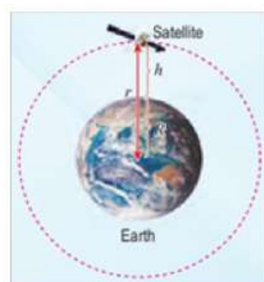


Figure 7.12

As the height above the surface of the earth increases, the value of the acceleration due to gravity decreases. Suppose, a satellite at a height h from the surface of the earth is orbiting the earth. The value of the acceleration due to the gravity of the earth at that height h is $g_1=\frac{GM}{(R+h)^2}$ The value of acceleration due to the gravity of the earth's surface is $g=\frac{GM}{R^2}$ In this case, the distance of the satellite from the center of the earth is d= R+h. Since the value of $(R+h)^2$ is greater than the value of R^2, the value of g1 is less than that of g.

Example 7.3

The mass of the earth is 5.97×10^{24} kg and its radius is 6371 km. Calculate the acceleration due to the gravity of the International Space Station situated at an altitude of 400 km above the surface of the earth.

According to the information given in the question,

Mass of Earth (M) $=5.97 \times 10^{24}$ kg

Radius of Earth (R) = 6371 km=6371000 m

Height of International Space Station above the surface of Earth (h)= 400 km = 400000 m

The acceleration due to gravity at that height,

$$g = \frac{GM}{(R+h)^2}$$

$$\text{or,} \quad g = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(6.371000 + 400000)^2}$$

$$\text{or,} \quad g = \frac{39.82 \times 10^{13}}{(6771000)^2} = \frac{39.82 \times 10^{13}}{4.60 \times 10^{13}}$$

$$\therefore \quad g_1 = 8.66\ m/s^2$$

Therefore, the acceleration due to the gravity of the International Space Station at an altitude of 400 km is 8.66m/s^2.

Since, the distance of the top of a hill from the center of the earth is greater than the distance (radius, R) of its bottom from the center of the earth, the value of 'g' is less at the top of the hill than that at its bottom. But such a difference is very small. For example, the height of Mt. Everest is 8848.86 m. The distance from the center of the earth to the peak of Mt. Everest, d= R + h = 6371×1000 m + 8848.86m = 6379848.86 m हुन्छ ।

Putting this value, $g = \frac{GM}{(R+h)^2}$

$$g_1 = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(6.379848.86)^2} = \frac{39.82 \times 10^{13}}{4.07 \times 10^{13}} = 9.78\ m/s^2$$

At the height of Mount Everest, the value of the acceleration due to gravity is only 0.03 m/s2 (9.81-9.78=0.03) less than that on the Earth's surface. So for a small change in the distance from the center of the earth like: (R+ h = 6371 km+8.85 km = 6379.85 km), the velocity also changes by a very small value.

Example 7.4

The value of acceleration due to the gravity of the earth is 9.8m/s^2. If the mass of the moon is 7.35×10^{22} kg and its radius is 1.74×10^6 m, what is the acceleration due to the gravity of the moon? Compare the acceleration due to the gravity of the Earth and thatof the Moon.

According to the information given in the question,

Value of acceleration due to gravity of the earth, $g_e = 9.8 m/s^2$

According to the formula for calculating the acceleration of gravity of the moon,

$$g_m = \frac{GM_m}{R_e^2}$$

$$g_m = \frac{6.67 \times 10^{-11} \times 7.35 \times 10^{22}}{(1.74 \times 10^6)^2}$$

$$g_m = 1.62\ m/s^2$$

Taking the ratio of the acceleration of gravity of the earth to the acceleration of gravity of the moon,

$$= \frac{g_e}{g_m} = \frac{9.8}{1.62} = 6.05$$

The value of the acceleration of gravity of the moon is about 6 times less than that of the earth.

Mass and weight

The weight of an object is related to the acceleration due to gravity. The total quantity of matter present in an object is its mass. This is a scalar quantity. Its SI unit is the kilogram (kg). No matter wherever a 1 kg mass of iron is kept either on Earth orthe International Space Station or the Moon or Mars, etc., the quantity of iron in it is always 1 kg. Therefore, the value of the mass of an object does not change according to the place. Like the smallest particle, an electron also has a definite mass. The value of mass is not zero. Similarly, even the smallest mass experiences the force of gravity.

Earth's gravity pulls objects on its surface toward its center.

Weight is the measure of the force of gravity acting on an object. Since weight is the force exerted on an object, its SI unit is the newton (N). This is a vector quantity. Weight is always directed towards the center of the planet/satellite because it is the force of gravity.

Figure 7.13: Measurement of weight by a spring balance

According to Newton's second law of motion, the force of gravity acting on an object of mass 'm', i.e., weight, is $W = mg$. where g is the acceleration due to gravity. The weight of an object dependson the object's mass and acceleration due to gravity.

Since the earth's gravity pulls every object towards its center, a force atleast equal to the force of gravity is to be applied in the upward direction to lift any object from the surface. Depending on the relationship between mass and weight, different forces are required to lift small and large objects. Since the value of acceleration due to gravity at a place remains constant, the weight of the object varies according to its mass. In this case, the weight of the object (W) is directly proportional to its mass (m), i.e.,Weight (W) $\propto$ Mass (m) [Keeping the value of g constant].

Therefore, objects with greater mass weigh more than objects with lesser mass. Hence, more force must be applied to lift an object with a greater mass than an object with a smaller mass. Also, it is easier to lift small stones thanbig ones.

Variation in weight due to change of acceleration due to gravity

The difference in weight for a definite mass depends on the force of gravity. Thus, the weight of an object is directly proportional to the acceleration due to gravity, i.e., Weight (W) $\propto$ Acceleration due to gravity(g) [Keeping mass constant]

Since the value of 'g' on Earth changes according to the location, the weight of the object also changes.

Activity 7.5: Comparison of the weight of an object at different places

As given in the table below, find the pairs of places where the acceleration due to gravity is less/more and mention the difference in the weight of an object at those places:

Pairs of places	place value of the acceleration of gravity is less	place value of the acceleration of gravity is more	Remark
Equatorial and polar regions	Equatorial region	Polar region	The weight of an object is lesser in the equatorial region than that in the polar region.
Base and top of the mountain	....	....	....

The value of the acceleration due to gravity is inversely proportional to the square of the distance from the center of the earth, i.e., $g \propto \frac{1}{R^2}$ Similarly, weight is directly proportional to acceleration due to gravity $(W) \propto g$ .As the value of acceleration due to gravityat placesfar away from the center of the earth such as hilltops, mountains, etc.is less, the weight of an object at those places is also less. At a place on the earth's surface where the value of acceleration due to gravity is maximum, the weight of an object is also maximum at that place. Acceleration due to the gravity of the moon (gm) is six times that of the earth (ge), i.e. $g_m \propto \frac{1}{6} g_e$ Therefore, the weight of an object of a definite mass on Earth is almost 6 times the weight of the same object on the moon. Therefore, one can jump about 6 times higher on the moon than on the Earth. On the moon, a person should be able to lift about 6 times the massas much as he/she can on the earth. Therefore, while comparing the acceleration due to the gravity ofthe Earth and other planets/ satellites, it can also be concluded that the weight of an object on those planets/ satellites is also different. Some examples are presented in the table below.

Mass of an object (m)	acceleration due to gravity (g) m/s^2 and weight ($W = mg$) in newton on different heavenly bodies									
	moon		mercury		mars		venus		earth	
50 kg	g_1	W_1	g_2	W_2	g_3	W_3	g_4	W_4	g_5	W_5
	1.63	81.5	3.61	180.5	3.75	187.5	8.83	441.5	9.81	490

Example 7.5

Calculate the mass that a person can lift on the moon if he/she can lift a mass of 100 kg on Earth. (Acceleration due to gravity of the moon $g = 1.63\ m/s^2$)

According to the information given in the question,

Mass that a person can lift on earth (M) = 100 kg

Acceleration due to gravity of the earth (g) = $9.8 m/s^2$

Acceleration due to the gravity of the moon (g^1) = $1.63\ m/s^2$

Mass that a person can lift on the moon (m) = ?

The force that human muscles can exert against gravity on the Earth and Moon is the same.

The weight that can be lifted on the moon = Weight that can be lifted on the earth

$$\text{Or } m \times g' = M \times g$$

$$\text{Or } m = \frac{M \times g}{g^1} = \frac{100 \times 9.8}{1.63}$$

$$\therefore \quad m = 601.23 \text{ kg}$$

Therefore, a person who can lift 100 kg on Earth can lift 601.23 kg on the surface of the Moon.

Free fall

As observed in activity 7.3, a sheet of paper and a falling stone can be considered as free fall when the air resistance on them is negligible. In that case, the acceleration of the stone is equal to the acceleration of gravity ($9.8\ m/s^2$) ofthe earth. Thus, an object falling under the influence of gravity alone without any obstruction is said to be in free fall. The acceleration of an object in free fall is equal to the acceleration due to gravity (g).

According to the structure of the objects falling into the earth's atmosphere, the frictional force on them creates a resistanceto their motion. The upthrust on a falling object also helps reduce the effect of the force of gravity. Thus, the actual free fall is possible only in a vacuum. Since there is no resistanceof the atmosphere to a falling body on the moon, free fall is possible.

Activity 7.6 Making a model of a parachute

Take scissors, a thin plastic sheet and thread. Stretch the plastic in different steps and cut it into a circular shape as shown in Figure 7.16. Tie equal pieces of thread at equal distances around the edges of the circular plastic. Tie the open section of the threads in a single knot and attach a toy or stone to it. Drop the prepared parachute model from a height. Observe its fall. Does the parachute fall at a high speed at the beginning and with a uniform speed at the last?

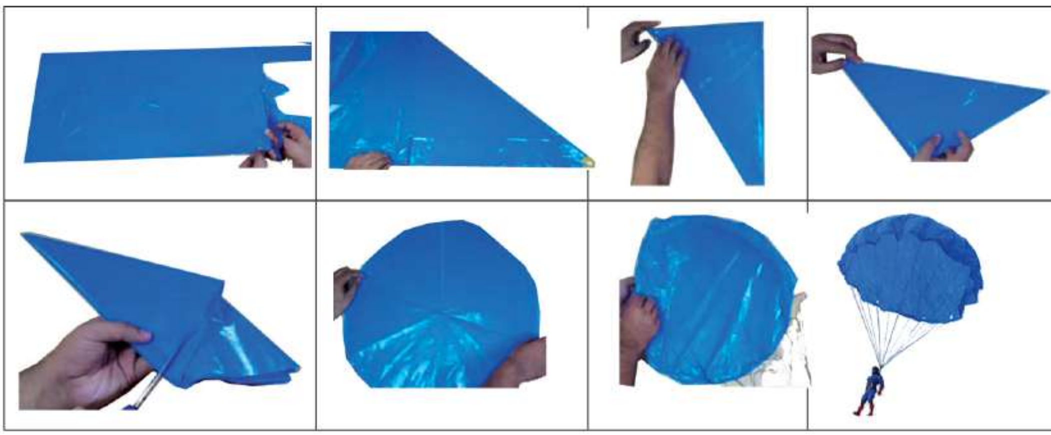


Figure 7.14 Construction of a model of a parachute

Question to think

Is it possible to land safely on the moon using a parachute like on the Earth?

Figure 7.15 Landing of parachute

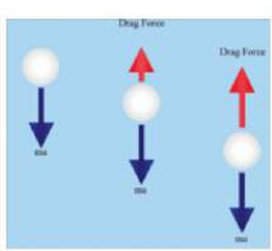


Figure 7.16 Resistance during a hail

Figure 7.17 Dispersion of seeds by wind

While jumping with a parachute, the air resistance increases with the speed of the parachute. This process leads to a situation where weight and air resistance become equal. In such conditions, the acceleration of the falling parachute becomes zero. Then the parachute falls towards the ground with a uniform speed. A safe landing on the ground is possible due to the uniformspeed of the parachute. This kind of parachute fall is not a free fall.

Atmospheric resistance is necessary for a safe landing with a parachute. Since the moon does not contain such resistance,jumping towards its surface with a parachute isa free fall. As a result, the speed increases continuously and lands on the surface at high speed. Thus, a safe landing on the moon using a parachute is not possible.

When hail falls on the earth's surface from a certain height, it falls ata certain constant speed instead of increasing continuously. It is due to the resistance offered by the air. It reduces the damage caused by hail on the earth's surface. The resistance or friction caused by the wind on the hail creates an upward drag force. The faster the hail falls, the greater the resisting force acting on it. When the force of gravity acting on the hail and the frictional force acting on it become equal, the hail falls at a constant speed.

As shown in Figure 7.17, a wind-dispersed seed contains a structure like a fur and a small fan. They worklike small parachutes. When these types of seeds are dispersed, they fall as if floating in the air due to air resistance and stay in the air for some time. As a result, the seeds are scattered far away. Therefore, due to air resistance, the seeds of the plants such as simal, sal, etc. are dispersed far away.

Activity 7.7 Observation of free fall

Take a 'U' shaped iron frame as shown in Figure 7.18. Tie the open part of the frame with a thread so that it is slack as shown in the picture. Also, tie a stone between the threads. As shown in the picture, hang the hook of the spring balance on the place where the stone is tied and raise the whole frame. What is the weight shown by the spring balance? Then release the frame from the hand and observe the condition of the stone tied to the rope attached to the frame and the reading of the spring balance. Lay a foam or cardboard on the floor to protect the spring balance during this activity. If possible, take a video of the falling spring balance and pause it.

In this activity, when the frame is released from the hand, then the spring balance, the stone and the iron frame fall downwards with the same speed. Although the stone-bound thread is tied in such a way that it is slack, it does not stretch downwards. This makes it look like the stone is flying in the air. This is possible with free fall. Since both the spring balance and the frame are in the state of free fall, there is no downward force on the spring of the spring balance and it shows zero weight. Thus, the weight of an object in free fall is zero, and hence, it is called weightlessness.Astronauts inside the artificial satellites orbiting the earth and space station are in a state of free fall. In such a situation, passengers inside the vehicle experience weightlessness.

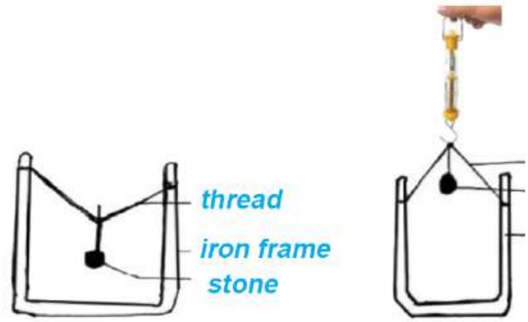


Figure 7.18 Observation of free fall

Equation of motion for free fall

The equations of motion are used to calculate the final velocity and acceleration of a freely falling stone in activity 7.2. In this way, the speed with which a freely falling body dropped from a height reaches the surface, the time taken to reach the surface, and the height can be calculated by using the equation of motion.

For the objects in linear motion	For the objects in free fall
$v = u + at$	$v = u + gt$
$v^2 = u^2 + 2as$	$v^2 = u^2 + 2gh$
$s = ut + \frac{1}{2} at^2$	$h = ut + \frac{1}{2} gt^2$

In this way, in the case where the acceleration is generated due to the force of gravity, the value of the acceleration due to gravity is substituted in place of the acceleration in the equation of motion. If the object is thrown vertically upwards, the value of the acceleration due to gravity is negative because the acceleration generated in such a situation is in the opposite direction.

Example 7.6

When a stone is dropped from a bridge over a river into the water, the sound of the stone hitting the surface of the water is heard after 2 seconds. Calculate the height of the bridge above the surface of the water.($g = 9.8\ m/s^2$)

According to the information given in the question,

The initial velocity of the stone (u) = 0 m/s because the stone is dropped from the hand.

Time taken by the stone to hit the water surface (t) = 2s

Acceleration of stone (g) = $9.8 m/s^2$

Using the equation of motion, the height of the bridge above the surface of the water

$$\text{Or } h = ut + \frac{1}{2} gt^2$$

$$\text{Or } h = \frac{1}{2} \times 9.8 \times 2^2$$

$$\text{Or } h = 19.6\ m$$

Therefore, the height of the bridge from the water level is 19.6m.

Example 7.7

A cricket ball thrown vertically upwards into the sky reaches a height of 30m.

Calculate the velocity with which it is thrown and the time taken to reach the maximum height.

As given in the question,

Maximum height of the ball (h) = 30 m

The final velocity of the ball (v) = 0 m/s (since the final velocity at maximum height is zero.

Acceleration of the ball (g) = - 9.8 m/s^2

Using the equations of motion for the initial velocity of the ball

$$0=u^2 + 2gh$$

Or $0=u^2 + 2 \times -9.8 \times 30$

Or $u^2 = 588$

$$u=\sqrt{588}=24.25 \text{ m/s}$$

For the time taken to reach the maximum height

$$v = u+at$$

Or $0 = 24.25-9.8 \times t$

Or $t= \frac{24.25}{9.8}$

$$t = 2.47 \text{ s}$$

So, the initial velocity of the cricket ball is 24.25m/s and it takes 2.47s to reach the maximum height.

Project work

Drop a stone from different heights like from the roof of a house or a school building with the help of your parents or teachers. Place a tin or some other sound-producing object on the surface of the ground to know when the stone hits the ground. After this, find the height and the time it takes to hit the ground. Find the height of a house, school building, etc. using the equation of motion. For this, take the average measurement to reduce the probable error. Finally, measure the actual height with a measuring tape and mention the error in the calculated height.

Exercise

1. Choose the correct option for the following questions:

(a) What is the relation between the distance between two objects (d) and the gravitational force (F) produced between them?

(i) $F \propto \frac{1}{d}$ (ii) $F \propto d^2$

(iii) $F \propto \frac{1}{d^2}$ (iv) $F \propto d$

(b) What is the change in the gravitational force between two objects when their mass is doubled?

(i) the force doubles

(ii) the force becomes four-time

(iii) the force is reduced two times

(iv) the force is decreased four times

(c) If the gravitational force between two objects on Earth is 60 N, what is the gravitational force between those two objects on the moon?

(i) 10 N (ii) 6 N

(iii) 9.8 N (iv) 60 N

(d) Whichone of the following statements is correct?

(i) The value of acceleration due to gravity increases as we go deeper from the surface of the earth.

(ii) The value of acceleration due to gravity decreases as the height above the surface of the earth increases.

(iii) The value of acceleration due to gravity is less in the polar region than that in the equatorial region.

(iv) The value of the acceleration of gravity is highest at the highest place on the Earth.

(e) At which of the following places do you weigh the most?

(i) peak of Mount Everest (ii) peak of Api Himal

(iii) Kechnakwal of Jhapa (iv) Chandragiri Hills

(f) The radius of the Earth is 6371 km and the weight of an object on the earth is 800 N. What is the weight of the object at a height of 6371 km from the surface of the earth?

(i) 800N (ii) 1600 N

(iii) 200 N (iv) 3200 N

(g) If the mass and the radius of a celestial body are two times the mass and the radius of the earth respectively, what is the value of acceleration due to the gravity of that body?

(i) 9.8 ms^{-2} (ii) 4.9ms^{-2}

(iii) 19.6ms^{-2} (iv) 10ms^{-2}

(h) What will be the weight of a man on the moon, if his weight on earth is 750 N? (The acceleration due to the gravity of the moon = 1.63 m/s^2)

(i) 124.74N (ii) 125 N

(iii) 126.8 N (iv) 127.8 N

(i) The mass ofplanet B is twice the mass of planet A but its radius is half of the radius of planet A. Similarly, the mass of planet C is half of the mass of planet A, but its radius is twice the radius ofplanet A. If the weight of an object in planets A, B and C is W_1, W_2 and W_3, respectively, which of the following order is correct?

(अ) $W_1>W_3>W_2$ (आ) $W_2>W_1>W_3$

(इ) $W_1>W_2>W_3$ (ई) $W_2>W_3>W_1$

(j) Which one of the following conclusions is correct while observing a freely falling object every second?

(i) the distance covered increases uniformly

(ii) velocity increases uniformly

(iii) acceleration increases uniformly

(iv) translation takes place uniformly

2. Differentiate between:

(a) Gravitational constant G and acceleration due to gravity g

(b) Mass and Weight

3. Give reason:

(a) Acceleration due to gravity is not the same in all parts of the earth.

(b) Jumping from a significant height may cause more injury.

(c) Mass of Jupiter is about 319 times themass of the Earth, but its acceleration due to gravity is only about 2.6 times the acceleration due to gravity of the Earth.

(d) Among the objects dropped from the same height in the polar region and the equatorial region of the earth, the object dropped in the polar region falls faster.

(e) Out of two paper sheets, one is folded to form a ball. If the paper ball and the sheet of paper are dropped simultaneously in the air, the folded paper will fall faster.

(f) When a marble and a feather are dropped simultaneously in a vacuum, they reach the ground together (at the same time).

(g) As you climb Mount Everest, the weight of the goodsthat you carry decreases.

(h) It is difficult to lift a big stone on the surface of the earth, but it is easy to lift a smaller one.

(i) Mass of an object remains constant but its weight varies from place to place.

(j) One will have an eerie feeling when he/she moves down while playing a Rote Ping.

4. Answer the following questions:

(a) What is gravity?

(b) State Newton's universal law of gravitation.

(c) Write the nature of gravitational force.

(d) Define gravitational constant (G).

(e) Under what conditions is the value of gravitational force equal to the gravitational constant (F=G)?

(f) Write two effects of gravitational force.

(g) Mathematically present the difference in the gravitational force between two objects when the mass of each is made double and the distance between them is made one forth their initial distance.

(h) What is gravitational force?

(i) Define acceleration due to gravity.

(j) What is free fall? Give two examples of it.

(k) Under what conditions is an object said to be in free fall?

(l) Write the conclusions of the feather and coin experiment.

(m) What is weightlessness?

(n) Mention any four effects of gravitational force.

(o) Prove that acceleration due to the gravity of the Earthis inversely proportional to the square of its radius ($g \propto \frac{1}{R^2}$)

(p) Mention the factors that influence acceleration due to gravity.

(q) The acceleration due to the gravity in the Earth surface is 9.8 m/s2. What does this mean?

(r) Mass of the Moon is about 1/81 times the mass of the Earth and its radius is about 37/10 times the radius of the Earth. If the earth is squeezed to the size of the moon, what will be the effect on its acceleration due to gravity? Explain with the help of mathematical calculation.

(s) The acceleration due to gravity of an object of mass 1 kg inouter space is $2 m/s^2$. What is the acceleration due to gravity of another object of mass 10 kg at the same point? Justify with arguments.

(t) A man first measures the mass and weight of an object in the mountain and then in the Terai. Compare the data that he obtains.

(u) A student suggests a trick for gaining profit in a business. He suggests buying oranges from the mountain selling them to Terai at the cost price.If a beam balance is used during this transaction, explain, based on scientific fact, whether his trick goes wrong or right.

(v) How is it possible to have a safe landing while jumping from a flying airplane using a parachute? Is it possible to have a safe landing on the moon in the same way?Explain with reasons.

(w) The acceleration of an object moving on the earth is inversely proportional to the mass of the object, but for an object falling towards the surface of the earth, the acceleration does not depend on the mass of the object, why?

5. Solve the following mathematical problems:

(a) The masses of two objects A and B are 20 kg and 40 kg respectively. If the distance between their centers is 5 m, calculate the gravitational force produced between them. Ans: 2.134×10^{-9} N

(b) Calculate the gravitational force between the two bodies shown in the figure. Ans: 3.14×10^{-11} N

(c) Mass of the Sun and Jupiter are 2×10^{30} kg and 1.9×10^{27} kg respectively.

If the distance between Sun and Jupiter is 1.8×10^{8} km, calculate the gravitational force between Sun and Jupiter. Ans: 4.17×10^{23} N

(d) Gravitational force produced between the Earth and Moon is 2.01×10^{20} N. If the distance between these two masses is 3.84×10^{5} km and the mass of the earth is 5.972×10^{24} kg, calculate the mass of the moon. Ans: 7.34×10^{22}kg

(e) Gravitational force produced between the Earth and the Sun is 3.54×10^{22} N. If the masses of the Earth and sun are 5.972×10^{24} kg and 2×10^{30} kg respectively, what is the distance between them? Ans: 1.5×10^{11} m

(f) The mass of the moon is 7.342×10^{22} kg. If the average distance between the earth and the moon is 384400 km, calculate the gravitational force exerted by the moon on every kilogram of water on the surface of the earth. Ans: 3.314×10^{-5} N

(g) If the mass of the moon is 7.342×10^{22} kg and its radius is 1737 km, calculate its acceleration due to gravity. Ans: 1.63 m/s^2

(h) Mass of the Earth is 5.972×10^{24} kg and the diameter of the moon is 3474 km. If the earth is compressed tothe size of the moon, how many times will be the change in acceleration due to the gravity of the earth so formed than that of the real Earth? Ans: 13.47

(i) If the mass of Mars is 6.4×10^{23} kg and its radius is 3389 km, calculate its acceleration due to gravity. What is the weight of an object of mass 200 kg on the surface of Mars?Ans: 3.75 m/s^2 and 750 N

(j) The acceleration due to the gravity of the earth is 9.8 m/s^2. If the mass of Jupiter is 319 times the mass of the Earth and its radius is 11 times the radius of the Earth, calculate the acceleration of gravity of Jupiter. What is the weight of an object of mass 100 kg on Jupiter? Ans: 25.83m/s^2 and 2583N

(k) Earth's mass is 5.972×10^{24} kg and its radius is 6371 km. Calculate the acceleration due to the gravity of the earth at the height of the artificial satellite shown in the figure. Ans: 0.56m/s^2

(l) Mass of the earth is 5.972×10^{24} kg and its radius is 6371 km. If the height of Mt. Everest is 8848.86 m from the sea level, calculate the weight of an object of mass 10 kg at the peak of Mt. Everest. Ans: 97.87N

(m) The acceleration due to gravity of the Mars is 3.75m/s^2. How much mass can a weight-lifter lift on Mars who can lift 100 kg mass on the Earth? Ans: 261.33 kg

(d) When a stone is dropped from a bridge over a river into the water, after 2.5 seconds the sound of the stone hitting the surface of the water is heard. Calculate the height of the bridge from the surface of the water. ($g = 9.8$ m/s^2) Ans: 30.62 m.

(n) If a stone is dropped from a height of 15 m, how long will it take to reach the ground? Calculate the velocity of the stone when it hits the ground. Ans: 1.75 s, 17.15 m/s

(o) If a cricket ball is thrown vertically upwards into the sky with a velocity of 15 m/s, to what maximum height will the ball reach? Ans: 11.47 m

8 Pressure

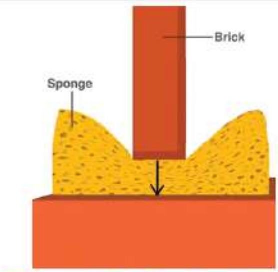


Figure 8.1 Pressure generated in the foam by the weight of the brick


Figure 8.2 Pressure exerted by water on the pipe wall

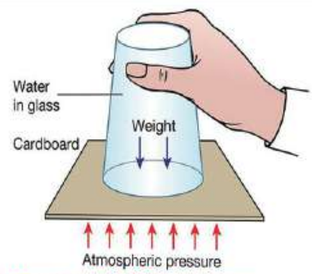


Figure 8.3 Pressure exerted by the air on the postcard

In the above figures, the pressure exerted by solid, liquid and gas is presented. Placing a brick on foam creates pressure on the surface of the foam [figure 8.1]. Solids exert pressure on the surfaces due to their weight. The pipe shown in Fig. 8.2, cracked because it could not withstand the pressure exerted by the water on its walls. When the pipe burst, water came out exerting high pressure on both the right and left sides of the walls. Similarly, in Figure 8.3, it is shown that the postcard is pushed up by the wind without letting it fall. Pressure is generated by the normal force (thrust) exerted by liquids and gases on the walls of various objects. A force acting perpendicular to the surface of an object is thrust. Its SI unit is Newton. The thrust acting per unit area of an object is called pressure. The SI unit of pressure is Pascal i.e., Newton per square meter (N/m^2).

Since liquid and gas are substances that can flow easily, they are called fluids. Like solids, the fluids too exert pressure. Fluid not only exerts pressure on the bottom of the vessel in which it is kept but on all the walls of the vessel.


Figure 8.4 Balloon placed in water


Figure 8.5 Hydrogen balloon released into the air

When an object is placed in a fluid, the fluid exerts pressure on the surfaces of the object. Figure 8.4 shows the upward force exerted on the surface of the balloon by the water pressure. If the balloon is filled with hydrogen or helium and released into the air, the balloon will fly due to the upward force caused by the air pressure. As the air density decreases with increasing height, the balloon will float at a certain height where the upward force exerted by the air and its weight are equal.

Transmission of pressure

The structure of molecules in solid, liquid and gas is shown in Figure 8.6. Molecules in solids are packed very close to each other. They have a definite shape and volume. The molecules in a solid do not move and change their position. When a force is applied to one side of a solid object, the pressure generated is not transmitted throughout the solid object. But, since molecules can move in liquid and gas, pressure is transmitted in the fluid kept in a closed container.

Activity 8.1 Transmission of pressure in fluid

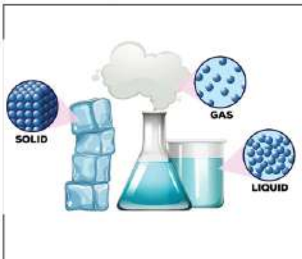


Fig.8.6 Structure of molecules in matter

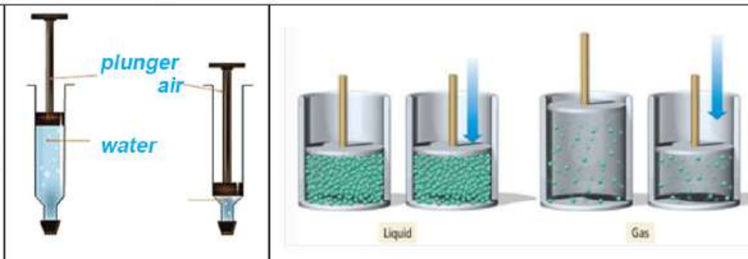


Fig.8.7 A process of compressing fluid in a closed vessel

Take two syringes. Fill one of them with water and leave the other empty. Close the nozzle of the empty syringe using a finger and push the piston inside as shown in Figure 8.7. Do the same with the syringe filled with water. Piston of which syringe can be pushed in? When the piston of an air-filled syringe is pushed in, did it show the same effect as in the water-filled syringe?

In this activity, when the piston of the water-filled syringe is pushed in, it does not move in. This means the water in the syringe cannot be compressed. But in a syringe filled with air, it is easy to push the piston in.But, when the air in it gets compressed, it becomes difficult to push the piston further just like in the syringe filled with water.

The intermolecular spaces between the molecules of liquids are very small. As shown in Figure 8.7, the external pressure cannot move the liquid molecules closer together. Therefore, since the liquid in the closed vessel cannot be pressed by pressure, its volume does not decrease. Hence, the pressure exerted at any point in the liquid gets transmitted uniformly in all directions. For example, in Figure 8.8a, it is shown that the toothpaste comes out of the mouth because the pressure generated by pressing the tube gets transmitted to the paste. But in gases, the space between molecules is larger than that in liquids. The volume of gas can be reduced by applying external pressure to them. Therefore, pressure is transmitted in compressed gas but not as effectively as in a liquid.

a b

Fig.8.8 Transmission of pressure in a fluid

Figure 8.8b shows the pressure generated by a force applied by a hand in a balloon containing compressed air being transmitted to all parts of the balloon. Therefore, to transmit the pressure in the gas, as in the liquid, it should initially be compressed sufficiently.

Pascal's law

Activity 8.2

Fill a polythene bag with water. As shown in Figure 8.9, squeeze the bag from the top with a fist and make fine holes around it and observe the water coming out of these holes. Does the water come out from all the holes uniformly? As the level of water decreases in the polythene bag, move the first downward and tighten the grip.

Fig. 8.9 Transmission of pressure in the water in a closed polythene bag

In the above activity, when the fist is tightened, the pressure generated in the water at the upper part of the polythene bag is transmitted through the water to the walls of the bag. As a result, water streams come out from all the holes' perpendicular to the surface of the bag. Here, the pressure generated at a point in the water enclosed inside the polythene bag is transmitted normally in all directions. French mathematician Blaise Pascal propounded a law about this in 1653 BC and it is known as Pascal's law.

This law states that, when a force is exerted at a point in an enclosed liquid, the pressure generated is transmitted normally throughout the liquid in all directions.

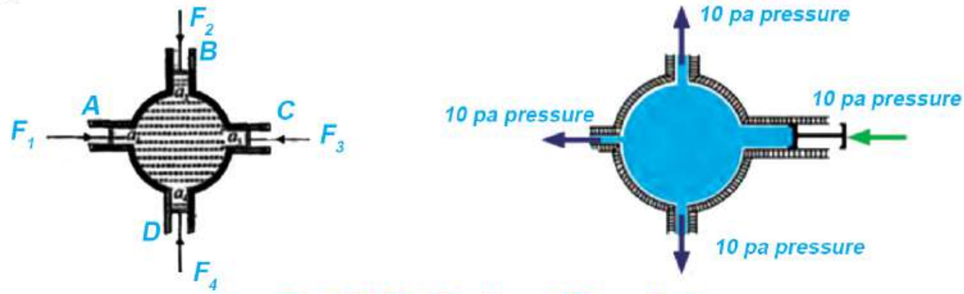


Fig.8.10 Verification of Pascal's Law

For verification of Pascal's law, a circular vessel with four pistons A, B, C and D can be taken as shown in Figure 8.10. Suppose the cross-sectional areas of the four pistons are a_1, a_2, a_3 and a_4 respectively. When the vessel filled with liquid is pushed inwards by applying a force F1 onto piston A, the pressure is generated on the cross-sectional area of this piston. Due to this pressure, the remaining three pistons move outwards. This means the pressure generated at piston A is transmitted normally throughout the liquid. If the inward forces applied to the outward moving pistons to prevent them from moving are, F_2, F_3 and F_4 respectively, the following result is obtained.

$$\frac{F_1}{a_1} = \frac{F_2}{a_2} = \frac{F_3}{a_3} = \frac{F_4}{a_4}$$

Therefore, the pressure generated at one point in a liquid kept in a closed vessel is transmitted equally everywhere.

Applications of Pascal's Law

Based on Pascal's law, various types of hydraulic machines such as hydraulic brakes, hydraulic lifts, hydraulic presses, etc. are manufactured.

Hydraulic machine

Activity 8.3 Making a model of a hydraulic machine

Take two syringes of different thicknesses, a saline pipe and water. Connect the mouths of both syringes with a saline pipe as shown in Figure 8.11.

Pull out the piston of a syringe and fill it with water. While filling with water, the barrel of the syringe should be filled a little more than halfway, leaving space for the piston to move outwards. If a weight is placed on top of the small piston and an object with a heavier weight is placed on the other side of the piston, will the heavier object be lifted?

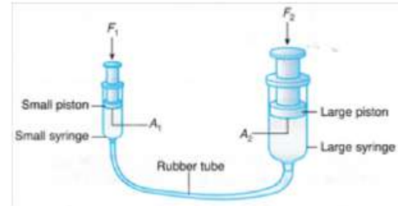


Fig.8.11 Construction of a model of a hydraulic machine

When the weight on the top of the larger piston increases and becomes equal to the maximum weight that can be lifted by the small piston, both pistons remain in a balanced condition. What is the weight necessary for that? Data can be tabulated in a table similar to the one shown below.

The weight placed on the smaller piston (F^1)	The weight placed on the larger piston (F^2)	Result
		Force on smaller piston increases ...... times

A hydraulic machine is a force-multiplying device based on Pascal's law. The excavator or backhoe shown in Figure 8.12 is an example of a hydraulic machine used for digging purposes. Hydraulic cylinders and pistons are used to move the digging part. While digging the ground, the upper part of the machine should bend towards the ground along with the backhoe so that the backhoe sinks into the ground. For that, as shown in the diagram above, the fluid in the black coloured flexible pipes is pushed with the help of the piston. As a result, the force exerted by the driver from the small piston magnifies and the ground is dug.

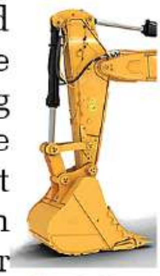


fig. 8.12

Construction and working mechanism of hydraulic machine

For the construction of a hydraulic machine, at least two cylinders with different cross-sectional areas are connected as shown in Figure 8.13. A piston is connected to each cylinder in such a way that the liquid inside does not leak.

The cross-sectional areas of the small piston and the large piston of the hydraulic machine shown in the figure are A_1 and A_2 respectively. Similarly, F_2 is the outward force produced on the large piston when a force F_1 is applied on the smaller piston.

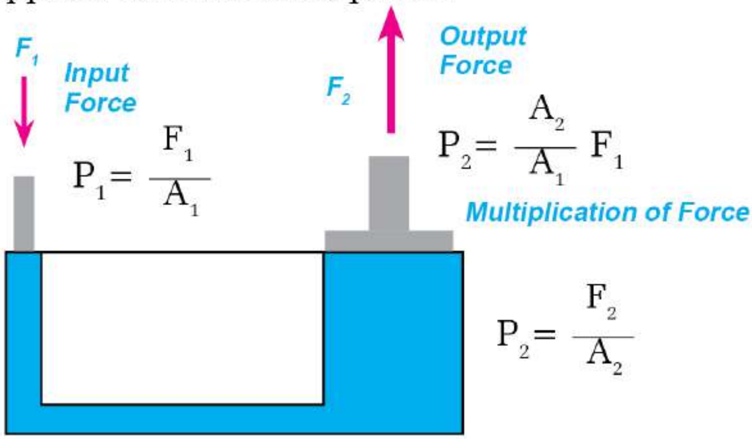


Figure 8.13 Structure and working principle of hydraulic machine

In a hydraulic machine, conditions are created for Pascal's law to apply. That is, when force is applied via the small piston of the machine, the pressure generated on the surface of the piston ($p_1 = \frac{F_1}{A_1}$) is transmitted perpendicularly and equally in all directions by the incompressible liquid in the cylinders. According to Pascal's law, the pressure generated on the surface of the small piston (P_1) = the pressure generated on the surface of the large piston (P_2)

Or $$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = F_1\left(\frac{A_2}{A_1}\right) \quad \text{.............................(i)}$$

From equation (i), the force acting on the larger piston (F2) is $\frac{A_2}{A_1}$ (the ratio of the area of the larger piston to the smaller piston) times F1. In this equation, the factor is always more than 1 because in $\frac{A_2}{A_1}$ a bigger number is divided by a smaller number. For example, if the cross-sectional area of the large piston is twice $(\frac{A_2}{A_1} = 2)$

the cross-sectional area of the small piston, then the force exerted on the small piston of the machine becomes double when it is transferred to the large piston.

Some examples of hydraulic machine

Hydraulic machines are constructed in various designs, shapes, and sizes depending on their uses. Some of the examples are presented below.

hydraulic lift

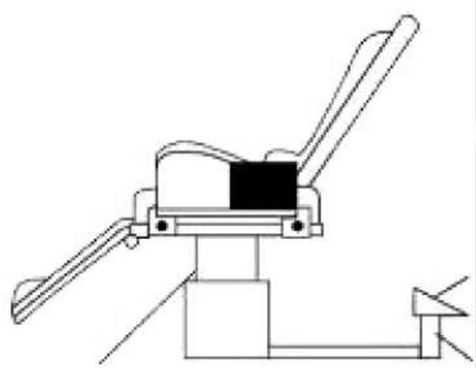


Figure 8.14 Hydraulic car lift

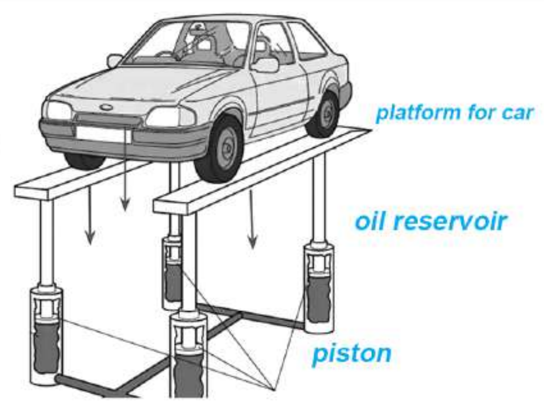


Figure 8.15 Hydraulic car lift

Figure 8.14 shows, the hydraulic lift used by the dentist to adjust the height of the chair according to the need during the treatment. The force applied to the small piston connected to the pedal of the chair gets amplified so that the surface of the big piston receives a large force and the patient is lifted upwards easily. Similarly, the hydraulic car lift, used to lift the car is shown in Figure 8.15. The oil in the small cylinder of the lift is pushed inward by the compressed air through the compressor and the car placed on the big piston on the other side is lifted. Hydraulic lift is used to lift heavy objects easily.

Example 8.1

In a hydraulic lift, the cross-sectional areas of the small piston and the large piston are $0.25\ m^2$ and $5\ m^2$ respectively. Calculate the force required to lift the car of 1200 kg using the lift.

The cross-sectional area of small piston $= 0.25\ m^2$

The cross-sectional area of large piston $= 5\ m^2$

The mass of the car lifted by the upward force on the big piston (m) =1200 kg

That is, the upward force on the large piston (F_2) =Weight of the car

(W) $= mg = 1200 \times 9.8 = 11760$ N

Force applied on the small piston (F_1)

According to Pascal's law,

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\text{Or} \quad F_1 = F_2 \times \frac{A_1}{A_2} = 11760 \times \frac{0.25}{5}$$

$$F_1 = 588\ N$$

The force required to lift a car of mass 1200 kg using the given lift is 588 N.

hydraulic brake

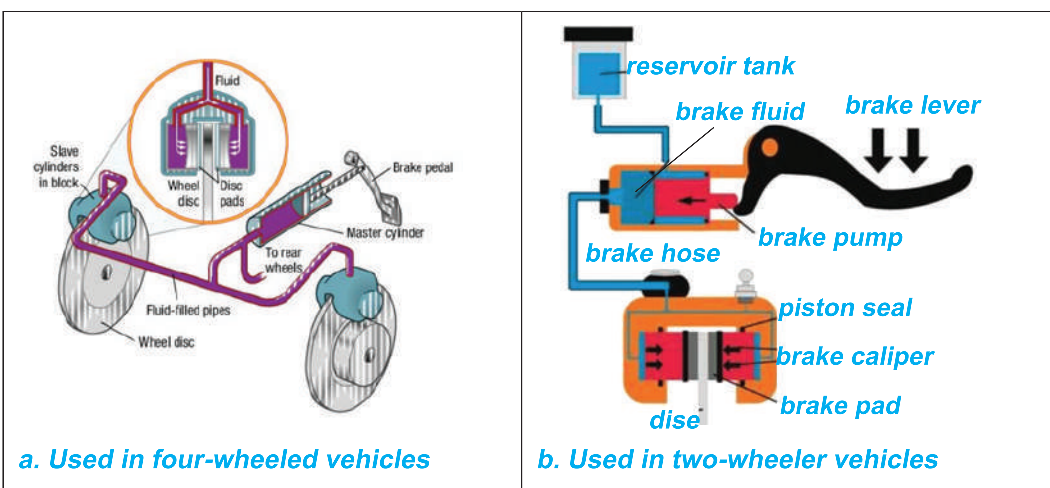


Fig. 8.16 Hydraulic brake system

In the hydraulic brake system, the pipe connected to the master cylinder and the brake cylinder is filled with a special type of brake oil. Pistons are fitted in both cylinders so that they become air-tight. As shown in Figure 8.16a, in four-wheeled vehicles, the piston of the master cylinder is connected to the brake pedal located at the driver's foot by a lever. Similarly, as shown in Figure 8.16b, in two-wheeled vehicles, the piston of the master cylinder is connected to the brake lever on the handle.

Brake cylinders are located on the wheels of vehicles. The piston of the brake cylinder is connected to the brake shoes or brake pads. By applying a small force on the small piston of the master cylinder, the pressure generated by pushing the fluid inside it is transmitted and a large force is applied to the large piston connected to the brake cylinder. Due to this a vehicle moving at high speed can be stopped in an instant.

(e) Hydraulic jack

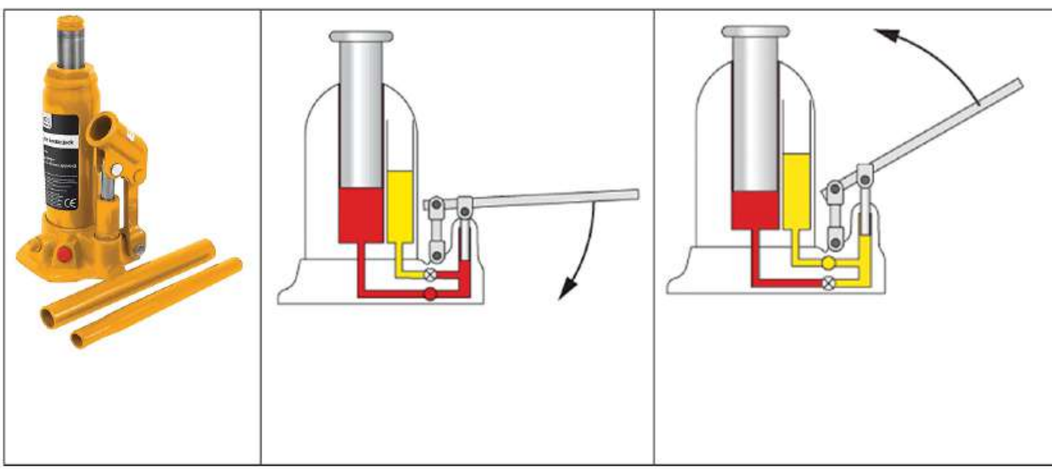


Figure 8.17 Hydraulic jack

Trucks, buses, cars, etc. are lifted at a certain above the ground by the use of hydraulic jacks. As shown in 8.17, a pumping piston with a small cross-sectional area and a lifting piston with a large cross-sectional area are connected. A bottom valve is kept between these two pistons for the one-way flow of the oil, from right to left only.

Similarly, a top valve is placed for the flow of oil from left to right, from the oil reservoir to the pumping piston.

In a hydraulic jack, when the releasing valve is tightened and the lever is pushed down, the upper valve closes and the lower valve opens. As a result, the force exerted on the pumping piston of the jack increases and the load on the lifting piston is pushed a little higher. After that, when the lever is pulled up, the bottom valve closes due to high pressure and the top valve opens. As a result, the oil from the reservoir fills the cylinder of the pumping piston. Then, in the next stage of pumping, the load is pushed up again. By repeatedly pushing the lever up and down, the load can be pushed up to the required height.

(e) Hydraulic press

Various objects can be pressed by applying a small force to the small piston of the hydraulic press. As in Figure 8.18, the object to be pressed is kept between a large piston and a rigid support above the piston. The hydraulic press is used to fit mechanical parts of vehicles, bend metal sheets or make holes in them, to pack paper, cotton and straw by compressing them.

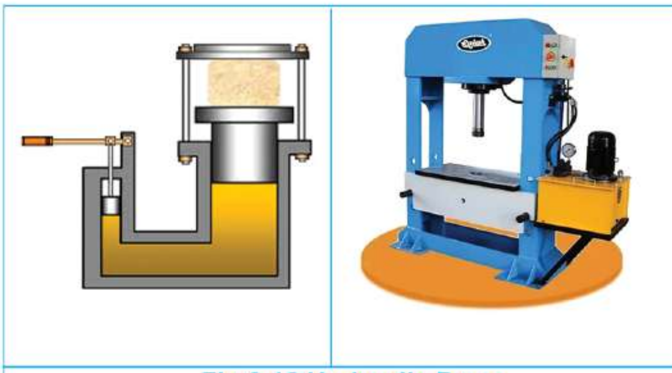


Fig.8.18 Hydraulic Press

Upthrust

Activity 8.4 Observation of Upthrust

Take an empty plastic bottle and some water in a bucket. Tighten the cap of the bottle to make it airtight. Drop the bottle into the bucket.

The bottle floats on the water. Push the bottle into the water. Observe, discuss and answer the following questions.

(a) When the bottle is pushed into the water, do you feel that the bottle is being pushed upwards?

(b) When the plastic bottle is let go in the air it falls because of gravity, but why doesn't it sink when it is placed on the surface of the water? Doesn't gravity act on the bottle when it is placed in water?

Figure 8.19 The upward force on the empty bottle when it is immersed in water

It is difficult to push the bottle into the water. It means the water is pushing the bottle upward. As the bottle is pushed into the water, the upward force exerted by the water goes on increasing until the bottle is completely submerged. When the bottle is released, it returns to the surface of the water. The net upward force by which water pushes the object in it is called upthrust. All fluids exert upthrust but the magnitude of the upthrust depends upon their density.

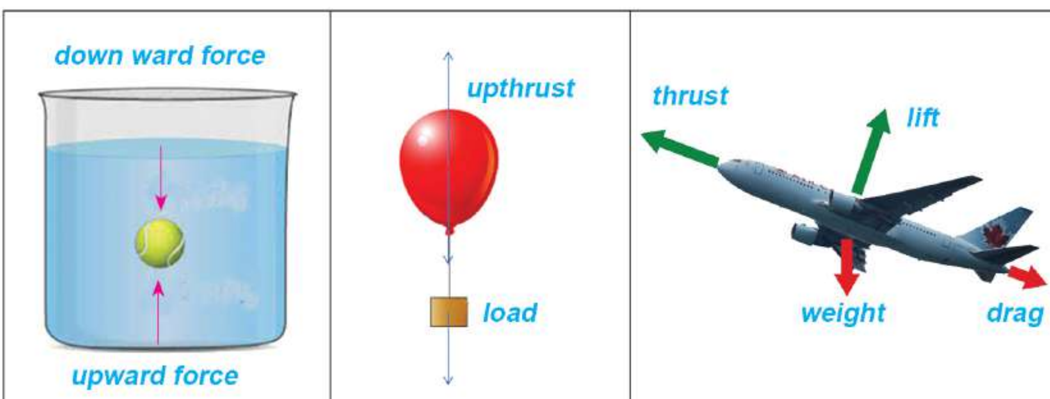


fig 8.20 | fig 8.21 | fig 8.22

As shown in Figure 8.20 and Figure 8.21, when an object is placed in air or water, it is acted upon by two forces; weight caused by gravity and the upthrust of the liquid. Since both these forces are in the opposite direction, the upthrust reduces or neutralizes the weight. For example, in the above activity 8.4, the weight of the bottle (W) i.e., the force of gravity is greater than the upthrust exerted by air exerted (U) on the plastic bottle. Upthrust cannot neutralize the downward pull of gravity (weight of the bottle) and the bottle sinks in the air or falls. On the contrary, when the bottle is forcefully submerged in the water, the upthrust becomes more than the weight of the bottle. The upthrust neutralizes the gravity and the submerged bottle comes out of the water. When the upthrust equals the weight of the bottle, the bottle floats on the water. Therefore, when an object is partially or completely immersed in a gas or liquid (fluid), the upward force acting on the object is called upthrust. Its SI unit is Newton (N).

Question to think

(a) What happens when the bottle used in the above activity 8.4 is filled with water and then placed in the bucket again?

(b) When a bucket submerged in water is pulled out with a rope, what is the difference between the force required to pull a bucket while it is in the water and after it comes out in the air?

When a bucket is dropped into a well, it initially floats for a while, but once it is filled with water, its weight increases. In that case, the downward force of gravity on the bucket cannot be neutralized by the upthrust of the water and the bucket sinks into the water. The upthrust acting on the bucket submerged in water reduces the weight of the bucket inside the water. In that case, the weight of the bucket is less than the actual weight. So, when the bucket submerged in the water is pulled up by the rope, less force needs to be applied than its actual weight. When the bucket is pulled out into the air, the upthrust of the air is negligible compared to that caused by the water. In that situation, the force required to pull the bucket increases. Therefore, it is easy to pull a bucket full of water when the bucket is inside the well.

In all cases, the upthrust caused by the air is not negligible. Plastic bottles, buckets, etc. occupy little space in the air and the upthrust on them is very small. But the aeroplane experiences a large upthrust.

Cause of upthrust

In Figure 8.23, the force exerted by water due to its pressure on the surface of a cubic object immersed in water is shown by the arrows. The forces acting on all surfaces, except the upper and lower surfaces, are equal and opposite in directions. Due to this, the force acting on the right surface is canceled by the force on the left surface and the force acting on the front surface is canceled by the force on the back surface.

The liquid exerts normal pressure on the object immersed in it from all sides. The pressure increases as the depth of the object increases. Since the lower surface of the cubical object is at a greater depth, the pressure and force on the lower surface are greater than the pressure and force on the upper surface. Thus, when the force on the upper surface of the object is subtracted from the force on the lower surface, the resultant force has an upward direction. Hence, the direction of the upthrust is upwards.

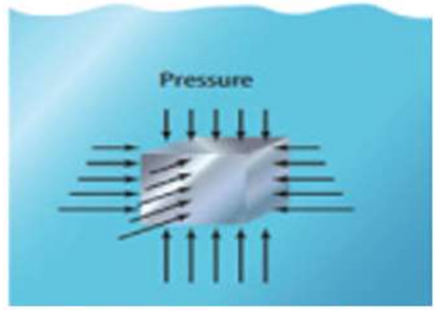


Figure 8.23Direction of upthrust

Activity 8.3 Calculation of the upthrust acting on a stone immersed in water

Take a small stone, a beaker that is filled more than half with water, a spring balance and a piece of thread. Tie the stone with the thread and hang it on the spring balance as shown in Figure 8.24. Measure the weight of the stone when it is suspended in air and the weight of the stone when it is submerged in water. Is the weight in air equal to the weight in water?

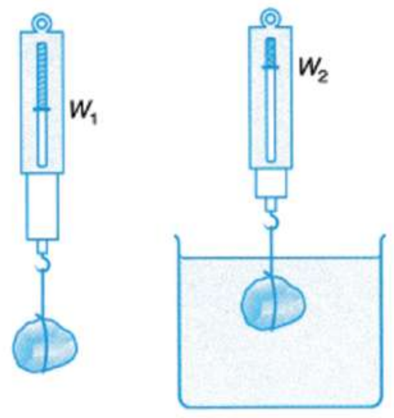


Figure 8.24 Upthrust acting on a stone submerged in water

When an object is immersed in a liquid, its weight is found to be decreased due to the upthrust exerted on it. The weight of an object measured in air (W_1) is called real weight and the weight of an object inside a liquid (W_2) is called apparent weight.

Therefore, the upthrust created when an object is immersed in a liquid can be represented by the following formula:

Upthrust (U) = Actual weight (W_1) - Unreal weight (W_2)

Factors affecting upthrust

(a) Density of a liquid

Activity 8.4 Observation of the weight of stones in different media

Prediction: In which liquid, is the weight of the stone least, when it is immersed in water, glycerin, and cooking oil respectively?

Take some amount of water and edible oil in two beakers. Hang the stone on a spring balance and measure the weight of the stone in these three liquids.

Weight in Water	Weight in edible oil	Results
....	....	....

The density of edible oil and water are 0.90g/cm^3 and 1g/cm^3 respectively. In the above activity, the weight of the stone is less in water than that in edible oil. Since the density of water is more than that of edible oil, the upthrust exerted by water is also more than that of edible oil. Thus, the upthrust exerted on a body is directly proportional to the density of the liquid. Therefore, when an object is immersed first in a liquid with lower density and then in a liquid with higher density, the upthrust exerted by the liquid of higher density is more.

Upthrust $\propto$ Density of liquid

Since the upthrust is directly proportional to the density of the liquid, the iron ball sinks in water but floats on the surface of mercury which has a high density. Similarly, as shown in Figure 8.25, when an egg is placed in a glass filled more than half with tap water, it sinks. But when salt is dissolved in the water, the egg starts to float. The density of salty water is higher than that of tap water.

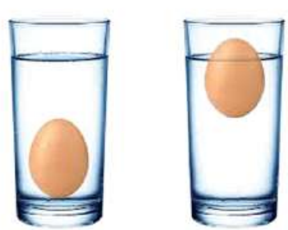


Figure 8.25 Eggs kept in tap water and salty water

That's why salty water exerts more upthrust than tap water. As a result, the egg sinks in tap water but floats on salt water. This is the reason why it is easy to swim in seawater. Similarly, a ship sinks less in seawater than in river water.

(b) Volume of liquid displaced

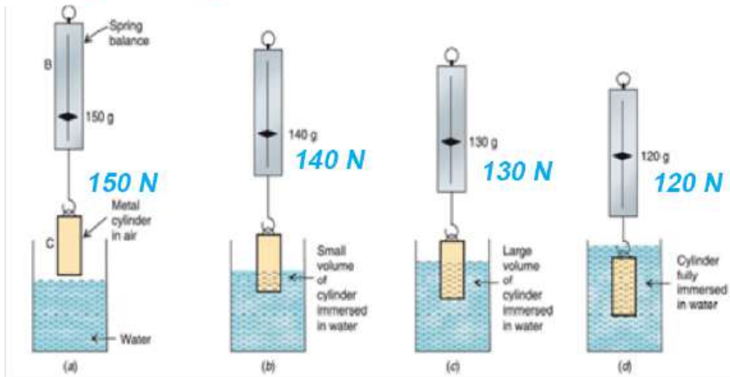


Figure 8.26 Upthrust and volume of the displaced liquid

Figure 8.26 shows the weight of a solid cylindrical object in different stages as it gets submerged in water. The figure shows the decrease in the reading on the spring balance as the volume of the immersed part of the object increases. The more the solid submerges in water the more volume it displaces. Once the object is completely submerged in water, the reading on the spring balance stays constant.

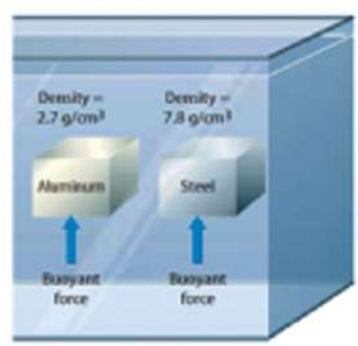


Figure 8.27 Upthrust acting on the object with the same volume

When a solid object is immersed in a liquid, as its volume inside the liquid increases, the 'upthrust' on it also increases and when the object is completely immersed in the liquid, the upthrust is maximum. After the object is immersed in the liquid, even though the depth of the object increases, the upthrust remains constant. For example, two cubic solids of different weights but equal volume are completely immersed in a liquid; the upthrust acting on them is the same as shown in Figure 8.27. Therefore, when an object is partially or completely immersed in a liquid, the upthrust acting on it is directly proportional to the volume of the displaced liquid.

This means, when the volume of an object immersed in liquid increases, the upthrust acting on it also increases.

Upthrust ∝ volume of fluid displaced

When trying to submerge a big water-tight plastic bottle and a small water-tight plastic bottle, the big bottle displaces more water than the smaller one. As a result, a large plastic bottle experiences more upthrust. Therefore, to submerge a large plastic bottle in water, more force should be applied than that on a small bottle. A similar effect applies to large and small balloons filled with helium gas. Since the large balloon displaces more air than a small balloon, the upthrust acting on it is also greater.

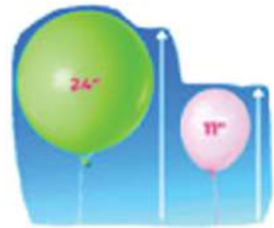


Figure 8.28 Upthrust on large and small balloons

When an object is placed in a fluid, the relationship between the upthrust on the object and the weight of the displaced fluid is given by Archimedes' principle.

Archimedes' principle

Activity 8.5: Verification of Archimedes' Principle

Take a spring balance, a eureka can (beaker that can collect displaced water), a beaker, a small stone, and a mug. Hang the stone on a spring balance as shown in Figure 8.29, and measure its weight first in the air and then in water in the eureka can. While measuring the weight of the stone in water, note the weight of the water displaced by the stone too. For this, first, weigh the empty beaker and subtract that weight from the weight of the beaker with displaced water.

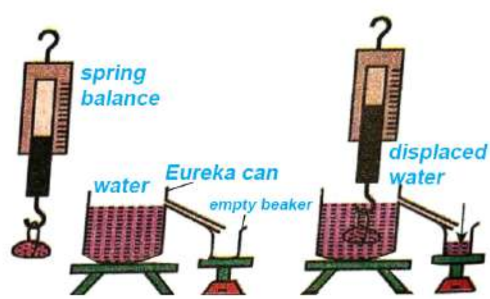
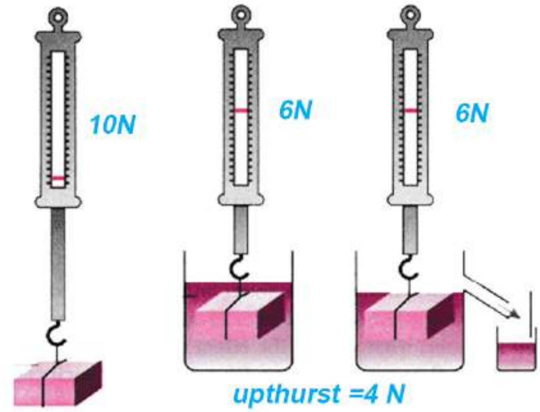


Figure 8.29: Verification of Archimedes' Principle

The data required for this activity can be collected in a table as the table below.

Weight of the stone in the air. (W1)	Weight of the stone in water (W2)	Upthrust (U)= (W1)-(W2)	Weight of the empty beaker (W3)	Weight of beaker and displaced water(W1)	Weight of displaced water (W1)	Result

In this process, when a stone is immersed in water, the upthrust exerted on it is equal to the weight of the displaced water. This proves Archimedes' Principle. For example, in Figure 8.30, it is shown that the upthrust exerted on the solid object immersed in water (4N) and the weight of water displaced, are equal.



Irq 8.30 upthurst and displaced liquid weight

Archimedes is a Greek mathematician born in 287 BC. According to Archimedes' Principle, when an object is partially or completely immersed in a liquid, the upthrust is equal to the weight of the liquid displaced by it. This principle is not only true for liquids but applies to all fluids.

Mathematically,

Upthrust (U) = Weight of liquid displaced (W)

$$U = mg = V \rho g \quad \text{Because, density of liquid } (\rho) = \frac{\text{Mass } (m)}{\text{Volume } (V)}$$

In the above equation, V, 'ρ'and g represent the volume of liquid displaced, density, and acceleration due to gravity respectively.

The upthrust exerted on an object placed in a liquid depends on the volume of liquid displaced by the object. Likewise, according to Archimedes' principle, the upthrust on an object is equal to the weight of the displaced liquid. Therefore, when an object is placed in a liquid, whether it floats or sinks depends on its weight of the object and the upthrust which depends on the volume of liquid displaced.

Floatation

Question to think

(a) Why do objects sink or float?

(b) Oil, which is less dense than water, floats on the surface of the water. Can an object made of iron, which is denser than water, also float on water?

If the density of the object is less than the density of the liquid, the object will float on the liquid. But, simply comparing the density of an object to the density of a liquid does not determine whether an object floats or sinks. The fact can be justified by the following activity.

Activity 8.6 Observation of the state of sinking and floating

Take two pieces of aluminum foil of equal area and a beaker that is filled more than half with water. Squeeze one of the aluminium foils in the shape of a ball. Then, as shown in Figure 8.31, drop both aluminium pieces into the water. Observe which floats and which sinks. If the aluminum foil is turned into a ball, its surface area gets reduced. Since it displaces less water, the upthrust acting on it will be less than its weight. So, it sinks in the water. If the aluminum foil is placed in the water as a sheet, the surface area increases and so does the upthrust acting on it. When weight and upthrust become equal, the foil floats.

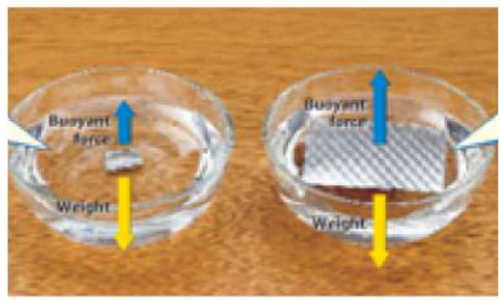


Figure 8.31 Aluminum foil placed in water

The density of aluminum is 2700kg/m^3 which is 2.7 times the density of water. Thus, it can be concluded that the foil sinks in water. But, according to the result of Activity 8.8, the aluminum foil kept as a sheet floats on the water. Therefore, whether an object floats or sinks in a liquid depends not only on the density of the substance but also on the shape of the object, i.e., the resultant force acting on an object when it is placed in the liquid.

The weight of an object and the upthrust are the forces acting on the object in exactly opposite directions. When the upthrust cancels the weight of the object, the resultant force becomes zero and hence the object floats in the liquid.

An object floating in a liquid may be partially or completely inside the surface of the liquid. When partially floating, only the submerged part of the object displaces the liquid. For an object to float in a liquid, the weight of the object must be equal to the weight of the liquid that it displaces. This is known as the law of floatation. This means, for an object to float on a liquid,

Weight of object = weight of the liquid displaced

This fact applies to various phenomena that occur in the liquid and air around us. Some examples are given below:

(a) Floating in a liquid

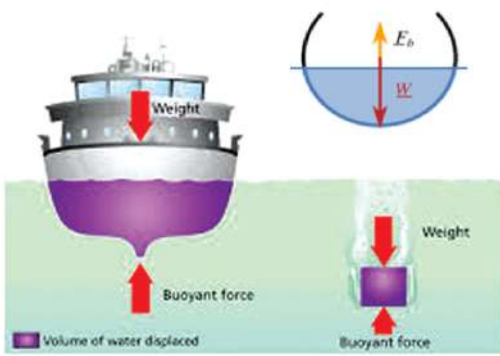


Figure 8.32 An iron block, bowls and a ship made up of iron in the water

Figure 8.33 An empty boat and a boat carrying passengers

As shown in Figure 8.32, when an iron block is placed in water, it cannot displace the volume of water whose weight is equal to its weight, and thus, it sinks. If the iron block is shaped like a bowl, the bowl can displace water equal to its weight. Similarly, in a ship, its hull is to be made wide, long and deep. Because of this, the ship can displace enough water to generate upthrust equal to its weight. For example, to prevent a ship weighing 50000 tons from sinking, the size of the hull should be able to displace 50000 tons of water. Therefore, iron sinks in water, but a ship made of iron floats on water.

Just like a ship, when a boat floats, the weight of the displaced water is equal to the boat's weight. As the lower part of the boat slowly sinks into the water, the volume and weight of the water it displaces also increases. According to Archimedes' principle, the upthrust exerted on the boat is equal to the weight of water displaced by the boat. As shown in Figure 8.33, the more people get on the boat, the more the boat sinks in the water and the boat displaces an additional amount of water. As the weight of the displaced water increases, the upthrust on the boat also increases. The increased upthrust supports the weight of the people added. If the water level reaches the top of the boat, no more water can be displaced and the upthrust does not increase. In that case, as the weight on the boat increases, the boat sinks. If a hole is formed at the bottom of a floating boat, it sinks, why? This concept applies to the submarine, too.

Submarines are built in such a way that they can float visibly on the surface of the water as well as inside the water. When its blast tank is filled with water, the weight increases and the submarine goes deeper into the water, and when the water is blown out of the tanks by the compressed air, the weight decreases and it floats back on the surface. Like submarines, fish also use Archimedes' principle to float and sink in water. When air is filled in the fish's swim bladder i.e. air sac, the volume of the body increases and the upthrust also increases. The fish floats toward the surface of the water. On the contrary, fish empty their bladders to reduce their body volume as well as the upthrust acting on their body. This helps them to go deeper into the water.

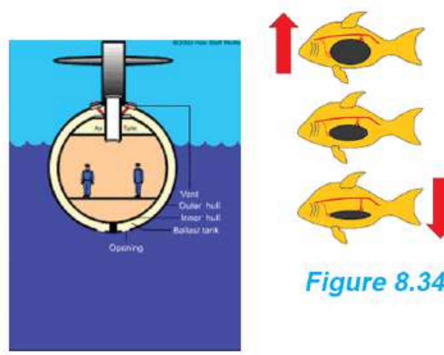


Figure 8.34

A hydrometer is a device used to measure the relative density of liquids. It contains a wide glass bulb filled with heavy metal which is attached to a calibrated fine tube. Due to the liquid displaced by its heavy bulb, it gets the necessary upthrust and floats vertically on the surface of the liquid. The hydrometer floats more on liquid of high density because such liquid exerts more upthrust. On the contrary, if the density of the liquid is low, the hydrometer sinks more. Lactometer is a type of hydrometer used to test the mixture of water in milk.

Figure 8.35 Use of Lactometer

(b) Floating in the atmosphere

Like in the water, there is upthrust in the air too. But the density of air is much less than that of water; therefore, the upthrust of air is much less than that exerted by water on an object.

Figure 8.36 Helium Balloons

Question to think

Why does a balloon filled with helium float in the air?

Objects can float on gases as well as on liquids. Objects float or fly in the air due to the upthrust produced by the air pressure. In Figure 8.36, balloons filled with helium gas are shown flying in the air. Air is denser than helium. If the weight of the air displaced by the helium-filled balloon i.e., the upthrust on it is greater than the weight of the balloon, the balloon will fly upwards. As the altitude increases, the density of air decreases and this makes the upthrust acting on the balloon decrease. When it reaches a certain height, the weight of the balloon equals the upthrust. As a result, the balloon floats in the air. At a certain height, the pressure inside and outside the balloon becomes unbalanced and the volume of the balloon keeps increasing until it finally bursts.

Like hydrogen or helium balloons, hot air balloons also fly in the air. The density of air inside a hot-air balloon is less than the density of the surrounding air. Since such a balloon displaces a large amount of air, the upthrust on the balloon becomes greater than its weight. As

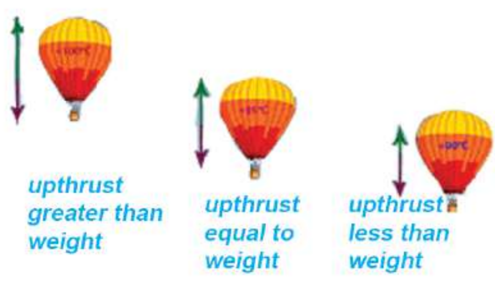


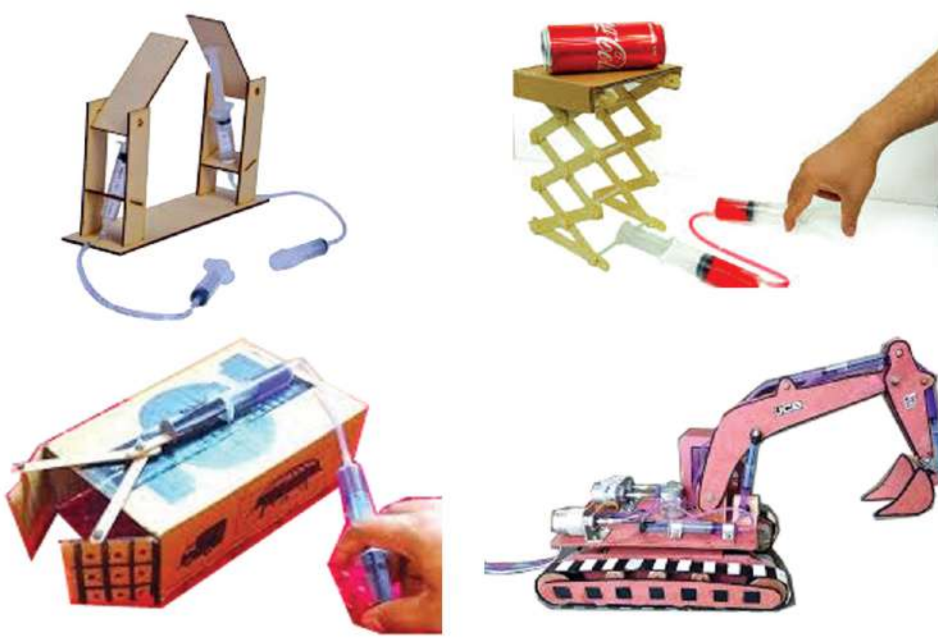
Figure 8.37 Hot air balloons in the air

a result, the balloon flies upwards in the air. When the balloon reaches a maximum altitude, the weight of the displaced air i.e., upthrust balances the weight of the balloon. Then the balloon floats in the air.

A balloon filled with hot air rises or falls in the air and such a condition is controlled by changing the temperature of the air inside the balloon with the help of a burner. When the flame from the burner heats the air in the balloon, the density of the air decreases. This causes the balloon to fly upwards. On the contrary, when the burner is turned off, the air in the balloon cools and its density increases. When the air in the balloon is cold enough, the weight of the balloon becomes greater than the upthrust on it and the balloon sinks in the air i.e., descends to the ground.

Project work

Use locally available plywood, cardboard, syringe, saline pipe, etc. as shown in the figure, and prepare the models of hydraulic bridges, hydraulic lifts, hydraulic doors, dozers, etc. based on Pascal's law.



Exercise

1. Choose the correct option for the following questions:

(a) On which law/principle is a lactometer based?

(i) Pascal's law (ii) Archimedes' principle

(iii) Law of Gravitation (iv) Newton's law

(b) What is the condition for flying a hydrogen balloon upwards in the air?

(i) weight of the balloon = weight of air displaced

(ii) weight of balloon > weight of air displaced

(iii) weight of the balloon = volume of air displaced

(iv) weight of balloon < weight of air displaced

(c) In a hydraulic machine, if the cross-sectional area of the larger piston is twice the area of the smaller piston, what is the correct group of the weights on the smaller piston (W_1) and the larger piston (W_2) to keep the machine balanced?

(i) $W_1 = 4$ N, $W_2 = 2$ N

(ii) $W_1 = 5$ N, $W_2 = 10$ N

(iii) $W_1 = 2$ N, $W_2 = 1$ N

(iv) $W_1 = 3$ N, $W_2 = 1.5$ N

(d) (d) When an object is suspended using spring balance in air, water and glycerin, the weight is founded to be W_1, W_2, and W_3 respectively. What will be the weight of the object in those mediums in increasing order?

(i) $W_1 < W_2 < W_3$

(ii) $W_2 < W_1 < W_3$ (iv) $W_3 < W_1 < W_2$

(iii) $W_3 < W_2 < W_1$

(e) When a ship enters a river from a sea, it was found to sink more than before. What is the reason for this?

(i) the temperature of seawater is more than that of river water

(ii) the density of seawater is more than that of river water

(iii) the temperature of seawater is less than that of river water

(iv) the density of seawater is less than that of river water

(f) Which one of the following statements is correct for a hand pushing a ball into the water as shown in the given figure?

(i) equal pressure acts on all parts of the ball under the water

(ii) the more the ball is pushed into the water, the lesser the upthrust it experiences

(iii) the pressure on the ball acts only in the upward direction

(iv) the upthrust on the ball increases until it completely sinks into the water

(g) If the same magnitude of upthrust acts on the three cubical balls made up of different materials on keeping them in water, which one of the following quantities is equal for them?

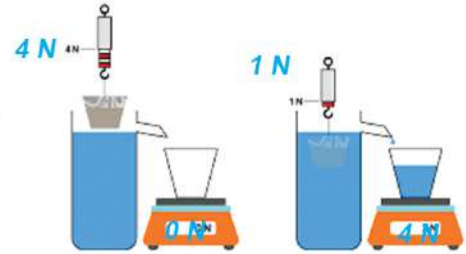
(i) density (ii) weight

(iii) volume (iv) mass

(h) What is the upthrust when the cork shown in the figure is placed in the liquid?

(i) 3N (ii) 4N

(iii) 5N (iv) 1N



2. Differentiate between:

(a) pressure and upthrust

(b) the reason for a steel pin sinking in water and a steel plate floating on water

(c) the process of a hot air balloon sinking and rising in the air

3. Give a reason for

(a) A special type of oil is used in hydraulic brakes.

(b) A wooden cork dipped below the surface of the water by applying force with a finger comes to the surface when the finger is removed.

(c) We feel lighter while floating on water.

(d) On lifting a stone submerged in water, it feels heavier when it comes out of the water.

(e) It is easier to float in the Dead Sea than in a swimming pool, (the density of water in the Dead Sea is 1240kg/m^3).

(f) If more passengers climb a boat than its maximum capacity, the boat is likely to sink.

4. Answers the following questions:

(a) State Pascal's law.

(b) Write any two applications of Pascal's law in daily life.

(c) What is a hydraulic machine?

(d) State Archimedes' principle.

(e) What is upthrust?

(f) Mention the forces acting on a floating object and their directions.

(g) State the law of floatation.

(h) Write any two applications of Archimedes' Principle.

(i) Explain, with a figure, the cause of the production of upthrust.

(j) When a stone is dropped into the water, it sinks. Does this happen because of the absence of upthrust?

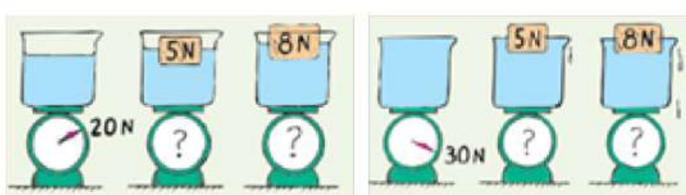
(k) A person is trying to lift a stone of 500N keeping it on the smaller piston of a hydraulic machine by applying a force on the larger piston. What suggestion would you give him/her so that he/she can lift the load easily? Explain, with an appropriate figure, the process of increasing the force in the hydraulic machine.

(l) Substances with a density greater than the density of the liquid sink in it. Is this statement always true? Justify with an example.

(m) Two balloons, one filled with air and the other with hydrogen, look identical. What difference can be noticed when they are released into the air? Explain with reasons.

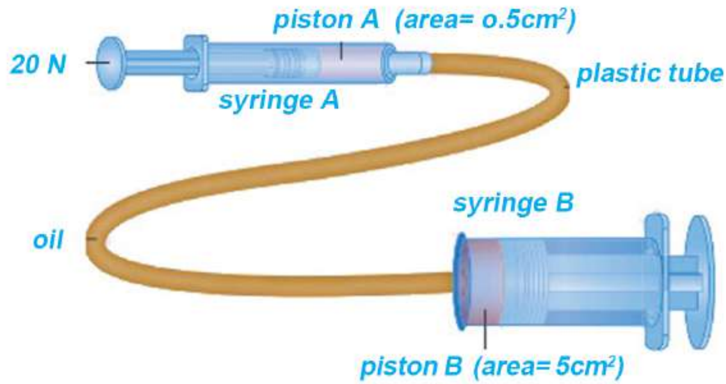
(n) An object is suspending /floating just below the surface of the water. If the amount of salt dissolving in the water goes on increasing, what change will occur in the position of the balloon? Explain with reasons.

(o) What are the readings shown by the weighing machine given in figures (a) and (b)? Explain with reason.



(p) When a person puts a lactometer into the milk, the whole part of the narrow stem sinks into the milk. What conclusions can be drawn from this event?

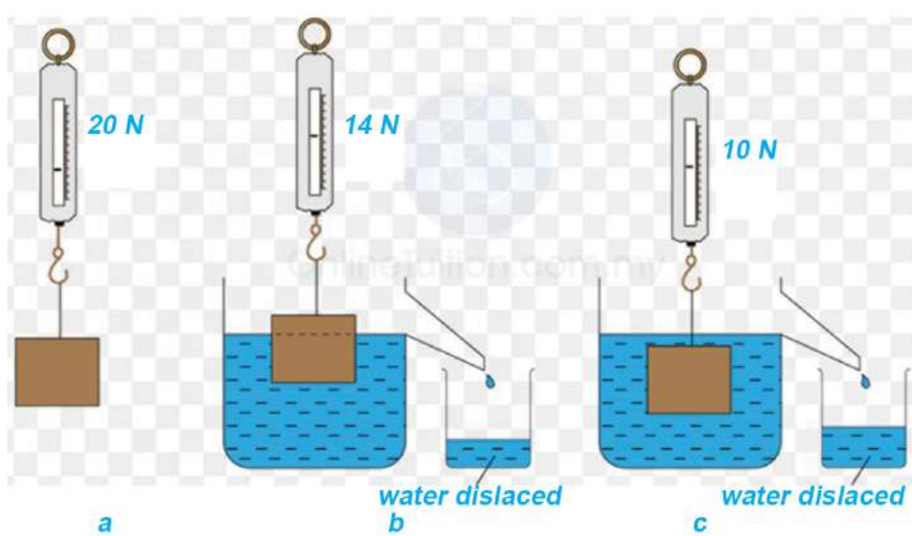
5. Solve the following mathematical problems:



(a) In the figure, a sample of a hydraulic machine constructed by using syringes is shown. How much force is to be applied through syringe B to balance the force on piston A?

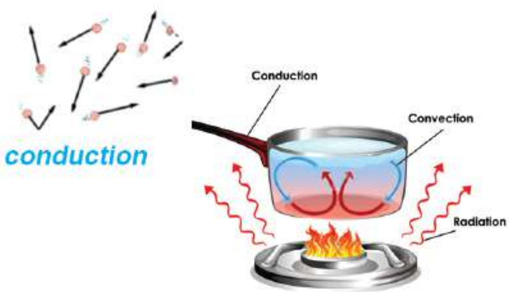
(b) Pressure of 30000 Pa is generated in the liquid of a hydraulic lift. If the cross-sectional area of the piston used to lift a weight is 0_1 m^2, how much load can it lift?

(c) Calculate the upthrust acting on the object in situations b and c shown in the figure. Mention the cause for the occurrence of different upthrusts under these two situations.



9 Heat

Discuss the scientific reasons related to the precautions given in the following table



We should not put our hands over boiling water.

Hot water should not be poured into a glass tumbler during the winter season.

A glass bottle full of water should not be kept in the deep fridge.

A steel plate covering the cooking food should not be taken out using bare hands.

Fig 9.1 Precautions used in daily life

In Figure 9.1, the rapid movement of molecules in water vapor is demonstrated by long arrows. Due to the rapid movement, the kinetic energy of the molecules is high. When the skin of our body comes in contact with steam, its molecules easily penetrate the skin and burn the inner parts. This causes a lot of pain.

When boiling water is suddenly poured into a thick glass tumbler, it cracks because theheat from its inner part cannot be transferred to the outer part and thus the increase in the volume of the inner part of the glass createspressure on the outer part. When a glass bottle filled with water is placed in the deep freeze, the volume of the water increases and the glass bottle cracks. Similarly, when different objects are heated, the temperature does not increase at the same rate. When boiling water is poured into a steel glass we are holding, the temperature of the steel glass increases instantly and burns our hands.

Thermal energy, heat and temperature

Activity 9.1

(a) Pour boiled water, tap water,and cold water from the refrigerator into three different beakers. Add an equal amount of food coloring agent or abirinto each and observe how the color mixes. If the movement of the color particles is considered to be the same as the movement of the water molecules, the molecules of which beaker has the fastest movement? Why?

(b) Pour lukewarm water, tap water, and cold water from the refrigerator into three separate beakers. Immerse the fingers of one hand in the lukewarm water and the fingers of the other hand in the cold water. After a minute, place all fingers in a beaker filled withtap water. Discussion about your observation.

Matter consists of many atoms or molecules. These atoms or moleculesare always in motion. The kinetic energy of molecules in lukewarm water is greater than the kinetic energy of molecules in cold water. The speed of molecules in hot water is even higher than that oflukewarm water. The sum of the kinetic energy of the molecules is the thermal energy. When the mass of warm water, tap water, and cold water are equal, the thermal energy of the hot water is the highest and that of the cold water is the lowest.

Absolute Zero Temperature: This is a theoretically considered state of zero thermal energy. $0\ K = -273.15^{\circ}C$.

When water is boiled, the external energy supplied makes the molecules move faster. The kinetic energy of all the atoms or molecules of a substance is not equal at any time. Therefore, their average kinetic energy is important. The average kinetic energy of the atoms or molecules of a substance determines its temperature. The temperature is an index of the average kinetic energy of the molecules in the substance. The SI unit of heat is the kelvin (K) but degree celsius (°C) is the most commonly used unit. It is measured using a thermometer.

The temperature of boiling water in a panis 100°C and the temperature of lukewarm water kept in the bucket is 30°C means that the average kinetic energy of the molecules of boiling water in the pan is much higherthan that of the molecules of the lukewarm water in the bucket. But the number of water molecules in the pan is much less thanthe water molecules in the bucket. Hence, although the average kinetic energy of the molecules in the boiling water in the pan is more, the sum of the kinetic energy of the molecules of the lukewarm water is higher because of the number of molecules. Therefore, the lukewarm water in the bucket has more thermal energy than the boiling water in the pan. The thermal energy of a substance depends on its mass and the average speed of its molecules.

When both the waters mentioned above are mixed, thermal energy is transferred from the boiling water to the lukewarm water. Thus, the amount of thermal energy transmitted from one place to another place due to the temperature difference is called heat. Like other types of energy, the SI unit of heat is the joule (J). It can be measured by using a calorimeter.

Heat is not stored in any object. It is only the quantity of thermal energy transferred from one object to another. When heat is transmitted, the thermal energy of one objectdecreases and that of the other increases. Therefore, when heat is transmitted, the temperature of one object decreases and that of another increases.

Heat is transmitted by the methods of conduction, convection and radiation. When we touch an object, if heat enters our body from the object feels hot and if heat leaves our body, itfeels cold.

Heat flows from a body at a higher temperature to a body at a lower temperature until both attain the same temperature.

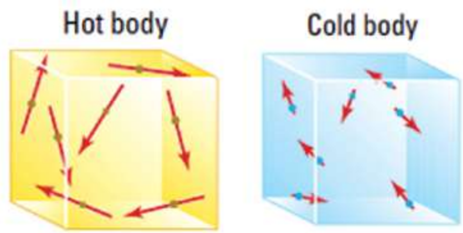


Figure: 9.2 the average kinetic energy of atoms/molecules of a hot object is greater than that of a cold object.

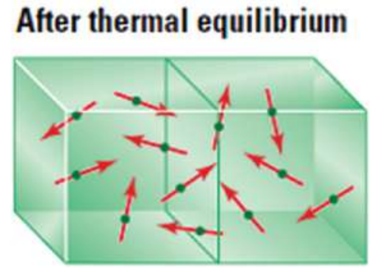


Figure: 9.3 Heat flows from a hotter object to a colder object until they attain thermal equilibrium.

Effect of heat on volume

In the figures below, the fact that the distances between the atoms/ molecules are different in solid, liquid and gaseous substances is demonstrated comparatively.

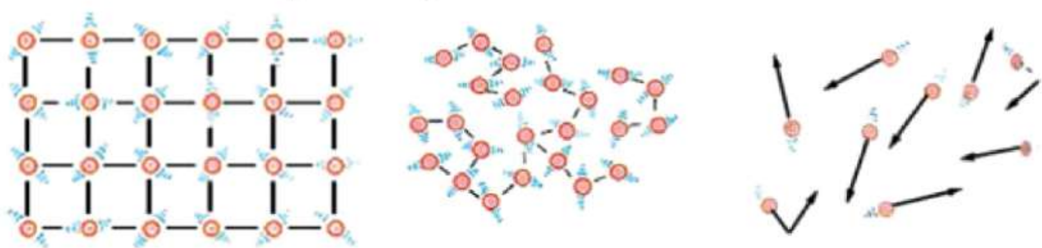


Figure 9.4 states of atoms/molecules in solids, liquids and gases

Molecules of solid matter are bound in a certain pattern due to the force of attraction between them. However, they are not stationary but constantly vibrating. When a solid is heated, its atoms/molecules gain more energy and their vibration increases. When heat is continuously supplied, the atom/molecules vibrate rapidly. That is why, the force of attraction between them weakens and they move away from each other, i.e.,the volume increases. Contrary to this, when an object releases thermal energy, average speed decreases. Therefore, temperature decreases and the object contracts.In this way, most of the matters expand when the temperature increases and contract when the temperature decreases.

Activity 9.2

Take an iron sphere having small hook and a similar-sized iron ring that fits the sphere. Heat the iron sphere for some time and try to pass it through the ring. Let the sphere cool down and then try to passit through the ring once again.Based on the concept of thermal energy or heat, discussyour observations. Fill up the following table and conclude.

Observation	**Observation**	**Explanation**	
	While trying to pass through the ring	Speed of the molecules in the sphere	Distance between the molecules in the sphere
On heating the iron sphere	....	increases/ decreases	increases/de- creases ....
On cooling the iron sphere	....	....	....

Anomalous expansion of water

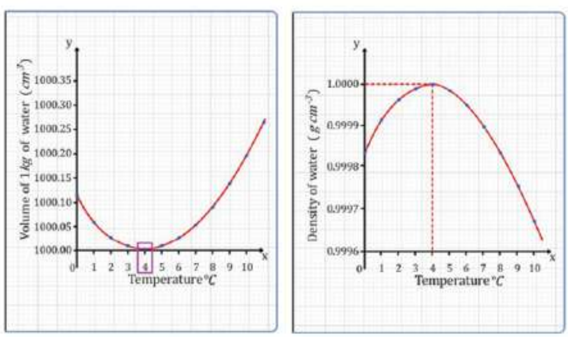


Figure 9.4 Relation between the volume and density of water, and between the density and temperature of the water

When most substances are heated, their volume increases. But water shows a different nature. Although its volume increases when heated, its volume decreases on heating from 0°C to 4°C. Also, on cooling down to 4°C, its volume decreases, but from 4°C to 0°C its volume increases (expands). Therefore, water at 4°C has the minimum volume and the maximum density.This unique property of water is known as the anomalous expansion of water.

The graph in Figure 9.4 shows the relation between the volume and the density of water. On heating or cooling the water at 4°C, its volume increases and the density decreases.

Effects of anomalous expansion of water

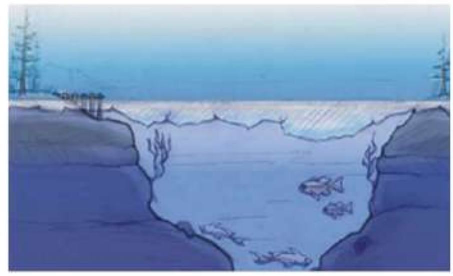


Figure 9.5 Aquatic organisms living under the surface of the ice

Invery coldplaces, the temperature of the environment drops below 0°C during the winter season. Along with the drop in the temperature of the environment, the temperature of the water also decreases. Once it reaches 4°C, the density of water becomes the heaviest. So, it sinks to the bottom. Above this, layersare formed of water at 3°C, 2°C, 1°C and 0°C respectively from the bottom to the top.As the surface water reaches 0°C, it freezes and floats on the surface of the water below. Therefore, fish and other aquatic creatures can survive in the water below the ice.

In winter in very cold places, as the temperature of the environment gradually decreases, the volume of water inside the pipe increases and it exerts pressure on the inner wall of the pipe. When the water freezes and becomes ice, the pressure can become very high and the pipe may burst. For the same reason, a bottle filled with water that is kept in the deep freeze cracks.

Specific heat capacity

Observe the groups of substances shown in the figure below.

Figure 9.6 Steel plate and ceramic plate

Figure 9.7 Wooden chair and a plastic chair

Figure 9.8 Sand and soil

Figure 9.9 Steel vessel and glass

Which one heats faster when all of the above materials are exposed simultaneouslyto the sun for about 15-20 minutes? What is the effect of the heat on each of these groups? Discuss.

Factors affecting the heat-absorbing capacity of matters

Even if the objects are made up of the same material but have different shapes, the rate and the amount of heat they absorb may differ according to the state they are in.

Activity 9.6 Relation among heat, temperature change (difference), and mass of the substance

(a) Take two beakers. Pour 200g of water into one of the beakers and 400g of water at the same temperature into the other beaker. Heat both beakers slowly with the help of sources of the same capacity.Water in which of the beakers absorbed more amount of heat energy when the temperature wasincreased by 10°C? Again, heat the water of 400g mass slowly. Note the quantity of heat absorbed by the water in each case when the temperature increases by 100C and 20°C respectively. In which case is the amount of heat absorbed more? Compare both the above activities and draw a suitable conclusion.

The quantity of heat absorbed by a substance (Q) is directly proportional to its mass (m)

$Q \propto m$......................i [Keeping the temperature constant]

The quantity of heat absorbed by a substance (Q) is directly proportional to the change/increase in temperature (T_2-T_1).

$Q \propto (T_2- T_1)$....................ii [Keeping the mass constant]

Combining (i) and (ii)

$Q \propto m (T_2 - T_1)$

$Q = ms (T_2 - T_1)$ ....(iii)

where s is a constant and refers to the specific heat capacity of the substance.

Therefore, the heat absorbed or released by a substance is equal to the product of the mass (m), the specific heat capacity (s) and the temperature change ($T_2 - T_1$) of that substance. This equation is called the heat equation.

From equation (iii) $\quad s = Q/m (T_2 - T_1)$

If the mass of the substance m = 1kg and the temperature change due to the quantity of heat absorbed or released is 1°C, then s = Q

Therefore, the heat required to change the temperature of a substance of 1 kg mass by 1°C is the specific heat capacity of that substance. Its SI unit is joule per kilogram per degree Celsius (J/kg°C). The specific heat capacity varies according to the nature of the material. Some materials and their specific heat capacities are presented in the table below.

Substance	**Specific heat capacity**	**Substance**	**Specific heatcapacity**
Water	4200	Aluminum	884
Ethyl alcohol	2400	Iron	460
Kerosene oil	2010	Copper	385
Ice	2100	Silver	236
Mercury	126	Gold	130

According to the specific heat capacity given in the above table, the amount of heat required to change the temperature of every 1kg of water by 1°C is 4200J. Similarly, the amount of heat required to change the temperature of every 1kg of iceby 1°C is 2100J. Here, even though ice and water are two states of the same substance, their specific heat capacities are different.

Example 3.1

Calculate the amount of heat energy consumed by an electric kettle to heat 5 kg of water at 10^0C up to 100^0C.(

Specific heat capacity of water = 4200 J $kg^{-1}\ {}^{o}C^{-1}$)

Solution:

Given in the question,

Mass of water(m) = 5 kg

Specific heat capacity of water (m)= 4200 J $kg^{-1}\ {}^{o}C^{-1}$

The initial temperature of the water $(T_1) = 10^\circ C$

The final temperature of water $(T_2) = 100^o C$

Change in temperature of water(dt) = $T_2 - T_1 = 100^o C - 10^o C = 90^\circ C$

According to the heat equation, $Q = m\ s\ (T_2 - T_1)$

Or Or $Q=5\times 4200 \times 90$

$\therefore Q=1890000\ J=1.89\times 10^6\ J$

When 5 kg of water at 10°C is heated to 100°C, the heat consumed is 1.89×10^6J.

Example 3.2

Calculate the final temperature of the water when 5 kg of water at 100°C is mixed with 15 kg of water at 15°C for bathing. (When the water of different temperatures is mixed with it, the heat lost to the outside environment is considered to be negligible.)

Solution: As given in the question,

Let the final temperature be T

For hot water,	For cold water,
Mass of hot water(m_1)=15 kg	Mass of cold water (m_2) = 5 kg
tem of cold water $(T_1) = 15^\circ C$	tem of cold water $(T_2) = 100^o C$

Specific heat capacity of hot water $s_1 = s_2 = s = 4200\ J\ kg^{-1}\ {}^{o}C^{-1}$

The final temperature of hot water $= T$

Heat released by the hot water = Heat absorbed by thecold water

or, $m_1\ s\ (T\text{-}T_1) = m_2\ s\ (T_2\text{-}T)$

or, $15 \times (T-15) = 5 \times (100-T)$

or, $3 \times (T-15) = (100-T)$

or, $3T - 45 = 100 - T$

or, $4T = 145$

$\therefore$ $T = 36.25\ {}^{o}C$

In the case of no heat lost to the outside environment, the final temperature of the water is 36.25°C.

Uses of specific heat capacity

The specific heat capacity of water is very high. Every kilogram of water absorbs or releases 4200J of heat to change its temperature by 1°C. This property makes water an effective coolant for cooling hot objects. For example, water is used as a coolant in car radiators. The water absorbs a large amount of heat from the car's engine, but the temperature of the water does not increase significantly. For this reason, water is also used as a coolant in thermal power stationsthat produce electricity.

Contrary to the purpose of heating, the high specific heat capacity of the hot water kept in the hot water bag releases its heat for a long time. That is why it is used as a hot compressor for soothing muscular pain. Water found naturally in the body of living creatures (about 70- 90 % of the body mass), controls the body temperature.

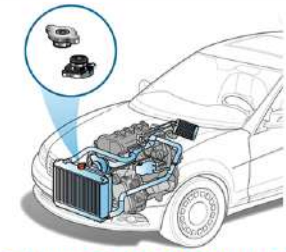
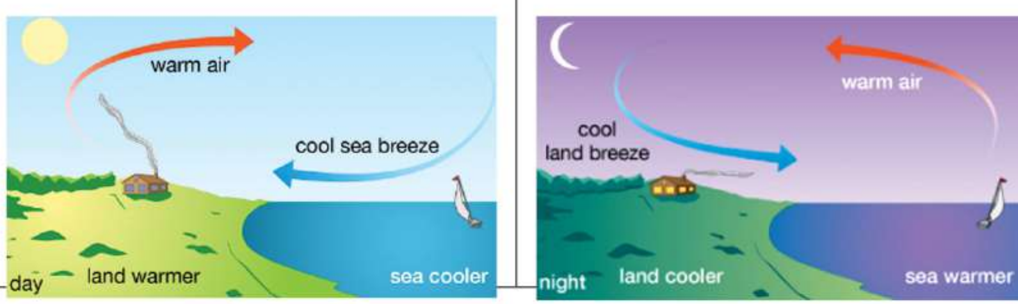


Figure 9.10 Water used as a coolant in a car radiator

Figure 9.11 Cloth wet in water used on the forehead of a person suffering from fever

Figure 9.12 Use of hot water bag

In the coastal area, because of the difference in the specific heat capacity of the land and the seawater, the air keeps circulating between the land and the sea.During the afternoon, the sun heats the land and the sea equally. But, since the specific heat capacity of land/sand is about five times less than that of the water, the temperature of land increases faster than that of water in the sea. Thus, the air above the ground becomes warm and light and rises to create a low-pressure above the ground. As a result, the cold air from the sea begins to flow toward the land. This is called Sea Breeze.



At night, the land and the sea release heat through radiation and their temperature decreases. In comparison to the temperature of seawater, the temperature of land decreases rapidly. Because of the higher specific heat capacity of water, the temperature of seawater remains higher than that of land at night. As a result, when the warm air above the seawater raises the air pressure above the sea level decreases and the cold air flows from the land to the sea. This is called the land breeze.

Thus, near the coastal areas, temperature varies much between the day and night because of the wind blowing from the sea to the land in the daytime and from the land to the sea at night.

Measurement of temperature

Different types of thermometers and their working principle

(a) Liquid in glass thermometer

A liquid in glass thermometer contains a thermometric liquid inside a heat-sensitive bulb. Mercury is a good conductor of heat and a high-density thermometric liquid. When the bulb of a thermometer is brought into contact with a hot object, heat is transferred from the object to the mercury and the mercury expands. The expanded mercury moves forward through the capillary tube attached to the bulb. The point where the mercury stops after the expansion indicates the temperature of the object. In a liquid in a glass thermometer, the temperature is determined by reading the scale marked on the outer wall.

(b) Digital Thermometer

It is a device for measuring the temperature of an object by using a heat-sensitive thermistor connected to an electric circuit. While using it, the thermometer is turned on and the end of the thermistor is brought in contact with the body. Due to the heat transmitted from the body, the electric current in the circuit changes because of the change in the thermistor's resistance. Based on this change, the measured temperature gets displayed as a number on the display panel.

(c) Radiation Thermometer

It is a device for measuring the temperature of a body without contact. Its working principle is based on theintensity of the infrared radiation produced by the body. To use it, the sensor is turned towards the body. The lens in the device focuses on the infrared radiation coming from the object on the sensor. Based on the heat carried by the radiation, electrical signals are generated and the temperature of the object is displayed on the display panel. This type of thermometer is very quick and easy to measure temperature.

Calibration of thermometer

Calibration is the process of determining the scale of a thermometer. At first, two fixed points (lower fixed point upper fixed point) are determined and then the distance between these two points is divided into a certain number of equal parts as per requirement. For the calibration of a thermometer, the temperature of melting ice (0°C) is taken as the lower fixed point and the temperature (100°C) of the steam just above the surface of the water boiling at one atmospheric pressure is taken as the upper fixed point. Then the distance between these two points is divided into 100 equal parts so that each part represents 1°C.

Activity 9.4

1. Take a thermometer.
2. Cover its scale by pasting a white paper over it.
3. Take some pieces of ice in a beaker.
4. Arrange a beaker, burner, stand, etc. required to boil water.
5. Insert the bulb of the thermometer into the melting ice and hold it on a stand for a while. Observe the falling mercury level inside the capillary tube of the thermometer. Mark the point on the paper at which the mercury stops andwrite 0°C.
6. Make an arrangement to hold the bulb of the thermometer in the steam coming from the boiling water. Observe the rising mercury level inside the capillary tube. Mark the point at which the mercury stops at 100°C.
7. Divide the portion between the two marks into 10 equal parts by drawing 9lines so that each line represents 10°C. The Celsius scale is ready.

The fixed points are different for different scales of a thermometer. For the Celsius scale, the lower and upper fixed points are taken as 0°C and 100°C respectively.For the Fahrenheit scale, the lower and upper points are taken as 32°F and 312°F respectively. Similarly, for the Kelvin scale, the lower and upper points are taken as 273K and 373K respectively.

Exercise

1. Choose the correct option for the following questions.

(a) Which statement defines heat?

(i) total kinetic energy of molecules

(ii) average kinetic energy of molecules

(iii) sum of kinetic energy and positional energy of molecules

(iv) energy transmitted due to difference in average kinetic energy of molecules

(b) On what basis can the increase in the volume of an object be explained when it is heated?

Order	The kinetic energy of atoms/ molecules	The attraction between the atoms/ molecules	Distance between the atoms/molecules
i	Increases	Decreases	Decreases
ii	Increases	Increase	Decreases
iii	Increases	Increases	Decreases
iv	Increases	Decreases	Increases

(c) Specific heat capacity of a substance depends on which of the following?

(i) mass of the substance

(ii) volume of the substance

(iii) temperature of the substance

(iv) nature of the substance

(d) What is the effect of the high specific heat capacity of water?

(i) water in the seaheats up faster than the land during the day in coastal areas

(ii) water in the sea cools faster than the land at night in coastal areas

(iii) the land heats up slower than the water in thesea in the daytime in coastal areas

(iv) the land cools faster than the water in the sea at night in coastal areas

(d) Which one of the following is the best way to insert a wide pipe into a narrower pipe?

(i) heat both the pipes

(ii) cool both the pipes

(iii) heat the wider pipe and cool the narrow one

(iv) cool the wider pipe and heat the narrow pipe

(f) What are the lower fixed points of the thermometer in Celsius, Fahrenheit, and Kelvin scales respectively?

(i) 0°C, 0°F, 0K (ii) 0°C, 32°F, 273K

(iii) 0°C, 180°F, 373K (iv) 0°C, 212°F, 373K

2. Differentiate between:

(i) Thermal energy and heat

(ii) heat and temperature

(iii) the lower fixed point and the upper fixed point of a thermometer

3. Give reason:

(a) An iron bar heats upwhen it is hammered continuously for some time.

(b) Tea in an open teacup stopscooling after some time.

(c) Water pipes crack in cold places in the winter.

(d) To cool the car's engine, water is kept in its radiator.

(e) The hot water bag is used to give hot pressure to the parts of a body.

(f) There is no significant difference in temperature between the daytime and the nighttime in the coastal areas.

(g) Temperature differs a lot betweenthe day and night in the desert.

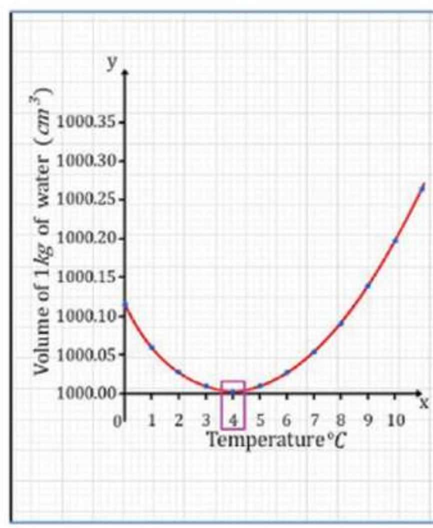
4. Answer the following questions:

(a) In the perception of a certain man, a bucket of lukewarm water contains more thermal energy than a large tank of cold water.Correct this understanding based onthe definitions of thermal energy and temperature.

(b) Touching a cup of hot tea feels hot but touching an ice cube feels cool. Explain it based on the motion of their molecules.

(c) If the lid of a glass bottle does not open, how may it be opened using your knowledge of the effects of heat? Explain based on the kinetic energy of molecules.

(d) Study the relationship between the volume and temperature of water shown in the given graph and answer the following questions.



(i) What is the special property of water shown in the graph called?

(ii) Mention the change in volume of water that appears when water is heated from 0^0C to 10^0C.

(iii) How does the property of water shown in the graph differ from the property of other liquids?

(iv) Explain the importance of this knowledge in daily life.

(v) Draw a model graph to show the relationship between the density of water and temperature based on the relationship shown in the graph.

(e) Once in winter, while drinking the water from a steel jug on the table Samir felt the water to be warmer towards the bottom. Justify his experience based on scientific facts.

(f) What are the differences between the process of freezing ghee and honey in terms of their volume and density?

(h) Of the two ice cubes of identical shape, one is kept in an aluminum box and the other in a wooden box. Which ice cube melts faster? Explain in terms of the melting process.

(i) What is specific heat capacity? Write its SI unit.

(j) What is the heat equation?

(k) Write any two applications of specific heat capacity.

(l) Describe the conditionin which water can be boiled at a temperature less than 100°C.

(m) Write the types of thermometers used in daily life. Also, mention their working principles.

(n) What is thermometer calibration? Describe the method.

5. Solve the following mathematical problems:

(a) Calculate the amount of heat required to raise the temperature of 500 g of water from 15°C to 85°C. [Answer:147 KJ]

(b) The specific heat capacity of iron is 460J/kg.Calculate the heat released by an iron sphere of mass 5kg while cooling it from 430°C to 30°C. [Answer: 920J]

(c) If 2kg of paraffin needs 4200J of heat to increase its temperature through 10°C, calculate the amount of heat required to increase the temperature of 4kg of paraffin from 20°C to 40°C. [Answer: 8.4×10^4J]

(d) If a substance of mass 500g needs 7938J of heat to increase its temperature from 100°C to 226°C, calculate its specific heat capacity. [Answer: 126J/kg°C]

(e) A bucket contains 16kg of water at25°C. Calculate the temperature of the mixture formed when 4 kg of water at 80°C is mixed with it. (Here, the heat lost to the surrounding is neglected) [Answer: 36°C]

10

Wave


fig. 10.1


fig. 10.2

fig. 10.3


fig. 10.4 rainbow

Figure 10.1 shows a pencil, which is partially dipped in water, bending at the air-glass interface (in between the borderline of water and air). This event is related to the difference in the speed of light waves in water and air media.

Figure 10.2 shows air bubbles shining in the water just the way a mirror shines when light is reflected from its surface. In this event, light passing from water to air gets reflected from its outer surface instead of passing into the air medium. In the same way, optical fiber is constructed on the principle that light going from one optical medium to another optical medium is reflected into the same medium.

Figure 10.3 shows the alphabet getting enlarged when the light coming from the letters passes through a hand lens. Because of the special structure of the glass used in the hand lens, the alphabets appear large when they are viewed through the hand lens.

A rainbow is shown in figure 10.4. During the formation of a rainbow, the light from the sun splits into its seven constituent colours. To observe the seven colours of the rainbow, the cone cells found in the inner rings ofour eye plays an important role. Rainbow is like a far object to us. It has become possible to see distant and nearby objects because our eyes have natural lensessimilar to the hand lens.

Sometimes, our vision becomes blurred due to the inability of our eye to change the thickness of its lens or because of the loss of transparency. Some people have the problems like not seeing distantor nearby objects distinctly or not being able to distinguish colours. The problem of not seeing distant or nearby objects is solved by getting the eyes checked and wearing spectacles with lenses of suitable power.

The light from the objects we observe is transmitted through different natural or artificial transparent medium. The speed of light in such media is different. These mediums can be categorized into rarer mediums and denser mediums by comparing the speed of light in a pair of mediums.

Denser and rarer medium

The substance through which light propagates is a transparent medium. Air, glass, and water are three different transparent media. The speed of light in a few media is given in the table below.

Medium	Speed of light(m/s)	Medium	Speed of light(m/s)
Air	3.00×10^8	Kerosene oil	2.08×10^8
Water	2.25×10^8	Glass	2.00×10^8
Alcohol	2.19×10^8	Diamond	1.24×10^8

From the above table, it is clear that among the given media the speed of light is the highest in the air whereas it is the least in the diamond. In a given pair of media, the medium in which the speed of light is less in comparison to another one is the denser medium. Likewise, the medium in which the speed of light is comparatively more is the rarer medium. For example, glass is a denser medium in comparison to air.In this example, air is rarer medium and glass is denser medium.

Question to think

Compare the speed of light in water and kerosene oil, given in the above table. Does an optically denser medium mean a medium witha higher physical density?

Kerosene oil floats on water; it means the physical density of kerosene oil is less than that of water. While comparing the speed of light in these two media, the speed of light is less in kerosene oil than that in the water. Thus, the medium with comparatively higher optical density does not mean that, it is physically denser. When light is passed from one medium to another medium, denser and rarer mediums can be identified onthe basis of change in the direction of the light ray with change in medium, i.e., the refraction of light.

Refraction of light

Activity 10.1

As shown in figure 10.5, take a laser beam pointer and a beaker filled more than half with water. If a laser beam pointer is not available, make a ray box (as shown in figure 10.6) by making a thin slit on a wall of a box made up of cardboard paper and a bulb inside it. To avoid the box from burning due to heat, put off the switch after some time.

Figure 10.5 Laser beam

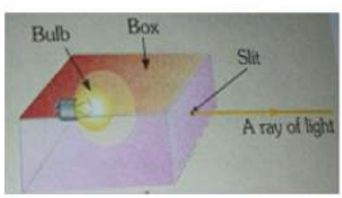


Figure10.6 Simple ray box

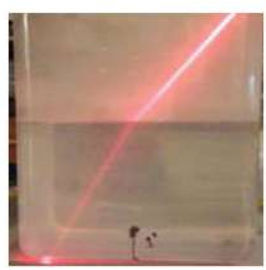


Figure 10.7 Transmission of light from air to water

Figure 10.8 Transmission of light from water to air

At first, pass the laser beam from the upper side of the beaker as shown in figure 10.7 and then observe the direction of the transmitted beam inside the water.Again, repeat the same activity from the lower part of the beaker as shown in figure 10.8 and observe the direction of the beam emerging out from the water. Is the direction of the transmitted beam while passing from air to water and water to air different?

The speeds of light in air and water are 3×10^8 m/s and 2.25×10 m/s respectively. When light enters from air to water, its speed decreases due to which the transmitted laser beam bends towards the imaginary normal as shown in figure 10.7. Since the transmitted beam in the water bends towards the normal, water can be considered a denser medium. When light entersfrom water to air, the speed of light increases. This results in the beam moving away from the normal as shown in Figure 10.8. Since the laser beam moves away from thenormal while passing from water to air, air must be a rarer medium.

In this activity, the light which moves away from the normal or bends towards the normal due to a change in speed while passing from one medium to another is the refracted light. The process of bending of light or changingthe direction of light while passing from one optical medium to another is called refraction of light. The change in the speed of light while passing from one medium to another is the cause of the refraction of light. Greater the change in speed of light, more the bending of light i.e., the refraction. Of course, not only the light waves but also the other waves like sound follow the laws of refraction.

Activity 10.2: Refraction through a glass slab

Take a light box or laser beam pointer, a pencil, a scale, a sheet of plain paper, etc. Put the glass slab on the paper and draw its outline PQRS with the pencil as shown in figure 10.9. Take a point O on the outline of the face PQ and draw a normal NN'. Draw a line AO making a desirable angle 'i' with the normal. Now from the face PQof the slab, pass a laser beam such that it passes along the line AO and emerges out from the face RS. Use the pencil to indicate a point B from which the beam emerges and take another point C on the emergent ray. Then remove the slab from the paper and draw a perpendicular N_1N_1' at point B. Join BC and OB. Here the lines AO, OB and BC represent incident ray, refracted ray, and emergent ray respectively.

Observe the bending or the change in the direction of the rays while entering the glass slab and while emerging from it.

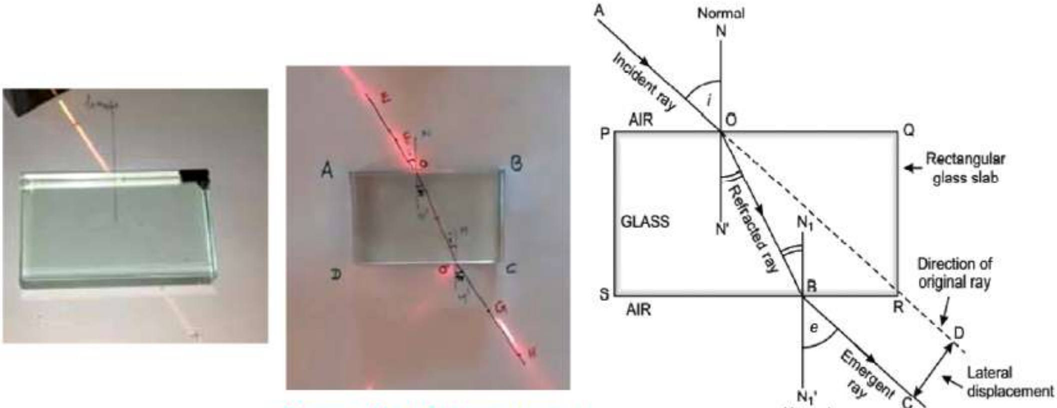


Figure 10.9 Refraction through glass slab

Some terminologies related to refraction of light are as follows:

a. Normal

The imaginary line perpendicular to the interface of two media is called the normal. In the above Figure NN' and N_1N_1' are normal.

b. Incident ray

The ray AO from the source of light is the incident ray.

c. Angle of incidence

The angle (∠AON) made by the incident ray AO with the normal NN' is the angle of incidence.

d. Refracted ray

The ray (OR) which bends at the border and enters the second medium is the refracted ray.

e. Angle of refraction

The angle (∠BON') made by the refracted ray AO with the normal NN'is called the angle of refraction.

f. Emergent ray

The ray (BC) which comes out of the object into the first medium after refraction is called an emergent ray.

g. Emergent angle

The angle ($\angle CBN_1'$) made by the emergent ray BC with the normal N_1N_1' is called the angle of emergence.

f. Lateral shift

The perpendicular distance (CD) between the emergent ray and the line formed when the refracted ray is produced, is called the lateral shift.

In this activity, when light is passed from the air (rarer medium) to glass (denser medium) it bends towards the normal. Contrary to this, it bends away from the normal while emerging out from the glass slab.

In the figure that you drew, which is similar to figure 10.9, measure the angle of incidence ($\angle AON$), angle of refraction ($\angle BON'$) and angle of emergence ($\angle CBN_1'$).Fill in the table given below. What is the length CD called? Also, measure it.

$\angle AON=i$	$\angle BON'=r$	$\angle CBN_1'=e$	**Result**
30°	....	....	.... $\angle$ .... , ... = ...

What will be the result when a ray of light is passed by changing the angle of incidence in activity 10.2?

In figure 10.9, for the light passing through air-glass interference 'PQ' the angle of refraction(r) is always smaller than the angle of incidence (i). Similarly, for the ray passing through glass-air interference 'RS', due to the increase in speed of light in air, light moves away from the normal. As a result, the value of the angle of incidence (i) and that of the angle of emergence (e) becomes equal. This means lateral shift CD occurs due to the bending of light ray AO towards the normal inside the glass slab and away from the normal when it emerges out to the air medium.When light ray entersfrom air into any transparent medium, the angle of refraction (r) depends on the nature of medium and the angle of incidence (i). On increasing or decreasing the value of angle of incidence,the angle of refraction also varies respectively. On the basis of law of refraction, the value of angle of refraction can be obtained for the particular value of angle of incidence.

Laws of refraction of light

Activity 10.3 Verification of laws of refraction of light

Take a semicircular glass slab, a ray box or laser beam pointer, a sheet of plain paper, a protector, a pencil, etc. Draw four quadrants on the plain paper as you used to draw on the graph paper as shown in figure 10.10. Draw the degree scales in the first and the fourth quadrants using a pencil and a protractor. Place the semicircular glass slab on the plain paper taking the x-axis as a base and the origin lies at the mid-point of its base as shown in the Figure. Pass the light beam making different angles of incidence through the base plane of the glass slab using the ray box or laser beam pointer. During this process, measure the angles of incidence and the angles of refraction and fill in their corresponding values in the given table. Do the necessary calculations and draw an appropriateconclusion.

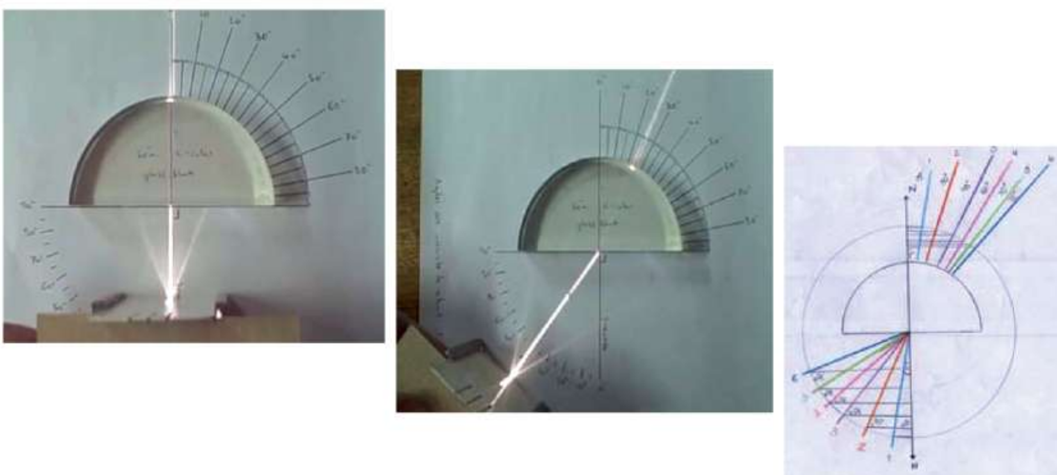


Figure 10.10 Refraction through semicircular glass slab

When the light beam falls normally on the glass slab, it passes through a straight line without bending as shown in figure 10.10. Then, on increasing the angle of incidence (i), the value of the corresponding angle of refraction (r) goes on increasing.

Ratio of speed of light in air to that in glass	Angle of incidence ($\angle i$)	Angle of refraction (r) ($\angle r$)	sin i	sin r	$\frac{\sin i}{\sin r}$	Result
$\frac{\text{speed of light in air}}{\text{speed of light in medium}} = \frac{(3\times10^8)}{(2\times10^8)} = 1.5$	15	10	.....	.....	1.49	$\mu = 1.49$
	....	....	....	...	.....	....
Conclusion:						

The laws of refraction of light are listed below.

a. When light passes from one optical medium to another medium, the incident ray, the normal and the refracted ray all lie on the same plane at the point of incidence.

b. The ratio of sine of the angle of incidence to the sine of the angle of refraction remains constant for a pair of media. The constant value is refractive index of pair of media which is denoted by μ.

or, $\frac{\sin i}{\sin r} = \text{constant } (\mu)$ ....(i)

This law is named as Snell's law after the name of the mathematician Willebrord Snellius, who discovered it.

The value of the constant μ, i.e., the ratio of Sini to Sinr, while passing the light from air to glass is equal to the ratio of the speed of light in the air (c) to the speed of light in glass(v). Thus, the ratio of the speed of light in a vacuum or air to the speed of light in any medium gives the refractive index of light in that medium.

This means, $\mu = \frac{\text{speed of light in air or vacuum (c)}}{\text{speed of light in the medium (v)}}$

The speed of light in some media and their refractive indices are given in the table below. What can be concluded from the study of the increasing order of refractive index of the different media given in the table and the decreasing order of the speed of light in those media?

Medium	**Refractive index**	**Speed of light (m/s)**	**Medium**	**Refractive index**	**Speed of light (m/s)**
Water	1.33	2.25×10^8	Glycerin	1.47	2.04×10^8
Alcohol	1.36	2.19×10^8	Glass	1.50	2.00×10^8
Kerosene oil	1.44	2.08×10^8	Diamond	2.42	1.24×10^8

Consequences of refraction of light

Activity 10.4 Observation of the coin at the bottom of a beaker lying below the line of sight

Take a steel glass, a coin and some water. Put the beaker on a table and drop a coin into the beaker. Shift your head in the backward direction until the coin lies outside the line of sight, i.e., not visible. Keep your head still at that point and ask a friend to pour water into the beaker without disturbing the coin. Does the coin reappear as the level of water rises?

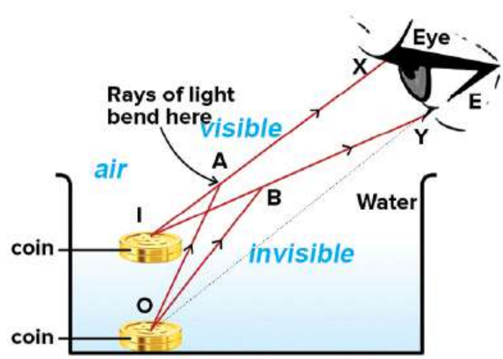
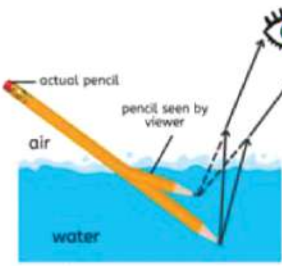


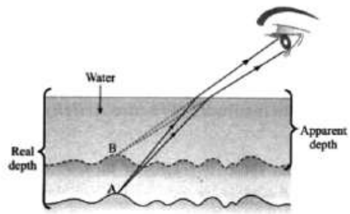
Figure10.11

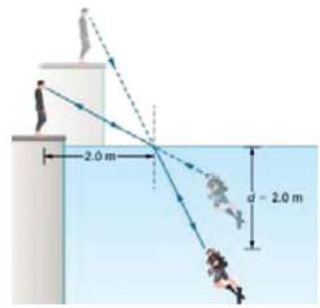
In this activity, the light rays reflected by the coin at the bottom of the glass pass from water to air when water is poured into the beaker. The rays of light move away from the normal at the water-air interface while passing from water (denser medium) to air (rarer medium) as shown in figure 10.11. When these refracted rays are produced backward, they form the image of the coin at the point 'I' and the observer sees the coin(O) at 'I'. In this way, the coin is seen due to the refraction of light rays at the surface of the water.

In our daily life, there are so many situations created in nature due to refraction of light. Some specific examples are listed below.

a. Consequences of the refraction of light in the water-air interface (from water to air)







Figures 10.12, *Figures 10.13,* *Figures10.14*

The above Figures show the bending of an object that is partially dipped in water and the depth of objects in water appearing less than their actual depths.

b. Consequences of refraction in the atmosphere

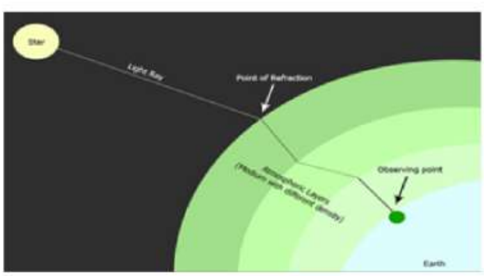


Figure 10.15 Refraction of light from the stars in the atmosphere

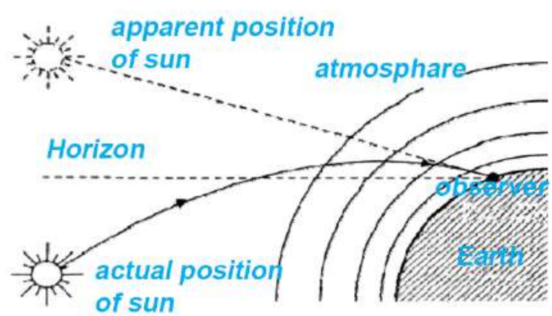


Figure 10.16 Refraction of sunlight in the atmosphere

While observing the stars, the rays coming from outer space reach the earth after successive refractions through different layers of the earth's atmosphere. Thedifferent layers in the atmosphere have different refractive indicesand the layers keep changing their position continuously. This results in the bending of light sometimes away from the normal and sometimes towards the normal even in the same place.

This causes a change in the brightness and the position of the stars. In this way, the stars appear to be twinkling due to the refraction of light in the atmosphere. But, the change of position of the planets and satellites due to the refraction of light in the atmosphere cannot be noticed because they are closer to the earth and appear big. Hence, they cannot be seen twinkling.

Question: Compare the sun seen below the horizon in figure10.16 and the coin inside the steel glass in figure 10.4. Just the way the coin in the empty steel glass becomes visible after pouring the water into it, the sun appears above the horizon even when it is actually below the horizon because of atmospheric refraction.

As shown in figure 10.16, as the rays of sunlight from outer space entering into the atmosphere pass from rarer medium to denser medium, they bend towards the normal. The refractive index of the atmospheric layers changes with the increase in altitude of the earth's surface. As the rays of light from the sun below the horizon reach the observer's eyes, they appear tocome from above the horizon since they suffer successive refractions through these layers of the atmosphere. Therefore, the sun is visible two minutes before and two minutes after the actual sunrise and sunset respectively.

Total internal reflection of light

In figure 10.17, the rays of light passing from water (denser medium) to air (rarer medium) are bending away from the normal. In this situation,the angle of refraction 'r' is greater than the angle of incidence (i) i.e., r ∠ i. If the value of the angle of incidence (i) increases, the value of the corresponding angle of refraction (r) also increases.

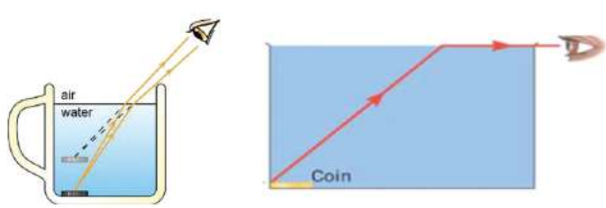


Figure 10.17 Observation of the coin in the water from different angles

Question: On increasing the value of angle of incidence (i) continuously, what could be the maximum value of angle of refraction (r)?

In the second figure of 10.17, the coin in the glass is seen even when we observe it along the air-water boundary. In this situation, the refracted ray makes an angle of 90o with the normal. This is the maximum value of the angle of refraction (r) when light passes from a denser medium to a rarer medium. In this situation, the angle of incidence (i) formed in water with the normal is known as the critical angle.

Critical angle

Activity 10.5 Refraction of light while passing from denser to the rarer medium by making different angles of incidence

Take a semicircular glass slab,a laser beam pointer or ray box, a protractor, etc. as shown in the figure. On a plain sheet of paper, draw lines as if they are the two axis of a graph. Prepare a scale for measuring the angles with the center of the protractor as the origin (O) and the reference line that is parallel to the x-axis as shown in the figure. Take a semi-circular glass slab and place it on the sheet such that its center lies at O and the flat edge becomes parallel to the x-axis. Pass the laser beam into the glass making itperpendicular to the semicircular surface. Measure the angle of incidence (i) and the angle of refraction (r) at O and then fill in the table below.

Keep on increasing the value of the angle of incidence. Observe the angle for which the refracted ray becomes parallel to the glass-air

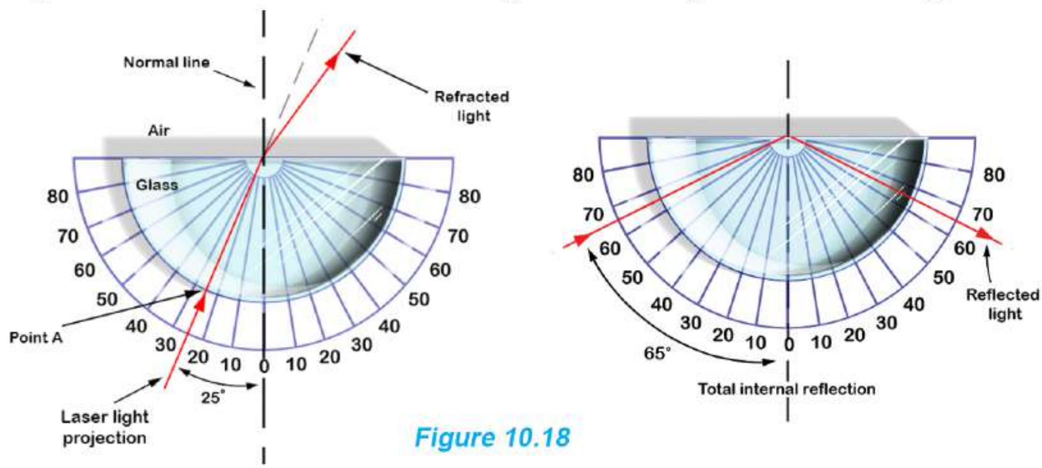


Figure 10.18

interface making an angle of 90° with the normal, and note it down. In which medium does the light goif the angle of incidence is increased after having the angle of refraction 90°?

Angle of incidence	Angle of refraction/ angle of reflection	Result: refraction of light/ reflection of light
30°	.....	Refraction of light
35°	....	...
.....	90°	Refraction of light
50°	....	....

On continuing to increase the angle of incidence in the denser medium as shown in the figure, for a particular value of angle of incidence, the refracted ray becomes parallel to the water-air interface, i.e., the value of angle of refraction becomes 90°. The angle of incidence in the denser medium under the condition whichthe value of its corresponding angle of refraction in the rarer medium becomes 90° is known asthe critical angle.

The value of the critical angle depends upon the materials of the two media. The values of the critical angle of a few substances to air are given in the table below.

Medium	Critical angle	Medium	Critical angle
Water	49°	Glycerin	43°
Alcohol	48°	Glass	42°
Kerosene oil	44°	Diamond	24°

Total internal reflection of light

If the angle of incidence becomes greater than the critical angle (figure 10.5), the light gets reflected in the same medium instead of being refracted. This means the light passing through the semicircular surface of the glass returns to the glass. The phenomenon of reflecting of light to the same medium when it is passed from a denser medium to a rarer medium is called the total internal reflection of light. All laws of reflection of light are applicable in this process.

When a fish inside the aquarium (figure 10.19) is viewed from a certain angle outside the aquarium, the light rays from the body of the fish suffer total internal reflection from the water-air interface and reach the observer's eyes. The observer sees the fish below the surface of the water, and its image above the mirror like a shiny water-air interface, i.e., in the air.

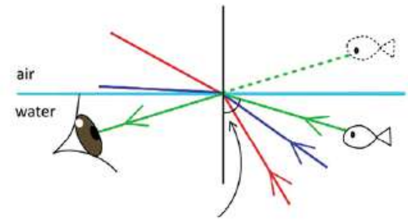


Figure 10.19 aquarium

Normally, when light falls on the interface between any two media, a part of it is reflected and the rest is refracted to the other medium. But, in the condition of total internal reflection, all the light is reflected. Therefore, the word 'total' is used here. The necessary conditions for the total reflection of light are given below.

a. Light must be travelling from the denser medium to the rarer medium.

b. The angle of incidence must be greater than the critical angle.

Activity 10.6 Total internal reflections that take place in different media

a. Total internal reflection in the water

As shown in figure 10.20, take a plastic bottle and a laser beam pointer.

Fill the bottle with water and make it blurred by adding a few drops of Dettol or milk in it and then shaking it. Now make a small hole in the bottle a little above its base. Pass a beam of laser light from its opposite side so that the light falls on the current of water coming from the hole. Does the light propagate along with the current of water?

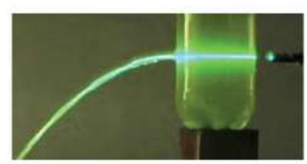


Figure 10.20

Pass a laser beam through the outer surface of a beaker filled with water as shown in figure 10.21.

Change the value of the angle of incidence by tilting the laser beam pointer. Does the laser beam suffer total internal reflection from the surface of the water at a certainangle of incidence?

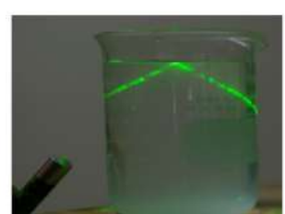


Figure 10.21

The drops of milk added to the water spreads out the laser beam and it becomes easier to observe the propagation of light in water.

In figure 10.22, water flowing out of the bottle from a hole in its surface is shown. A laser beam, directed from the opposite side of the bottle such that it is perpendicular to the hole, falls on the curved surface of the stream of water gushing out of the bottle. When the laser beam falls on this curved surface of the stream of water, the light istravelling from a denser medium (water) to a rarer medium (air) and the value of the angle of incidence is greater than the critical angle(49°) of water.

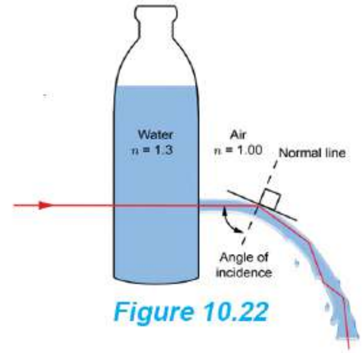


Figure 10.22

Hence, the laser light does not come out of the surface of the water but rather undergoes total internal reflection and returns to water. After that, the reflected ray falls on the opposite surface of the stream.Again, the total internal reflection takes place on that surface and the beam reflects to the water.In this way, the total internal reflection occurs repeatedly in a cyclic manner and the laser light travels downwards with the stream.

(a) Total internal reflection in a prism

As shown in figure 10.23 and figure 10.24, tilt a laser light pointer normally towards different faces of equilateral and isosceles triangular prisms. Observe the condition in which the total internal reflection occurs from the surface of the prisms.

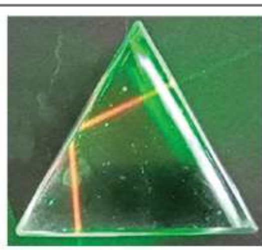


Figure 10.23 Total internal reflections in equilateral triangular prism

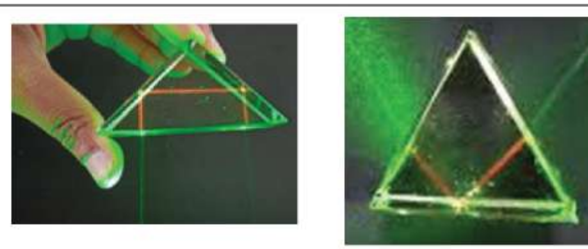


Figure 10.24 Total internal reflections in an isosceles right-angled triangular prism

A prism is a three-dimensional solid object. It is boundedby three rectangular surfaces and two triangular surfaces. The base of an equilateral triangular prism is in the form of an equilateral triangle.

Similarly, the base of the right-angled triangular prism is in the form of a right-angled triangle. As seen in figure 10.25, a ray of light PQ, falling normally on a face of an equilateral triangular prism, passes straight through the glass without deviation. When that ray falls on the face of the prism it makes an angle of 60o with the normal.Here, the ray is travelling from the denser medium (glass) to the rarer medium (air) and the angle of incidence is greater than the critical angle for the glass(42°). Hence, a total internal reflection of light occurs. Then it falls normally on the face BC and emerges in the air.

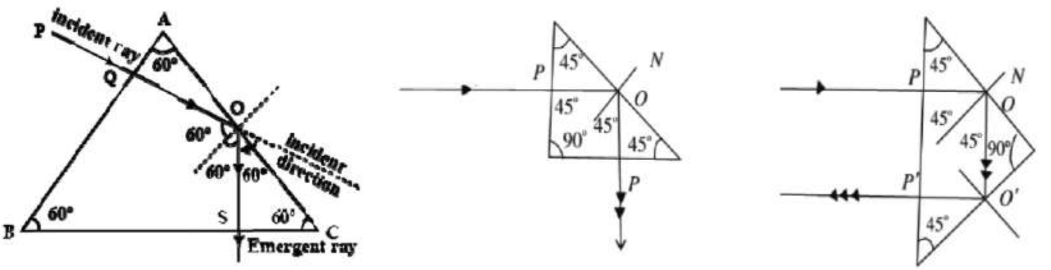


Figure 10.25 Total internal reflection of light in a prism

In Figure 10.25a, as well as in figure 10.25b and figure 10.25c, the light suffers total internal refraction once and twice respectively and finally emerges in the air. Since light can be reflected through 90o in the right-angled triangular prism due to total internal reflection, prismsare used in periscopes, Single Lens Reflector (SLR) cameras and binoculars as shown in figure 10.26.During the total internal reflection of light, the power of the waves is not weakened and the objects can be seen clearly.

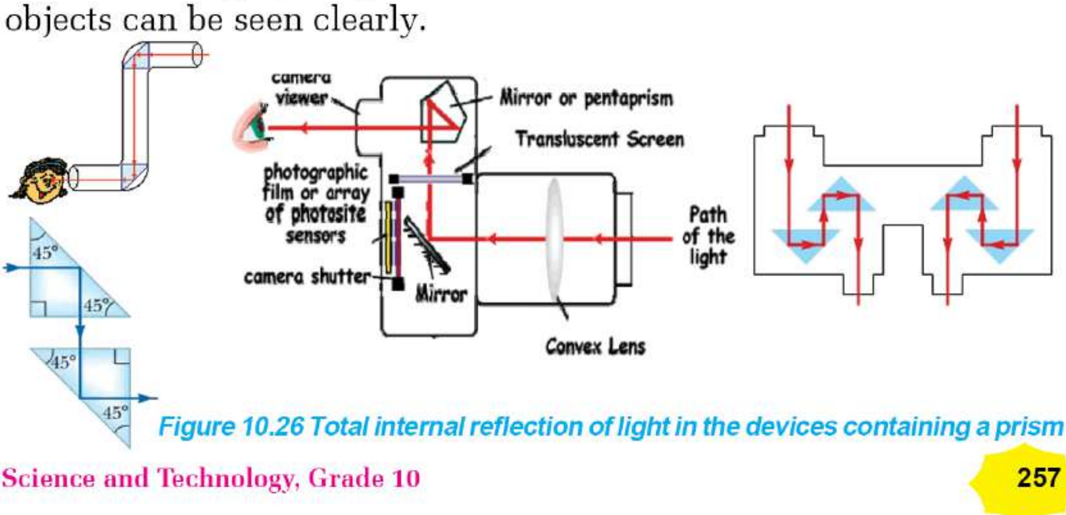


Figure 10.26 Total internal reflection of light in the devices containing a prism

Consequences of total internal reflection of light

a. Sparkling of diamond

Due to the high refractive index of the diamond, its critical angle is small (24°). The angle of incidence at the diamond-air interference easily becomes greater than its critical angle. This results in the total internal reflection of light in the diamond.

The shape of the diamond is determined by the number of its faces. It is cut intovarious faces in such a way that maximum numbers of raysof light that enter the diamond undergo multiple internal reflections. Because of this, the rays of light that aresupposed to pass throughthe diamond experience total internal reflectionand thus the diamond sparkles. If, however, a block of glass is cut with faces like a diamond, this glass will not shine like a diamond because thecritical angle for glass is 42° and most of the rays of light that enter ontheglassisarerefractedand come out fromthe opposite face.

b. Shining of a surface

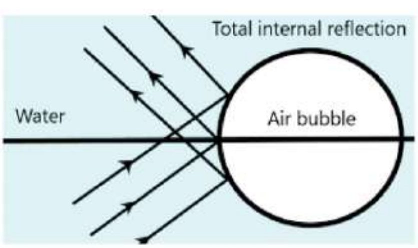


Figure 10.27 An air bubble inside the water

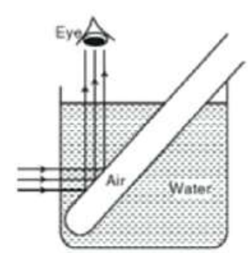


Figure 10.28 Outer wall of a test tube dipped into the water

An object shines due to the reflection of light from its smooth surface. Due to the total internal reflection of light from the water-air interface and glass-air interface, these surfaces appear to be shining.As shown in Figure 10.37, when the light goes from water (denser medium) to air (rarer medium), the angle of incidence at the interface of water-air becomes greater than the critical angleand thus, total internal reflection takes place at the surface of the air bubble formed inside the water. While observing the air bubble from outside, it shines. Also,as shown in figure 10.28, the rays of light going from water (denser medium) to the air (rarer medium) inside an empty test tube,whichis partiallydipped in water and held at an angle,undergoes total internal reflection at the thin wall of the glass testtube. When it is observed from outside the beaker, the immersed part of the tube appears shiny.

c. Mirage

Question: Have you ever seen an illusionof a pool of still water on a pitched road as shown in figure 10.29, while traveling during the summer days?

Figure 10.29 Mirage on pitched road

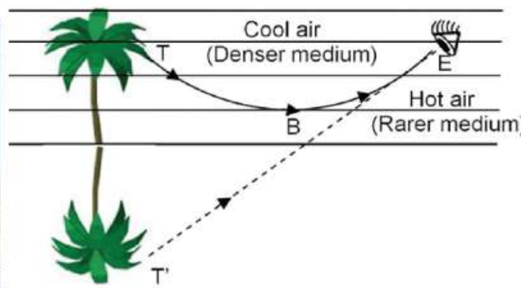


Figure 10.30 Total internal reflections during the formation of mirage

As shown in figure 10.29, while walking on the pitched road on a hot summer day, usually an illusion of a pool of still water is created in front of the observer. When the observer reaches that place, the road is found to be dry. This type of illusion is called a mirage.

Mirage occurs due to the total internal reflection of light. When the surface of the earth gets heated up due to intense sunlight, there is a formation of different layers of air having a different temperature that decreases as we go up. This happens because the layer which is closer to the hot surface becomes hotter than the above one. That is why the refractive index of the upper layer is higher than that of the layer just below it. Thehot layerbehaves like the rarer medium whereas the comparatively colder layer behaves like the denser medium. Hence, the reflected rays from tall objects in the areatravel down from the cold layer (denser medium) tothe hotter layer (rarer medium). When refraction of light occurs continuously at different air layers as it travels from denser to rarer medium, at a certain layer, the angle of incidence becomes greater than the critical angle for that layer.

As a result, the total internal reflection of light occurs. Hence the reflected rays start travelling upwards and finally fall on the observer's eyes. The observer, thus, sees an inverted image of an object on the surface of the road. Since the refractive indices of the layers of air change continuously, the image so formed seems to be flickering on the surface of a pool ofwater.

Considerable question

What effect would be observed, when sound waves undergo refraction as the refraction of light waves occurred during the formation of mirage?

Figure 10.31 Refraction of sound

As shown in figure 10.31a, during the daytime, as the sound waves travel through the upper layer of air, they continuously refract towards the normal at different air layers. Thus,sound waves bend upward and a listener some distance away from the source cannot hear the sound distinctly. Likewise,at night, refraction of the sound waves at various air layers makes the sound waves bend away from the normal (downwards) and at a certain layer;the total internal reflection of sound waves takes place, as shown in figure 10.31b. Due to this, a listener on the ground, even at a distance away from the source, can hear the sound distinctly.

Application of total internal reflection of sound

Optical fibre

Activity 10.7 Observation of the internet cables based on fibre optics

Take a piece of internet wire based on fibre optics. Observe its outer plastic coat andthe inner fibres by gradually removing the plastic coat.

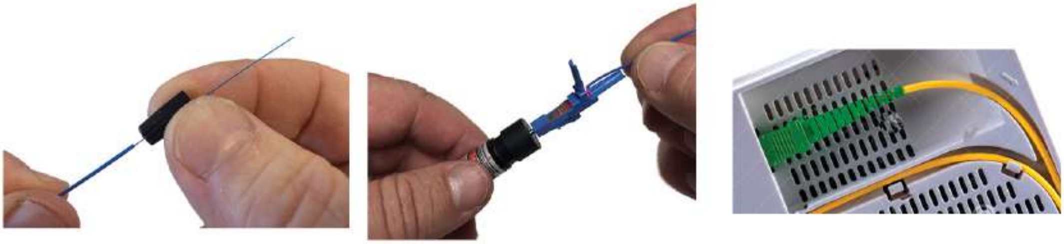


Figure 10.32 Connection of optical fibre connector in a router

For a cabled network internet service, the internet provider brings a cable up to our home. The outer covering of one end of a cable is removed toexpose a thin fibre. Then the fibre is connected to the router using a connecter as shown in Figure 10.32. In the cabled internet system, the optic fibreinside the cable provides fast communication and internet service based on fibre optics. Fibre optics is a technology of transmitting light through a thin and transparent medium like glass. The thin optical medium used for the transmission of light in fibre optics is called optical fibre.

Figure 10.33 Router connector

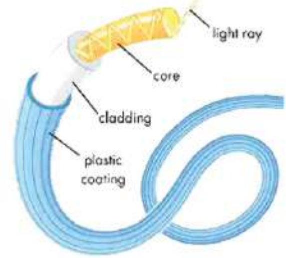


Figure 10.34 Transmission of light through an optical fibre.

As shown in figures 10.33 and 10.34, the inner part of an optical cable has a core that contains a bundle of thin fibers made of transparent material like glass.The core is surrounded by a cladding which is made of material ofa lower refractive than the core creating a suitable environment for total internal reflection in the core. Light is passed through the fibremaking the angle of incidence on the fibre-cladding layer greater than the critical angle. Then as the light travelsin the core without coming out from the cladding, irrespective of the condition of the fibre, be it straight or bent, finally emerges from another end of the fibre.

At first, the optical fibres were used in the medical field to observe the internal part of the body by passing the light into the body.

After that, they are used to transmit communication signals at the speed of light. Nowadays, although optics fibres are used to check up and to makedecorative items and many more, they have been widely used in the communication sector.

a. Use of optical fibres in telecommunication

In communication technology, optical fibres are used for the rapid transmission of signals or data in the form of light waves using the principle of total internal reflection. For this purpose, the communication signal is converted into light and transmitted through optic fibers, which allows for high-speed propagation through total internal reflection. Compared to other methods such as wire and copper cables, a large volume of data can be transmitted very fast and securely over a long distance using optic fibres. For example, data can be transmitted at the rate of 1 Gigabyte per second (1Gbps). An optical fiber can transmit data of thousands of telephone calls simultaneously. The same feature allows people to use optical fiber to receive internet signals and watch high-definition videos, upload and download large files to the internet, and perform other tasks.

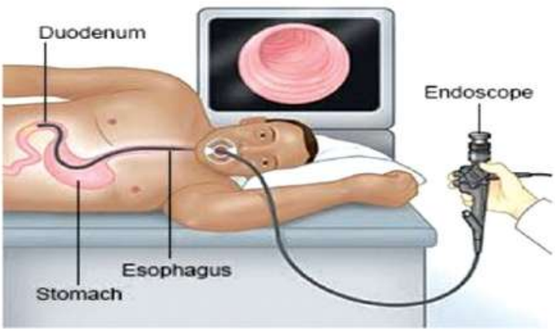
As shown in figure 10.35, fibre cables are bundled and laid on the ground. Optical fibre cables have been laid alongvarious national roads such as the East-West Highway, the Mid-hill Highway, and other roads in our country. These cables are connected to the international network through India and China. Optical fibre cable bundles are also laid not only on the ground but also in the air and under the sea for long-distance communication purposes. An international network of optical fibre has been created using these cables.

b. Use of optical fibres in the medical field

Endoscopy and colonoscopy

Endoscopy is a nonsurgical method for examining the internal organs of the body.

In this technique, an endoscope with an optical fiber and a camera is used to examine the digestive system including the esophagus, stomach, and small intestine. For example, endoscopy can be used to diagnose ulcers in the stomach. To do this, the endoscope is inserted through the patient's mouth and guided to the stomach viathe esophagus.



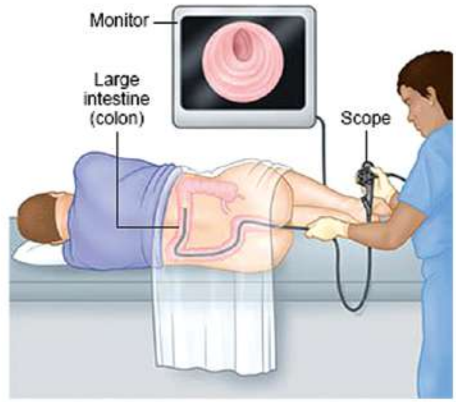


Figure 10.35 Use of endoscopy

Figure 10.36 Use of colonoscopy

In an endoscope, two bundles of optical fibers are kept parallel to each other. One bundle carries light to the internal organs of the body while the other bundle collects the light reflected by the illuminated organs. The shape of the internal organ can be viewed directly or displayed on a video monitor connected to a camera. Colonoscopy is a type of endoscope that is used to examine the colon and large intestine by inserting it through the rectum.

Keyhole surgery

Keyhole surgery is a procedure performed by a surgeon to operate inside the body through a small incision in the skin. The keyhole surgery is also referred to as laparoscopic surgery because the laparoscope is used in this procedure to visualize the shape of the internal organs, is inserted through a small incision. The laparoscope incorporates bundles of optical fibers and a camera to send light inside the body and capture the shape of the internal organs, which is displayed on a monitor. Surgeons performing keyhole surgery also use other surgical instruments along with the laparoscope.

This procedure is used to remove damaged or diseased organs, take tissue samples for examination (biopsy), remove gallstones and kidney stones, etc.

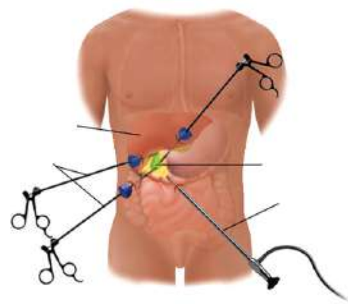


Figure 10.37 Keyhole surgery

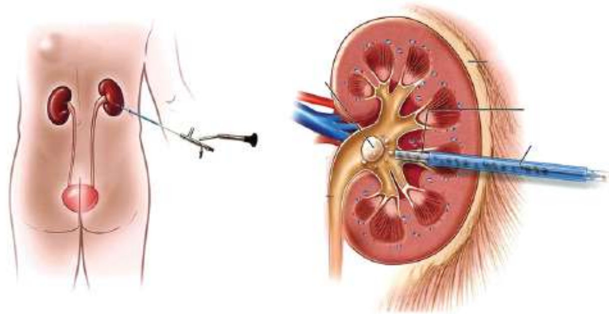


Figure 10.38 Keyhole surgeries to remove the kidney stone

Dispersion of light

Figure 10.39 Color from the burning natural gas

Figure 10.40 Color from the sodium vapour light

In figure 10.39, a blue light source is shown and in figure 10.40, a yellow light source is shown. Even though the sunlight we see every day is a mixture of red, orange, yellow, green, blue, indigo and, violet colours we see it as white, not theindividual colours. These seven colors of sunlight can be separated by passing it through a specific medium.

Dispersion of light through a prism

Activity 10.8 Observation of dispersion of light through a prism

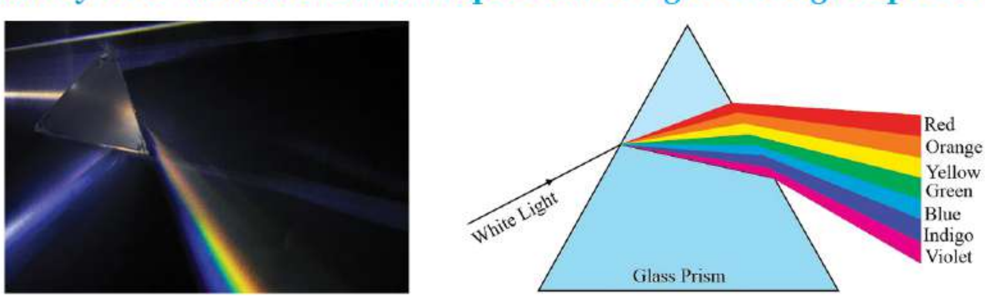


Figure 10.41 Color from the sodium vapour light

Take a ray box and a prism. Send the narrow beam of light from a ray box or the sun light onto the rectangular surface of a prism. Can you project the light passing through the prism onto a wall or a screen as shown in figure 10.41? Now, keep the prism rotating until a band of seven colours is created on the wall or the screen.

The process in which light falling on the surface of a prism or a similarly shaped object splits into seven colours [i.e.,red, orange, yellow, green, blue, indigo, and violet respectively] while passing through the object is known as the dispersion of light. The waves of these seven colors have different wavelengths. Their values are presented in the table below.

Color of light	**Limit of wavelength(in meters)**
Red	From 6.2×10^{-7} to 7.8×10^{-7}
Orange	From 5.9×10^{-7} to 6.2×10^{-7}
Yellow	From 5.8×10^{-7} to 5.9×10^{-7}
Green	From 5.0×10^{-7} to 5.8×10^{-7}
Blue	From 4.6×10^{-7} to 5.0×10^{-7}
Indigo	From 4.4×10^{-7} to 4.6×10^{-7}
Violet	From 3.8×10^{-7} to 4.4×10^{-7}

The band of the seven colors with the decreasing order of their wavelengths given above is called the visible spectrum. The seven colors of the visible spectrum can be remembered as "VIBGYOR".

Cause of dispersion of light

The speed of all electromagnetic waves is same in vacuum but it is different in different media. The speed of a wave in a given medium depends on its wavelength. The speed of different colors in the visible spectrum is different. The light wave with the longest wavelength in the visible spectrum is red light. Its speed is comparatively more than that of waves of other colors in the visible spectrum. The speed and the wavelength of violet are the least among these seven colors.

As shown in figure 10.41, when light rays enter a prism and exit from it, two refractions occur. As a result, the light rays of different velocities that have separated inside the prism exit it by bending toward the base and falling on the screen at different places. In this process, red light rays having the longest wavelength and the fastestspeed deviate the least and are thus seen at the upper portion of the screen. In contrast, violet rays with the shortest wavelength andthe least speed deviate more than others and fall on the lower part of the screen.

Light as a group of seven colours

Activity 10.9 Newton's disc

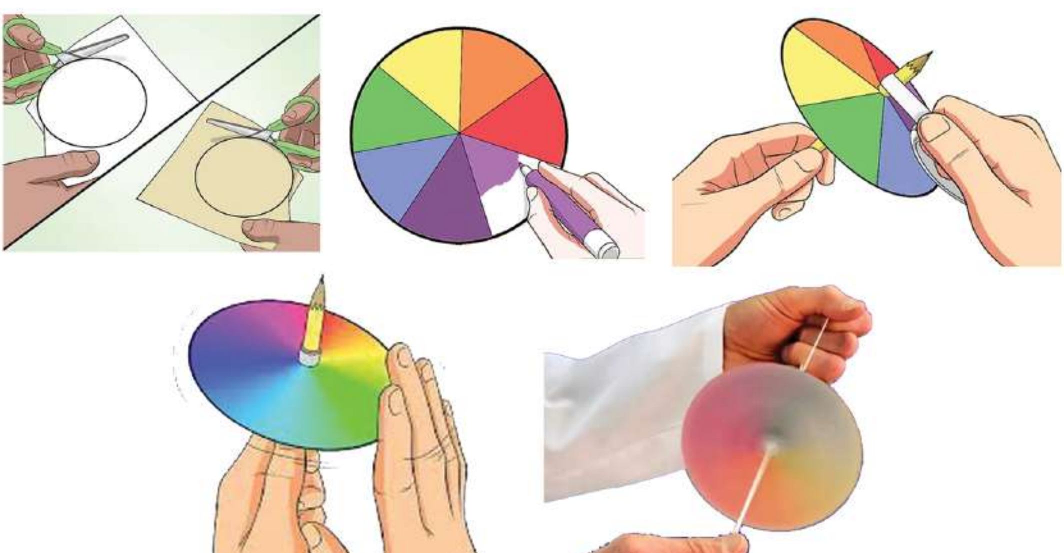
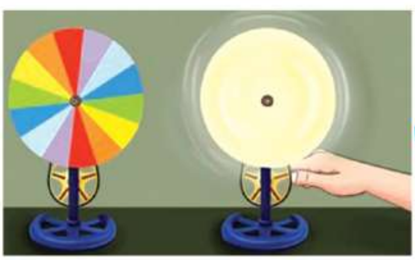


Figure 10.42 Making Newton's disc

Takea cardboard, printing paper, seven colours found in the visible spectrum, scissors, a pencil, a pair of compasses, and a piece of strong thread (about 60 cm long). Paste the printing paper on the cardboard and cut it in the shape of a circle with the help of a compass, pencil, and a pair of scissors. Divide the circle into seven equal parts on the printing paper of the circle.Now paint the parts with the colours in the order VIBGYOR. This is the model of Newton's disc. Now, make two thin holes near the centre such that the centre lies in between the holes. Insert the two ends of the thread through the holes separately and then tie the ends that come out from the holes. Hold the strings with one hand and use the other to spin the wheel quickly. When the wheel spins fast enough, pull both strings outwards, and then back towards each other. By doing this, the strings wind and unwind, causing the wheel to spin fast. As the wheel spins, observe the seven colors of the rainbow that are painted on its surface. Will the colors of the rainbow combine and disappear to form a white colour?



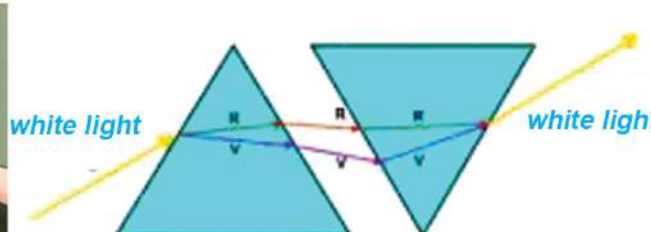


Figure 10.43 Newton's disc *Figure 10.44 Recombination of seven colours of light.*

A disc made by painting seven constituent colours of light in proportion on it is called Newton's disc. As shown in Figure 10.43, on spinning the disc at high speed, the seven colours mix and the disc appears white.

In figure 10.44, two identical prisms are shown with one prism placed upside down near the other. The seven colors of light rays separated by the first prism are recombined by the second prism as they pass through it. The ray emerging out from the second prism becomes parallel to the direction of the light entering from the first prism.

Rainbow

A rainbow is a circular colourful arc that appears in the sky when the sun lies behind water droplets present in the air. A rainbow is formed due to the dispersion of light by the water droplets that are suspended in the air. In this process, water droplets play a role similar to that of a prism.

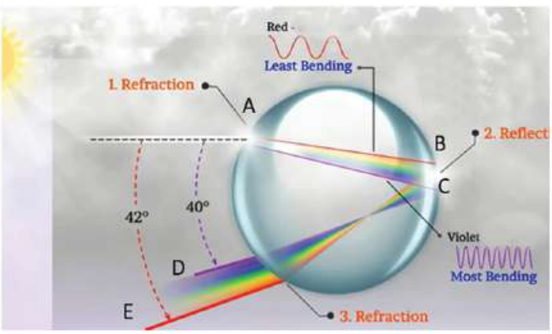


Figure 10.45 Dispersion of light through a water droplet

Figure 10.46 The circular rainbow observed from the sky

In figure 10.45, the ray of light from the sun strikes the point A on the surface of the spherical water droplet and then enters it. Because of refraction, the light rays get separated into seven colors inside the droplet. Then, the seven colours of light in the droplet are totally internally reflected by the opposite surface of the droplet. In the figure, the red light, which is deviated the least, is reflected from point B, while the violet light, which is deviated the most, is shown to be reflected from point C. Finally, the light rays come out of the droplet and form a rainbow. The rainbow appears to be semicircular while observed from the ground but can be seen as a circle from the sky.

Lens

A pair of spectacles is shown in figure 10.47. The glasses used in it have spherical surfaces.

Figure 10.47

The shape of glass or plastic used in a hand lens also has a spherical surface. The refraction of light that occurs through such types of surfaces causes light rays to converge at a single point or diverge from a single point.

Activity 10.10 Making a hand lens

Figure 10.48 Making a hand lens

As shown in figure 10.48, take a plastic bottle, scissors, a hot glue gun, a syringe, and water. Cut the plastic bottle into circular pieces. Overlap the two pieces in such a way that the raised portions lie outside, and stick them together with a hot glue gun. Then fill it with water with the help of a syringe. Can you use the resulting lens to read small letters in a book or magnify small objects?

By filling water between the two circular surfaces made of plastic, a lens is created. That lens refracts light rays. When light passes through this lens, objects appear larger than they are. The lens and the spherical mirror have some similar properties. In figure 10.10, a convex lens and a concave mirror are shown being made from a spherical glass ball. Similarly, by filling water between the two circular surfaces, a sample lens is formed in the above activity. Even when water is poured into one of the circular pieces of the bottle, it will refract light like a lens. The resulting lens, shown in figure 10.50, appears to have been made from two solid spherical portions. Therefore, a lens is a transparent medium that has at least one spherical surface.

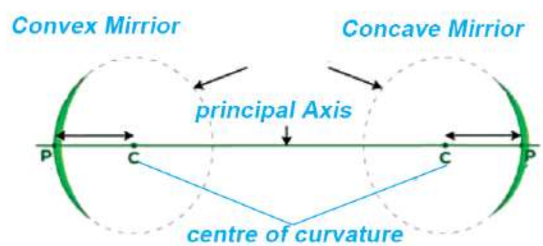


Figure 10.49 Circular mirrors

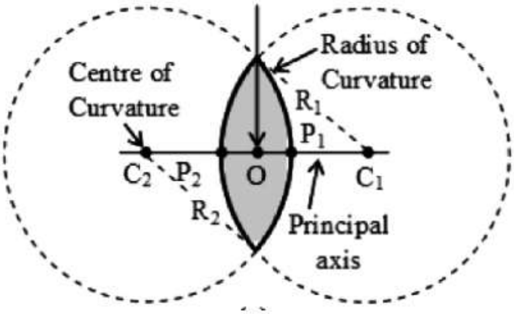


Figure 10.50 Convex lens

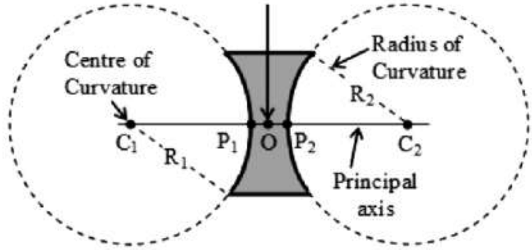


Figure 10.51 Concave lens

Types of lenses

Mainly there are two types of lenses. They are convex lens and concave lens. As shown in figure 10.50, the lens which is thicker at the middle part than that at the edges is a convex lens. Since convex lens can converge the light rays, it is also known as a converging lens. Convex lenses are used in devices such as spectacles, cameras, microscopes, projectors, etc. Natural convex lenses also exist in our eyes.

As shown in figure 10.51, the lens which is thinner in the middle part than that at the edges is concave lens. The concave lens is known as a diverging lens because of its ability to diverge light rays.

					
a.biconvex	b. planoconvex	c concavo convex	a.biconcave	b. plano concave	c.convexo concave)
Figure 10.52 Converging lenses			Figure 10.53 Diverging lenses		

Terminologies related with lens

a. centre of curvature

The center of curvature is the center of the sphere that forms the curved part of the lens. Since most lenses are formed from two spherical curved surfaces, they will have two centers of curvature, usually labeled C_1 and C_2.

b. Radius of curvature

The radius of curvature is the distance from the center of curvature to the surface of the lens. In a ray diagram, it is denoted by R.

c. Optical center

The optical center is the geometrical center of the lens, where the principal axis intersects the lens surface. In a ray diagram, it is denoted by O.

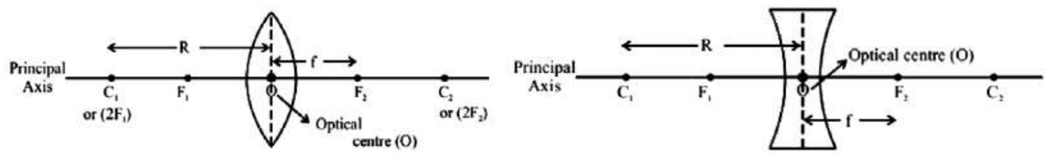


Figure 10.54 Terminologies related to lens

d. Principal axis

The principal axis is the line passing through the optical center and the two centers of curvature of the lens. It divides the lens into two symmetric halves.

e. Principal focus

Activity 10.11 Converging action in convex lens and diverging action in concave lens

Take a ray box with three slits, and thick convex and concave lenses. As shown in figure 10.55, place the convex lens and concave lens in front of the box in turn.

a. b.

figure 10.55 observing and diversing process

Observe how the rays coming out of the ray box are bent and measure the distances mentioned below.

Convex lens	**Distance between the midpoint of the lens and the point where light rays conversed**	....
Concave lens	Distance between the midpoint of the lens and the point where light rays diverged	....

A convex lens can be considered as a combination of prisms. As shown in figure 10.56, on the upper half of the convex lens, the bases of the prisms face downwards and on the lower half, the bases of the prisms face upwards. The emergent rays from the prism are always bent towards the base. The prisms in the center of the lens refract the light more than those on the edges and the rays passing through the principal axis passes in a straight line without any deviation. As a result of this, rays that are travelling parallel to the principal axis converge at a point on the principal axis after passing through the lens as shown in figure 10.57. That point is known as the principal focus of the convex lens and is denoted by F in the diagram.

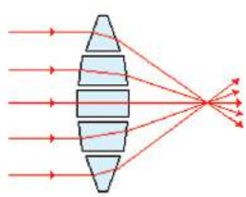


Figure 10.56 Converging process in a convex lens

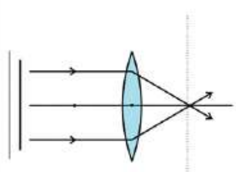


Figure 10.57 Focal length of a convex lens

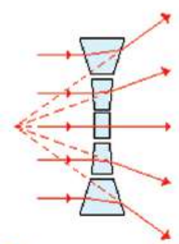


Figure 10.58 Diverging process in concave lens

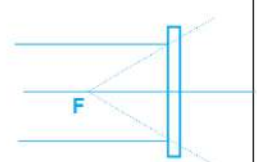


Figure 10.59 Focal length of a concave lens

A concave lens can also be considered as a combination of prisms. As shown in figure 10.58, on the upper half of this lens, the bases of the prisms face upwards and on the lower half of the lens the bases of the prism face downwards. Like in a convex lens, the rays of light are refracted towards the base of the prism and the center portion refracts more than the edges. This makes the rays travelling parallel to the principal axis diverge after passing through the lens. The rays travelling along the principal axis do not deviate. As a result of this, the diverged rays from a concave lens do not intersect each other but appear to diverge from a point as shown in figure 10.56. Thus, the point from where the light appears to diverge is called the principal focus of the concave lens. The principal focus is the point on the principal axis from where the light rays travelling parallel to the principal axis converge or appear to converge after passing through the lens.

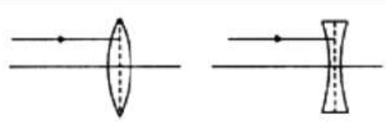
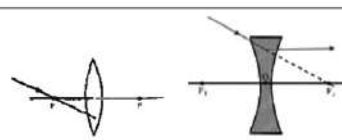
focal length

The focal length is the distance from the optical center O of the lens to its focus F. It is denoted by f. The radius of curvature is twice its focal length.

Rules to draw image formed by a convex lens

Activity 10.11

Take a convex and a concave lens whose focal lengths were determined in activities 10.11. Pass a laser beam through each of the lenses as shown in the ray diagrams below and observe the results.

The direction of a laser beam	Ray diagram	Result (direction of emergent beam)
Through the optical centre O		....
Parallel to the principal axis		....
Through focus F		....

The ray diagrams of images formed by lenses depend on their shape. When light rays are converged by a convex lens and diverged by a concave lens, the following rules apply while drawing the ray diagrams:

(a) Light rays passing through the optical center of the lens do not bend. They continue to move forward in a straight line.

(b) light rays travelling parallel to the principal axis converge and pass through the focus. When the same rays pass through a concave lens, they appear to diverge from the focus.

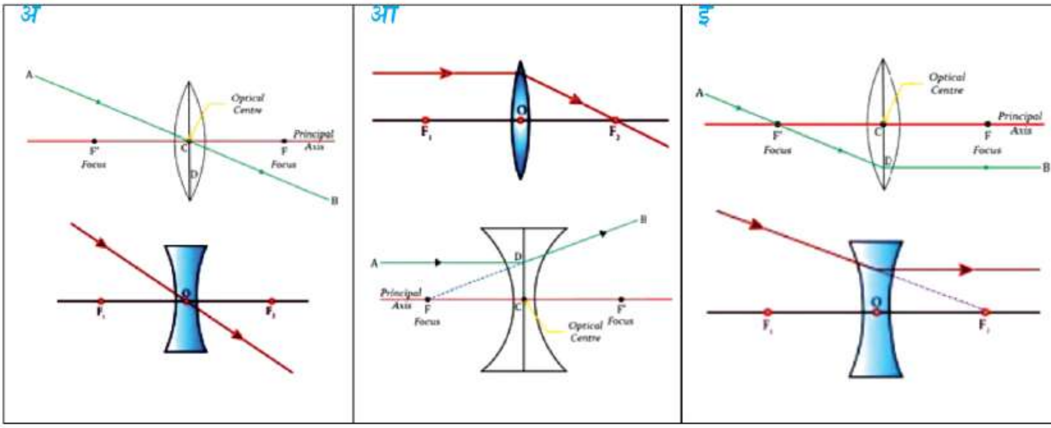


Figure 10.60 Rules to draw a ray diagram

(c) Light rays that pass through the focus of a lens emerge parallel to the principal axis after the refraction in the lens.

The image formed by a convex lens

Activity 10.13 Observation of the image of a candle formed by a convex lens

Take a convex lens whose focal length was measured in activity 10.11, a small screen prepared by pasting cardboard on a rectangular piece of wood, a candle, a one-meter scale or measuring tape. As shown in figure 10.61, lay the scale or tape on the table. Stand the lens somewhere in the middle of the ruler such that at least a 2f (f = focal length) distance is left on either side of it. Now, place a candle at one side of the lens at various positions. For each position of the candle, put the screen on the opposite side and move it forward and backward until a clear image of the candle is formed on the screen and observe the characteristics of the image. The characteristics of the image formed by a convex lens depend on the position of the object relative to the optical center O. The images formed by placing an object at different positions in front of the convex lens are shown in the diagram and their characteristics are presented in the table.

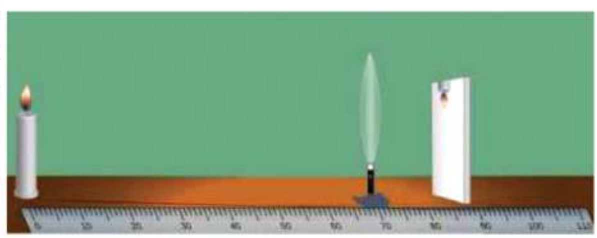
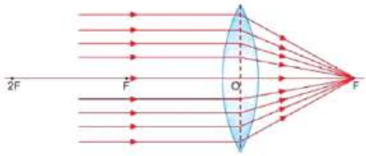
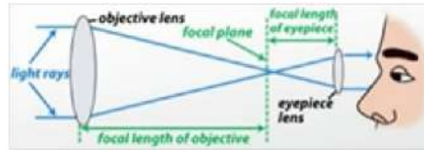
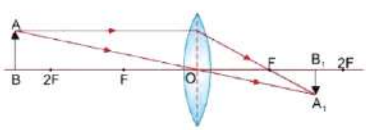
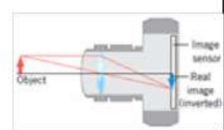
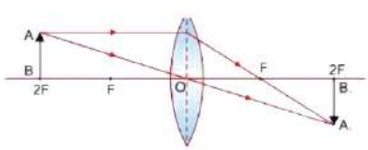
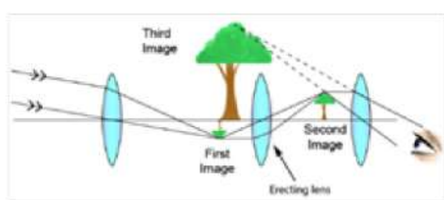


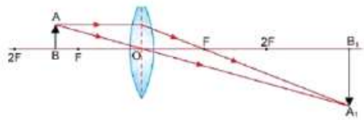
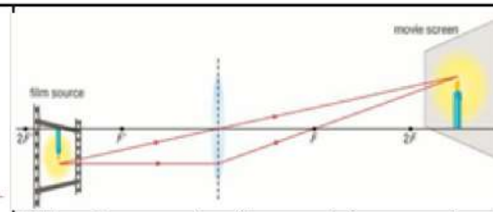
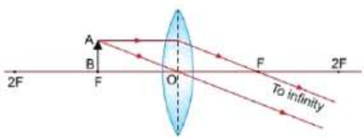
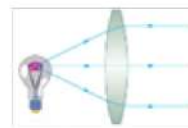
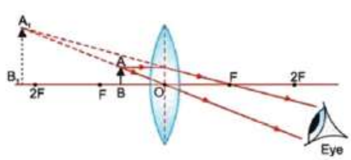
Figure 10.60 image formed by convex lens

<table>
<tr><th>Position of the object</th><th>Ray diagram</th><th>Position, characteristics and use of image</th></tr>
<tr><td rowspan="2">At infinity</td><td rowspan="2">

</td><td>

The image is formed at F. It is real, inverted and highly diminished. The objective lens of a telescope forms this type of image.</td></tr>
<tr><td>In the picture at the side, the parallel rays of sunlight are converged by a hand lens. If the lens is kept stationary for some time, a piece of paper can be burnt as the lens converges the radiation from the sun.</td></tr>
<tr><td>Beyond 2F</td><td>
</td><td>The image is formed between F and 2F. The image is real, inverted and diminished. This type of image is formed by a camera.

</td></tr>
<tr><td>At 2F</td><td>
</td><td>

The image is formed at 2F which is real, inverted and it is of the same size as the object. This type of image is formed by erecting the lens of a terrestrial telescope.</td></tr>
</table>

Between F and 2F		 The image is formed beyond 2F which is real, magnified and inverted. This type of image is formed by a projector.
At F		The image is formed at infinity and it is real, inverted and highly magnified. It is applicable in a flashlight to project the light over a long distance. 
Between F and O		The image is formed on the same side of the object and it is virtual, erect and magnified. It is applicable in hand lenses to enlarge the image.

During the formation of the image, as the object is kept closer to the convex lens, the size of the image gradually increases and vice versa is also true.

Image formed by a concave lens

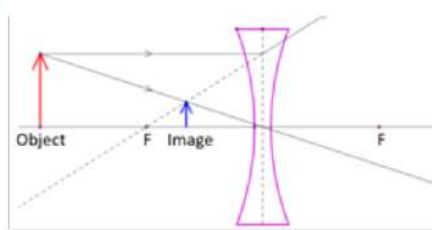


Figure 10.62

Light rays passing through a concave lens move away from the principal axis after the refraction and never intersect each other physically. As shown in figure 10.62, if the refracted rays are produced in the backward direction, they cut at a point forming a virtual image. Thus, the image of an object at any point in front of a concave lens becomes virtual, erect and diminished. This type of image is formed by the lens used in peephole of a door.

Power of a lens

As in activities 10.14 and 10.11, take a ray box with three slits and three concave and convex lenses having different thicknesses. Then perform the following activities.

a. Allow the light rays from the ray box to fall on the lenses of your friend's or relative's spectacles and then observe their converging and diverging capacities. Then after, ask whether the power of the lens is -4 dioptre (D) or +2 dioptre (D), and so on, to the owner of the respective spectacles. Here, the lenses having positive power are convex lenses whereas those having negative power are concave lenses. The power of a lens is measured in dioptre. Compare the degree of refraction and thickness of two or more lenses. One possible observation is given in the table below.

Order of thickness of the lens	Diverging capacity	Power of the lens used in spectacles
Thickest lens	Having the highest diverging capacity	+4D
....	....	....

Conclusions: : ....

b. Arrange the collected lenses in ascending order of their thicknesses. Measure their focal lengths as in activity 10.11.

c. While measuring the focal length, the distance between the lens and the focus formed by the intersection of real rays is taken as a positive focal length. Similarly, in the case of a concave lens, the refracted rays do not intersect but if they are extended backward in the side of the incident rays then they appear to intersect at a point which is called apparent focus. The distance between this apparent focus and the lens is the focal length and it is taken as negative. Using these distances, the power of lenses can be calculated by using the formula given in the table below.

For convex lens

Order of thickness of the lens	Focal length	Power $P = \frac{1}{f\,(\text{in metre})}$	Result (relation between focal length and refracting capacity)
Thinnest	$+40\text{cm} = +\frac{40}{100}\text{m} = +0.4\text{m}$	$\frac{1}{(+0.4\text{ m})} = +2.5\text{ D}$	....
....	....	....	
Thickest	....	....	

When light rays refract through a lens, the degree of refraction is more in a lens with large curvature, i.e., thick lens than the lens with small curvature, i.e., thin lens. The ability of a lens to converge or diverge the light rays is called the power of that lens.

If a convex lens with greater curvature and thickness converges parallel light rays closer to its optical center (O) then its focal length is shorter, but its ability to converge light rays is higher. Similarly, a concave lens of shorter focal length also has a higher ability to diverge the light rays. Therefore, the power of a lens depends on its focal length (f). Mathematically, the power of a lens is defined as the reciprocal

of its focal length in meters, i.e., lens power $$P = \frac{1}{f\,(\text{in metre})}$$

The SI unit of power is diopter. It is indicated by D. The power of a convex lens with a positive focal length is also positive. Likewise, the power of a concave lens with a negative focal length is negative.

The curvature of glass lenses remains constant. It does not change on its own. However, the curvature of the convex lens in our eye can be changed when we observe distant objects or nearby objects, resulting in a change in its power.

Human Eye

The optical instrument that forms the images of objects naturally by refracting the light through a convex lens is the human eye. As shown in figure 10.63, the aqueous humor and vitreous humor inside the eye give it a spherical shape. Important parts of the human eye are described below.

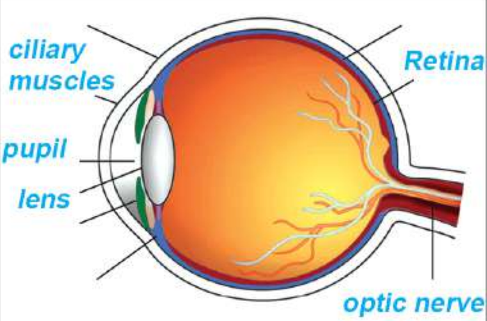


Figure 10.63 Parts of an eye

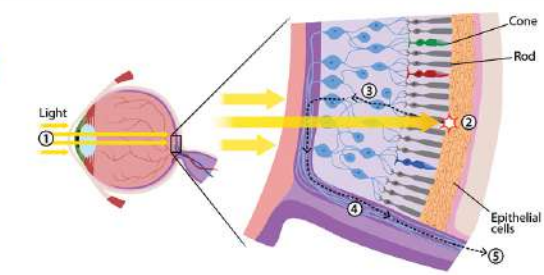


Figure 10.64 Rod and cone cells of the retina

(a) Cornea

Cornea is a transparent layer in front of the eye that allows light to enter. It helps to focus light on the retina. In the process of light rays coming from objects reaching the retina by passing through the air, cornea, aqueous humor, lens and vitreous humor, the cornea bends (refracts) the light more than any other parts of the eye. Thus, the cornea acts like the main lens in the eye.

(b) Pupil

The pupil is the dark hole in the middle of the eye through which light enters. Its size changes according to the brightness of the light. The colour layer of the muscles around the pupil, i.e., the iris, changes the size of the pupil. In bright light, the muscles in the iris relax and the pupil becomes smaller, while in dim light, the muscles in the iris contract and the pupil becomes wider. Thus, the controlled amount of light enters the eye even at places where the light is very bright or dim.

(c) Eye lens

The convex lens of the human eye is a transparent part made of a natural protein called crystalline. The rays of light refracted from the cornea are refracted further in the lens to converge onto the retina.

(d) Ciliary Muscles

Ciliary muscles are the flexible muscles that change the thickness of the eye lens. The ciliary muscles attached to the lens ensure that light rays converge onto the retina. During the relaxation and contraction of ciliary muscles, the curvature of the lens and its focal length change.

(e) Retina

The retina is a layer of light-sensitive cells located at the back of the eye that can detect the color and brightness of light. When the rays of light are focused onto the retina, an image of the object is formed. Retina has two types of cells - rod cells and cone cells. Cone cells help to detect and identify colours while rod cells convert the light into electrical signals and help determine the brightness of the light.

(f) Optic Nerve

The optic nerve is a bundle of nerve cells in the retina that transmit information about the image to the brain in the form of electrical signals.

Although an inverted image is formed by the convex lens on the retina, our brain inverts it and we see the objects right way.

With the complex structure of the human eye and the functions of its different parts mentioned above, the formation of an image is possible. To form a clear image on the retina, the light rays must always be refracted and focused exactly on the retina whether the rays come from a nearby object or a distant object.

Accommodation of eye

Considerable question

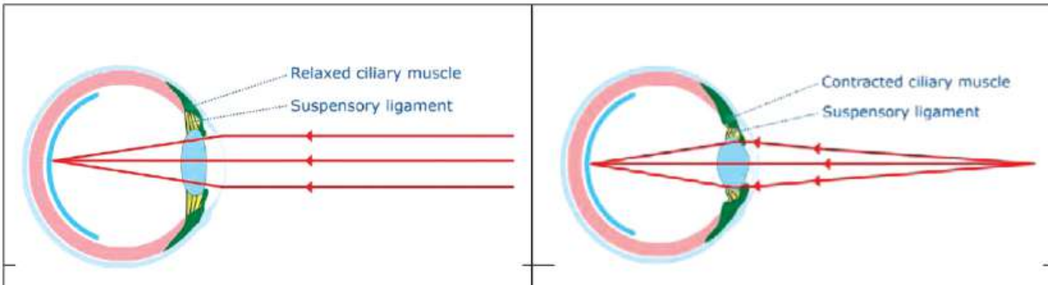
Compare the change in distance of an object when you move your eyes from the letters on the textbook in your hand to the distant object outside the window, such as clouds in the sky. Also, compare the distance between the lens and the retina (the image distance) in these two cases.

(a) During the process of forming an image by a convex lens, the image distance changes with the change in object distance. Is this process possible for the eye lens too?

(b) In the situation where the image distance of the eye lens remains constant, how should the curvature of the lens change so that it focuses the rays of light from nearby objects as well as from the distant object exactly on the retina?

The object distance becomes shorter on looking the letters in a book that is taken in our hand, while looking at the clouds in the sky, the object distance becomes longer. Since the images of objects at various distances are all formed on the retina, the image distance or the distance between the lens and the retina remains constant. In such a situation, to form a clear image, the curvature of the lens must change, making the rays of light converge more or less. For this, the ciliary muscle of the eye can increase or decrease the thickness of the lens.

As shown in figure10.56, when we look at a distant object, the ciliary muscles relax. In this situation, the lens becomes thin, i.e., its curvature decreases and the focal length increases. As a result, the incoming rays from the distant objects are focused on the retina and we can see the objects clearly. In the same way, while looking at a nearby object, the ciliary muscles contract. In this condition, the curvature of the lens increases, the lens becomes thicker and the focal length decreases. As a result, the incoming rays from the nearby object are refracted more strongly and focused on the retina. This process of adjusting the focal length of the eye lens according to the distance of the object from the eye by the process of relaxation and contraction of the ciliary muscles is called accommodation of the eye.



a (Far point of eye) lens refraction   b (near point of eye)

Figure 10.65 Accommodation of the eye

Far point and near point of human eye

The far point is the farthest distance from the eye at which it can see objects clearly. For a normal eye, this point is at infinity. As shown in figure 10.65 a, on looking at a distant object, the lens of the eye becomes the thinnest and it has maximum focal length. Similarly, as shown in figure 10.65b, on shifting the object to a certain distance from the eye, the ciliary muscles attain their maximum possible contraction. If the object is shifted even closer, the ciliary muscles cannot contract any further and hence the image on the retina cannot be clear.

The nearest distance from the eye at which it can see objects clearly is called the near point of the eye. For a normal eye, the near point is at a distance of 25 cm from the eye. This distance is also referred to as the least distance of distinct vision. While looking at an object at the near point, the eye lens has the maximum curvature i.e., it becomes the thickest and has the shortest focal length.

The near point of the eye can vary depending on the person's age and the condition of the eye. For a person with no visual defect, the range of human vision is from 25 cm to infinity (∞). For individuals with visual defects, the near point and far point of the eye differ from those with normal vision.

Defects of vision

If the letters appear blurry when a book is kept at a normal distance from the eyes, the book has to be brought closer or further away until the letters become clear. As shown in figure 10.66, to see a nearby or distant object clearly, the light rays from the object must be focused on the retina forming a clear image. Otherwise, the object will appear blurry. For humans, the phenomenon where nearby or distant objects appear blurry, i.e., not forming clear images of these objects on the retina, is called a defect of vision.

Types of defects of vision

There are two types of defects of vision in human eyes. They are shortsightedness (myopia) and longsightedness (hypermetropia).

Shortsightedness or myopia

For those suffering from shortsightedness, images of distant objects appear blurry, as shown in figures 10.66a and 10.66b, because the rays of light coming from those objects are focused in front of the retina. However, for closer objects, the retina creates a clear image. The problem, in which one sees nearby objects clearly but not distant objects, is called shortsightedness. This problem occurs primarily for two reasons.

(a) In some people, the eyeball gets elongated, and the distance between the lens and the retina increases. As a result, the parallel rays coming from distant objects are focused in front of the retina.

(b) When looking at distant objects, if the ciliary muscles do not contract enough, then the lens cannot be thin enough. As a result, the focal length of the lens becomes less than required and the parallel rays of light coming from distant objects are focused in front of the retina. Sometimes, not only the curvature of the lens but also the curvature of the cornea causes myopia. As shown in figure 10.75c, for myopic eyes, the far point is not at infinity but at some finite distance from the eye.

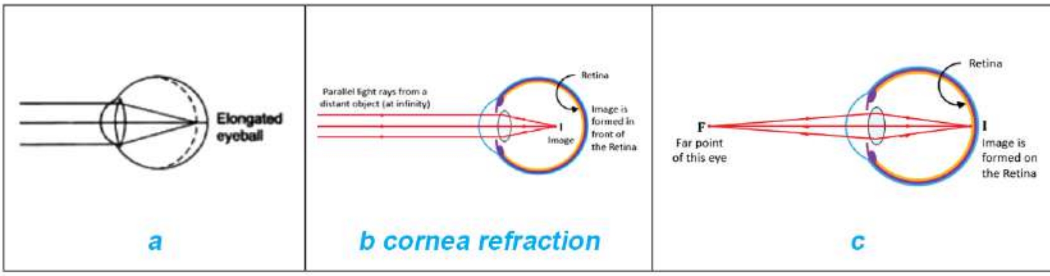


Figure 10.66 Causes of shortsightedness

Correction of shortsightedness

For an eye with the problem of shortsightedness, if the parallel rays coming from distant objects are diverged to some extent before entering the eyes, the problem could be solved. For this, a diverging lens, i.e., concave lens, of suitable focal length is to be kept in front of the eye as shown in figure 10.67. As a result, the incoming parallel rays of light from the distant object get diverged by that lens before entering the eye. After refracting these diverged rays through the cornea and the lens of the eye, they get focused on the retina and the object appears clear.

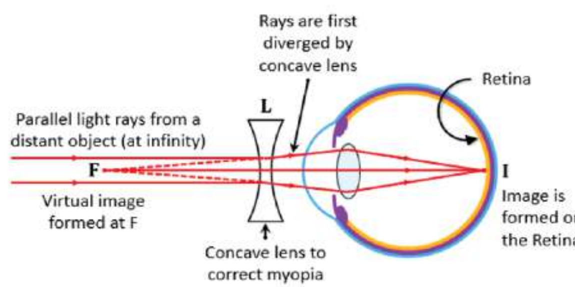


Figure 6.67 Correction of shortsightedness

The focal length of the lens used in the spectacles to correct the defect is selected in such a way that rays diverged by the lens get focused exactly on the retina and the rays from distant objects appear to be coming from the far point F of the defective eye.

Long-sightedness or Hypermetropia

For the eyes with a problem of longsightedness, as shown in figures 10.68a and 10.68b, objects close to them appear blurry because the light rays coming from nearby objects are focused behind the retina. But, for the distant object, a clear image is formed on the retina. The problem, in which one sees distant objects clearly but the nearby objects appear blurry, is called long-sightedness. This problem occurs primarily for two reasons.

(a) In some individuals, the eyeball becomes too circular and hence the distance between the lens and the retina decreases. This causes light rays from nearby objects to be focused behind the retina.

(b) While looking at nearby objects, if the ciliary muscles in the eye cannot contract enough, the lens cannot be made thick enough. This causes an increase in focal length and the light rays from nearby objects get focused behind the retina. As shown in Figure 10.68c, for those with long-sightedness, the near point is not at 25cm from the eye but beyond. Usually, this problem is seen in old age.

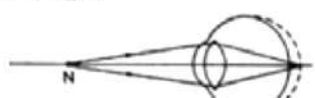


Figure: 68 a

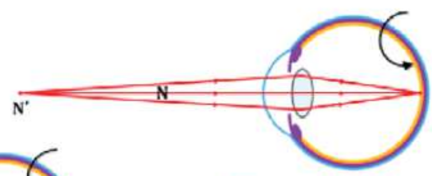


Figure 10.68 c

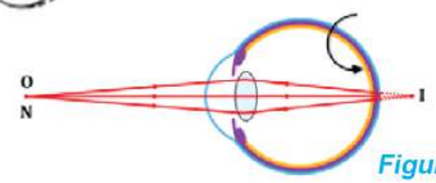


Figure 10.68 b

Figure: 10.68 Cause of long-sightedness

Correction of longsightedness

For eyes with longsightedness, the problem can be solved if the light rays coming from the nearby object are converged to some extent before they enter the eyes. For this purpose, a converging lens, i.e., convex lens, should be placed in front of the eye, as shown in figure 10.69, so that, the rays

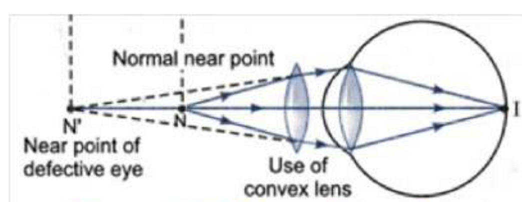


Figure: 10.69 Correction of longsightedness from nearby objects get converged to some extent by the lens before entering the eye. When those rays refract through the cornea and the eye lens, they get focused on the retina and the nearby objects start to be seen clearly.

The focal length of the convex lens used in the spectacles for the correction of long-sightedness is selected in such a way that the rays converged by the lens get focused on the retina and they appear to come from the near point N of the eye suffering from longsightedness.

Other ways for correction of defect of vision apart from using spectacles

(a) Contact lens

As shown in figure 10.70, a contact lens is a thin artificial lens worn on the surface of the cornea to correct defects of vision. It sits above the thin film of tears on the cornea and covers the iris and pupil of the eye. This refracts the light rays by just the necessary amount before reaching the eye lens. Contact lenses are useful in situations where one does not want to use glasses, for example, while playing sports contact lenses with powerless sunglasses are to be used.

Figure 10.70 Contact lens

The use of glasses and the use of contact lenses have their distinct advantages and disadvantages. Glasses are very easy to use. The lenses used in it are of high quality and available in different sizes. However, spectacles with high-power lenses are thick and the peripheral vision is distorted while looking right and left through it. But this problem does not occur in the case of contact lenses because they move along with the cornea. Since contact lenses are very closer to the eyes, contact lenses with low power can be used instead of thick glass lenses.

Contact lenses require more careful handling than spectacles. They are to be stored and cleaned in specific ways. Contact lenses are to be cleaned and disinfected before they are reused. To prevent infection, one should always wash his/her hands before wearing contact lenses and before removing them. One should not sleep overnight with contact lenses. The improper use of contact lenses can affect the cornea.

b. Laser eye surgery

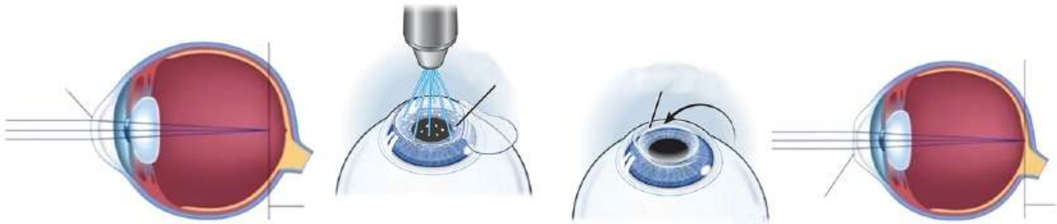


Figure: Before the correction of short sightedness *Figure:Laser beam focused on the cornea* *Figure: After the correction of short sightedness*

Figure 10.71 Laser surgery of the eye to correct shortsightedness

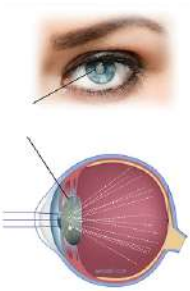
Figure 10.71 shows the cornea of a shortsighted eye being flattened a bit by focusing a laser beam on the central part of the cornea. Hence, the rays of light through the cornea are refracted a little less than before and the myopia problem gets solved. On the contrary, if the laser beam is focused on the edges of the cornea, the middle part of the cornea gets raised a little, and the problem of long-sightedness gets solved. In this way, the process of correcting defects of vision by reshaping the cornea using a special type of ultraviolet laser, i.e., excimer laser, is called laser eye surgery.

Laser eye surgery is performed on the outermost part of the cornea. LASIK (Laser-assisted in situ keratomileusis) is themost popular technique among different laser eye surgery techniques. In this, the laser beam focused on the cornea cuts out a flap. The cutout flap is flipped to reshape the cornea.

Other problems related to the eye, apart from defects of vision

(a) Cataract

As the age of people increases, the crystalline proteins of the lens stick together and the lens becomes cloudy. Thus, the rays coming from the objects do not reach the retina properly and the objects appear blurry. As the opacity of the lens increases, the transparent quality of the lens gets lost and finally complete blindness occurs. A gray-coloured spot appearing in the pupil of the eye due to the cloudiness of the lens is called a cataract. Cataracts are mostly seen in elderly people.



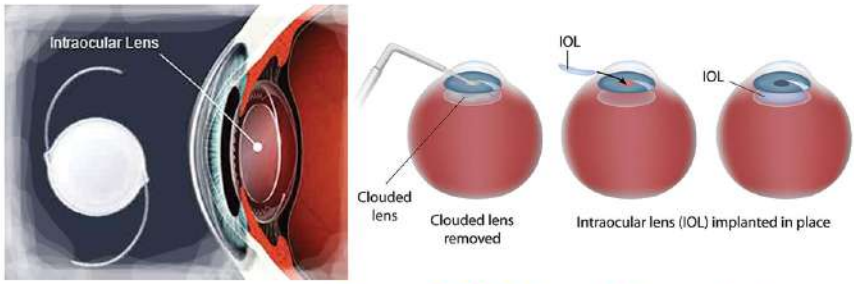


Figure 10.72 Cataract

Figure 10.73 Cataract intraocular lenses

In some people, exposure to ultraviolet radiation from the sun, cigarette smoking habits, high diabetes, etc. increase the possibility of cataractbefore reaching old age. Cataracts are treated with surgery.

For cataract surgery, a fine hole is made on the edge of the cornea. The cloudy lens is broken into small pieces by sending an ultrasound through the hole and the pieces are taken out with the help of a vacuum tube. In its place, an intraocular lens made of silicone or acrylic is kept.

Figure 10.74 Dr. Ruit

Nepali Ophthalmologist Dr. Sanduk Ruit developed a very cheap intraocular lens in 1995 and made cataract treatment cheap.

(b) Colour Blindness

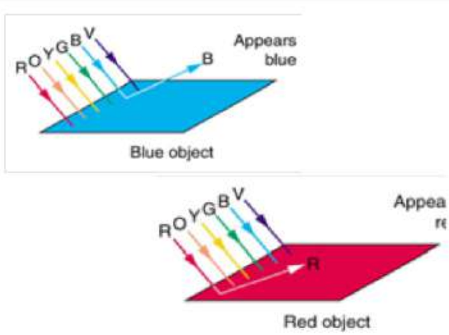


Figure 10.75 Reflection of colour

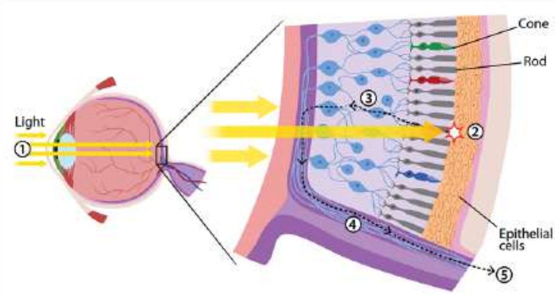


Figure 10.76 Cone cells in the retina

The colour we perceive depends on the light waves of that colour and the cells that identify colors in the retina. As shown in figure 10.75, when looking at a blue-coloured object, the blue-coloured light wave reflected from the surface of the object is absorbed by the blue cone cells of the retina of the eye. The message that the blue color is observed is then sent to the observer's brain. In the retina, there are millions of three types of cone cells, namely blue cone cells, red cone cells, and green cone cells. These cells separate colors. If the cone cells in the retina stop working, we cannot distinguish colors.

People with red-green color blindness cannot distinguish red and green colors. Thus, color blindness is the inability of the eyes to distinguish colors due to defects in the cone cells of the retina. The main reason for this is heredity. In addition to this, color blindness occurs when the cone cells are destroyed by mutations and harmful rays. Can you see the number inside the above (10.77) circles?

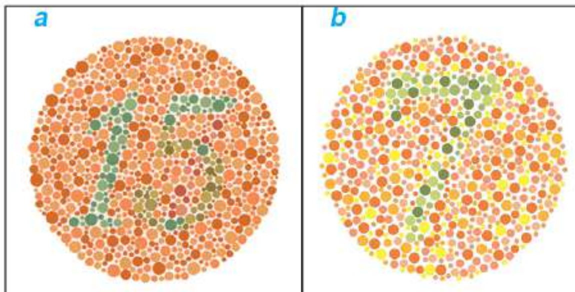


figure 10.77

(c) Night Blindness

The rod cells in the retina enable us to observe objects in dim light. For example, even if the light is very dim in a room, the position of the furniture in that room can be determined. Sometimes, due to disease, injury, lack of proper nutrients, or many other reasons, the rod cells do not function properly and objects in very dim places cannot be seen. Night blindness or nyctalopia is the inability to see well at night or in dim places. This is the problem of the retina. Since the rhodopsin pigment in the rod cells of the retina is made from a type of protein and vitamin A, this pigment is deficientwhen there is a lack of vitamin A in the body. Therefore, the lack of vitamin A in the body is one of the main causes of night blindness. This diseasecan also be caused due toheredity.

Effects of injuries to the cornea in the eyes

Question to consider

What do you do when dust or sandparticles enter the eyes sometime during a storm? What is the effect of continual rubbing of eyes in such situations?

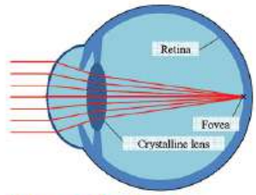


Fig. refraction through the cornea

Fig. Corneal ulcer

Fig . Corneal edema

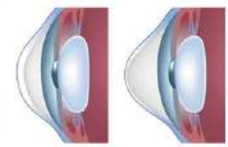
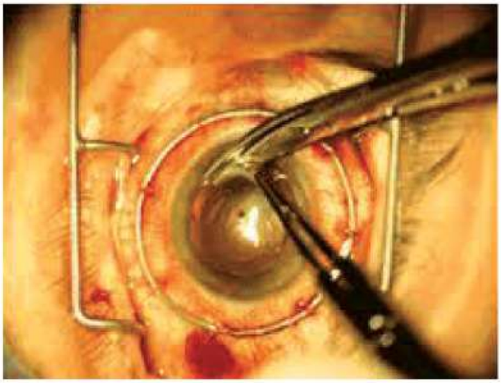


Fig. Keratoconus

Figure10.78 Effectsof corneal injuries on the vision

Cornea plays an important role in refracting light in the eye. The maximum refraction takes place at the cornea. The refractive index of the cornea is 1.376 and its converging power is about +43 D. It represents about two-thirds of the light-refracting capacity of the eye. Thus, the cornea of the eye must be protected from being scratched, hurt or injured. Sometimes, when dust or sand enters the eyes during a storm, the cornea gets scratched if the eyes are constantly rubbed with hands. Similarly, stones, pieces of metal, accidents, etc. may injure the cornea. Continual use of contact lenses and using them without proper cleaning can lead to infection in the cornea. Bacterial, viral, or fungal infections in the cornea can cause corneal diseases and vision problems. The corneal infection causes corneal ulcer i.e., keratitis. If the corneal ulcer is not treated immediately, it will make people go blind. Corneal edema caused by fluid accumulation between the corneal layers also causes blurred vision. Similarly, keratoconus, which occurs when the surface of the cornea changes into a conical shape, causes shortsightednessat first and later the eye loses its vision. Normal corneal problems can be cured by proper treatment. In cases the cornea cannot be cured by treatment, it can be replaced.

Corneal transplantation



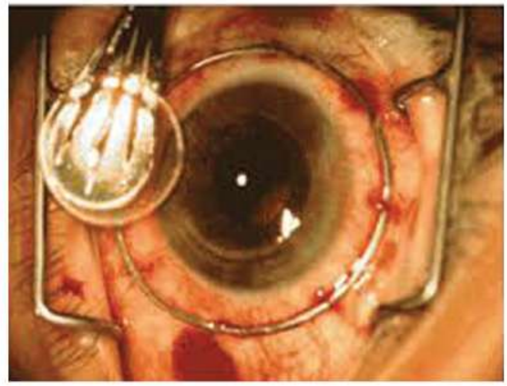


Figure 10.79 Corneal transplantation

The second leading cause of blindness in our country after cataract is corneal degeneration.

Corneal replacement can be done for people who were born with puffy eyes, and people whose corneas were damaged due to the absence of immediate treatments duringvarious infections, injuries, etc. As shown in Figure 10.79, the process of replacing the damaged cornea with a good cornea by eye surgery is cornea transplantation.

Some people donate their eyes to the eye bank so that other people can use the cornea of their eyes after their death. After the death of people who have donated eyes, doctors remove the cornea, not the whole eye, and store it safely. After the death of the donor, the eyelids are closed properly to protect the cornea from direct sunlight, and the cornea is removed from the eye within 8 to 12 hours. The sooner the cornea is removed after death, the better is its quality. In our country, Nepal Eye Bank has been established under Tilganga Eye Institute for the collection, storage, and distribution of corneas.

Project Work:

(a) Contact people of different age groups around your area and collect data about the eye-related problems they have faced, the measures taken to solve those problems, awareness about eye donation, etc. A table like the one below can be prepared for data collection:

S.N	Name	Age	Eye related problem	Adopted remedies	Awareness about eye donation
....	....	...	....	....	Have/does not have

Analyze the data obtained from the survey and prepare a report including the problems observed, awareness about eye donation, etc.

(b) Get in contact with the people having cornea transplantation or treatment of cataracts and request them to share their experiences. Then, prepare a report.

Exercise

A. Choose the correct option for the following questions.

a. Which of the following rules applies during the refraction of light?

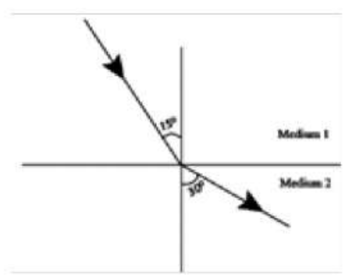
(i) Lightbends onlywhile passing from a rarer medium to a denser medium.

(ii) Light bends towards the normal as it passes from a denser medium to a rarer medium.

(iii) When light passes from a rarer medium to a denser medium, the angle of incidence is smaller than the angle of refraction.

(iv) The angle of refraction becomes greater than the angle of incidence when light travels from a denser medium to a rarer medium.

b. Study the given ray diagram and select the correct statement.



(i) Medium 2 is a denser medium and medium1 is a rarer medium.

(ii) The speed of light in medium 2 is lesser than in medium 1.

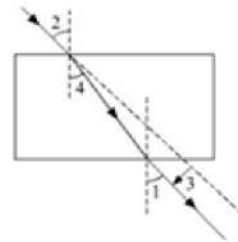
(iii) The speed of light is twice in medium 1 than that in medium 2.

(iv) Medium 1 is a denser medium and medium 2 is a rarer medium.

c. In the refraction of light through a glass slab shown in the figure, identify the correct names that should be placed in the place of the numbers: angle of incidence, angle of refraction, angle of emergence, lateral shift

(i) 1- angle of incidence, 2- angle of refraction, 3- lateral shift, 4- angle of emergence

(ii) 1- the angle of emergence, 2- the angle of incidence, 3- lateral shift, 4- the angle of refraction



(iii) 1- angle of refraction, 2- angle of emergence, 3- lateral shift, 4- angle of incidence

(iv) 1- lateral shift, 2- the angle of refraction, 3- the angle of incidence, 4- the angle of emergence

d. Which of the following is the result obtained from the observation of refraction through a glass slab?

(i) $\angle i = \angle e < \angle r$ (ii) $\angle i > \angle r = \angle e$

(iii) $\angle i < \angle e = \angle r$ (iv) $\angle i = \angle e > \angle r$

e. What is the value of the critical angle of the glass?

(i) 42° (ii) 49°

(iii) 24° (iv) 48°

f. Among endoscopes, spectacles, mirages, dispersion of light, rainbows, optical fibres, and hand lens, in which instruments and processes does the total internal reflection of light, take place?

(i) endoscope, spectacles, and mirage

(ii) dispersion of light, rainbow, and hand lens

(iii) rainbow, optical fibre, and mirage

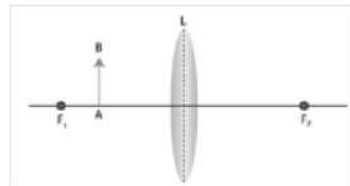
(iv) endoscope, mirage, andoptical fibre

g. The velocities of the green, violet and red light rays seen during the dispersion of the light through a prism are denoted by vg,vv, and vr respectively. Which order is correct for those velocities?

(i) $v_g > v_v > v_r$ (ii) $v_g > v_v < v_r$

(iii) $v_g < v_r < v_v$ (iv) $v_g > v_r < v_v$

h. Identify the characteristics of the image of the object AB kept in front of the lens as shown in the given figure.



(i) virtual, erect, magnified

(ii) real, inverted, diminished

(iii) real, erect, magnified

(iv) virtual, inverted, inverted

i. Distinguish the correct statement based on the characteristics of the image formed by concave and convex lenses.

(i) Convex lens forms a real, inverted, and diminished image of an object.

(ii) Concave lens forms a virtual, erect, and diminished image of an object.

(iii) Convex lens forms a real, inverted, and magnified image of an object.

(iv) Concave lens forms avirtual, erect, and magnified image of an object.

j. What is the correct understanding of eye problems and related causes?

(i) When the lens of the eye becomes cloudy, color blindnessoccurs.

(ii) When the focal length of the lens of the eye increases, shortsightednessoccurs.

(iii) When the shape of the surface of the cornea changes, defect in vision is seen.

(iv) Night blindness occurs due to the weakness of the cone cells of the retina.

2. Differentiate between

(a) reflection of light and total internal reflection of light

(b) concave lens and convex lens

(c) near point of the eye and far point of the eye

(d) shortsightedness and longsightedness

(e) color blindness and night blindness

3. Give reasons:

(a) Between glass and water, glass is considered a denser medium and water is a rarer medium.

(b) When a coin is placed in glass containing water, it appears to rise a bit.

(c) When the letters written on the paper are observed from the top of a glass slab, the letters appear to be slightly raised.

(d) Stars twinkle.

(e) The sun appears on the horizon about two minutes before the actual sunrise.

(f) A diamond appears to shine but a piece of glass cut to the same shape does not shine.

(g) Sunlight is refracted when it is passed through a prism.

(h) A convex lens converges light rays.

(i) A concave lens diverges the rays of light.

(j) Deficiency of vitamin A in the body is one of the main causes of night blindness.

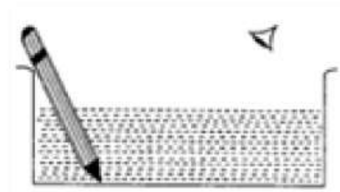
(k) Color blindness occurs when the cone cells of the retina stop functioning.

4. Write short answers to the following questions.

a. What is the refraction of light?

b. Write the laws of refraction of light.

c. What change is noticed in the shape of a pencil that is half immersed in water as shown in the Figure? Explain with a ray diagram. Write the name of the process associated with this observation.



d. When a light ray passes from water to air, the angle of incidence and angle of refraction formed at the water-air separation layer are 40.5o and 60orespectively. Draw a ray diagram showing the refraction and write the reason why an object outside appears to be farther away from its actual position when it is viewed by an observer inside the water.

e. What is a critical angle?

f. What is a total internal reflection of light?

g. Write two conditions necessary for total internal reflection of light.

h. At present, data can be transmitted at a very fast rate through fiber internet. Mention the role of total internal reflection of light in fiber internet.

i. In endoscopy, colonoscopy and keyhole surgery, how is total internal reflection of light applicable to the devices used to send light to the internal organs of the human body without incisions?

j. What is a dispersion of light?

k. Mention the reason for the dispersion of light.

l. Draw a raydiagram showing the following processes:

(i) Refraction of light through a glass slab

(ii) dispersion of light through a prism

m. A person is curious to know why a rainbow always appears semicircular and of the same size. Write down the solution to hiscuriosity. Include in your answer the position of the sun in the rainbow, the position of the water droplets in the air and the process of dispersion of light.

n. Define the following terms related to the lens.

(i) Centre of curvature (ii) Optical centre

(iii) Principal axis (iv) Focus

o. What ismeant by the power of a lens?

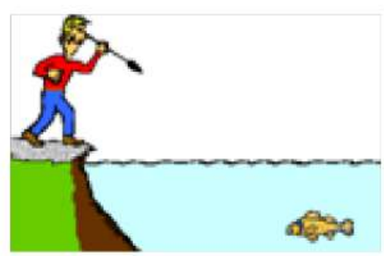
p. The powers of two convex lenses are +2D and +4D respectively.

(i) Which of them is thicker? Give reason.

(ii) Calculate the focal length of each lens.

q. In which case is the image formed by a convex lens real and of the same size as the object? Show the ray diagram.

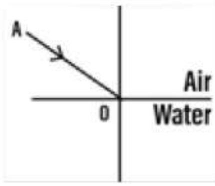
r. Will the spear thrown by the man shown in the figure, from outside the water hit the fish in the water? Explain it based on the real depth of the fish in the water.



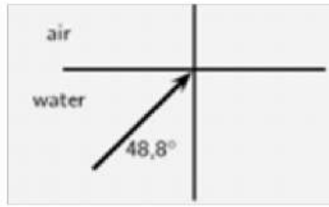
s. What process is shown in the ray diagram? Name any two devices that operate on this process.

t. Complete the ray diagram by copying the given figures to the answer sheet.

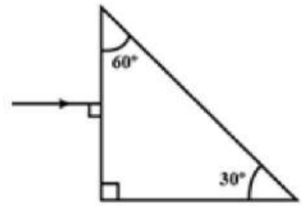
(i)



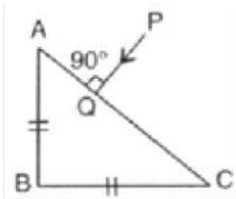
(ii)



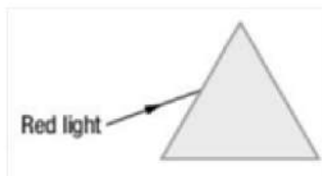
(iii)



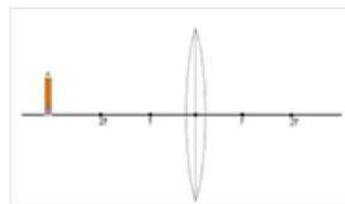
(iv)



(v)

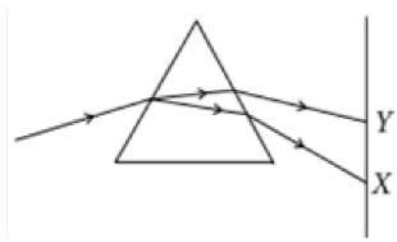


(vi)



u. Mention the facts, along with the ray diagram, applicable to the uses of the lens shown in the figure.

v. The given figure shows the dispersion of a light ray through a triangular prism. Answers the following questions based on the given ray diagram.



(a) Which colours of light waves are indicated by X and Y?

(b) Write down the reason why Y is bent less than X when the light rays come out of the prism.

w. How can the light dispersed by a prism be converted back into white light?

x. The focal lengths of the two lenses are 20cm and -20cm respectively. Mention the types of these two lenses. Out of these two lenses, which one forms a virtual and magnified image when an object is kept 16 cm away from the lens? Explain it by drawing a scaled ray diagram.

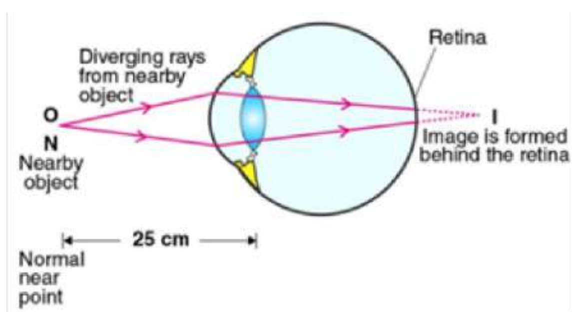
y. Write the functions of the following parts of the eye.

(i) Ciliary muscle	(ii) Cornea
(iii) Lens	(iv) Iris
(v) Pupil	(vi) Retina

z. Write any two problems that may be seen in corneal injury.

27. Explain the role of the ciliary muscle in the change in the thickness of the eye lens when a studentsitting in a classroom shits his eyes from the letters written on the whiteboard to a distant object seen out the window.

28. Identify the type of defect of vision indicated by the given ray diagram. Write two causes of the defect along with its correction.



29. A student in the class has difficulties in seeing the letters written on the whiteboard when he sits on the last bench but he sees them clearly when he sits on the first bench. Based on this, answer the following questions:

 (i) What type of defect of vision does the student have?

 (ii) Draw a ray diagram showing this type of defect of vision of the student.

(iii) Write any two reasons for this defect.

(iv) Explain, with a ray diagram, the role of the lens used to correct this defect.

30. Explain, with a ray diagram, the role of the lens used to correct long-sightedness.

31. A student concludes that, 'the effect of defect of vision is more on a person wearing spectacles with thick lenses than one wearing that with thin lenses'. Is this understanding, correct? Justify withappropriate reasons.

32. Compare the use of spectacles and the use of contact lenses to correct visual defects.

33. Explain the laser surgery method used to solve eyesight problems.

34. What is a cataract? Write the role of the intraocular lens developed by Nepal's ophthalmologist Dr. Sanduk Ruitin the treatment of cataracts.

5. Solve the following mathematical problems.

a. If the speeds of light in air and glass are 3×10^8 m/s and 2×10^8 m/s respectively, thencalculate the refractive index of glass with respect to air. [Answer 1.5]

b. T he refractive index of a diamond is 2.42. If the speed of light in glass is 3×10^8 m/s, calculate the speed of light in a diamond. [Answer 1.24×10^8 m/s]

c. When a ray of light falls on the surface of a plastic block, the angle made by the ray with the normal and the angle of refraction are found to be 45^0 and 33^0 respectively. Calculate the refractive index of that plastic. [Answer 1.3]

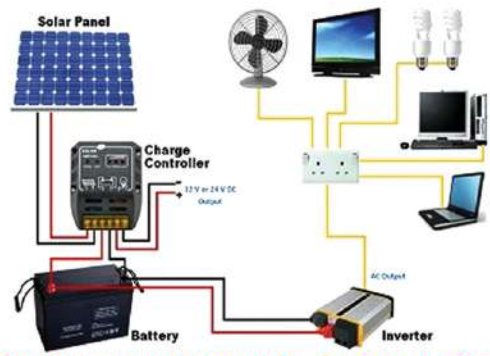
d. Calculate the power of a lens having a focal length of 25 cm. [Answer +4D]

e. The power of the lens used in the spectacles worn by a student is -6D. Calculate the focal length of the lens. Also, mention the type of lens. [Answer 16.67cm]

11 Electricity and Magnetism

The picture showsthe alternative arrangements made by the people during load shedding (electrical power cut).

People use rechargeable emergency lamps. The battery in such devices is charged when there is electricity in the main line.



People use solar panels. By connecting an inverter with this, different electrical devices can be operated.

When there is a main power supply battery can be charged, and many electrical devices can be operated by connecting the battery with an inverter.

Electricity can be generated by using petrol/diesel generators of different capacities whenever there is a need.

Topics related to the various information mentioned above are included in this unit. Types of current, construction of generators, and transformers and their working principles, etc. will also be discussed here.

Direct current and alternating current

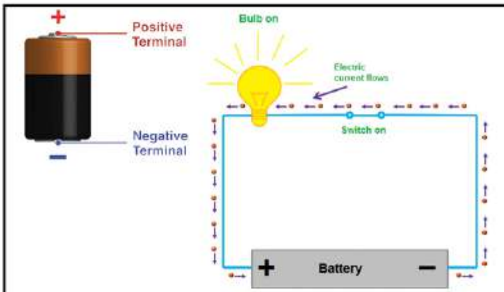


Figure 11.1 Direct current obtained from the cell

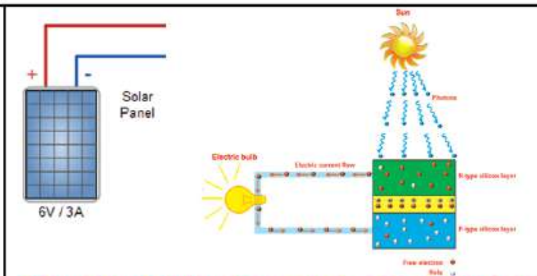


Figure11.2 Direct current obtained from the solar panel

Figure 11.1 shows two poles of a dry cell. It also shows that the electric charges in the conducting wire are flowing in a certain direction (from the negative terminal of the cell to its positive terminal) when the cell is connected to the electric circuit and the light is turned on. Similarly, Figure 11.2 shows the flow of current through a conducting wire in a particular direction when abulb is lit by the electric current from a solar panel.In this way, the current which flows in a particular direction is called the direct current (d.c.). Dry Cells, photocells (Solar panels), batteries, etc. are the sources of d.c.

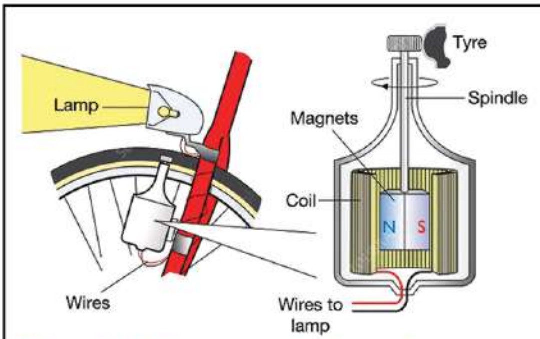


Figure 11.3 Sources of alternating current

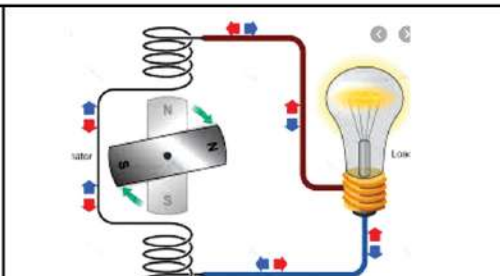


Figure 11.4 Direction of current produced by rotating magnets inside a dynamo

A glowing bulb run by the electricity produced by a dynamo is shown in Figure 11.3. In the above picture, the negative terminal and the positive terminal are not separated as in the dry cell and solar panel. In Figure 11.4, the direction of the current generated when the magnet is rotated between the coils in the dynamo is presented in a simplified manner.

In the same figure, the blue arrow shows that the charge on the conducting wire moves forward, and the red arrow shows that after a while the same charge flows in the opposite direction. The direction of a current of this type changes at a certain time interval. In the same way, the magnitude of the current also gradually changes from the minimum value to the maximum value. Thus, the current in which magnitude and polarity change continuously at a fixed interval of time is called alternating current (a.c.). Dynamo, a.c. generator, etc. are sources of a.c.

Current time graph

The fact that the magnitude of the current remains constant with respect to time in direct current can be demonstrated in a time current graph as shown in Figure 11.5. Similarly, the variation of magnitude and direction of alternating current with respect to time can be presented as shown in Figure 11.6.

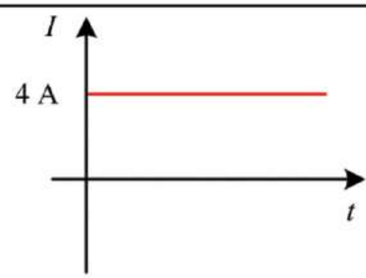


Figure 11.5 Time–current graph of direct current

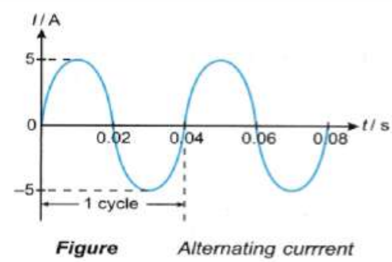


Figure 11.6 Time-current graph of alternating current

In the current time graph of direct current, it is shown that the magnitude of the current is constant at 4A even though the time is increasing. Similarly, in the current time graph of the alternating current, it is shown that themagnitudeof the current first increases from zero to 5A and then decreases to zero. After that, the value of the current increases again but in exactly the opposite direction (i.e. goes to -5A) and then again decreases to zero. Thus a cycle is completed. For a.c., the number of cycles completed in one second is called frequency. If one cycle of a.c. is completed in one second, the frequency of that a.c. is 1 hertz (1 Hz). The frequency of a.c. used in our country is 50 HZ and the average voltage ranges from 220 V to 240 V. This means that the direction of a.c. used in our country changes 100 times every second. Since the direction of the current in d.c. does not change with time, the frequency is zero.

Among different electrical appliances used in our daily life, some are run ona.c, some on d.c. and some on both a.c and d.c. Electrical devices such as fans, motors, refrigerators, etc. run on a.c whereas d.c. is used in the internal circuits of electrical appliances such as mobile phones, computers, etc.Electric heaters, filament lamps, etc. can operate in a.c as well as d.c.We can use a rectifier to convert alternating current into direct current.

Figure11.7 Rectifier block line graph

Activity 11.1

Fill in the differences between direct current and alternating currents in the table below.

Direct current (d.c.)	**Alternating current (a.c.)**

Magnetic effect of electric current

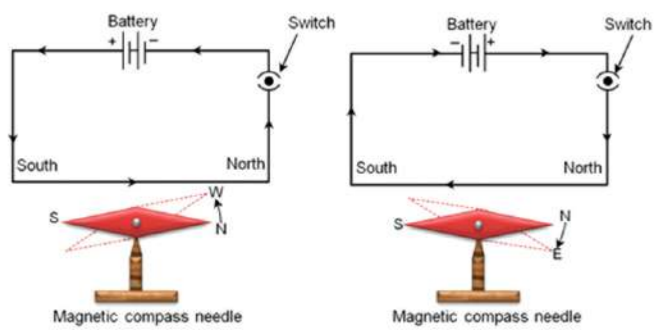


Figure 11.8 Direction of current along with the direction of motion indicated by the compass needle

In the year 1820, Hans Christian Oersted,a Danish physicist and science teacher, discovered the fact that electricity and magnetism are related to each other. He observed the needle of a magnetic compass deflecting near an electric circuit while performing an experiment involving electric current. After further study, it was found that the direction of the deflection of the magnetic needle changes along with the change in the direction of current flow in the circuit. Orested concluded that the deflection of the compass needle is due to the magnetic effect produced by the electric current.

The formation of a magnetic field around a conducting wire when there is electric current init, is the magnetic effect of current. The direction of the magnetic field thus formed depends on the direction of the electric current in the wire.

Magnetic field around a current carrying straight wire

Activity 11.2

(a) Take a square piece of cardboard. Pierce it with a straight wire and connect it to an electric circuit and connect the wire to the circuit as shown in Figure 11.9. Place plotting compasseson the cardboard and position them around the wire as shown in the figure. Turn on the switch to pass the current in the wire and then observe the needles of the compasses. Observe whether the needles of the magnetic compass around the wire rotate in a certain direction when the switch is turned on. Because there is no proper load in the circuit, the switch should be turned off immediately. Otherwise, the wire heats up if the switch is left on for a long time. Swap the poles of the cell and turn the switch on again and observe if the direction of the needles is opposite to the previous one.

(b) Pierce the cardboard with a straight wire as mentioned above and connect it to an electric circuit. Sprinkle very fine iron powder over the cardboard as shown in Figure 11.10. Turn the circuit switch on and then tap the cardboard gently with your fingers. Observe whether the iron dust settles in a circular geometric pattern or not.

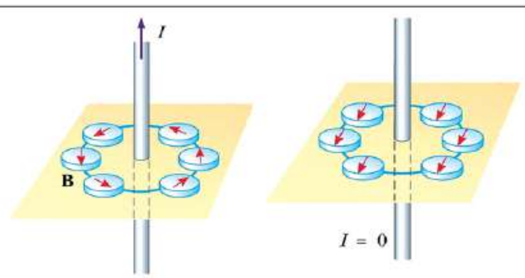


Figure 11.9 The circular magnetic field shown by a magnetic compass around a straight wire when it is carrying current

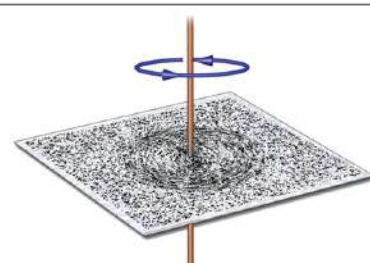


Figure 11.10 Circular magnetic field shown by iron dust when there is current in a straight wire

The magnetic field formed around a straight wire due to the electric current in it can be observed by drawing lines of magnetic force as shown in Figure 11.10.

When magnetic compasses are placed around the wire in the above activity, the needles of the compass point in a certain direction and indicate a circular pattern as shown in Figure 11.11. This effect is caused by the magnetic field formed in a circular pattern around the wire when there is current in it. The direction of the magnetic field thus formed depends on the direction of the electric current flowing in the wire. As shown in Figure 11.12, if the electric current is going upwards through the wire, the direction of the magnetic field is anticlockwise. On the contrary, if the current flows downwards from the wire, the direction of the magnetic field is clockwise. In the above activity as well, the direction of the magnetic field can also be determined by observing the direction of the pointer of the compass needle.

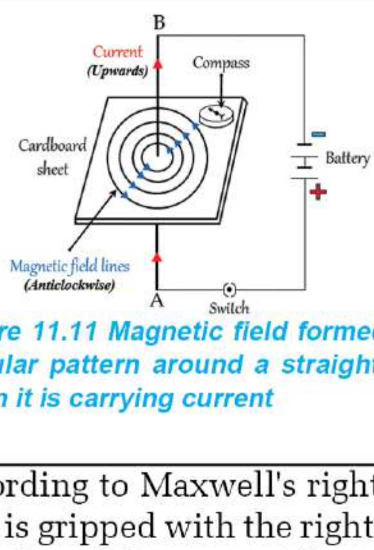


Figure 11.11 Magnetic field formed in a circular pattern around a straight wire when it is carrying current

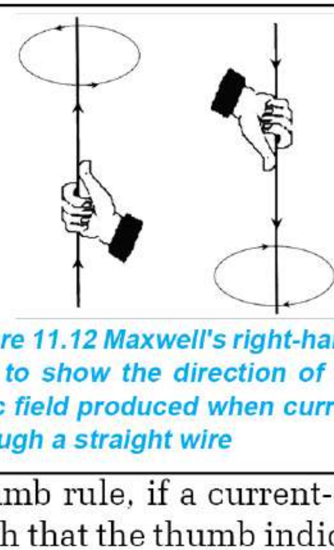


Figure 11.12 Maxwell's right-hand thumb rule to show the direction of the magnetic field produced when current flows through a straight wire

According to Maxwell's right-handthumb rule, if a current-carrying wire is gripped with the right hand such that the thumb indicates the direction of the current flow, as shown in Figure 11.12, then the fingers surrounding the wire indicate the direction of the magnetic field.

The magnetic field around a solenoid

Activity 11.3 Identification of the magnetic poles of a solenoid

Take an insulated copper wire, magnetic compass, 9V battery, and battery connector as shown in Figure 11.13. Wrap the wire around a cylindrical object such as a fine pipe or a marker pen. Make several loops around itand then pull out the cylindrical object to form a spring-shaped coil. Remove the layer of insulation at both ends of the wire by scratching it with a knife or by heating it in a burning candle. Place a magnetic compass on one side of the coil. Now, connect the two ends to the battery. When electric current flows in the coil, observe which pole of the needle of the magnetic compass is attracted by the coil, and fill in the table shown below. Now swap the poles of the battery connected to the coil. Observe which pole of the needle of the compass is attracted this time, and fill in the table.

figure 11.13

Before changing the poles of the batteries connected to the coils		After changing the poles of the battery connected to the coil	
When the magnetic compass is placed on the right-handside of the coil, the attracted magnetic pole	By placing the magnetic compass on the left-handside of the coil	When the magnetic compass is placed on the right-handside of the coil, the attracted magnetic pole	By placing the magnetic compass on the left-handside of the coil
........pole	........pole	........pole	........pole
Result: Since the .... Pole is attracted when the magnetic compass is on the right-hand side, the just opposite pole, i.e., ... Pole must have been created in the coil.		....	

A solenoid is a cylindrical coil made of insulated wire as shown in Figure 11.14. Generally, a solenoid is made by wrapping insulated wire around a cylindrical object. When the insulation of the two ends of the wire used to make the solenoid is removed and connected to a battery, current flows through the wire and a magnetic field develops in and around the solenoid. The magnetic field outside the solenoid is similar to the magnetic field around the bar magnet, i.e., the magnetic field of a solenoid is strong on both sides and weak in themiddle portion. There is a uniform magnetic field inside the solenoid. Generally, when electric current flows in the solenoid, one end of it becomes the North Pole and the other the South Pole.

If the electric current flows in the opposite direction, the poles of the magnetic field formed around it are also reversed.

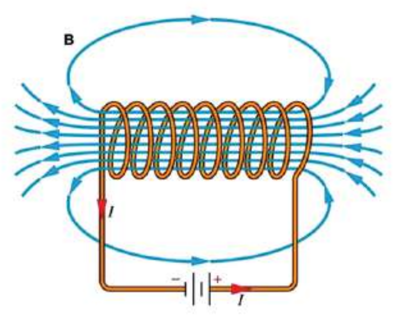


Figure 11.14 Magnetic fields around a solenoid

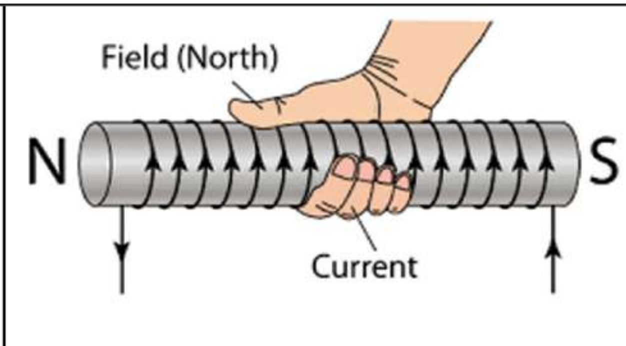


Figure 11.15 Maxwell's right-hand grip rule

The direction of the magnetic field formed around the current flowing solenoid can be found by using Maxwell's right-hand grip rule. According to this rule, if a solenoid is held in the right hand such that the fingers indicate the direction of the current through the solenoid, the thumb points to the north pole of the magnetic field developed in the solenoid. The strength of the magnetic field around a solenoid depends on the following factors.

(a) Magnitude of the current in the solenoid

(b) Number of turns in the coil of the solenoid

(e) A material placed inside the solenoid (core). Material such as a soft iron cylinder increases the strength of the magnetic field.

Since the magnetic field created by the solenoid is temporary, it is used to make an electromagnet.

Magnetic flux

Figure 11.16, shows the magnetic lines of force around a current carrying a straight wire, a wire loop, a solenoid, a bar magnet,and theEarth. Depending on the source of the magnetic field, the shape of the lines of magnetic force varies. As shown in Figure 11.17, the number of magnetic lines of force on an object placed in a magnetic field depends on location.

To obtain information about the effect of a magnet at different locations within a magnetic field one can simply look at the number of magnetic lines of force on the surface of an object.The total number of magnetic lines of force passing through the surface area within the magnetic field represents the magnetic flux. Magnetic flux is a measure of the magnetic field passing through a surface area within a magnetic field. Magnetic flux is denoted by the Greek letter Φ (Phi). Wb indicates the unit of magnetic flux, weber. The unit is named after the surname of the German physicist Wilhelm Eduard Weber.

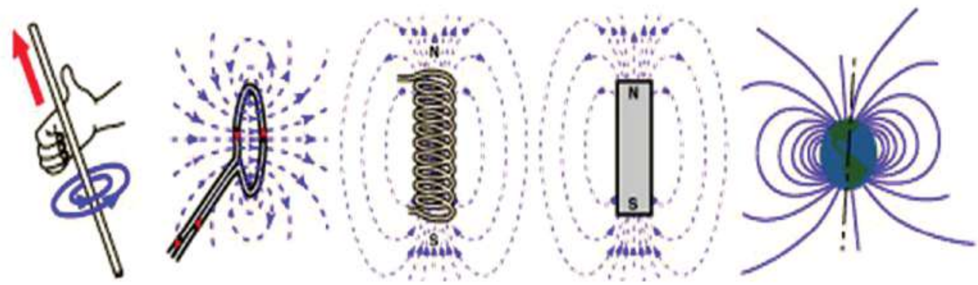


Figure 11.16 Various types of magnetic fields and magnetic lines of force

The density of magnetic lines of force indicates the magnitude of the magnetic flux.The area with denser magnetic lines of force means a strong magnetic flux whereas that of less density means a weak magnetic flux.

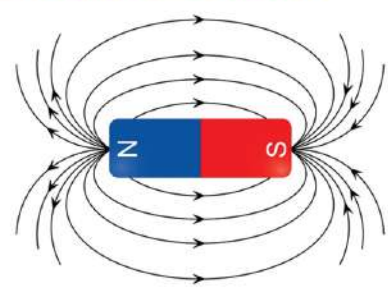


Figure 11.17 Magnetic lines of force of a bar magnet

On observing the density of magnetic lines of force of the bar magnet in figure 11.17, we can tell that the magnetic flux is stronger at the poles than that in the middle portion.

Motor effect

Activity 11.4

Collect a powerful U-shaped magnet, a piece of flexible conducting wire, 6V d.c. supply or a 9V battery, a thread, etc. As shown in the figure, tie the conducting wire to a thread and hang it so that it can move freely between the two poles of the magnet. Connect the two ends of the wire to the battery and a switch.

Turn the switch on for a moment and observe the wire. Did the wire move in any direction? Present your observations in the table below.

The direction of wire movement before changing the poles of thebattery	**The direction of wire movement after changing the poles of the battery**
Right/Left/Forward/Back-ward.........	Right/Left/Forward/Back-ward.........
Result:	

The production of motion in the wire placed in a magnetic field when current is passed through it is called the motor effect. Fans, water pumps, mixer grinders, etc. work because of the motor effect.

In Figure 11.19, the direction of the magnetic field of a bar magnet and the circular magnetic field developed around a wire when electric current flows in it are shown. The force of attraction and repulsion between the two magnetic fields produces motion in the wire.

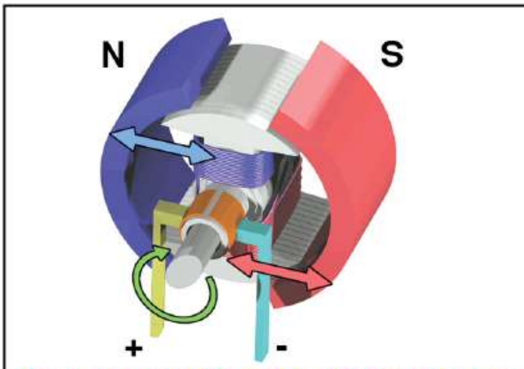


Figure 11.18: DC motor rotor and permanent magnet

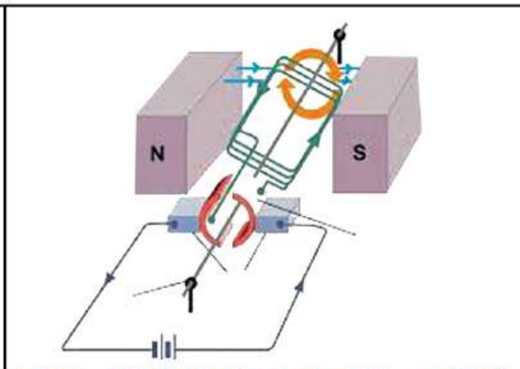


Figure 11.19 Force acting on a DC motor coil

A coil of a motor is formed by winding an insulated wire around a core. The coil is placed between two opposite magnetic poles as shown in Figure 11.17. Then a.c. is passed through the coil. When current is passed through the coil, a magnetic field develops around it. Because of the alternating current, the direction of the magnetic field in the coil changes continuously. The coil rotates due to the interaction between the magnetic field of the permanent magnet and that developed in the coil. This then rotates the other object attached to it.

Measures such as increasing the number of turns and the surface area of the coil, using a more powerful magnet, and using a soft iron core, can be adopted to increase the speed of rotation of the coil of a motor.

Question to think

Is it possible to generate an electric current from a conducting wire placed in a magnetic field, just the way a magnetic field is developed around the wire when an electric current passes through it?

Electromagnetic induction

Around the beginning of the nineteenth century (1800 AD), the voltaic cell was used as the main source of current. In the year 1831, Michael Faraday discovered that when the magnetic force lines are cut perpendicularly by a conducting wire, a voltage is generated in the conducting wire and an electric current flows when the two ends of the wire are connected in a circuit. This discovery brought a remarkable change in the field of the source of electricity.

Activity 11.5

Connect a galvanometer with the two ends of the solenoid prepared in activity 11.2.

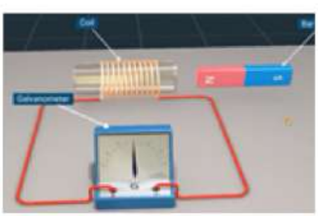


Figure 11.20

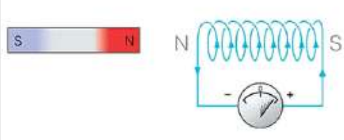


Figure 11.21

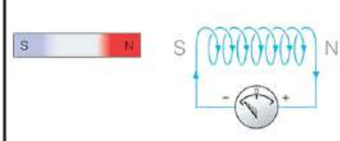


Figure 11.22

Pass a bar magnet in and out ofthe hollow part of the solenoid.Keeping the bar magnet fixed in front of the solenoid as shown in Figures 11.21 and 11.22, observe the position of the needle of the galvanometer when the north pole and the south pole of the bar magnet enter the solenoid. Note down the observation in the table below.

Poles of the bar magnet	The process by which the poles of a bar magnet enter or exit the solenoid	The direction of deflection of the needle of the galvanometer
North pole	In	Left/right
South pole	Out	

What is the difference between the new observation and the previous observation that can be observed when the bar magnet is quickly moved in and out?

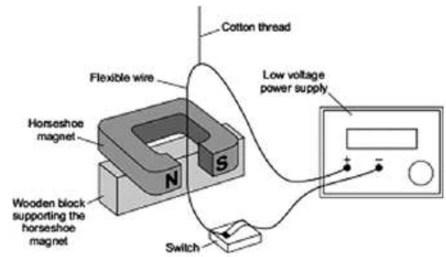


figure 11.23

As shown in activity 11.5, when a bar magnet is moved inside and outside a coil of conducting wire, the number of magnetic lines of force on its surface, i.e., the magnetic flux, changes continuously. As a result, voltage is induced in the coil. Even when a coil of conducting wire is rotated in a magnetic field and the magnetic flux linked with the coil is continuously changed, the voltage gets induced in the coil. In both cases, the work done while changing the speed of the coil or magnet, i.e. mechanical energy, is converted into electrical energy.

In this way, the process of inducing electromotive force (e.m.f.), i.e., voltage, in a conductor when there is a change in magnetic flux linked with that conductor is the electromagneticinduction.

Faraday's law of electromagnetic induction

The voltage produced in a coil depends on the strength of the magnetic field (electromotive force) and the number of turns in the coil. The greater the strength of the magnetic field and the number of turns of the coil, the more the voltage produced. The magnitude of the resulting voltage also depends on how quickly or slowly the magnetic field lines link the coil. On moving the magnet in and out of the coil at a very slow speed, negligible voltage is induced in the coil, but on moving the magnet in and out at a higher speed, more voltage is induced in the coil.

Based on the magnitude of the e.m.f. induced, Faraday's Law can be stated as follows:

When there is a relative motion between a conductor and a magnet, an electromotive force (e.m.f.) is induced in the conductor and the magnitude of such electromotive force is directly proportional to the rate of change of the magnetic flux linked with the conductor.

According to Faraday's law, when a conducting coil is rotated inside the magnetic field, an e.m.f. is induced in the coil due to the change in magnetic flux linked with the coil. This is the working principle of a generator. An induced e.m.f. lasts as long as the change in magnetic flux continues in the circuit or the coil keeps on moving. On increasing the number of turns of the coil, increasing the strength of the magnet, or the speed of rotation of the coil, the rate of change of magnetic flux linked with the coil increases. Thus, the magnitude of induced e.m.f. increases.

Dynamo and a.c. generator

Electric current is produced in bicycles and motorcycles by using a dynamo. Likewise, an a.c. generator is used to produce current that is used in the domestic electric circuits in daily life. A dynamo is used to induce the current on a small scale whereas a generator is used to generate current on a large scale.

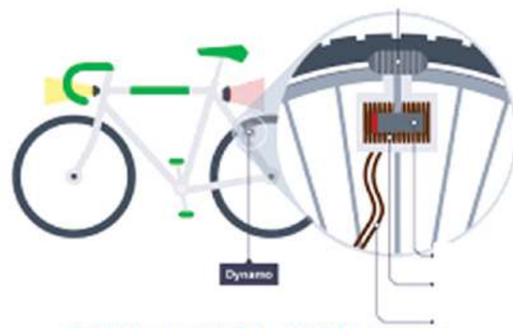


Figure 11.24 Bicycle Dynamo

As shown in Figure 11.24, a magnet is rotated in the bicycle dynamo. A coil is kept closer to the magnet such that it cuts the magnetic lines of force. To change the magnetic flux linked with the coil, the magnet is rotated by producing friction between the cap of the dynamo and the tire of the bicycle.Thus, the magnitude of the induced voltage in the coil depends on the number of turns in the coil, the strength of the magnetic field and the speed of rotation of the magnet, i.e., the rate of change of magnetic flux.

Large-scale sources of electricity

A large quantity of electricity is produced from the generator. For this, a coil placed in a strong magnetic field is rotated at a very high speed. As shown in Figure 11.25, the water stored in the dam of the hydropower station is allowed to flow at high pressure through the tunnel to the turbines of the generator and rotated with great speed to produce large amounts of electricity from the generators in the hydropower station.Likewise, fossil fuels like coal, diesel,etc. are used in thermal plants to produce electricity. In the thermal plant run with coal, a large amount of coal is burnt to produce heat energy which is used to heat water and produce vapour. The vapour produced in this way generates high pressure androtates the turbine of the generator to produce electricity.In the case of the diesel power plant, the turbine is rotated by a diesel engine. Apart from the sources mentioned above, the turbine of the generator in the windmill is rotated by wind energy and electricity is produced.

The working principle of a thermal plant run by coal is also applied in nuclear power plants. Instead of using coal, the heat energy required to boil water is obtained from the tremendous amount of energy released during the fission of radioactive elements like uranium under the controlled mechanism. This technology for producing electricity is not used in Nepal. According to the data published by the Nepal Electricity Authority in 2022 AD, the hydroelectric potential of Nepal is 2200 MW. In addition, about 487 MW of electricity is produced in Dubahi and Hetauda from the thermal plants. According to the report mentioned above, hydroelectric projects of about 487MW capacity are under construction. Additional 3219 MW of electricity from the Upper Arun Project, Uttar Ganga, and Dudha Kosi (with reservoir) Hydroelectricity Project have been proposed.

Alternating current generator

Figure 11.25: Water stored in Upper Tamakoshi Hydroelectric Dam located in Dolakha District

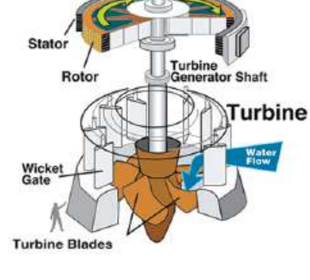


Figure 11.26: A turbine used to spin a generator at high speed in a hydroelectric plant

In Figure 11.26, a rectangular coil of conducting wire is placed in the magnetic field of ana.c. generator. As the coil rotates, it cuts the magnetic field, and the magnetic flux associated with the coil changes. As a result, an electromotive force (e.m.f.) is produced in the coil, and its magnitude is directly proportional to the rate of change of magnetic flux linkage.

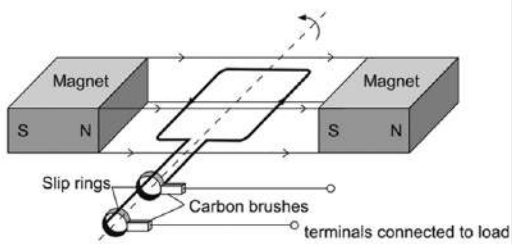


Figure: 11.27: The coil of the a.c.generator

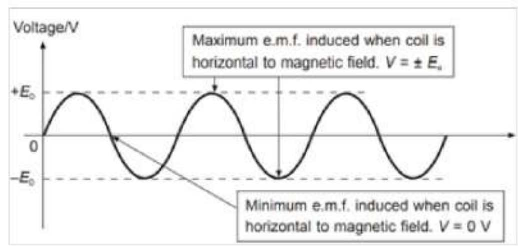


Figure: 11.28: The voltage induced in the coil of the a.c. generator

Transformer

Figure 11.29 shows the specified output voltage rating (5.3V) of a mobile charger. We put the mobile charger in a plug connected to a circuit with an alternating current (AC) of 220V. Here, the device installed inside the charger reduces the 220 a.c. to 5.3V a.c. which is required to charge the mobile.

Figure 11.29 Voltage rating indicated on a mobile charger

Similarly, about 2100V is required to generate microwaves in a microwave oven. For this, the transformer installed inside the oven converts 220V a.c. to 2100V a.c. In this way, the device used to increase and decrease the voltage of alternating current is called a transformer.

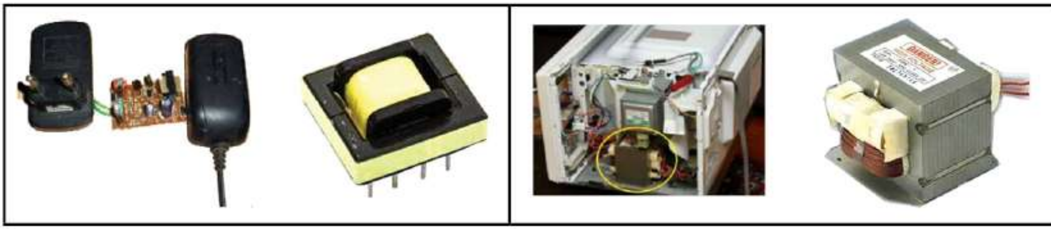


Figure 11.30: Use of transformers in chargers and microwave ovens

Activity 11.6: Compilation of voltage rating of equipment using transformers

Which other devices need a transformer? Collect their voltage rating and fill in the table given below.

Device	Input voltage rating	Output voltage rating
Router adaptor	....	
Laptop adaptor	....	

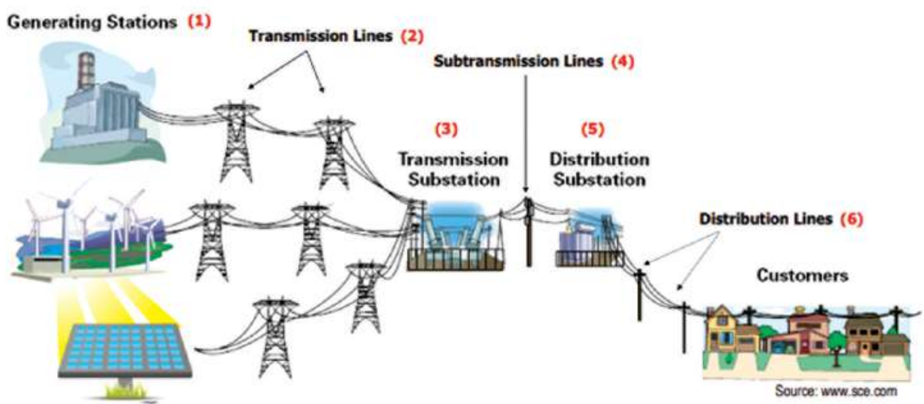


Figure 11.31: Electricity generation, transmission and distribution

The use of a.c. electricity includes three major sections - production, transmission, and distribution. The electricity produced by the generator in the powerhouse is converted into the high voltage (for example 132 kV) a.c. and then transmitted through the transmission line.

Figure 11.32: 400 kV Sub-station located at Dhanusha, Dhalkevar

Before distributing the transmitted electricity for use, its voltage is reduced to a lower value (for example, 220V) at the load transmission center (substation). Transformers are used to change the voltage as required in powerhouses and load transmission centers.

The electricity produced by various power plants in our country can be transmitted within or outside the country through high-voltage transmission lines. For example, the load transmission station at Dhunsha transmits electricity at 400KV.

Construction and working principle of transformer

Although there are some differences in the structure of transformers used in electrical appliances and transformers used for the transmission and distribution of electricity produced by power plants, theirworking principle is the same. They contain two coils that are made by wrapping thin insulated copper wire. As shown in Figure 11.33, a transformer used in electrical equipment consists of two coils. These coils are not connected. When an alternating current is sent through a coil, a magnetic field is created around it that changes periodically. As a result, when the magnetic intensity linked to the nearby coil changes, an emf is induced in the coil. The output current is then drawn from the two ends of this coil. Inducing emf in a coil by changing the current in the adjacent coil is the principle of mutual induction. The transformer is based on the principle of mutual induction. Since there is no mutual induction when direct current flows in the coil instead of alternating current, the voltage of d.c. cannot be changed by using a transformer.

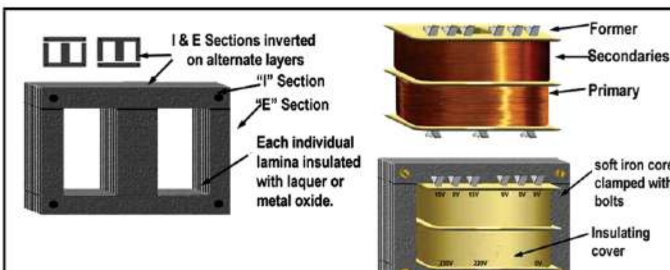


Figure 11.33: Transformer core lamination

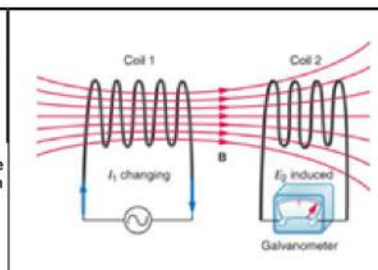


Figure 11.34: Mutual induction

To keep the coils apart in a transformer, the core is constructed by tying several E, U, and shaped iron sheets coated with non-conductive paint into a single block with the help of nutsand bolts.

This process is called core lamination. Laminating the core of the transformer prevents excessive heating of the core caused by the current induced in the core due to the change in the magnetic flux linkage.

Among the two coils of the transformer, the coil into which alternating current is fed (input coil)is called the primary coil and the coil in which alternating current is induced (output coil) is called the secondary coil. The number of turns of wire wound in the primary coil is called primary turns (Np) and the number of turns of wire wound in the secondary coil is called secondary turns (Ns). To change the voltage of alternating current in the transformer, the number of primary windings and secondary windings are kept different. The AC voltage sent to the primary coil of the transformer is called the input voltage or primary voltage (Vp) and the AC voltage received from the secondary coil is called the output voltage or secondary voltage (Vs).

Types of transformer

Transformer increases or decreases the input voltage depending on the number of turns in the coils in the transformer. For the block diagram of the transformer shown in Fig. 11.35, the ratio of the number of primary windings to the number of secondary windings is 2:1. If the input voltage in the said transformer is 220V, then the output voltage is exactly half of the input voltage i.e. 110V. A transformer with fewer turns in the secondary coil than in the primary coil reduces the voltage. A transformer that reduces the voltage of an alternating current is called a step-down transformer.

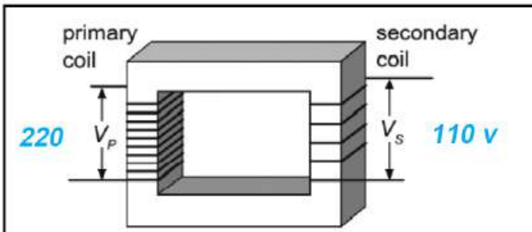


Figure 11.35: Step down transformer block diagram

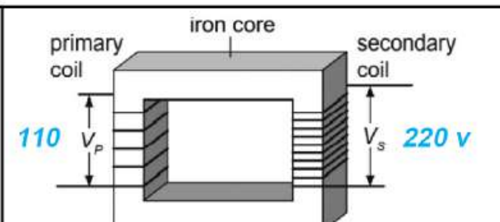


Figure 11.36: Step up transformer block diagram

For the block diagram of the transformer shown in Fig. 11.36, the ratio of the number of primary windings to the number of secondary windings is 1:2. If the input voltage in the said transformer is 110V, then the output voltage is exactly twice the input voltage, i.e., 220V.

A transformer in which the number of windings in the secondary coil is more than the windings in the primary coil increases the voltage. A transformer that increases the voltage of an alternating current is called a step-up transformer.

In transformer, the ratio of the number of turns in the primary coil to the number of turns in the secondary coil is equal to the ratio of the primary voltage to the secondary voltage. This can be presented as the transformer formula:

$$\frac{\text{Primaryturns } (N_p)}{\text{Secondary turns } (N_s)} = \frac{\text{Primary Voltage } (V_p)}{\text{Secondary Voltage } (V_s)}$$

Example 11.1

The accompanying picture shows a router to be connected to a 220V power supply. Observe the voltage rating mentioned on the router adapter. If the number of primary winding in the transformer inside the adapter is 500, calculate the number of secondary winding.

Solution: As given in the question,

Primary Voltage (Vp) = 220V

Secondary Voltage (Vs) = 12V

As per the voltage rating mentioned in the figure

Primary turns (Np) = 500

Secondary turns (Ns) = to be calculated

According to the transformer formula,

$$\frac{\text{Primaryturns } (N_p)}{\text{Secondary turns } (N_s)} = \frac{\text{Primary Voltage } (V_p)}{\text{Secondary Voltage } (V_s)}$$

Substituting the corresponding values into the formula,

$$\frac{500}{N_S} = \frac{220}{12}$$

Or $\frac{N_S}{50} = \frac{12}{22}$

Or $N_s = \frac{6 \times 50}{11} = \frac{300}{11}$

$$\therefore \quad N_s = 27.27 \cong 28$$

As mentioned in the question, the number of the secondary winding of the transformer is 28.

Example 11.2

The ratio of primary winding to secondary winding in a transformer is 1:10. Calculate the secondary voltage obtained when the transformer is connected to a 220V power supply.

Solution: As given in the question,

Primary Voltage (Vp) = 220V
Secondary Voltage Voltage (Vs) = to be calculated
Primary turns (Np): Secondary turns (Ns) = 1:10
Secondary turns (Ns) = to be calculated

According to the transformer formula,

$$\frac{\text{Primary turns } (N_p)}{\text{Secondary turns" } (N_s)} = \frac{\text{Primary voltage } (V_p)}{\text{Secondary voltage } (V_s)}$$

Substituting the corresponding values into the formula,

$$\frac{N_p}{N_s} = \frac{220}{V_s}$$

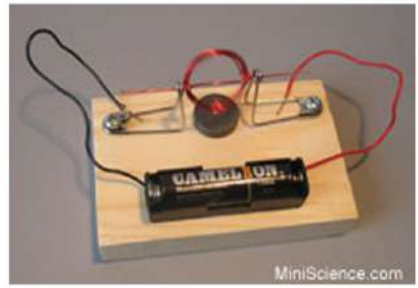
or $\frac{1}{10} = \frac{220}{V_s}$

$\therefore \quad Vs = 2200 \text{ V}$

The secondary voltage of the given transformer is 2200V.

Project work

(a) Prepare a model using locally available materials, insulated copper wire, etc. to demonstrate the working principle of an a.c. generator/dynamo.



(b) Prepare a model of a motor by connecting coils, magnets, drycells, pins, conducting wires, etc. as shown in the figure.

Exercise

1. Choose the correct option for the following questions:

(a) Which of the following is the source of a.c.?

(i) drycell (ii) solar panel

(iii) dynamo (iv) voltaic cell

(b) Which scientist discovered the magnetic effect of electric current?

(i) Michael Faraday (ii) Hans Christian Oersted

(iii) John Ambrose Fleming (iv) James Clerk Maxwell

(c) Which is the direction of the magnetic field when current is flowing upwards through a conducting straight wire?

(i) anticlockwise direction

(ii) clockwise direction

(iii) perpendicular to the direction of electric current

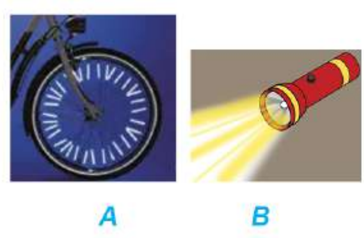
(iv) opposite to the direction of the electric current

(d) Which of the following statements is true for the current source shown in the figure?Figure

(i) The value of electric current produced by A is constant.

(ii) The frequency of electric current produced by B is constant.

(iii) The brightness of the lamp fluctuates if the current produced by A is used.



(iv) The direction of the electric current produced by B changes constantly.

(e) On which of the following principlesis the working of a transformer based?

(i) Electromagnetic induction (ii) Mutual induction

(iii) Motor effect (iv) Lighting effect of current

(f) Which is the transformer's formula?

(अ) $\frac{V_p}{V_s} = \frac{N_s}{N_p}$ (आ) $\frac{V_s}{N_p} = \frac{N_s}{V_p}$

(इ) $\frac{V_s}{V_p} = \frac{N_p}{N_s}$ (ई) $\frac{V_s}{N_s} = \frac{V_p}{N_p}$

2. Differentiate between:

(i) a.c and d.c (ii) dynamo and generator

(iii) motor and generator

(iv) step-up transformer and step-down transformer

3. Give reasons:

(a) When a ceiling fan is connected to the circuit of the solar panel, the fan does not rotate.

(b) When a magnetic compass is placed near a circuit in which an electric current is flowing, its needle deflects.

(c) Electromagnet is used in the electric bell.

(d) The number of primary windings and secondary windings of a transformer are not the same.

(e) The core of a transformer is laminated.

(f) Transformers are used in mobile chargers.

4. Answers the following questions:

(a) The frequency of a.c. in our country is 50 Hz, what does it mean?

(b) Draw the time graph of direct current and alternating current.

(c) Draw the magnetic field lines around the current-carrying straight wire and solenoid.

(d) Explain the following rules.

  (i) Maxwell's right-hand thumb ruleto show the direction of the magnetic field produced when an electric current flows through a straight wire.

  (ii) Maxwell's right-hand grip rule to find the direction of magnetic field lines of force around a solenoid.

(e) What is the magnetic effect of current?

(f) Define magnetic flux.

(g) How can the magnetic field produced around straight current carrying be demonstrated by using iron dust, cardboard, and conducting straight wire? Explain it.

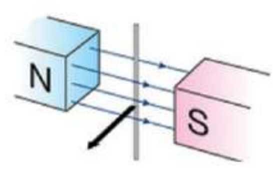
(h) Draw the magnetic field developed around a straight current-carrying wire.

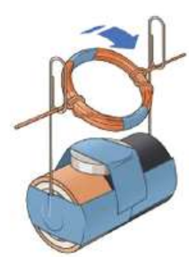
(i) What is Solenoid? Drawa picture showing the magnetic field developed around a solenoid

(j) Write two uses of the solenoid.

(k) Which effects are demonstrated in the given figures?Figures

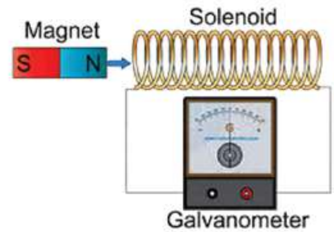
(l) A simple electric motor constructed by usinga coil, paper clips, a dry cell, and a permanent magnet, is shown in the figure. Explain its working process based on motor effect





(m) What is electromagnetic induction?

(n) Study the given picture and write what happens in the following situations.Figure



(i) As the bar magnet is slowly introduced into the solenoid

(ii) While introducing the bar magnet rapidly into the solenoid

(iii) Holding the bar magnet stationary inside the solenoid

(iv) On pulling the bar magnet quickly out of the solenoid

(o) State Faraday's law of electromagnetic production.

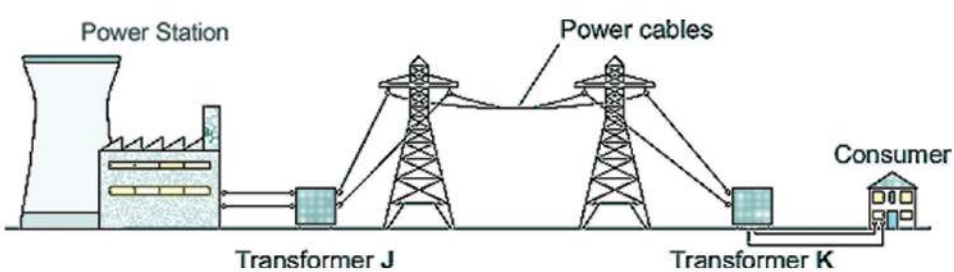
(p) A bulb connected to a dynamo attached to the tire of a bicycleis not found to be glowing with steady brightness. It was found that the bulb was bright, dimmed and also turned off when the cycle came to rest.Mention the reasons for such observations based on the working principle of dynamo.

(q) What can be done to increase the magnitude of current produced by a dynamo? Write any two ways.

(r) Prepare a researchreport on any two sources of electricity in Nepal(Hydro power station, solar power plant) including theircapacity, type of electricity produced, and transmission.

(s) What is a transformer?

(t) Write the type of transformers X and Y shown in the figure.



(u) Draw the block diagrams of the step-up transformer and step-down transformer and write two uses of each.

5. Solve the following mathematical problems:

(a) To charge a laptop of 20V, a charger with 550 primary turns is connected to an a.c. source of 220V. Calculate the number of secondary windings of the charger. [Answer: 50]

(b) The number of secondary windings of the coil of a transformer used in a microwave oven is 10 times the number of windings in the primary coil. If it is connected to a source of 220V, what is the secondary voltage obtained from the transformer?

(c) The ratio of the number of the primary winding to the number of secondary windings of a transformer is 22:1. If an adopter with that transformer is connected to an electric circuit having a potential difference of 220V, calculate the output voltage so obtained.

12

Universe

Look at the picture.Discuss the questions based on your day-to-day experience and observationsand then draw a conclusion.

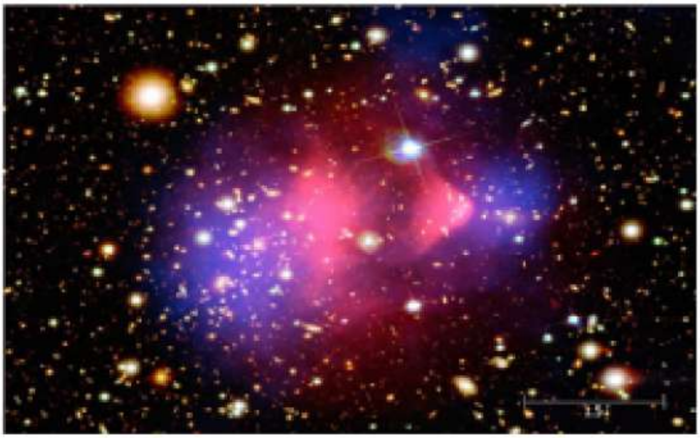


Figure 12.1 Celestial bodies in the universe

(a) What different types of celestial bodies exist in space?

(b) How are all these heavenly bodies stuck in space?

(c) How did the universe with all these celestial bodies originate?

(d) Areall the celestial bodies in the universe,in motion?

We have discussed various celestial bodies in the previous grades as well. The vast area around us is called the universe. There are many celestial bodies in this universe including the planets, stars, comets, satellites, meteors, meteorites, asteroids, etc. A group of many stars form a galaxy. The Solar System is located in the Milky Way galaxy. The universe is a huge region. Even science has not yet been able to obtain concrete information about the size, origin and spread of the universe. There are some very large celestial bodies in the universe. Their mass is also very large. But some celestial bodies are very small too. Their mass is also less.

Some of them are in a gaseous state and some are in a solid state. Celestial bodies have been namedasstars, planets, satellites, baby planets, comets, meteors, meteorites, etc. Due to the gravitational force of attraction, every celestial body including the planets, satellites and starsis held in its position. The collective name of all these celestial bodies is the universe. Astronomers at different times have proposed various theories about the origin of the universe. But, among them, the Big Bang theory is considered to be the most reliable one. According to this theory, all celestial bodies in the universe are moving. Hubble's study of the movement of these celestial bodies is important. Due to the gravitational force that exists between these moving celestial bodies, different hypotheses such as the open universe, closed universe and flat universehave been propoundedabout the future of the universe.

Activity 12.1

Divide the students in your class into four groups. Study the above-mentioned topics on the internet and find out more information on them. Based on this, prepare a collage about the celestial bodies in the universe such as planets, stars, comets, satellites, meteors, meteorites, and baby planets.Exhibit the collages prepared by all four groups in the class and discuss them.

12.1 Importance of gravitational force in the universe

Observe the figure and discuss.

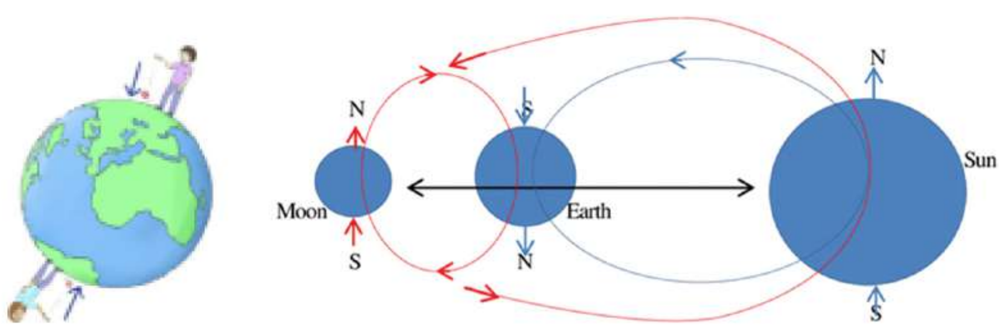


Figure 12.2 Gravitational force

(a) What is the secret of the fact that when a ball is thrown vertically up from either of the poles of the earth, as shown in the above picture, the balls always fall towards the surface of the earth?

(b) The Sun, the Earth and the Moon are shown in the picture. The Earth revolves around the sun and the moon revolves around the Earth. What is the reason for this?

(c) All these three celestial bodies have their gravity, but how is it possible for them to stay in their place?

(d) Why planets and satellites do not collide with each other while moving in their orbits?

Earth is a planet; it has its mass. That's why it has gravity. Sun, earth and moon have their gravity. As shown in the picture above, there is a mutual force of attraction between them in which the sun is attracting the earth towards its center and the earth is also attracting the sun towards its centre. Similarly, the Earth is attracting the moon towards its center and the moon is also attracting the earth towards its centre. In this way, there is a mutual force of attraction among all celestial bodies in space. This force of attraction is called gravitational force. Due to this gravitational force, the earth rotates on its axis as well as revolvesin its orbit. The moon also revolves around the Earth. Similarly, every celestial body in the solar system revolves around the sun. Gravitational force is responsible for maintaining the alignment of the planets in their orbits and making them revolve around the sun.

12.2 Study of the Universe

Have you ever thought about how the universe originated? What is the shape of the universe?

With similar questions, scientists have carried out various research about it at different times.Universe science is the branch of science that studies various facts about the universe including the history and future of the universe.One of its branches, Astrophysics, studies the origin, structure, and future of the universe.

Big-bang theory

Activity 12.2

Get divided into different groups in the class and search the Big Bang theory on the internet. After collecting the information about it, have a group-wise presentation via PowerPoint slide in the class.

fig 12.3 Huge explosion of atom

Our solar system lies at a distance of about 30,000 light years from the centre of a spiral galaxy named the Milky Way galaxy having a diameter of about 100,000 light years. It is estimated mathematically that there are about 1.5 billion stars in this galaxy alone. Many theories about the origin of the universe have been proposed, the Big Bang theory is considered the most reliable theory. This theory but is believed to have been born from the observation that all the galaxies along with the Milky Way are moving far away from each other with tremendous speed. According to this theory, the universe is believed to have originated from the big explosion of a single atom. The four fundamental forces existing in the universe: gravitational force, electromagnetism, strong nuclear force, and weak nuclear force are considered to have unified as a single force before the explosion. Therefore, in the first stage of existence, the universe is considered to be in a very compressed state. At that time, the universe is believed to be in a very energetic state in the size of a small single atom. According to the Big Bang theory, due to excessive force and pressure, a huge explosion of the atom took place and the universe originated. All celestial bodies in the universe are believed to have originated from this explosion.

Just as the particles scatter and move away from each other in the explosion of an explosive, all the celestial bodies are moving far away from each other after the huge explosion of that dense atom. So, the size of the universe is also increasing day by day. Its expansion is slow but continuous. But, the speed of these bodies is decreasing due to the force of gravity.

Activity 12.3

Take a balloon. Blow a little bit of air into it and close its mouth by pressing with your fingers. Mark a few dots of different colours using sign pens on the surface of the balloon. Now inflate the balloon gradually and observe the distance between the dots. Notice that, as the size of the balloon changes (increases/decreases) so does the distance between any two dots.

Hubble's study

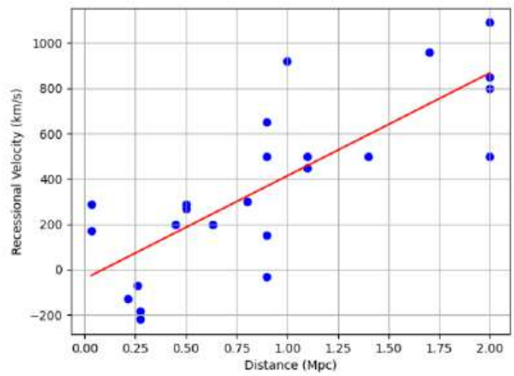


Figure 12.4 Hubble's relation between velocity and distance

It has been discovered that the galaxies in space are moving away from each other. In 1929 BC, the American astronomer Edwin Hubble tried to calculate the velocities of various galaxies using the 100-inch Hooker telescope on Mount Wilson. During his research, he discovered that every galaxy is moving away from other galaxies. His estimation showed that the farther the celestial bodies are from the earth the smaller they appear.And they also have a greater velocity.

He then plotted the velocities of the constellations against their distances on a graph and explained the relationship between the velocities of the constellations and their distances. This relation is represented by the equation $v = Hd$, and is known as Hubble's law. Here, vrepresents the velocity with which galaxies are moving away from each other, d represents the distance between them and H is Hubble's constant. The value of this constant is 73km/s/Mpc [Kilometer per second per Mega parsec]. This means, if any two galaxies are at a distance of one mega parsec,they are separating away from each other with a velocity of 73 km/s.

If the distance between any two galaxies is expressed in parsec and then multiplied by Hubble's constant, the velocity with which these galaxies are moving away from each other is obtained. Based on the such calculation,we came to know the fact that the galaxies are moving very far away very quickly. It can also be known from Hubble's equation that the farther the galaxies are,the faster they are separating.

From this conclusion, just as every dot moves away from each other as the size of the air-filled balloon increases, the size of the area occupied by the entire universe is increasing. It is clear that the constellations in the universe are moving away from each other. Therefore, it can be assumed that they were close to each other in the past, which in turn means they were all at the same point a long time ago. Thus, Hubble's study helps to confirm the Big Bang theory.

Question to think:

Why are the stars in the universe moving away day by day?

12.3 Future of the Universe

Activity12.4

After launching a rocket from the earth, the distance of the rocket from the earth increases due to its initial speed, but the speed of the rocket decreases due to the force of gravity. But, the gravitational force also goes on decreasing as distance increases.

(a) If the effect of gravity becomes zero before the speed of the rocket becomes zero, what will be the future of the rocket?

(b) If the speed of the rocket becomes zero before the force of gravity becomes zero, what will be the future of the rocket?

(c) What will happen if the effect of gravity becomes exactly zero when the speed of the rocket becomes zero?

As discussed above, all the galaxies in the universe are moving away from each other at a certain velocity and the size of the universe is increasing, but due to the gravitational pull of the masses in the universe, the velocity of all the galaxies is decreasing. As the distance between the bodies increases, the effect of gravity also decreases. Now the question remains whether the velocity becomes zero before the effect of gravity, the effect of gravity becomes zero before the velocity becomes zero, or both of them become zero at the same time. This determines the future of the universe.

Let us know

According to Newton's universal law of gravitation, every mass exerts a gravitational force on every other mass and they pull each other towards themselves. The magnitude of that force is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres. Hence, it is obvious that the net gravitational force on any celestial body depends on the total mass in the universe and the volume of the universe. Since the ratio of mass to volume is called density, the net magnitude of the gravitational force depends on the average density of the universe.The average density of the universe required to stop the expanding universe, which could be after billions of years, is called the critical density.

(a) Open universe

If the celestial bodies retain some velocity when the gravity becomes zero, they will then continue to move away from each other forever and the size of the universe will continue to increase. This situation is considered an open universe. If the average density of the universe is less than the critical density, then gravity cannot hold the expanding process and the universe which is continuously expanding now will continue to expand in the future too.

(b) Flat universe

If the gravity and the velocity of the celestial bodies become zero at the same time, the celestial bodies remain in the same position after that and the universe remains stable. Such a state is called a flat universe. If the average density of the universe is equal to the critical density, then the expansion rate of the continuously expanding universe gradually decreases and finally stops. Till then, there will be an infinite distance between each celestial body because of this they will not be affected by mutual gravitational force. Such universe is called flat universe.

(c) Closed universe

If the gravitational effect remains nonzero when the speed of the celestial bodies becomes zero, the celestial bodies will start to come closer and the universe will come to a single point. The phenomenon in which the vast universe filled with unlimited mass and energy will at one point shrink and collapse is called the Big Crunch. If this happens, the universe created by the explosion of a single point will end up being a point and explode again to form a new universe like the present one. This means, just like the life cycle of a star, the age of the universe is fixed and it also has a life cycle. For the life cycle of the universe to continue, the Big Bang and the Big Crunch must keep appearing in turn. Such universe is called closed universe.

The above facts can be presented in graphs. Open, flat and closed universes are named according to the nature of the graphs. The main factor that determines the future of the universe is gravity. The magnitude of gravity depends on the mass and size, i.e., density of the universe. The density of the universe is estimated based on the masses seen in space.

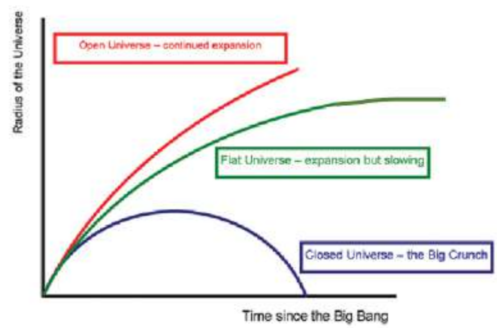


Figure 12.5 Types of Universe

Question to think

Can the actual density of the universe be determined in the days to come? Present your arguments.

Project work

Search the facts about the open, flat and closed universe using the internet or other media. Make models, present in the classroom and discuss.

Exercise

1. Choose the correct option for the following questions:

   (a) Due to the effect of which force,are the celestial bodies in the universe situated at their position?

   (i) nuclear force of attraction

   (ii) gravitational force

   (iii) magnetic force

   (iv) electromagnetic force

   (b) Which theory is considered the most realistic theory about the origin of the universe?

   (i) Geocentric theory

   (ii) Heliocentric theory

   (iii) Big Bang Theory

   (iv) Newton's Law of Gravitation

   (c) According to the Big Bang theory, how did the universe originate?

   (i) from the explosion of an atom

   (ii) from the collision of celestial bodies

   (iii) from the explosion of a star

   (iv) from the adjustment of nebulae

   (d) According to Hubble's theory, which one of the following facts is correct?

   (i) The farther away the galaxies are the more speed they will have.

   (ii) The farther away the galaxies are the lesser the speed they will have.

   (iii) There is no relation between the speed and distance of galaxies.

(iv) The gravitational force of the galaxies does not affect their speeds.

(e) Under what condition can an open universe behypothesized?

(i) When the average density is greater than the critical density.

(ii) When the average density is less than the critical density.

(iii) When average density and critical density are equal.

(iv) When average density and critical density are not comparable.

(f) What is the meaning of H in Hubble's law; v = Hd

(i) height

(ii) gravitational constant

(iii) constant of proportionality

(iv) distance

2. Differentiate between:

(a) Closed Universe and Open Universe

(b) Flat Universe and Closed Universe

3. Give reason:

(a) As the distance between celestial bodies increases their separating speedincreases.

(b) Celestial bodies continue to remain in their own place.

4. Answer the following questions:

(a) What is the universe?

(b) State the Big Bang theory.

(c) Write the conclusion of Hubble's study.

(d) According to the Big Bang theory, the universe is continuously expanding. Is there no limitation to the expansion of the universe? Explain your arguments.

(e) Write the importance of gravitational force in the position of celestial bodies in the universe.

(f) Earth revolves around the Sun; Moon revolves around the Earth. They have their force of gravity as well as the gravitational force between them, but they never collide with each other. Clarify this with reasons.

(g) Explain the concept of a flat universe.

(h) In your opinion, what might be the future of the universe: open, flat or closed? Explain your answer with suitable arguments.

13 Information and Communication Technology

Fig. 13.1 TV with an antenna

Figure 13.2 TV connected with a cable

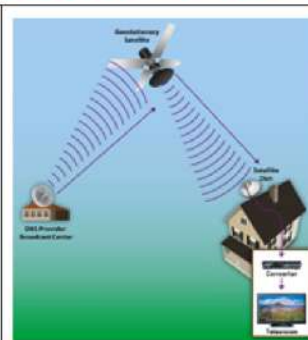


Figure 13.3 Dish TV

Antenna-powered television shown in Figure 13.1 is now replaced with Internet TV and Dish TV shown in Figure 13.2. Before Dish TV came into existence, cable TV like the one shown in Figure 13.2 was very popular. Among all the three types of TV mentioned above, the antenna-connected TV has the poorest audio-visual quality. In this type of transmission, the waves emitted from the transmitter lose energy to the surrounding as they pass through the air before reaching the user's home. Hence, they generate less p.d. on the antenna and the electrical current generated in the wire connected to the antenna also weakens. The same current acts as the modulated signal for television broadcasting.

The signal travelling through the wires similar to the one in Figure 13.4 gets converted to digital signals by the internal circuits of the television, and the audio-visual content is transmitted using these digital signals. In cable TV too, the signals travelling in the wire are the modulated signals. If a computer is to be used as a television by connecting the cable from the computer, it is necessary to have a cable modem. Dish TV, on the other hand, broadcasts digital signals received from the satellite.

In such broadcasts, digital signals must be converted back to analogue signals to regenerate signals that are visible to the eyes and audible to the ears. Thus, for the signal broadcasting, it is necessary to have a device that converts the analogue signals into digital signals and again the digital signals into analogue signals as shown in Figure 13.5.

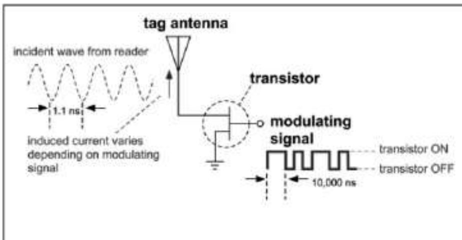


Fig. 13.4 Conversion of signals from the antenna into digital signals

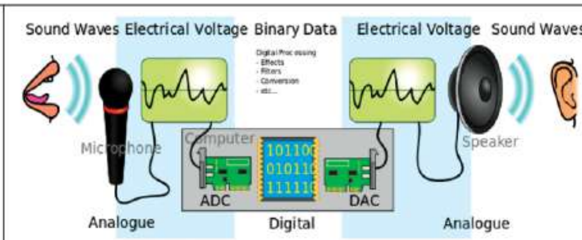


Figure 13.5 Conversion of analogue into digital and again digital into analogue signals

With the ease of transmission of digital signals, its uses have become more extensive in the field of information and communication. With this, a new terminology, 'Digital Native' (Digital Citizen), has been coined due to active participation and the changed behavior of people on social media. Courtesy and other positive behavior while doing online conversation improves people's online reputation. While online facilities can create many positive impacts, their improper use can badly impact our physical, mental, and emotional aspects.

Digital signal

Activity 13.1: Observation of Digital Signal Graph

As shown in Fig. 13.6, construct an electric circuit by connecting a 5 V alternating current source, a bulb, a switch, and conducting wire. If the potential difference between the two ends of the bulb is 5 V, while turning the switch on, then this voltage is considered as a high signal (1). When the switch is turned off, the potential difference between the two ends of the bulb becomes zero. This is considered as a low signal (0). Note the high signals and low signals generated in the circuit as time passes and record them in a table and draw graphs similar to the one shown in Figure 13.6.

समय	1	2	3	4	5
पोटेन्सियल फरक	0	1	1	0	...

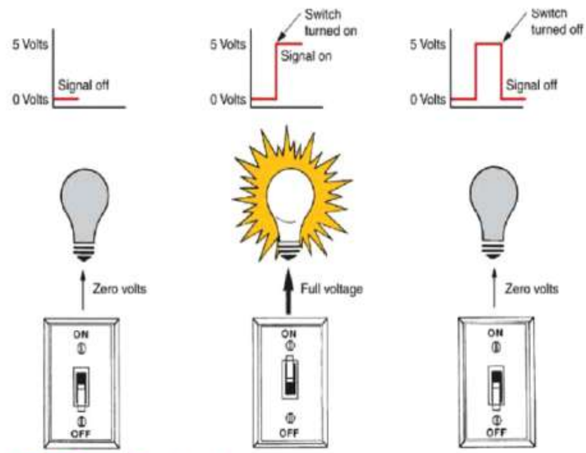


Figure 13.6 On-off signal

The physical quantity that changes with time is a signal. In activity 13.6, digital signals are created by turning the switch on and off. A special device, such as a transistor, is installed in electronic devices to create this type of signal. In the above activity, if the switch was not turned off and a graph of potential difference across two ends of the lightbulb against time were drawn, the voltage would have been seen increasing and decreasing continuously as shown in Figure 13.7. This is an analogue signal.

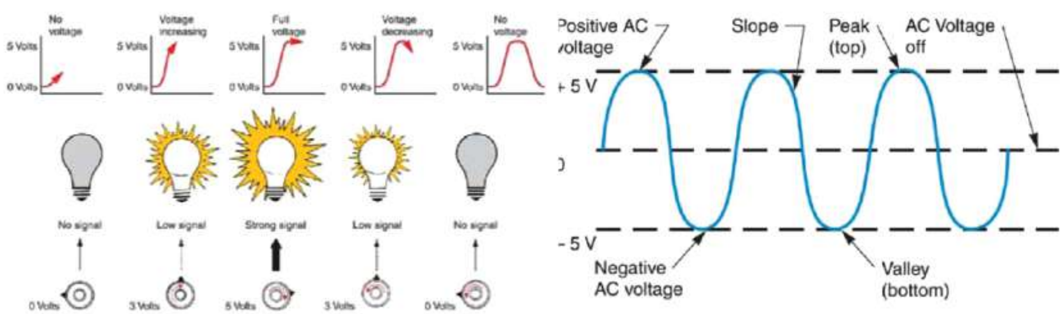


Fig. 13.7 Figure of the bulb showing fluctuation of voltage and related analogue signal

The digital signal is represented by only two digits (0, 1) and is used in the binary system. The combination of these two binary digits represents the digital signals. For example, as shown in Table 1, a binary number is a combination of only two digits, 0 or 1. There are four possible combinations of two binary digits. There are eight possible combinations of the three binary digits.

Table 1		Table 2			
Number of binary digit	**Possible combination**	**Binary number**	**Switches**	**Binary number**	**Switches**
1	0 1	0000		0011	
2	00 01 10 11	0001		0100	
3	000 001 010 011 100 101 110 111	0010		1010	

The digital signals shown in Table 2 indicate different data. This type of data is stored in the computer's memory. In the computer, memory capacity is determined according to the needs of the user. It can store a large amount of data permanently. Users can easily store data in different formats such as text, graphics, audio and video.

The storage capacity of computer memory is measured in the units like Bits, Bytes, Kilobytes (KB), Megabyte (MB), Gigabyte (GB), Terabyte (TB), etc. The relationship between these units is presented in the table below:

1 Bit (Binary Digit)	Binary 0 or 1	1024 kiloBytes	1 MegaBytes (MB)
4 Bits	1 Nibble	1024 MegaBytes	1 GigaBytes (GB)
8 Bits or 2 Nibble	1 Byte	1024 GigaBytes	1 TeraBytes (TB)
1024 Bytes	1 kiloBytes (kB)		

Let us know

Bit : A bit is a smallest form of data on a computer. It is short form of binary digit and it can be either 0 or 1.

Byte : A group of eight bits which works as a single unit of data in computer.

Difference between the digital signal and the analogue signal

Analogue signal	Digital signal
Analogue signal is a signal that indicates the constantly changing physical quantity.	The digital signal is the signal that represents the physical quantity that is changing in segments.
Analogue signal constantly changes with time.	The digital signal changes by any two fixed values continuously along with time.
Analogue signal is represented by a sine wave. For example; the signal that represents -5V to +5V is presented here.	The digital signal is indicated by a square wave. For example; the signal that represents 0V or 5V is presented here.
Analogue to digital converter, ADC changes analogue signal into a digital signal. For example; temperature sensor.	Digital to analogue converter, DAC changes the digital signal into analogue signal. For example; playing music on the computer.

Signal transmission

In our daily life, we communicate with sound as a medium. It is an analog signal. For example, in landline phones, analogue signal of communication is sent through the wire for effective transmission. In this way, the process of signal transformation through a medium or channel is called signal transmission. Similarly, communication can also be done by the transmission of signals created in the form of potential differences, electromagnetic waves, etc. In the traditional method of communication, analogue signals are used for communication.

For example, a radio broadcast using medium waves and the short wave is an analogue signal transmission. In this type of transmission, external effects like the mixing of other waves, atmospheric effects, etc. can make the transmitted signal unclear. Likewise, illegal recording of a telephone conversation that is transmitted in the form of analog signals is also possible. To avoid the problem of signal distortion and for signal protection analog signals are digitalized using various technologies. Digitalized signals make the given signals more clear and more distinct without changing the data. In a digital system, data can be stored, transmitted and recreated using a group of 0 and 1. In this system, data processing work is easier and the possibility of error in processing is very low.

Components of Digital Communication System

The components of digital communication are mentioned below in the block diagrams:

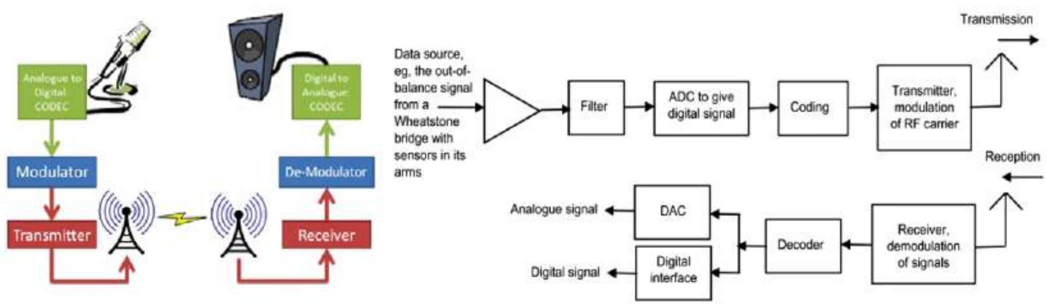


Figure 13.8 Digital Signal Transmission Process and Block Picture

(a) Source

Analogue signals, sound waves, for example, can be taken as a source for signal transmission.

(b) Input Transducer

The input transducer converts the received signals into an electrical signal. For example, a microphone converts sound into electricity.

(c) Encoder

The encoder compresses the data to a minimum number of bits. This process will help in the effective utilization of the available frequency range i.e., Bandwidth.

(d) Modulator

The modulator modulates the data to be transmitted by the carrier. These signals are directed to the medium, i.e., channel for transmission, after converting them into analogue signals. The analogue signals are generated from a digital sequence for transmission through channels or mediums.

(e) Channel

Channel or medium provides the way to the analogue signals up to the receiver after coming out from the transmitter.

(f) Demodulator

This is the first step on the side of the receiver. The signal received in the receiver is demodulated.

(g) Decoder

The received demodulated signals are re-digitized by the decoder. Thus removes the possible errors in the final output signals.

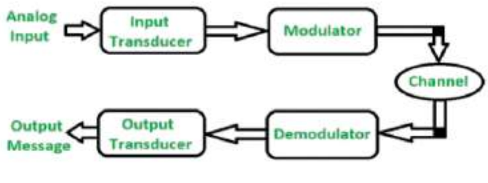
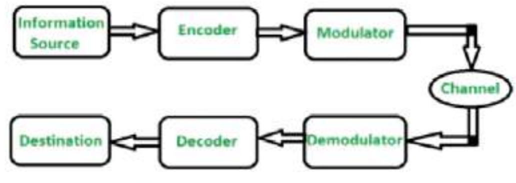
(h) Output transducer

It converts the decoded signals into the original physical signal sent through the source. It changes the electrical signals into physical output. For example, a loudspeaker converts current to sound.

(i) Output Signal

This is the result of the overall signal transmission process. For example, if the sound waves from a source are sent for transmission, the output is obtained as sound waves.

Difference between analogue communication and digital communication

Analogue communication	Digital communication
 Analog Communication System In analogue communication, data are transmitted between transmitter and receiver with the help of analogue signals.	 Digital Communication System The analogue signals are digitalized, transmitted, and then transformed again into analogue signals as output.
Signals through this transmission are highly affected by external influences.	Signals through this transmission are less affected by external influences.
Coding is not possible.	Coding is possible.
It needs small bandwidth.	It needs a large bandwidth.

Baseband transmission and broadband transmission

Baseband transmission means the transmission of digital signals through channels without conversion of digital signals into analogue signals. In this transmission, the process of sending and receiving the signals is done simultaneously in the same channel. It is done for short-distance transmission. For example, sending data from one computer to another one by connecting them with cables is baseband transmission.

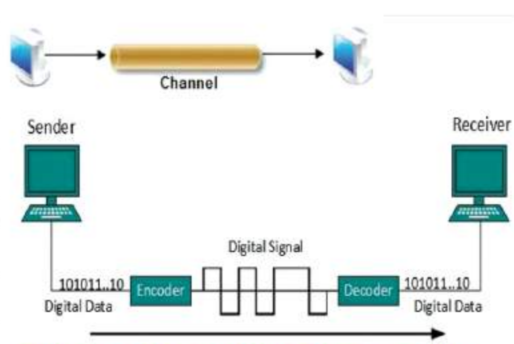


Figure 13.9 Baseband Broadcasting Channel

Activity 13.2

Open the internet browser in the internet-connected device (smartphone or laptop) available to you and search www.speedtest.net. As shown in the figure13.10, click on GO and find the speed of the internet that you are using.

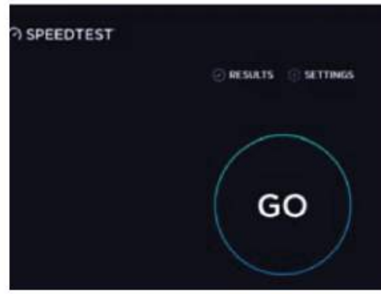


Figure 13.10 Broadband Internet Speed Test

Internet provider	Speed
Nepal Telecom (4G wireless home brand)	....
....	....

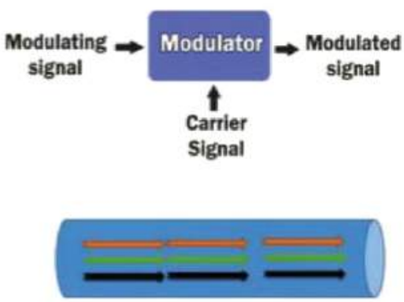


Figure 13.11 Broadband Broadcast Channel

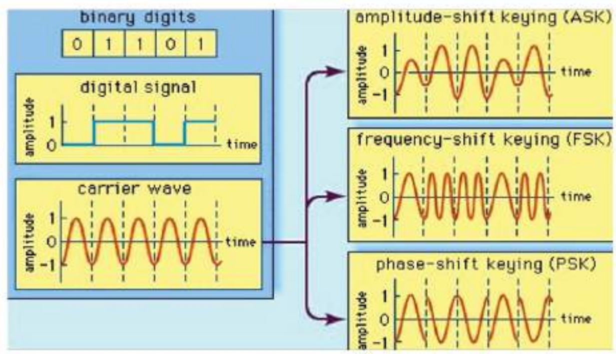


Figure 13.12 Digital Signal Modulations

Generally, in our language, broadband internet is regarded as high-speed internet. Broadband internet is the broadband transmission of data through various devices. Broadband transmission means the transmission of digital signals to a channel after converting digital signals into analogue signals. This type of transmission requires modulation. By broadband transmission, analogue signals can be transmitted in the form of optical or electromagnetic waves in various transmission frequencies. To send and receive signals, the transmission medium or channel gets divided into two separate channels. As an alternative to this, two separate cables can also be used for broadband transmission. This type of transmission is done for long-distance transmission.

Advantages of digital transmission

The main advantages of digital are as follows:

a. Deterioration and noise effects are very less in digital signals.

b. The circuits used for digital transmission are much more reliable.

c. It is cheap and easy to design digital circuits than the analogue circuit.

d. There is less possibility of signal overlap and cross-talk in digital transmission.

e. The properties of digital signals do not change in normal conditions.

f. The security of information can be maintained in digital transmission by encoding and compression.

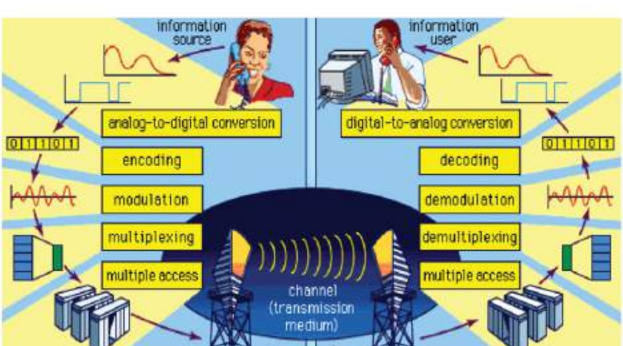
g. Since codes for finding and correcting errors are used, there is less chance of error during transmission.

Influence of digital technology on the development of information and technology

The development of digital technology has increased the quality of information and technology along with its prevalence in use. The modernization of telecommunication, internet facilities, digital media, digital TV, etc. has become possible due to the development of digital technology.

a. Digital telecommunication

Fast communication has become possible due to digital communication. Similarly, through a single channel or bandwidth many telephone calls can be transmitted.



b. Digital media

These days, various mediums are available for information and communication as shown in Figure 13.14. The electronic devices used for communication are digital media. The activities like creating new digital media, watching the news, and online information transmission can be done via electronic devices.

c. Digital TV

As shown in Figure 13.15, digital TVs are of different shapes and unique characteristics. High-definition TVs are made with the latest digital technology.

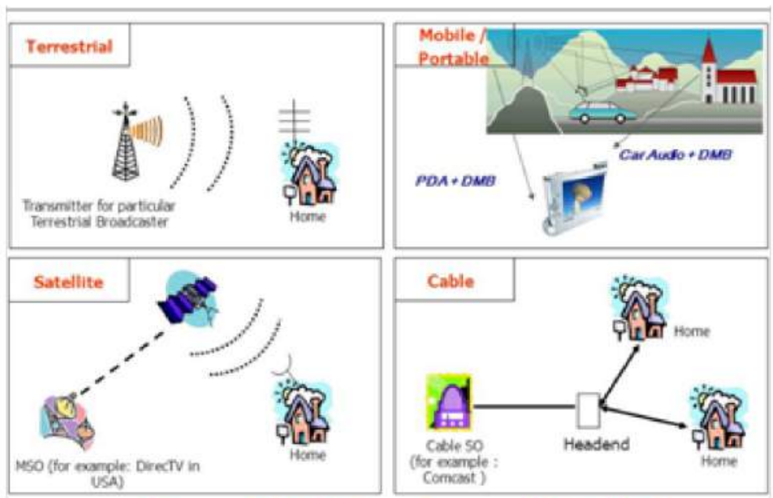


Figure 13.15 different types of digital TV

Dish TV has expanded its television service to different parts of the country.

Digital technologies used in daily life

 *Infrared and digital thermometer*	 *Calculator*	 *Online Newspaper*	 *Digital wallet*

Online library | *Speedometer* | *Digital camera* | *Smartwatch* | *Calendar*

fig 13.16

Digital devices, the product of the development of digital technology, have helped to make human activities very easy. As shown in the figure above, digital technologies are applicable in various fields such as education, health, entertainment, and finance. Although the use of digital technology can make life easier, its misuse and reckless use can also create problems.

Positive and negative effects of digital technology on daily life

With the continuous development of digital technology, the number of users also increases. Some of them can even change the lifestyle of the users. Some of the positive aspects of digital technology are as follows:

(a) Digital Library: Digital versions of textbooks and other reading materials are available in the digital library. It develops book-reading habits in people. For example, various textbooks and different reference materials are kept in the CDC library.

(b) Online newspapers: With the condition of availability of the internet and smartphones, different online newspapers can be read. For example, www.gorkhapatraonline.com is an online portal.

(c) Digital Payment: Digital payment solves the problem of people having to carry a lot of money for shopping. As shown in Figure 13.17, money can be sent to the seller's bank account by scanning the QR code. Digital payments can also be used to pay taxes, book bus and plane tickets, etc.

Figure 13.17 QR code in the market

(d) Online business: It can be used to promote and sell business materials through the Internet.

(e) Social Networks: Social networks have given people the opportunity to express their opinion in public. It connects people digitally even if they are far away physically.

(f) Entertainment: With the development of digital technology, various games and music applications are available for people's entertainment.

Digital media has a direct impact on our lifestyle. Some of the negative effects of digital technology are as follows:

(a) The people who spend an excessive amount of time online experience changes in their social behavior, i.e., the way of interacting with others.

(b) Crimes might be committed through social media and affect people's personal, family and social lives. When a person's reputation is damaged, it creates mental stress.

(c) Excessive use of digital material has reduced the consumption of physical material. This will result in the loss of business opportunities.

(d) Lack of physical exercise in children creates problems like obesity and weakness.

(e) Digital games containing murder and violence adversely affect the mental health and social well-being of an individual as well as spread antisocial activities.

(f) Misuse of digital technology causes harm to other people through activities such as cybercrime.

The use of the Internet plays an important role in creating the positive and negative effects of digital technology mentioned above. Since internet users around the world spend a long time engaging in various common activities, the term 'netizen' is used for such people.

Digital citizenship

In the present age of the internet, all people of the world have the same rights to use the internet and to actively participate in it. So, everyone can be introduced as a citizen of the net. A person who actively uses and engages in the internet is known as a netizen. The word netizen refers to a citizen of the internet. A netizen is therefore a citizen of a globally connected internet. Likewise, digital citizenship is the citizenship of the netizen in the virtual world of the internet. The concept of digital citizenship helps to improve the overall internet world. The development of digital technology has made it possible to connect citizens of different places of the world through different types of communication channels such as telephone, internet phone calls, social network communication, etc. As a result, the concept of global village has been developed.

Questions for discussion

What should be the characteristics of a good digital netizen like the characteristics of a good citizen of a state? List them on a chart paper and discuss them in class.

Characteristics of a good Netizen

The duties of a good netizen and internet etiquette are also connected with digital citizenship. The behavior displayed by netizens online should be socially acceptable. You should use polite and civilized language in online dialogues and communication through email, comments made public on social networks, etc. Online behavior should demonstrate personal respect and respect for others. Everyone should be treated with respect even if they do not see each other personally. Anything posted online is permanent. Intellectual property on the internet is someone else's product. Unauthorized use of such material is not permitted. If the material is to be used, the source must be cited.

Online Reputation

Reputation management is essential for netizens in the world of the internet just as reputation is connected to people's practical life. A person's real name, photo, and other publicly available details should be used on the online profile.

This shows the authenticity and reliability of the person's profile. Likewise, all social media profiles should have the same user name. The posts, comments, shares, etc. made by the same person in the real and virtual world on social networks show the person's knowledge, expertise, etc. For online reputation management, a person should be careful about internet security. Poor privacy settings on social networks lead to password theft and the possibility of posting content that harms the reputation of an individual.

Online reputation is not only personal but also associated with an organization. Information published on an organization's website and statuses posted on its social media pages are official. The number of followers of that page indicates the credibility of that organization. Similarly, presence on all major sites and social networks is required for institutional digital reputation. Online reputation can be managed by the timely resolution of comments and complaints made on institutionally opened websites and pages.

Digital wellbeing

Figure 13.18 Digital wellbeing

As shown in Figure 13.18, staying online for a long time without maintaining the necessary physical balance can be harmful to health. It can cause problems like obesity, insomnia, vision problems, and mental stress. Likewise, unregulated internet use can cause the problems such as depression, anxiety, dishonesty, low self-esteem, social isolation, loneliness, aggressiveness, etc.

Due to the existence of such problems, the concept of digital health is applied in our online life. The state of being healthy mentally, physically, socially, and emotionally by balancing the time spent on online and offline activities, is called digital well-being. When using online technology, we should take care of digital health and use it in such a way that it does not affect our overall health.

Figure 13.19 Balance for health

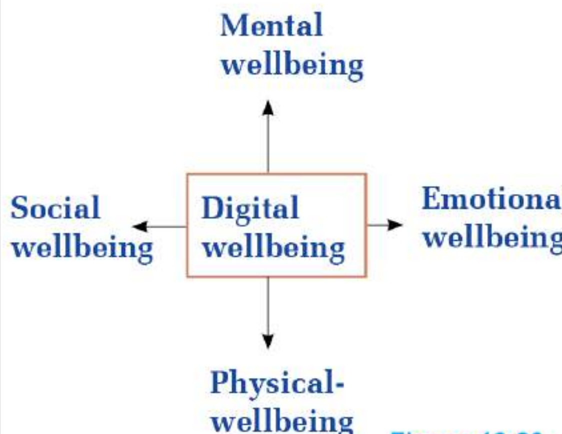


Figure 13.20

Cautions for Digital Wellbeing

Activity 13.3

On average, how much time do members of your household spend on the use of digital devices every day? Discuss the long-term effects of continuous use of digital devices and note down the possible effects.

Addiction to digital technology makes our lifestyle chaotic. Therefore, digital well-being skills are necessary to have awareness of the possible effects of the unnecessary use of digital technology. Digital well-being can be achieved by cultivating the habits such as separating screen time, setting time limits for social media use, and turning off mobile notifications at work. Awareness of digital well-being can be adopted by installing the digital well-being application on the smartphone. For example; the applications such as Beta, Action Dash, Digital Detox, Microsoft Launcher, etc. can be used.

Such applications help reduce the screen time of users.

Activity 13.4 Use of the Digital Wellbeing Application

Download the Digital Wellbeing application from the Play Store with the icon shown in Figure 13.21a. As shown in Figure 13.21 b, when it is opened, the time duration of the use of a particular smart phone by a user per day can be observed. Actions such as turning off notifications and setting a particular time interval for an application can be performed by the use of such applications. Also, mention other features that can be notified from the use of the installed application.

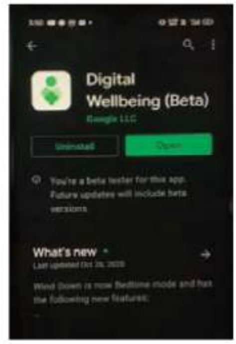


Fig 13.21a

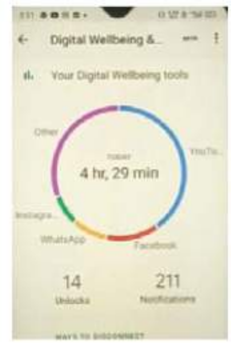


Fig 13.21b

Learning materials can be searched through the use of the Internet. While searching and observing for those materials, caution should be taken for digital well-being. For example, by visiting the website https://www.youtube.com/c/NCEDVirtual, one can get information on audio-visual content related to different subjects. In the same way, additional audio-visual materials can be designed by recording required audio-visual content.

Making audio and audio-visual materials

Audio content can be created by recording sound with the microphone of a computer or smartphone. Audio-visual content can also be created from camera recordings. A smart phone camera or a digital camera can be used for this.

Activity 13.5 Video recording

Take a smart phone, a spring balance and an object with a mass 500g such that it can be hung in the spring balance.

Take the spring with hanging mass and release it from a certain height. At the same moment, tell one of your friends to take a video in slow motion so that the position of the needle of the falling spring can be observed. Does the pointer of the falling spring balance on the video appear to return to zero?

In this activity, the video file extension is also added to the name of the recorded video file, such as class 10 ICT. MP4 file is a video file. Similarly, 3GP, SVI, MOV, etc. are also video file formats. If the audio-visual material recorded here is unnecessarily recorded at any point, the segment can be cut out from the video or more than two video file clips can be combined to form a single video file. This kind of work comes under video editing.

Video editing

A mobile application or software is needed to edit the video recorded by the camera. For example, video can be edited by using computer software like Adobe Premiere Pro and Filmora. Similarly, by using the Windows video editing software in the system software of a computer, a video can also be edited.

Activity 13.6 Video Editing

Copy the video recorded in activity 13.5 to the computer for editing. Remove the unnecessary section in the video. Similarly, combine the fragmented clips to create a complete file. For this, follow the steps given below:

(a) Video cutting

Cut the recorded video and prepare a short clip. Follow the following steps for this purpose.

First of all, launch the Video Editor by clicking on the search bar as shown in Figure 13.22. Click on New video project and type the project name. For example, type Class 10 ICT and click on OK.

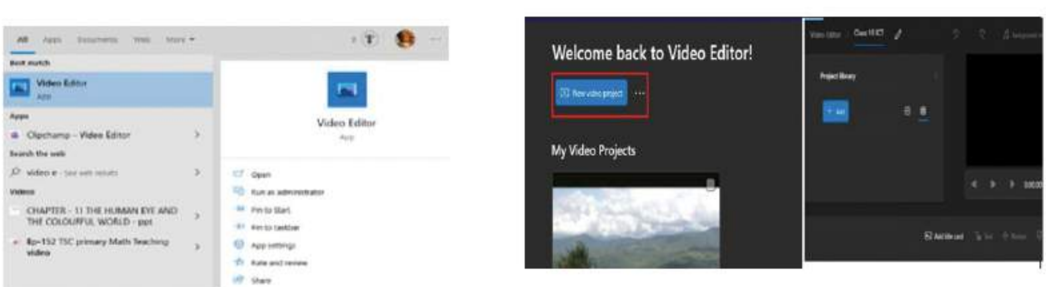


Figure 13.22

Select the video from the computer memory and add it to the project library by dragging it to the editing panel as shown in Figure 13.23. For the video cutting, select the video and click on trim.

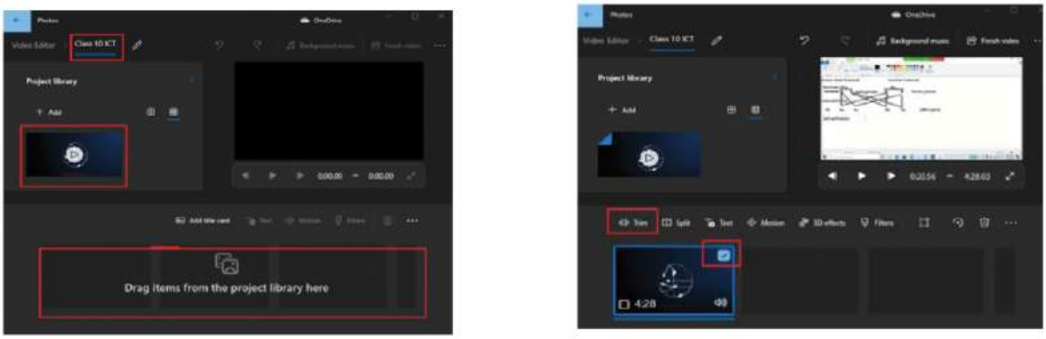


Figure 13.23

To choose the place where the video is to be cut, play the video. Then separate the start time and end time using two blue drag bars as shown in Figure 13.24. Finally, check the required clip length and click on done.

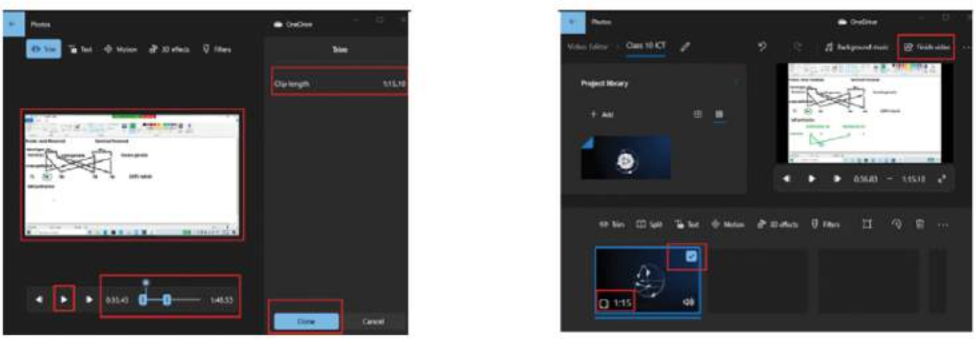


Figure 13.24

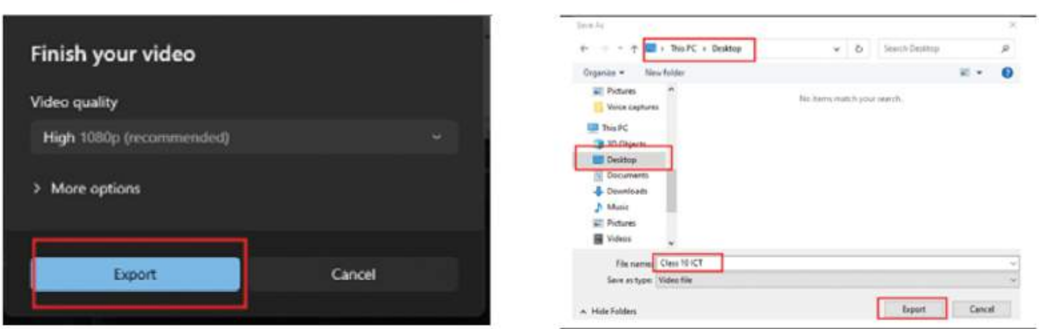


Figure 13.25

Select the cut clip in the editing panel and click finish video at the end. Then click on export in the window that appears. In the end, choose a location on the computer to save the video clip. In Figure 13.25, it is shown that the video file has been saved on the desktop.

(b) Video joining

Copy the clips cut and prepared by all your friends into a single folder. Select all the video clips to be joined and copy them to a single place on the computer. After that, open a video editing software, select the required file from the computer memory and add them to the project library. Select these videos and drag them to the editing panel. As shown in Figure 13.26, select all the files to be joined in the editing panel and click on finish video.

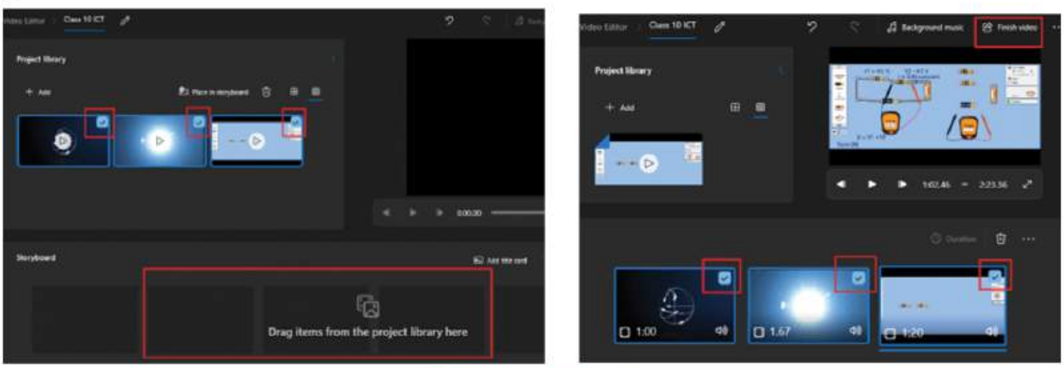


Figure 13.26 a, b

While clicking on the video, a location is to be chosen to save the file on the computer. For this, the video prepared by making clips can also be saved on the desktop, just like saving the file in Video Cutting.

Editing can be done on both computers and smartphones. Smartphones have a separate editing application. To edit the video recorded from the camera, it can be opened from the mobile gallery. While clicking on the video, an edit icon as shown in Figure 13.26 will appear. On clicking on that icon, the cut and crop icon will be seen as shown in Figure 13.26 b. The video can be cut or cropped by clicking on it.

If there is no video editing application on the phone, the required application can be downloaded from Play Store. The application file can be installed on the mobile by clicking on the downloaded location.

Just like editing the video using computer software, an audio file can also be edited. The file extensions of the audio file are MP3, WAV, WMA, etc. If software or application required for audio editing are not installed on the computer or smartphone, they can be downloaded and installed from the windows store, app store, etc. For example, to edit an audio file, audacity can be downloaded from ww.audacityteam.org. Similarly, mp3 cutter software can be downloaded from any official source by using Google search.

Project work

Prepare and conduct a debate programme among classmates on the topic 'use of digital technology has a positive impact on society'.

Exercise

1. Choose the correct option for the following questions.

(a) Which of the following represents an analogue signal?

(i) infrared ray thermometer

(ii) computer

(iii) smartwatch

(iv) medium wave radio

(b) ...... indicates 1byte memory.

(i) 0000 (ii) 00000000

(iii) 100000 (iv) 000001

(c) Which one of the following is the group of variables in the correct order among the steps of digital signal transmission?

(i) source, input transducer, decoder, modulator, channel, demodulator,encoder, output transducer

(ii) source, input transducer, encoder, demodulator, channel, modulator decoder, output transducer

(iii) source, input transducer, encoder, modulator, channel, demodulator decoder, output transducer

(iv) source, encoder, input transducer, modulator, channel, decoder, demodulator, input transducer

(d) Which of the following is an audio file format?

(i) SVI (ii) MP4

(iii) MP3 (iv) 3GP

(e) What does the behavior of posting information about new scientific discoveries from time to time on social networks indicate?

(i) unsystematic use of social networks

(ii) digital well-being skills

(iii) awareness of digital wellbeing

(iv) digital reputation management

2. Differentiate between:

(a) Analogue Signals and Digital Signals

(b) Analogue Signal Transmission and Digital Signal Transmission

(c) Digital Integrity and Digital Reputation

3. Answers the following questions:

(a) Define the bit and byte used in computer memory.

(b) Present the currently used high-speed internet as a Broadband transmission.

(c) Write four advantages of digital transmission.

(d) Explain the impact of digital technology on the development of information and communication technology with any two examples.

(e) Present any four examples of digital technology used in daily life.

(f) Write two positive and negative effects of digital technology in daily life.

(g) Define digital citizenship.

(h) Write four characteristics of a good netizen.

(i) What is online reputation? Write with examples.

(j) What is digital well-being?

(k) Write the advantages of digital well-being.

(l) What four precautions are necessary for digital well-being?

(m) What is digital reputation management?

(n) Give two examples of digital reputation management.

(o) Mention four importance of digital reputation management.

(p) Write two positive effects based on the use and utility of social media.

(q) Write two possible negative effects of using social media.

(r) Write your plan to make a 5-minute audio-visual material covering the topics included in any one unit under the science and technology of class 10. What can be done to make that audio-visual material of 3 minutes? Write, including, the necessary steps.

14

Classification of Elements

There are pure and impure matters around us. They are in the form of elements, compounds, and mixtures. Till now 118 elements have been discovered so far, among which 92 are natural and 26 are artificial.

Think and discuss these questions: Are all the elements made up of same type of atoms? Are the physical and chemical properties of one element similar to that of the other element? How has it made the study of elements easier? What is classification of elements? Why are the elements classified? What is the basis of classification of elements? The elements having similar properties are kept in one group and the elements having different properties are kept in different groups for classification.

Activity 14.1

Classify the elements used in our daily life like oxygen, iron, silver, sodium, chlorine, aluminium, carbon, sulphur and nitrogen as metals and non-metals and fill in the table.

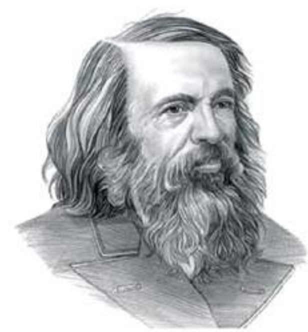
Metal	Non Metal

Do all metals have the same properties? Is there any relation between the atomic structure of elements with the similarity or differences between the properties of elements? Or how are the properties of elements related to the atomic structures?

Periodic table

The scientific table made for the study of elements by keeping elements of similar properties in the same group and elements of different properties in different groups is called a periodic table.

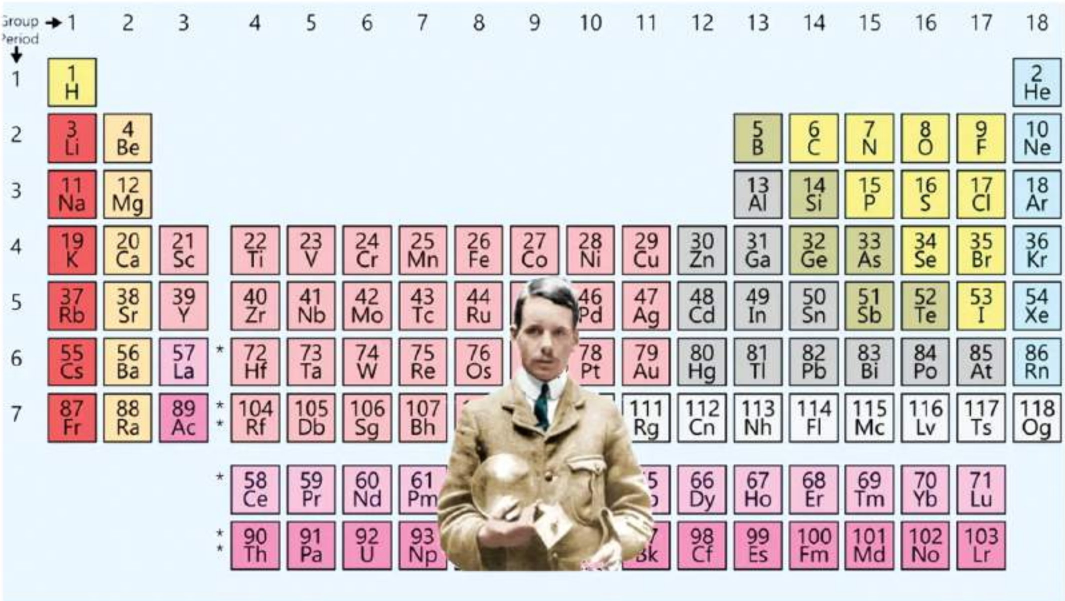
Russian scientist Dmitri Mendeleev had created a periodic table for the classification of elements by the scientific study of elements on the basis of their atomic weight. He had formulated a periodic law for the classification of elements on the basis of his study. This law is known as Mendeleev's Periodic law. It states that "The physical and chemical properties of elements are the periodic functions of their atomic weight."



It means that when the elements are arranged according to the increasing order of their atomic weights then their physical and chemical properties recur periodically. Elements with similar properties lie in the same vertical column and the elements with different properties in between them lie in a horizontal row. In this way a classification table for elements is made which is known as periodic table. The vertical columns of a periodic table are called groups and the horizontal rows are called periods.

Modern Periodic Table

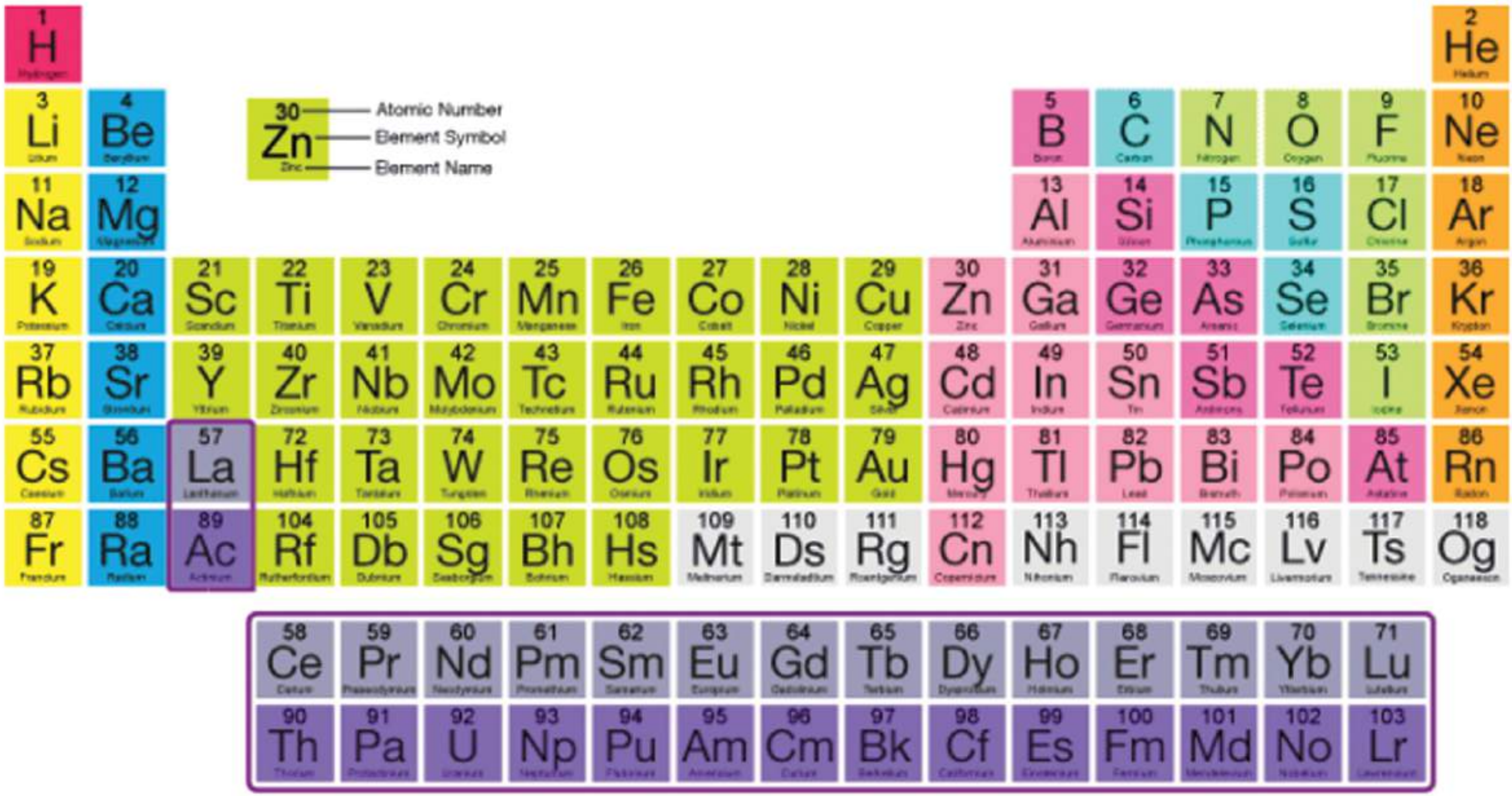
Mendeleev had considered atomic weight of elements as their fundamental property. Many complexities had been seen in the periodic table when the elements were classified on the basis of atomic weight. Some elements have more than one atomic weight, for example: C-12, C-13, and C-14 are the three forms or isotopes of carbon. Their atomic weights are 12, 13 and 14 respectively. The forms of the same element having different atomic weights are called isotopes. The number of protons in an atom is always constant whereas the number of neutrons may differ thus forming the isotopes. Mendeleev's periodic table was made on the basis of the atomic weight so separate spaces should be given for the isotopes of the same elements. However, he had allocated only one space for an element and had not given separate spaces for their isotopes. Similarly, his periodic law could not explain some other properties of the elements. After the detailed study, scientists went on to prove that atomic weight is not the fundamental properties of elements and kept searching for a new law for the periodic table.



Henry Moseley and Periodic Table

In this context, English scientist Henry Moseley in 1913 AD discovered that the properties of elements depend on atomic number rather than on atomic weight. He formulated modern periodic law on this basis. The modern periodic law can be stated as, "the physical and chemical properties of elements are the periodic function of their atomic number."

He had made a new periodic table on the basis of his periodic law. His periodic table is known as the modern periodic table or long form of periodic table. The elements have been arranged in the increasing order of their atomic number. In the modern periodic table also, the elements with similar properties are kept in the same vertical column which is known as a group. Similarly, elements with the increasing order of their atomic number are kept in horizontal row which is known as period.



Elements of the modern periodic table

Modern Periodic Table

Characteristics of modern periodic table

There are 7 periods in the modern periodic table. The elements in the same period have the same number of valence shells. The characteristics of modern periodic table can be listed as:

1. The elements are arranged in the increasing order of their atomic number in the modern periodic table.

2. There are 7 periods and 18 groups.

Period	Number of elements	Nature of period
First	2	Very short
Second	8	Short
Third	8	Short
Fourth	18	Long
Fifth	18	Long
Sixth	32	Very long
Seventh	32	Very Long

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIB	IVB	VB	VIB	VIIB		VIIIB		IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	AS	Se	Be	Kr

3. Modern periodic table has been divided into 18 groups according to the IUPAC system.

4. Metals are placed on the left side, non-metals are arranged on the right side and metalloids are kept in the middle of the modern periodic table.

5. There are alkali metals in group IA, alkaline earth metals in group IIA, transitional metals from group IIIB to IIB, halogens in group VIIA and noble gases in group 0 (18).

6. The group of 15 elements from Lanthanum (La), atomic number 57 to Lutetium (Lu), atomic number 71 are called lanthanides. Similarly, the group of 15 elements from Actinium (Ac), atomic number 89 to Lawrencium (Lr), atomic number 103 are called lanthanides. They are kept separately below the main block of the periodic table.

7. The elements from groups IB to VII B along with three columns of group VIII B (altogether 10 columns) are kept between metals and nonmetals. These are called transition metal.

8. The elements are classified as s, p, d or f blocks according to their electronic configuration based on sub-shell.

Activity 14.2

Study the modern periodic table. Prepare the periodic table in cardboard paper or chart paper. Keep separate colours for the groups and discuss the prepared table.

Activity 14.3

Prepare a periodic table as shown below and arrange the elements from atomic number 1 to 20. Show the alkali metals, alkaline earth metals, halogens and inert gases with different colours.

IA	IIA	IIIA	IVA	VA	VIA	VIIA	0

Electronic configuration of elements based on sub shells

Electronic configuration of elements based on sub shells

The path in which electrons revolve around the nucleus of an atom is called orbit or shell. A shell may be divided into one or more subshells. There are one or more orbitals in a subshell. Electrons are found in these orbitals.

As all the properties of elements could not be explained using the electronic configuration of elements based on shells, scientists developed the electronic configuration of elements based on the subshells through their research. There are 1, 2, 3 and 4 subshells in K, L, M and N shells respectively. The subshell in K shell is denoted as 1s. Similarly, 2s and 2p are the subshells of L shell, 3s, 3p, and 3d are the subshells of M shell. 4s, 4p, 4d, and 4f are the subshells of N shell.

s, p, d, and f subshells can accommodate a maximum of 2, 6, 10, and 14 electrons respectively.

Example: 14.4 a

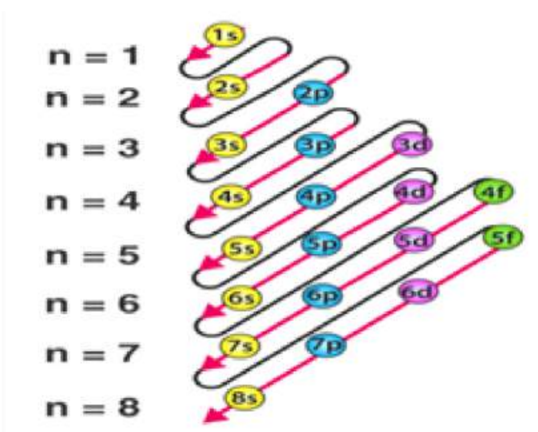
Subshell	**Shell**	**Subshell**	**Total electrons in shell**
1	K	$1s^2$	2
2	L	$2s^2$, $2p^6$	8
3	M	$2s^2$, $2p^6$, $3d^{10}$	18
4	N	$4s^2$, $4p^6$, $4d^{10}$, $4f^{14}$	32

Table 14.4 b electronic configuration of elements on the basis of their subshell

Atomic Num ber	Elements	Symbol	Electronic configuration				
			based on shells		based on sub shells		
			K	L	M	N	
1	Hydrogen	H	1				$1s^1$
2	Helium	He	2				$1s^2$
3	Lithium	Li	2	1			$1s^2$, $2s^1$
4	Berylium	Be	2	2			$1s^2$, $2s^2$
5	Boron	B	2	3			$1s^2$, $2s^2 2p^1$
6	Carbon	C	2	4			$1s^2$, $2s^2 2p^2$
7	Nytrogen	N	2	5			$1s^2$, $2s^2 2p^3$
8	Oxygen	O	2	6			$1s^2$, $2s^2 2p^4$
9	Fluorien	F	2	7			$1s^2$, $2s^2 2p^5$

10	Neon	Ne	2	8			$1s^2$, $2s^2 2p^6$
11	sodium	Na	2	8	1		$1s^2$, $2s^2 2p^6$, $3s^1$
12	magnesium	Mg	2	8	2		$1s^2$, $2s^2 2p^6$, $3s^2$
13	Alluminium	Al	2	8	3		$1s^2$, $2s^2 2p^6$, $3s^2 3p^1$
14	silicon	Si	2	8	4		$1s^2$, $2s^2 2p^6$, $3s^2 3p^2$
15	Phosphorus	P	2	8	5		$1s^2$, $2s^2 2p^6$, $3s^2 3p^3$
16	Sulphur	S	2	8	6		$1s^2$, $2s^2 2p^6$, $3s^2 3p^4$
17	Chlorine	Cl	2	8	7		$1s^2$, $2s^2 2p^6$, $3s^2 3p^5$
18	Argon	Ar	2	8	8		$1s^2$, $2s^2 2p^6$, $3s^2 3p^6$
19	Potsssium	K	2	8	8	1	$1s^2$, $2s^2 2p^6$, $3s^2 3p^6$, $4s^1$
20	Calcium	Ca	2	8	8	2	$1s^2$, $2s^2 2p^6$, $3s^2 3p^6$, $4s^2$

The electronic configuration of elements on the basis of subshells is guided by Aufbau's principle. Aufbau's principle states that electrons are filled in a subshell in the increasing order of energy of these subshells. The increasing order of energy of subshells or electrons are filled in subshells in the following order:



The order of subshells according to their increasing energies is:

1s< 2s< 2p < 3s < 3p < 4s < 3d < 4p<5s < 4d < 5p< 6s < 4f < 5d < 6p.....

The maximum number of electrons which s, p, d, and f subshell can accommodate are 2, 6, 10, and 14. The electrons could not be filled in 2s subshell till 1s subshell is not completely filled. So, electrons should be filled serially in the order:

1s, 2s2p, 3s 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p....

Activity 14.4

Study the table and complete it:

shell	subshell	Maximum number of electrons accommodated in subshell	maximum number of electrons in the shell
K	1s	2	2
L	2s		2 + 6 = 8
	2p	6	
M	3s		
	3p		
	3d	10	
N	4s		
	4p		
	4d		
	4f	14	

Study the prepared table and explain the relationship between electronic configuration based on shell and subshell.

Classification of elements in modern periodic table

Study the prepared table and explain the relationship between electronic configuration based on shell and subshell.

The elements are classified in the modern periodic table on the basis of their properties.

Activity 14.5

1. Write the electronic configuration of hydrogen, alkali metal, and halogen.
2. Write the similarities between the electronic configurations of hydrogen, halogen, and alkali metals.

3. What are the differences between the electronic configurations of hydrogen, halogens and alkali metals?

4. Which group of the periodic table is suitable for hydrogen? Discuss and draw a logical conclusion.

Metals, nonmetals and metalloids

Elements are classified into three groups i.e., metals, nonmetals, and metalloids on the basis of their metallic characters.

Metal

Metals are placed on the left side of the modern periodic table. All the elements of group IA to IIIA (except boron) are metals. The metals of group IIA and IIIA are less reactive than the metals of group IA. The elements of group IIIB to IIB are less reactive transitional metals. For example: Fe, Co, Ni, Ag, Au, Hg, Zn etc. Their properties lie between the active metals and nonmetals so they are also known as transitional metals. Metals are the good conductors of heat and electricity.

The elements having one electron in their outermost shell lie in group IA. Elements like Li, Na, and K lie in this group. These are the reactive metals. They form a strong base or alkali when dissolved in water so they are also known as alkali metals. Their valence shell electronic configuration is ns1. Here 'n' denotes the shell. For example, the electronic configuration of sodium is $1s_2$, $2s_2$ $2p_6$, $3s_1$. The elements of this group are soft and have less density.

The elements having two electrons in their outermost shell lie in group IIA. The elements like Mg and Ca lie in this group. Their valence shell electronic configuration is ns2. For example, the electronic configuration of magnesium is $1s_2$, $2s_2$ $2p_6$, $3s_2$. The elements of this group are known as alkaline earth metals because the oxides of these metals are soluble in water and they are found on the earth's surface.

Non-metal

Nonmetals are kept on the right side of the periodic table. Group of elements of VA, VIA and VIIA along with elements of group VIIIA or 18 (0) are non-metals.

The elements having seven electrons in their valence shell are kept in group VIIA (17) of the modern periodic table. Elements like F, Cl, Br, I lie in this group. These elements easily take part in reaction to gain one electron from others to fulfil their valence shell with eight electrons. So, they are very reactive. The outermost electronic configuration of these elements is given as ns^2np^5. For example, the electronic configuration of chlorine is $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^5$. The elements of this group (F, Cl, Br, I) are called halogens. The elements of this group are soft and have less density. These are the most reactive nonmetals.

The elements having eight electrons in their valence shell and two electrons in their first shell which is also their valence shell are kept in group 0. The elements like He, Ne, Ar, Kr, Xe and Rn are kept in this group. The valence shell electronic configuration of these elements are denoted by ns^2 np^6. For example, the electronic configuration of Argon is $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^6$. These elements are also known as noble gases or inert gases. Since they have octet state in their valence shell, they do not take part in chemical reactions so they are known as inert gases.

Metalloid

The elements which lie between metals and nonmetals in the periodic table and show some properties similar to metals and some properties similar to nonmetals are called metalloids. They are the poor/semiconductors of electricity. Their electrical conductivity is less than metals and more than nonmetals. Silicon (Si), Germanium (Ge), Bismuth (Bi) etc. are metalloids.

Activity 14.6

Study the modern periodic table. Fill the elements from atomic number 1 to 20 in groups IA to 0. Use different coloured inks for filling the names of metals, nonmetals and metalloids. Demonstrate the model of your periodic table in your classroom.

Characteristics of period and group in periodic table

The properties of elements depend on the group and period of that element in the periodic table. It is due to this fact that the periodic table is important to study the properties of the elements. Periods and groups have their own properties in the periodic table.

A. Valency

The outermost shell of an atom is called its valence shell. The electron present in the valence shell of an atom is called valence electron. There is change in the electronic configuration of elements as we move from left to right in a period. Although the number of shells is the same in a period, the number of valence electrons goes on increasing due to which the valency of elements changes even in the same period. So the valencies of elements in a period as we move from group IA to VIIA and group 0, are 1, 2, 3, 4, 3, 2, 1, and 0 respectively.

The valency of an element is determined by the number of valence electrons. All the elements of a group have the same valency. The valency of elements of group IA and VIIA is 1 and that of elements of group IIA and VIA is 2. Similarly, the elements of group IIIA and VA have their valency 3 generally.

Activity 14.7

Write the elements of group IA and 3rd period in vertical column and horizontal row respectively as in the periodic table and write their electronic configuration. Write similarities and differences in their properties on the basis of their number of shells and valencies.

What changes are seen in the valencies as we move from top to bottom of a group and left to right of a period in the periodic table? Draw a conclusion.

A. Atomic size

The atomic size of elements decreases from left to right of a period. The number of protons and electrons increases with the increase in atomic number while the number of shells remains the same. So, the increased electrons are filled in the same shell. Similarly, due to the increase in the number of protons, the positive charge of the nucleus also increases and the electrons in the shell are attracted with more force. As a result, the atom gets contracted. So, the size of atoms is decreased from group1 to 18 in a period.

Atomic size is determined by the distance of the valence shell from the nucleus of that atom. For example, Lithium atoms have K and L shells whereas sodium atoms have K, L, and M shells. So, the size of the sodium atom is more than the size of the Lithium atom in group IA.

Activity 14.8

1. Draw the atomic structure of Li, Be, B, N, and C.
2. Arrange these elements in the increasing order of their atomic size.
3. Draw the atomic structure of K, Li, and Na.
4. Arrange these elements in the increasing order of their atomic size.
5. What are the changes in atomic size as we move from left to right in a period and top to bottom in a group? Draw conclusions from it.

C. Electropositivity and electronegativity

The property of an element to lose its valence electrons and form positive ions (cations) is called electropositivity. The property of an element to gain electrons in its valence shell to form negative ions (anions) is called electronegativity. The atomic size of elements decreases from left to right of any period so their electron losing capacity decreases along the period whereas their capacity to gain electrons increases accordingly. Due to this, the electropositivity or metallic character of elements decreases from group 1 to 18 of any period whereas their electronegativity or nonmetallic character increases.

As we move from top to bottom of a group, the tendency of elements to lose electrons increases due to the increment in their atomic size. So, their electropositivity character also increases. But their capacity to gain electrons decreases due to the increase in distance from the nucleus. Hence, electronegativity decreases down a group.

Activity 14.9

1. Write the electronic configuration of Na, Mg, Al, Si, P, S, and Cl.
2. Arrange these elements in the increasing order of their electronegativity.
3. Similarly arrange them in the increasing order of their electropositivity.

4. Write the electronic configuration of Be, Mg, and Ca.
5. Arrange them in the increasing order of their electropositivity.

Draw conclusions from this activity by observing and studying the periodic table also and present it in the class.

d. Chemical reactivity

The chemical reactivity of metals decreases along a period whereas the chemical reactivity of nonmetals increases along a period. But the element in the extreme right of a period is inert. For example, let us study the second period of the modern periodic table:

Atomic number	11	12	13	14	15	16	17	18
Element	Na	Mg	Al	Si	P	S	Cl	Ar
Number of valence electron	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

As we can see, the atomic number increases from left to right in the third period. The number of protons and electrons also increases accordingly while the number of shells is the same. The electrons go on adding inthe same shell. The number of protons also increases inside the nucleus due to which the attraction force of the nucleus also increases. Hence, the electrons in the shell are attracted more towards the nucleus. Due to this, atoms contract. Thus, sodium has the largest size among the elements given above. And sodium is the most electropositive or the most reactive metal in the third period. Argon is the smallest among them but it is an inert gas so chlorine is the most electronegative or most reactive nonmetal among them.

The chemical reactivity of metals increases from top to bottom of a group whereas the reactivity of non-metals decreases. The size of elements increases down a group due to which they can easily lose their valence electrons so the reactivity of metals increases. For example, the reactivity of group IIA elements increases in the order of Be $<$ Mg $<$ Ca. The tendency of nonmetals to gain electrons decreases when their size increases. So, the chemical reactivity of nonmetals decreases down a group. For example, the reactivity order of nonmetals of group VIA is O $>$ S $>$ Se.

Project work

1. Make the atomic models of Lithium, Sodium and Potassium using clay or paper or any other suitable materials. Make the size of sodium larger than that of lithium and size of potassium larger than that of sodium. Observe these atomic models and discuss the properties of group IA of the periodic table.

2. Make the atomic models of elements of the second period like Lithium, Beryllium, Boron, Carbon, etc.using clay or paper or any other suitable materials. Discuss the properties of the second period on the basis of these models and present in the classroom.

Exercise

1. Choose the correct option for the following questions.

a. In which group do the elements having electronic configuration $1s^2$, $2s^2$ $2p^3$ lie?

(i) III A (ii) III B

(iii) V A (iv) V B

b. What are the elements between groups IIA and IIIA called in the modern periodic table?

(i) Alkali metals (ii) Transition metals

(iii) Alkaline earth metals (iv) Rare Earth metal

c. Which one of the given nonmetals are the most reactive?

(i) Fluorine (ii) Chlorine

(iii) Bromine (iv) Iodine

d. Which one of the given metals are the most reactive metals?

(i) Lithium (ii) Sodium

(iii) Potassium (iv) Cesium

e. Which group does the inert gases belong in the modern periodic table

(i) 0 (ii) IA

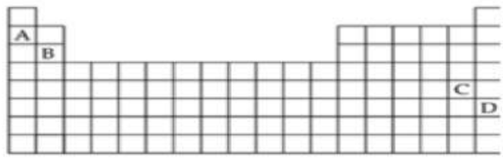
(iii) VIIB (iv) VIIA

f. Which one represents the correct order of increase in chemical reactivity of metals?

(i) Be < Mg < Ca (ii) Na < Li < K

(iii) Mg < Al < Si (iv) C < O < N

g. The position of elements A, B, C, and D are shown in the periodic table. Which of them can form acidic oxide?



(i) A (ii) B

(iii) C (iv) D

2. Give reason:

a. Classification of elements is necessary.

b. The size of atoms increases on going from top to bottom in a group of the periodic table.

c. The size of atoms decreases on going from left to right of a period in the periodic table.

d. Hydrogen is a non-metal but it is kept with metals in the modern periodic table.

e. Potassium is more reactive than sodium.

f. Fluorine is more reactive than chlorine.

g. The metallic characters of elements decrease and non-metallic characters increase on going from left to right of a period in the modern periodic table.

h. Inert gases are kept in group 0 of the modern periodic table.

i. A portion of the periodic table is shown below. The atomic size decreases from Li to Ne.

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
Li	Be	B	C	N	O	F	Ne

3. Write the differences between:

a. Group and period

b. Chlorine and Sodium

c. Elements of group IA and VIIA

d. Electronegativity and electropositivity

4. Answer the following questions:

a. State modern periodic law.

b. How many groups and periods are there in the modern periodic table?

c. Write the position of sodium in the modern periodic table. Why is it known as alkali metal?

d. Write the position of following elements in the periodic table: alkali metals, alkaline earth metals, inert gases, transition metals, lanthanides, and actinides.

e. Write the electronic configuration of sulphur and write its position in the modern periodic table.

f. On which basis do the group and period are separated in the modern periodic table?

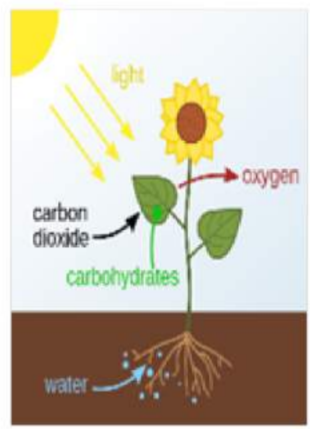
g. In which group does Fluorine, Chlorine, and Bromine lie in the periodic table? Which one is more reactive among them?

h. If you are given a chance to make improvements in the modern periodic table, what changes would you make in it? Explain with reasons.

15 Chemical Reaction

We have already studied about physical and chemical change in lower classes. What is physical change? What do you mean by chemical change? What are the differences between physical and chemical changes? What type of change is the rusting of iron, forming of curd from milk, cooking rice, burning of wood to formash, combustion of matchstick and photosynthesis? What do you mean by reactants and products? How many types of reactions are there? What are the types of chemical reactions? Discuss on these questions and draw conclusions. Similarly observe the figure given below and discuss the type of chemicalchange in them.





Activity 15.1

Observation of a chemical reaction:

Objective: To observe a chemical reaction

Materials required: a test tube, dropper, dilute hydrochloric acid, sodium hydroxide

Procedure:

1. Take a test tube in the laboratory.
2. Put about 10 drops of dilute hydrochloric acid in the test tube with the help of dropper according to the guidelines of your teacher.

$$N_2(g) + 3H_2(g) \xrightarrow{200\text{-}900atm} 2NH_3(g)$$

4. Surface area

If the surface area of contact of reactants is less, then the reaction takes place faster.Similarly, if the surface area of contact of reactant is more, then the rate of reaction is also more.

Activity 15.9

Objective: To observe the effect of surface area of contact of reactants on the rate of reaction.

Materials Required: two glasses, water, a capsule of vitamin C, and powdered form of the vitamin C capsule

Procedure:

1. Take two glasses.
2. Fill both glasses with same volume of water.
3. Put a capsule of vitamin C in one of the glasses and put a powdered form of the vitamin C capsule in another glass at the same time.
4. In which glass the reaction takes place faster? Observe and draw a conclusion.

Conclusion: ....

5. Light

Activity 15.10

Objective: To observe the effect of light on the rate of reaction

Materials Required: a beaker, hydrogen peroxide

Procedure:

1. Take a little amount of hydrogen peroxide in a beaker.
2. Place the beaker in sunlight for some time and observe the change in rate of the reaction.

3. Discuss about the causes of change of rate of reaction in sunlight and draw a conclusion.

Conclusion: ....

Some chemical reactions need light. The presence of light increases the rate of reaction.

$$6CO_2 + 6H_2O + \text{light} \xrightarrow[\text{chlorophyll}]{} C_6H_{12}O_6 + 6O_2$$

Carbon Dioxide water glucose oxygen

$$2AgNO_3 \xrightarrow{\text{Light}} 2NO_2 + O_2 + 2Ag$$

Silver nitrate nitrogen dioxide Oxygen Silver

Exercise

1. Choose the best option for the following questions:

a. What type of chemical reaction is the reaction between sodium chloride and silver nitrate?

i. Combination reaction

ii. Single displacement reaction

iii. Decomposition reaction

iv. Double displacement reaction

b. What type of reaction is $4Na + O_2 \rightarrow 2Na_2O$?

i. Addition reaction ii. Decomposition reaction

iii. Acid base reaction iv. Displacement reaction

c. Which substance is X in the given chemical reaction?

$HCl + X \rightarrow NaCl + H2O$

i. NaOH ii. Na

iii. NaH iv. $Na + H_2O$

d. What type of reaction is the heating of $CaCO_3$?

i. Combination reaction

ii. Singledisplacement reaction

iii. Decomposition reaction

iv. Double displacement reaction

2. Give reason:

i. Hydrogen peroxide is not stored in a transparent vessel.

ii. Acid base reaction is also known as neutralization reaction.

iii. The rate of chemical reaction is different according to type of the reaction.

3. Write differences between:

a. Single and double displacement reaction

b. Combination and decomposition reaction

4. Balance the following chemical reactions and mention their types.

a. $KClO_3 \rightarrow 2KCl + 3O_2$

b. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

c. $Fe + O_2 \rightarrow Fe_2O_3$

d. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

e. $Al + H_2SO_4 \rightarrow Al_2(SO4)_3 + H_2$

5. Answer the following questions:

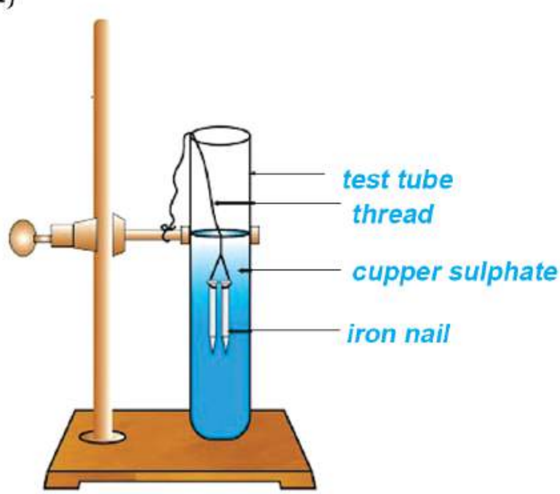
a. What do you mean by a chemical reaction? Explain with an example.

b. What is the rate of chemical reaction? Write any four factors which affect the rate of chemical reaction.

c. What do you mean by a displacement reaction? Write its two examples with their balanced chemical equations.

d. Write two examples of decomposition reactions with balanced chemical equations.

e. What is the type of chemical reaction occurring inside the test tube shown in the given figure? Write the balanced chemical equation of that reaction.(Reaction of cupper sulphate with iron)



f. Four students A, B, C, and D are allowed to carry out decomposition reactions in the laboratory. All of them perform it differently as given below.

i. Student A burnt magnesium(Mg) ribbon

ii. Student B mixed Zn in $FeSO_4$ solution

iii. Student C heated $KClO_3$ in a hard glass test tube

iv. Student D mixed Zn and HCl solution

Which student followed the correct procedure? Write the balanced chemical reaction of that process.

g. Samir burns a magnesium ribbon which is like a small strip or a ribbon. It burns brightly and forms white ash'A'. Write the name of substance 'A'. Write a balanced chemical reaction of the process.

3. Add about 10 drops of dilute sodium hydroxide in the test tube containing dilute hydrochloric acid.
4. Now, observe the change inside the test tube and draw a conclusion. Present the conclusion in your classroom.

Conclusion: ....

Chemical equation:

During a chemical change, there is loss and gain or sharing of electrons between the reactants where they either combine or decompose or exchange their ions to form products. Such a change process is known as chemical reaction. The chemical reaction in which the reactants and products are written in the form of words, symbols orchemical formula is known as chemical equation.

Activity 15.2

Study the balanced chemical equation given below. On this basis,discuss the questions given below and draw a conclusion. Present your conclusion in the class.

$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

a. Name the reactants and products.

b. How many atoms of each element are there in the reactants and products?

Types of chemical reaction

On the basis of types of reactants and products, chemical reactions are of following types:

1. Combination reaction

The chemical equation of combination reaction is of following type:

$A + B \rightarrow C$

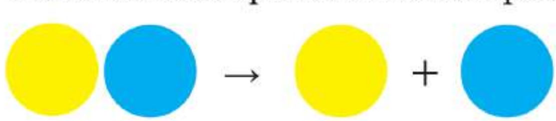
The chemical reaction in which two or more reactants combine to form only one product is called combination reaction.

Some examples of combination reaction are:

1.	$2Na$	+	Cl_2	$\rightarrow$	$2NaCl$
	Sodium		Chlorine		Sodium Chloride
2.	C	+	O_2	$\rightarrow$	CO_2
	Carbon		Oxygen		Carbon dioxide
3.	N_2	+	$3H_2$	$\rightarrow$	$2NH_3$
	Nitrogen		Hydrogen		Ammonia
4.	$2Mg$	+	O_2	$\rightarrow$	$2MgO$
	Magnesium		Oxygen		Magnesium Oxide
5.	$4Fe$	+	$3O_2$	$\rightarrow$	$2Fe_2O_3$
	Iron		Oxygen		Ferric Oxide

2. Decomposition reaction

The chemical equation of decomposition reaction is of following type:



$$AB \rightarrow A + B$$

The chemical reaction in which a reactant breaks down into two or more products is called decomposition reaction. A reactant decomposes due to the effect of heat, pressure or other causes. For example, let us observe some chemical reactions:

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

$2NaOH(s) \rightarrow Na_2O(s) + H_2O(l)$

$H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l)$

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

Activity 15.3

Study the picture given above and discuss the questions asked. Present your answers in the class:

a. What are the reactants and products in the chemical reaction given above?

b. What type of chemical reaction is it?

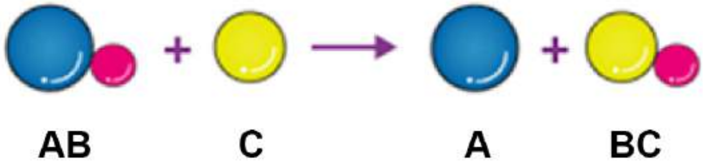
c. Write the balanced chemical equation of this reaction.

3. Displacement Reaction

The chemical reaction in which an atom or radical of one reactant is displaced by the atom or radical of another reactant is called displacement reaction. There are two types of displacement reaction.

i) Single displacement reaction

In a single displacement reaction, one element or radical displaces an element or radical of another compound.



AB	+	C	$\rightarrow$	A	+ BC
Compound		Element		Element	Compound

$Zn(s) + H_2SO_4\ (aq) \rightarrow ZnSO_4(aq) + H_2(g)$

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

$Cu + 2AgNO_3 \rightarrow 2\ Ag + Cu(NO_3)_2$

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$

$Br_2 + 2KI \rightarrow 2\ KBr + I_2$

Activity 15.4

Objective: Copper plating on an iron nail

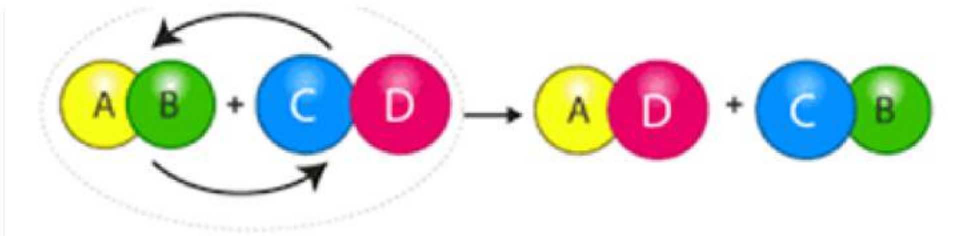
Materials Required: beaker, copper sulphate solution, iron nail, thread

Procedure:

1. Take a beaker and half fill it with copper sulphate solution.
2. Dip the iron nail into the solution and leave it overnight.
3. Observe the changes and discuss the following questions.
    a. What change do you observe?
    b. What are the reactants and products in this process?
    c. What type of chemical reaction is it?
    d. Write the balanced chemical reaction equation of this process.

ii) Double displacement reaction

The chemical reaction in which two new compounds are formed by the mutual exchange of atoms or radicals between two reactants is called double displacement reaction.



$$AB + CD \rightarrow AD + CB$$

NaCl + AgNO → AgCl + NaNO

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

$Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 + PbI_2$

4. Acid base reaction

Activity 15.5

Take half a glass of vinegar. Put lime water into it. Observe the changes that occur and discuss with your friends. Draw a conclusion and present it in your class.

The reaction in which acid and base reacts to form salt and water is called acid base reaction. It is also a type of double displacement reaction. In the acid base reaction, both the properties of acid and base are lost by each other and form neutral compounds. So, it is also known as a neutralization reaction.

Acid + Base → Salt + Water

HCl (acid) + $NaOH$ (base) → $NaCl$ (base) + H_2O (water

H_2SO_4 (acid) + $2NaOH$ (base)→ Na_2SO_4 (base) + H_2O (water)

KOH (base) + HNO_3 (acid) → KNO_3 (salt) + H_2O (water)

$$CaO \text{ (base)} + 2HCl \text{ (acid)} \rightarrow CaCl_2 \text{ (salt)} + H_2O \text{ (water)}$$

Rate of chemical reaction

The rate of different chemical reactions is different. Some reactions are fast whereas some reactions are slow. For example, the reaction between acid and base is fast whereas rusting of iron is a slow process. Thus, the change of reactants to products per unit time in any chemical reaction is known as the rate of that chemical reaction. At the initial stage of reaction, the concentration of reactants is maximum and the concentration of product is zero as no product is formed at that time. When the reaction starts then the concentration of product goes on increasing and the concentration of reactants goes on decreasing. Thus the concentration of both the reactants and products changes with time during the course of chemical reaction.

Activity 15.6

Objective: To observe the rate of chemical reaction

Materials: beaker, lemon juice, baking soda

Procedure

1. Take about 100 ml lemon juice in a beaker.
2. Put about 1 gram of baking soda inside that beaker and observe the change that occur.
3. Baking soda ($NaHCO_3$) is a base and lemon juice contains acid.
4. Observe the time of disappearance of baking soda.
5. Make a conclusion of the rate of chemical reaction between baking soda and lemon juice.

Conclusion:

....

Factors affecting rate of chemical reaction:

1. Catalyst

Activity 15.7

Objective: To observe the effect of a catalyst in the rate of chemical reaction.

Materials: test tubes, hydrogen peroxide (H_2O_2), Manganese dioxide (MnO_2)

Procedure:

1. Take two test tubes.
2. Put 5 ml of hydrogen peroxide in each of the test tubes with the help of your teacher.
3. Put 2g of manganese dioxide (MnO_2) in one of the test tubes.
4. In which of the test tube does the chemical reaction complete faster? Observe and draw a conclusion.

Conclusion:

....

The substance which increases or decreases the rate of chemical reaction is called a catalyst. These substances change the rate of chemical reaction but they do not undergo permanent chemical changeduring chemical reaction. The catalyst which increases the rate of reaction is called a positive catalyst. For example, Manganese dioxide (MnO_2), Vanadium Pentoxide (V_2O_5), iron (Fe),etc. are some positive catalysts. Similarly, the catalyst which decreases the rate of chemical reaction is called a negative catalyst. For example, Phosphoric acid (H_3PO_4) is a negative catalyst.

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

Here MnO_2 is positive catalyst

$$2H_2O_2 \xrightarrow{H_3PO_4} 2H_2O + O_2$$

Here H_3PO_4 is negative catalyst

2. Heat

Activity 15.8

Objective: To observe the effect of heat in rate of chemical reaction

Materials: two glasses, hot water, cold water, capsules of vitamin C

Procedure:

1. Take two glasses.
2. Fill one glass with 100 ml hot water and another glass with 100 ml cold water.
3. Put one capsule of vitamin C in each of the glasses at the same time.
4. In which glass does the reaction complete faster? Observe and draw a conclusion.

Conclusion: ....

Generally, the rate of chemical reaction increases with the increase in temperature.

$$2KClO_3 \xrightarrow{Heat} 2KCl + 3O_2$$

3. Pressure

The rate of reaction of gases depends on the pressure of the gases during a chemical reaction. Generally, the rate of reaction increases with the increase in pressure of the gases. So the reaction takes place with greater speed when the pressure is more.

16 Gases

You might have heard of the death of people due to suffocation during the cleaning of deep wells. Similarly, you mighthave felt breathlessness inside caves. What might be the cause of suffocation inside the well? What might be the cause of breathlessness inside the cave? Which gas is used in refrigerators? Why is this gas used there? What may be the answers of these questions, let's think for some time! We will discussthe gases like carbon dioxide and ammonia related to these questions in this chapter.

16.1 Carbon dioxide gas

Carbon dioxide is produced when coal, wood, kerosene, fat, oil, wax etc. burns and gets mixed in air. This gas is also produced during the respiration process of plants and animals, volcanic eruption, and decaying process of organic matter. Atmospheric air contains about 0.03% carbon dioxide by volume. Deforestation, and burning of fuel are the artificial sources of carbon dioxide in the atmosphere. Van Helmont had discovered carbon dioxide in 1630 AD by burning wood. Similarly, in 1755 AD, Joseph Black had prepared this gas by burning magnesium carbonate. Later Lavoisier proved that carbon dioxide gas as a compound of carbon and oxygen.

Fact about Carbon dioxide gas

Symbol	Molecular weight
CO_2	44

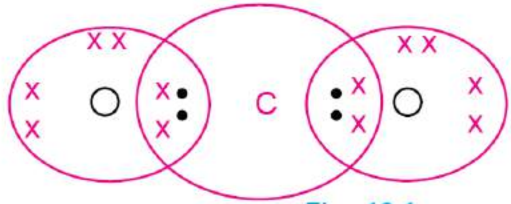


Fig. 16.1

Laboratory preparation of carbon dioxide gas

In laboratory carbon dioxide gas is prepared by the chemical reaction of limestone ($CaCO_3$) with dilute hydrochloric acid (dil. HCl).

Calcium Carbonate + dilute Hydrochloric acid → Calcium chloride + water + Carbon dioxide

$$CaCO_3(s) + 2HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2(g)$$

Apparatus required

Wolfe's bottle, gas jar, thistle funnel, delivery tube, rubber cork, and some test tubes.

Chemicals required

Limestone or marble pieces or calcium carbonate powder or egg shells, dilute hydrochloric acid, phenolphthalein, lime water, sodium hydroxide solution, blue litmus paper.

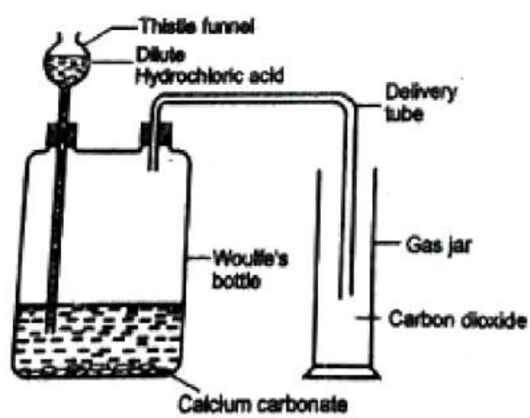
Method/Procedure

Practical activity: 1

a. Collect the apparatus and chemicals required for the preparation of gas.

b. Keep some pieces of limestone or marble pieces or calcium carbonate powder or egg shells into the Woulfe's bottle.

c. Arrange the delivery tube in one of the openings of the Woulfe's bottle and the delivery tube in another and make them airtight using rubber corks. Fix the delivery tube and thistle funnel in the opening of woulfe's bottle making it air tight with the help of rubber cork as shown in the figure.



Picture 16.2

d. Pour dilute hydrochloric acid into the Woulfe's bottle through the thistle funnel till it covers limestone or marble pieces or calcium carbonate powder or egg shells and opening of thistle funnel should be inside the acid layer.

e. Allow the gas to pass through the delivery tube and collect in the gas jar kept straight upright.

f. Observe the reaction between calcium carbonate and acid.

g. Carbon dioxide is formed during the reaction and the gas passes from Woulfe's bottle to the gas jar through the delivery tube. This gas being heavier than air, it is collected in the gas jar by the upward displacement of air.

Precautions

1. The end of the delivery tube should not be dipped into the acid.
2. The end of the thistle funnel should be dipped into the acid.

Test of gas

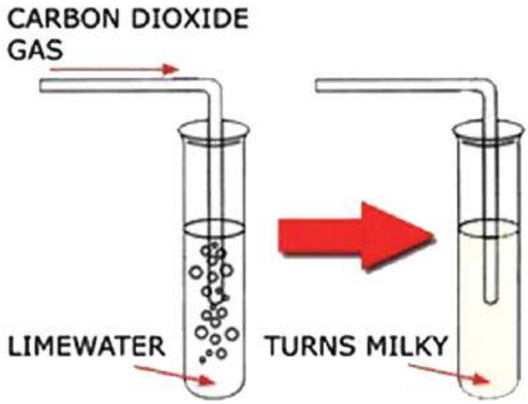
a. For a test of carbon dioxide, when a burning matchstick is brought near the mouth of the gas jar containing carbon dioxide, it extinguishes because carbon dioxide is neither combustible nor the supporter of combustion.

b. When a moist blue litmus is brought near the mouth of the gas jar containing carbon dioxide, it turns to blue. Similarly, when a few drops of phenolphthalein is put inside the gas jar, it remains colourless or unchanged. This proves that the gas inside the gas jar is carbon dioxide.

c. A little lime water is taken in a test tube and carbon dioxide is passed through it for some time, it changes to milky white. It is because of the formation of insoluble calcium carbonate as a result of the reaction of carbon dioxide and calcium hydroxide of the lime water. On passing carbon dioxide for a long time, the milky white colour disappears due to the formation of soluble calcium bicarbonate.

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s)\ (milky) + H_2O(l)$$

$$CaCO_3(s) + CO_2(g) + H_2O(l) \rightarrow Ca(HCO_3)_2(aq)\ (Colourless)$$



Picture 16.3

Properties of carbon dioxide gas

Physical properties

a. It is an acidic or non-metallic oxide which is colourless and odourless.

b. This gas dissolves in water to form carbonic acid, so it is sour in taste.

c. It is slightly soluble in water.

d. It is 1.5 times heavier than air.

e. It shows acidic properties and changes moist blue litmus paper red.

f. This gas is nontoxic, however, organisms die in the environment of carbon dioxide by suffocation due to lack of oxygen gas.

g. It can be changed to liquid at high pressure and low temperature.

h. When Carbon dioxide is cooled below -78^{0}c, it changes to solid form which is known as dry ice.

i. This gas is neither combustible nor it supports combustion.

Chemical properties

1. Carbon dioxide is neither combustible nor a supporter of combustion.

It helps to extinguish the fire. But when a burning magnesium is inserted into the jar full of carbon dioxide, it burns brightly and produces white powder of magnesium oxide (MgO) and black carbon powder.This shows CO2contains carbon.

$$2Mg\ (s) + CO_2\ (g) \rightarrow 2MgO\ (s) + C\ (s)$$

2. Carbon dioxide dissolves in water to form carbonic acid. This gas is mixed in soft drinks at high pressure to bring a sour taste in them.

$$CO_2\ (g) + H_2O\ (l) \rightleftharpoons H_2CO_3\ (aq)$$

3. When carbon dioxide gas is passed into lime water for some time then lime water turns milky white due to the formation of insoluble calcium carbonate.

$$Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)$$

Similarly, when this gas is passed into the lime water for a long time then the milky white colour disappears due to the formation of soluble calcium bicarbonate [$Ca(HCO_3)_2$].

$$CaCO_3\ (s) + H_2O\ (l) + CO_2\ (g) \rightarrow Ca\ (HCO_3)_2\ (aq)$$

4. When a few drops of KOH are added inside a test tube filled with CO_2 and inverted in water,the water level rises inside the test tube. During this process KOH absorbs CO_2 inside the test tube creating low pressure there rushing water into it.

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

5. Green plants prepare their food in the form of carbohydrates by the reaction of carbon dioxide absorbed from air and water absorbed by roots in the presence of sunlight trapped by chlorophyll in their leaves.

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Solar energy}} C_6H_{12}O_6 + 6O_2$$

6. Carbon dioxide reacts with red hot coke at 900° to form carbon monoxide.

$$CO_2 + C \rightarrow 2CO$$

Uses of carbon dioxide gas

1. Carbon dioxide is dissolved in soft drinks at high pressure.
2. Plants use carbon dioxide as a raw material for the preparation of their food.
3. This gas is used to extinguish fire. The device used to put off fire is called a fire extinguisher. Generally, a concentrated solution of sodium bicarbonate is placed inside the cylinder. A concentrated sulphuric acid is placed inside a glass vessel attached to a plunger near the mouth of the extinguisher. When the plunger is jerked, sulphuric acid gets mixed with sodium bicarbonate and carbon dioxide is produced which comes out with a very high speed and covers fire forming thick blanket. Due to this there will be a lack of oxygen and the fire gets extinguished.

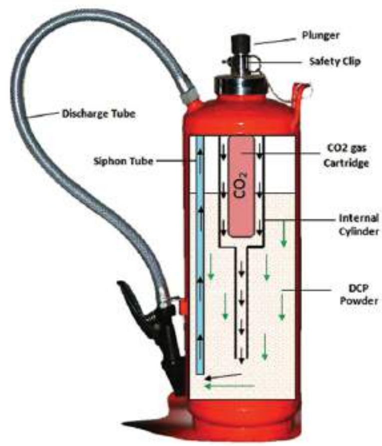


Fig. 16.4

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

4. Carbon dioxide is used to prepare dry ice which is used to preserve fruits, vegetables, meat etc. in lower temperatures.
5. Liquid carbon dioxide is used in the purification of sugar by the carbonation process in sugar mills.
6. It is also used to prepare urea (NH_2CONH_2), washing soda (Na_2CO_3), and baking soda ($NaHCO_3$).

7. It is used to make carbogen. Carbogen is a mixture of 95% oxygen and 5% carbon dioxide. Carbogen is used to treat patients suffering from pneumonia for their artificial respiration.

8. Green plants use carbon dioxide for photosynthesis.

$$6CO_2 + 6H_2O + \xrightarrow[\text{Chlorophyll}]{\text{Solar energy}} C_6H_{12}O_6 + 6O_2$$

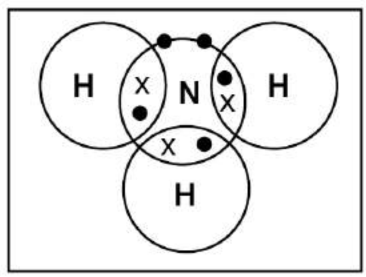
9. It is used in bakery products.

Ammonia

Ammonia is found in both free and combined states in nature. This gas is produced when nitrogenous substances decay in absenceof oxygen. Similarly, in combined form, ammonia gas is found in ammonium chloride and ammonium sulphate. Lavoiser had prepared this gas by heating the mixture of ammonium chloride and calcium hydroxide.

Fact about ammonia gas

Symbol	Molecular weight
NH_3	17



Picture 16.5

The molecular weight of ammonia is 17. The molecular weight of oxygen is 32, whereas the molecular weight of nitrogen is 28 and that of carbon dioxide is 44, so this gas is lighter than air.

Laboratory preparation of ammonia gas

In laboratory, ammonia gas is prepared by heating the mixture of ammonium chloride (NH4Cl) and calcium hydroxide [Ca(OH)2] in the ratio of 2:1 in a hard glass test tube.

Ammonium chloride + Calcium hydroxide → calcium chloride + water + ammonia

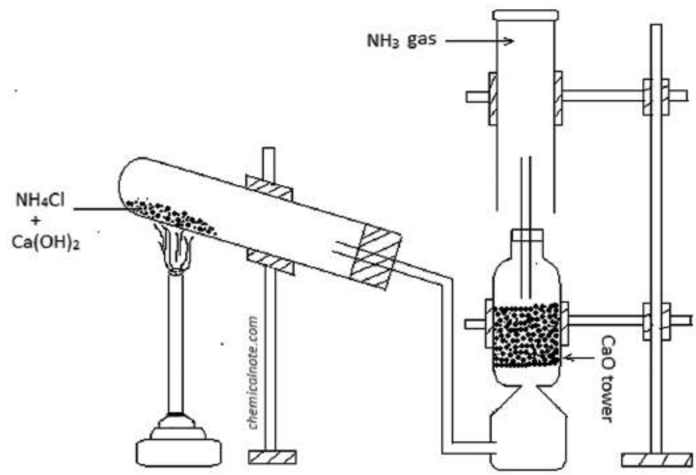
$$2NH_4Cl\,(s) + Ca(OH)_2\,(s) \rightarrow CaCl_2\,(s) + 2H_2O\,(l) + 2NH_3\,(g)$$

Apparatus required: Hardglass test tube, source of heat, gas jar, stand, lime tower, delivery tube, etc.

Chemicals required: Ammonium chloride andCalcium hydroxide

Method/ Procedure

1. Collect the apparatus and chemicals required for the laboratory preparation of ammonia gas.



Picture 16.6

2. Mix ammonium chloride and calcium hydroxide in the ratio of 2:1 and put the mixture into the hard glass test tube.

3. Fix a delivery tube in the mouth of the test tube with a rubber cork to make it airtight as shown in the figure. Arrange the hard glass test tube in a slightly inclined position with the help of a stand.Connect the other end of the delivery tube to the lime tower to obtain pure and dry ammonia gas.We can perform the experiment without lime tower to get impure ammonia.

4. Now heat the mixture gently and observe the formation of ammonia gas.

5. Lime tower filled with Calcium oxide (CaO) is used to obtain dry and pure ammonia. This gas is quite soluble in water so it is not obtained by the displacement of water. It is collected by the downward displacement of air as it is lighter than air.

Precautions

1. The mouth of the hard glass test tube should be slightly inclined downward so that the water vapour produced in this process passes to the lime tower through the delivery tube and prevents thehard glass tube from cracking.

2. The mouth of hard glass test tube should be airtight with the help of cork.

3. To obtain dry ammonia gas, the gas should be passed through a lime tower. Since the gas is highly soluble in water, it should not be collected by the displacement of water.

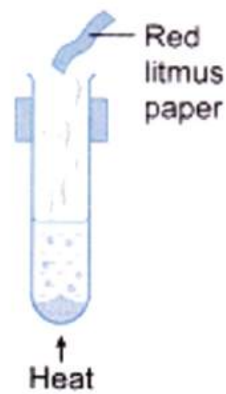
Do you know?

Calcium oxide absorbs moisture from ammonia. So, when ammonia is passed through the lime tower, we get pure and dry ammonia.

Test of the gas

1. The gas is basic so it changes moist red litmus to blue.

2. When a glass rod dipped to concentrated hydrochloric acid is brought near the mouth of a gas jar with ammonia, white fumes come out of it.



Picture 16.7

Properties of ammonia

Physical properties

1. It is a colourless gas. It has a strong and pungent odour like rotten egg.

2. It is lighter than air.

3. This gas is highly soluble in water.

4. It is a basic gas so it changes moist red litmus to blue.

5. Ammonia liquefies at -33.4°C and solidifies at -78° C.

Chemical properties

1. This gas is soluble in water. It forms ammonium hydroxide when dissolved in water.

$$NH_3\,(g) + H_2O\,(1) \rightarrow NH_4OH\,(aq)$$

2. Ammonia reacts with acids to form ammonium salts.

$$NH_3\,(g) + HCl\,(aq) \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl\,(aq)}$$

$$2NH_3(g) + H_2SO_4\,(aq) \rightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4\,(aq)}$$

3. Ammonia solution (NH_4OH) reacts with acid to form salt and water.

$$2NH_4OH\,(aq) + H_2SO_4\,(aq) \rightarrow (NH_4)_2\,SO_4\,(aq) + 2H_2O\,(l)$$

$$NH_4OH\,(aq) + HCl\,(aq) \rightarrow NH_4Cl\,(aq) + H_2O\,(1)$$

4. Ammonia and carbon dioxide react at a high temperature of 1500° and at high pressure to form urea.

$$NH_3\,(g) + CO_2\,(g) \xrightarrow[\text{pressure}]{1500^0\text{C}} NH_2 - CO - NH_2\,(s) + H_2O\,(1)$$

Urea is an important chemical fertilizer.

5. When ammonia burns in the atmosphere of oxygen, it produces nitrogen gas and water.

$$4NH_3\,(g) + 3O_2\,(g) \rightarrow 6H_2O\,(1) + 2N_2\,(g)$$

6. When a mixture of ammonia and oxygen is passed through the

platinum gauze at about 800°C, it produces nitric oxide.

$$4NH_3\,(g) + 5O_2\,(g) \xrightarrow[Pt]{800^0C} 6H_2O\,(1) + 2NO\,(g)$$

7. When ammonia is passed through the molten sodium then it forms sodamide and hydrogen gas.

$$2NH_3\,(g) + 2Na\,(S) \rightarrow 2NaNH_2\,(s) + H_2(g)$$

Uses of ammonia

1. This gas is used to make fertilizers like ammonium sulphate, ammonium nitrate, urea, ammonium phosphate, etc.
2. It is used in the manufacture of nitric acid, plastic, etc.
3. This gas is used to make washing soda.
4. It is used to make medicines of ammonium salts.
5. Ammonia is used to make the blue prints of maps.
6. It is used as a cooling agent in refrigerators.
7. It is used as a cleansing agent to remove the stains of oil, grease, etc.

Activity 16.1

Construction of fountain

Apparatus required: stand, dropper, rubber cork, round bottomed flask, glass tube

Chemicals required: dry ammonia gas, phenolphthalein

Method/Procedure:

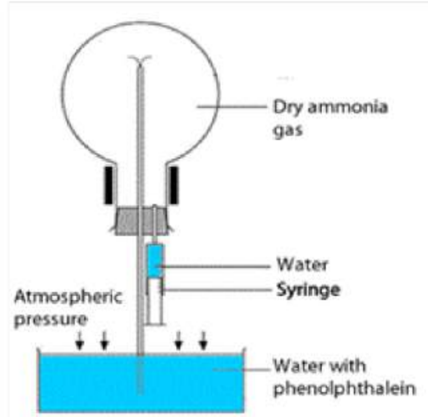
1. Collect the apparatus and chemicals required.

2. Set the apparatus as shown in the figure.

3. Fill a round bottom flask with ammonia gas and make it airtight.

4. Put a few drops of water inside the flask with the help of a syringe or a dropper.

5. This water combines with ammonia gas inside the flask creating vacuum.



Picture 16.8

6. The air pressure inside the flask becomes less due to which water with phenolphthalein from the beaker rushes upwards. The water mixes with ammonia and changes pink due to the formation of ammonium hydroxide which is basic in nature.

7. This experiment proves that ammonia is highly soluble in water.

Precautions

The bottle of liquid ammonia should be placed in cold water or ice before opening its lid. Ammonia is highly soluble in water.Due to the high pressure,ammonia solution may spill when its lid is removed.

Greenhouse effect

You might have felt hotter on cloudy nights than on clear nights. What may be the reason for it? Similarly, you might have seen plastic tunnels or glass houses in parks, botanical gardens, and agricultural farms. These are the examples of green houses. These houses, made of transparent glass or plastic, which stores the solar heat inside them and help in proper growth of plants and maintain greenery are called greenhouses. And the process of trapping solar energy inside a greenhouse increasing temperature inside them is called the greenhouse effect. Greenhouses may be artificial or natural. The earth is a natural greenhouse and the houses made of transparent glass and plastic are artificial greenhouses. What is the importance of greenhouses in our daily life? What happens if there are no greenhouses? What are the advantages of greenhouses? Let's think about these questions.

Picture 16.9

The process of heating earth's surface is called the natural greenhouse effect. When the solar radiation reaches the earth's surface, some of it gets reflected back and some of it is absorbed by the earth. The earth's atmosphere consists of layers of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chloro fluro carbons (CFCs), ozone (O_3), etc. These gases help to return some of solar radiation back to the earth's surface.

The layer of greenhouse gases is increasing in the atmosphere due to human activities, industrialization, and pollution. Due to this, more solar radiation is reflected back to the earth's surface and prevents the rays from escaping to space. Thus, human activities increase the greenhouse effect. It is necessary to have a layer of greenhouse gases in the atmosphere. If there were no greenhouse gases, the temperature of the earth would be very low. Due to which there would be no existence of life on the earth. The temperature of the earth has been increasing abnormally due to the increase of greenhouse gases in the atmosphere. As a result, we are facing climate change causing different negative impacts.

Question to think

What are the sources of carbon dioxide in the atmosphere?

Consequences of greenhouse effect

a. Increase in temperature

b. Change in water cycle

c. Negative impacts on human health

d. Decrease in agricultural productivity

e. Melting of snow in Himalayas and glaciers and decrease of snow

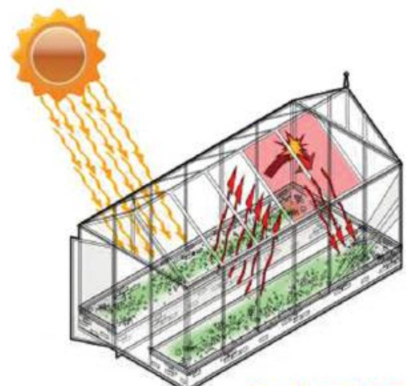
f. Increase in sea level causing sinking and flooding of coastal regions

g. Degradation in biodiversity

h. Desertification

i. Imbalance in the ecosystem

Artificial greenhouse



Picture 16.10

Picture 16.11

Artificial greenhouses are made of transparent plastic or glass which allow solar radiation to enter into them. They are also known as hot houses. The structure made of glass and plastic to keep plants is called a greenhouse. The short waves of solar radiation can enter the greenhouse where some of the energy is absorbed by the greenhouse and they change to long waves. These waves with long wavelengths cannot escape from there. These long wavelength radiations changes into heat energy. As a result, heat is stored inside the greenhouse causing temperature to increase inside it. This is known as the artificial greenhouse effect.

Activity 16.2

Objective: To observe the temperature difference inside and outside of a plastic

Materials Required: a box made of a transparent plastic, thermometer

Method/ Procedure

1. Take a box made of transparent plastic.
2. Keep the box in sunlight for an hour.
3. Then measure the temperature of air inside and outside of the box with the help of a thermometer and note down on a table. Discuss the following questions based on the observation and draw a conclusion.

a. What difference is seen in the temperature of air inside and outside of the box?

b. What is the cause of the difference in temperature outside and inside of the box?

Importance and utility of artificial greenhouse

There is warm temperature inside a greenhouse so plants of any season can be grown inside it. We can earn money by growing unseasonal vegetables inside it. The existence of plants which are going to extinct due to extreme cold climate can also be protected. Similarly, we can also conserve rare plants found in cold places. The importance and utility of greenhouse can be listed below:

a. Plants of any season can be grown inside it throughout the year.

b. It helps thefood crops in very cold places.

c. Greenhouses are useful to produce flowers, green leafy vegetables, fruits, and different types of plants.

d. Plants inside the greenhouses can control environmental pollution.

e. Summer plants can be grown in the winter season as well.

f. Plants grown in summer season can be grown in cold places too.

How is the earth a natural greenhouse?

The earth is surrounded by the atmosphere of gases like carbon dioxide, ozone, water vapour, etc. These gases allow the solar radiation to enter the earth's surface but do not let them escape after reflection.

So, the rays are trapped inside the earth.

In this way the greenhouse gases increase the temperature of the earth. It plays the similar role as glass in an artificial green house. Thus, we can say that the earth is a natural greenhouse.

Ways to decrease greenhouse effect on the earth

To decrease the greenhouse effect, the production and use of greenhouse gases must be controlled. For this, we can adopt following methods:

1. The production and use of chloro fluoro carbons must be fully banned.
2. The use of petroleum products and coal should be decreased while use of renewable energy sources should be increased.
3. The use of alternate sources of energy like hydroelectricity, wind energy, solar energy etc. must be promoted.
4. Trees should be planted.
5. Production of carbon dioxide must be reduced.

Acid Rain

What would happen if acid is dropped on a leaf? The monuments as shown in the picture, are being faded day by day. What might be the cause of it? Why is this happening? What must be done to prevent it? Let's think about these questions.

Activity

Takehalf-filled glass bottle with hydrochloric acid. Dip a piece of bone into it and keep it for a day. Cautiously take out the bone after a day and observe it. What do you find? Discuss it and draw a conclusion.

Picture 16.12

Acid rain was first confirmed in 1960 AD. The gases like sulphur dioxide, carbon dioxide, nitrous oxide, chlorine,etc. produced from various industries and vehicles get mixed with water vapour in the atmosphere and form acids like, sulphuric acid, Carbonic acid, nitric acid, hydrochloric acids etc. These acids come down along with rain water which is known as acid rain. Generally, rain water is acidic. Its pH is 6. The pH value of acid rain ranges 3 to 5.

$$2SO_2 + O_2 \rightarrow 2SO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Effects of acid rain on the earth

1. The acid rain fades the monuments like temples, buildings, statues etc. made from marble.

$$CaCO_3\,(s) + H_2SO_4\,(aq) \rightleftharpoons CaSO_4\,(s) + CO_2\,(g) + H_2O\,(l)$$

2. It increases the acidity of soil thereby decreasing productivity.
3. The acid rain gets mixed to water sources and affects the aquatic animals.
4. It causes skin diseases in humans.
5. It causes negative effects on human health.

Methods to prevent acid rain

1. Less production of oxides of nitrogen and sulphur
2. Use of renewable sources of energy in place of fossil fuel
3. Awareness raising about the causes and effects of acid rain

Exercise

1. Choose the correct option for the following questions:

a. What products are formed on heating of limestone to a high temperature using coal?

   i. Methane and lime

   ii. Lime and carbon dioxide

   iii. Acetylene and carbon dioxide

   iv. Ammonia and lime

b. Which of the following statements is true?

   i. Carbon dioxide is collected in the gas jar by the upward displacement of air.

   ii. Carbon dioxide is collected in the gas jar by the downward displacement of air.

   iii. Carbon dioxide is collected in the gas jar by the upward displacement of water.

   iv. Carbon dioxide is collected in the gas jar by the downward displacement of water.

c. Which compounds are formed when carbon dioxide gas is passed through lime water for some time?

   i. Calcium bisulphate   ii. Calciumbicarbonate

   iii. Calcium sulphate   iv. Calcium carbonate

d. In what ratio should ammonium chloride and calcium hydroxide be mixed for the laboratory preparation of ammonia gas.

   i. 3:1   ii. 2:3

   iii. 1:2   iv. 2:1

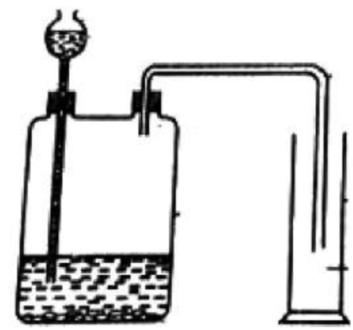
2. Give reason

a. Carbon dioxide can be collected in an open glass jar.

b. The bottle of liquid ammonia should be placed in cold water or ice for some time before opening its lid.

3. Answer the following questions:

a. Describe the laboratory preparation of carbon dioxide with a labelled diagram.



b. Study the given figure and answer the following questions:

i. Which gas is being collected in the gas jar?

ii. Write a balanced chemical reaction for preparation of this gas.

iii. Which litmus paper is used to identify the gas?

iv. Why is this gas collected in the gas jar kept straight upright?

c. Write any three properties of carbon dioxide gas.

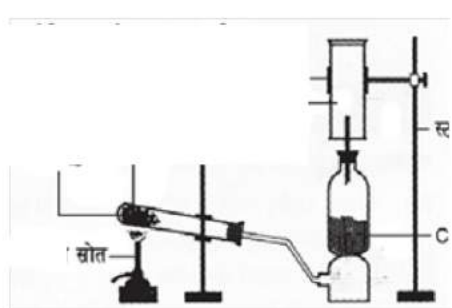
d. Write any four uses of carbon dioxide gas.

e. Describe the laboratory preparation of ammonia gas with a labelled diagram.

f. Study the given figure and answer the following questions.

i. Which gas is being collected in the gas jar?

ii. Write the balanc chemical equation iui the preparation of this gas.



iii. Which litmus is used to identify this gas?

iv. Why the hard glass test tube is slightly inclined?

v. What is the use of the lime tower?

g. Write any four uses of ammonia gas.

h. What happens in the following processes? Write with a balanced chemical reaction.

i) Carbon dioxide is passed through lime water for some time.

ii) Carbon dioxide is passed through lime water for a long time.

iii) A burning magnesium is inserted into the jar full of carbon dioxide gas.

iv) The mixture of ammonium chloride and calcium hydroxide is heated.

v) Ammonia is mixed with water.

vi) Ammonia reacts with hydrochloric acid.

17

Metal and Not metals

Observe the pictures below and discuss the given questions:







a. Which of the given objects are metals and which of them are non-metals?

b. What type of materialsare used to make these substances?

c. Write the similarities and dissimilarities in the constituents of these objects?

d. From where and how are the raw materials required to make these objects obtained?

We use different types of matter in our daily life. These substances are classified into two types, pure and impure. Elements and compounds are the pure substances whereas mixture is the impure substance. Scientists have discovered 118 elements till now.

These elements are classified as metals, nonmetals and metalloids on the basis of their properties. Most of the elements are metals among the 118 elements in the modern periodic table whereas some are non-metals and only few are metalloids. We have already studied in previous class about the sources, properties and importance of metal, nonmetal and metalloid. In this unit, we will study about where and how these metals are found in nature as well as how these metals can be purified.

Minerals

Picture 17.2 potassium, sodium, and calcium rock

Almost all metals, except some, are found in the form of compounds on the earth's crust. These elements and compounds which are found naturally are called minerals. Minerals are the sources of metals. The rocks found on earth's surface are mainly made of metallic and nonmetallic matter. Some rocks are made of one or more types of minerals. Non-reactive metals like gold, silver, etc. are found in pure state in nature whereas reactive metals like sodium, potassium, calcium, iron, etc. are found in the form of compounds. Almost all minerals are inorganic, pure, solid and crystalline in nature. In this way, the pure, solid and crystalline compounds found in nature are called minerals. They have a fixed chemical formula. The earth's crust is composed of about 90% of silicate minerals. Besides this, sulphide, oxide, carbonate, sulphate, phosphate ores are also found on it. Minerals like hematite, cuprite, granite, limestone, talc, red clay, coal, etc. are found in different parts of Nepal. Dang, Salyan, Rolpa, Gulmi, Pyuthan, Lalitpur, Palpa, Nawalparasi are some places where minerals are found in Nepal.

Ore

A lot of impurities are found in the ores obtained from mines. Metals can be obtained from these ores only after removing these impurities.

The process of removing impurities from the ores depends upon the physical and chemical properties of the substances found in them.

Different amounts of metals are found in different minerals. Some minerals contain more amounts of metals from which the metals can be extracted easily and economically whereas some minerals contain less amount of metals and thus metals cannot be extracted easily and economically from them. The mineral from which a metal can be extracted in a large amount with low cost is called the ore of that metal. The minerals from which a metal cannot be taken out easily are not the ores. Thus all ores are minerals but all minerals are not ores. The metals used in our daily life are obtained from different ores.

Some ores of iron

Picture17.3 Ores of Iron

Some ores of iron are as follows:

a. Hematite (Fe_2O_3)

b. Magnetite (Fe_3O_4)

c. Siderite ($FeCO_3$)

d. Limonite ($2Fe_2O_3.3H_2O$)

e. Iron pyrite (FeS_2)

Among them hematite is the chief ore of iron. It contains a maximum amount of iron (about 75%).

Some ores of aluminium

Some of the ores of aluminium are as given below:

a. Bauxite ($2Al_2O_3.2H_2O$)

b. Cryolite (Na_3AlF_6)

c. Corundum (Al_2O_3)

Picture 17.4

Among these ores, Bauxite is the chief ore of aluminium which contains about 40-60% of aluminium.

Some ores of copper

Picture 17.5

Some ores of the copper are follows:

a. Chalcocite or copper glance (Cu_2S)

b. Copper pyrite or chalcopyrite ($CuFeS_2$)

c. Cuprite (Cu_2O)

d. Malachite [$Cu_2(OH)_2CO_3$]

Copper pyrite or chalcopyrite is the main ore of copper which contains about 34.5% of copper.

Some ores of Silver


fig 17.6 Argentite

a. Argentite (Ag_2S)

b. Horn silver ($AgCl$)

c. Ruby silver ($Ag_2Sb_2S_3$)

d. Silver copper glance ($Ag(Cu)_2 S$)

Among these the chief ore of silver is the argentite which consists of about 87% silver.

Some ores of gold

Gold is found in pure state in nature or the ores of gold contain it in pure form. Gold is a non-reactive metal so it is found in pure state. It is found mainly in rocks and alluvial soil formed from rocks.

Activity 17.1

Collect the pictures and name of ores of iron, aluminium, copper, and silver and paste them on a chart paper. Present it group wise in your class.

Metallurgy

Mining

For extracting metals, the ores of metals are first taken out from their mines by digging the earth's surface. This process of extracting useful substances and minerals from the earth's geological surface is called mining. Mining is done to take out coal, petroleum, gold, and ores of different metals from the Earth's crust. Then metals are extracted from their ores through different steps.

Metallurgy is the science which deals about the properties, production and purification of metals. It also includes the stepwise extraction process of metals from their respective ores. Generally, five main steps are to be adopted for extracting pure metal from their ores.

General steps of metallurgy

Grinding

This is the first step of metal extraction. The process of crushing the ores into small particles form with the help of rollers of the machines is called grinding.

1. Concentration

The grounded or crushed ores contain impurities like mud, sand, rocks, etc. which is known as gangue. So these impurities must be removed first. Concentration is done to remove the impurities from ores. Thus the process of removing impurities from the ores thereby increasing the percentage of metals in them is called concentration. A specific method is used to remove these impurities from the ores according to their properties. For example, if the density of ore and impurities is different than hydraulic or gravity separation method is used. Similarly, magnetic separation is used if one of them is magnetic and the other is non-magnetic substance. If either ore or impurities are hydrophilic and other being hydrophobic, a froth floatation process is used to concentrate the ore.

Activity 17.2

Use of magnetic method to separate the mixture of magnetic and non-magnetic substances.

Materials required: Iron dust, aluminium dust, sand, and a magnet

Method/Procedure: Make a mixture of iron dust, aluminium dust, and sand.Bring a magnet near to the mixture.

Observation: What do you see? Why does it happen?

In this way magnet attracts iron dust (magnetic substance) but does not attract aluminium and sand (non-magnetic substance) and they get separated.

Conclusion ....

3. Oxidation

It is easier to obtain metals from their oxides, so the concentrated ores are changed to metal oxide. There are two processes for the oxidation of metals.

a. Roasting

It is the process of strongly heating the ore to their oxides by passing air or in presence of oxygen. This process is done for non-oxide ores. Generally roasting is done to convert sulphide ores to their oxide ores. For example, Zinc sulphide (ZnS) is converted to Zinc oxide (ZnO) by the process of roasting.

b. Calcination

It is the process of strongly heating the ores to their oxides in the absence of air or without passing oxygen. Calcination is done to convert carbonate ores to their oxides. For example, calcium carbonate is converted to calcium oxide by using a calcination process.

4. Reduction

It is the process of removing oxygen from metal oxide. The metal oxides like copper oxide, lead oxide,and iron oxide are treated with reducing agents like carbon, carbon monoxide, hydrogen, etc. which removes oxygen from these metal oxides.

But zinc oxide can be reduced by carbon only. Silver oxide and mercury oxide are unstable and they are reduced when heated. The oxides of reactive metals like sodium, potassium, calcium, magnesium, aluminium, etc. are very stable and they can be reduced only by the electrolysis method.

Smelting

After oxidation, metal oxides are reacted with reducing agents like carbon, coke, or hydrogen above the melting point of the metals.

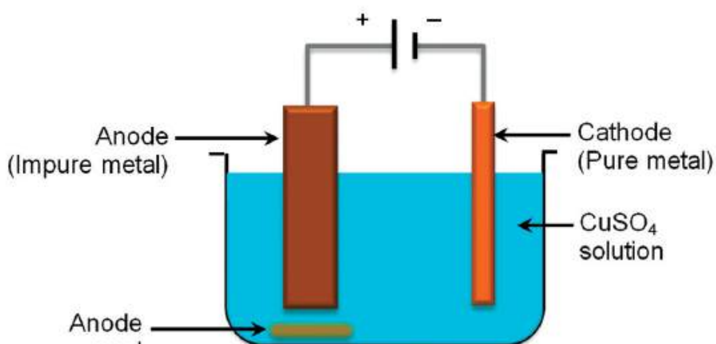
In this process, metals are separated from their oxides in the molten form and the remaining impurities are separated in the form of gases or slag. This process of heating metals beyond their melting points along with a reducing agent is called smelting.

5. Refining

The metals obtained after the reduction process may still contain some impurities. So to obtain metals in pure state, refining is done. Metals can be refined through various processes like distillation, electro refining, etc. In this way, pure metals can be obtained after refining through various methods.

a. Distillation

In this method, the impurities present in metals are removed by boiling. This process is done when either the metals or impurities would change to vapour when heated. It is used for the purification of metals which poses a low boiling point and gets vaporized such as mercury.



Picture 17.7

B. Electro-refining

Electro-refining is one of the processes of refining metals obtained from the reduction process. For electro-refining, the electrolysis method is used. This process is used to obtain metals like iron, silver, copper, gold,etc. in pure state. The metals obtained by this process are about 99% pure. In this method, a voltameter (vessel to perform electrolysis) is taken and impure metal is connected to anode (positive terminal of cell) whereas pure metal is connected to the cathode (negative terminal of cell). In this method, one of the salt of metal to be refined is used as an electrolyte. For example, do the activity of purifying impure copper by the method of electro-refining.

Activity 17.3

Purifying impure copper by the method of electro-refining.

Materials required: voltameter, impure copper, pure copper plate, battery, copper sulphate solution, or solution of any other copper salts.

Method:

Take the solution of copper sulphate in the voltameter. Connect impure copper to the positive terminal of the battery and the pure copper plate to the negative terminal of the battery as shown in figure 17.7 thus by making impure copper an anode and pure copper as cathode. Now pass electricity into the voltameter.

Observation

What do you see? Why and how does it happen?

The impure copper plate in anode erodes and pure copper gets deposited on the cathode.

Conclusion

In this way, we can get the pure copper from its impure form by the process of electrolysis.

Activity 17.4

Make a flowchart showing different steps of metallurgy in a chart paper and present it in the class.

Project work

Search the internet and observe an audio visual materials on the extraction of metals. Prepare a report on metallurgy and present it in the classroom.

Exercise

1. **Choose the correct option for the following questions:**

   a. Which is the main ore of iron?

   i) Bauxite ii) Argentite

   iii) Hematite iv) Pyrite

   b. Which metal is found in pure state in nature?

   i) Aluminium ii) Iron

   iii) Copper iv) Gold

   c. Which is the primary step of purifying metal?

   i) Smelting ii) Roasting

   iii) Concentration iv) Grinding

   d. Which of the following ore is oxidised by roasting method?

   i) Hematite ii) Siderite

   iii) Bauxite iv) Cuprite

   e. In which process is smelting included?

   i) Grinding ii) Refining

   iii) Oxidation iv) Reduction

2. **Give reason:**

   a. All ores are minerals but all minerals are not ores.

   b. Ores are oxidised after concentration.

3. **Write the differences between:**

   a. Mineral and ore

   b. Roasting and calcination

c. Oxidation and reduction

4. Answer the following questions:

a. What are the sources of metals?

b. Make a list of ores of iron, copper, aluminium, and silver.

c. How is metallurgy a stepwise process? Explain.

d. How pure metals are obtained from electro-refining? Explain it with an activity.

18

Hydrocarbon and its Compounds

There are different types of compounds around us. These compounds can be classified as carbonic and non-carbonic or organic and inorganic. The compounds obtained from minerals are called non-carbonic compounds or inorganic compounds and the compounds obtained from plant and animal sources are called carbonic compounds or organic compounds. All the compounds of carbon except its oxides, carbonates, bicarbonates, and carbides are the organic compounds. The carbonic compounds composed of only carbon and hydrogen are called hydrocarbons.

Hydrocarbon

Activity 18.1

Collect locally available materials like wood pieces, sugar, stone, water, cooking oil, ghee, rice, maize, glass, iron pieces, etc. Make fire using the wood pieces in an open place. Then put the above materials in the fire one by one and observe. Classify the objects which burn in fire and which do not burn and fill the given table.

S.N.	Name of the object	Combustible	Non combustible

Conclusion: On this basis, all combustible substances are organic and non-combustible substances are inorganic.

All the combustible substances consist of carbon and hydrogen. Hydrocarbons are made of carbon and hydrogen. Kerosene lamps are lit in the villages where there is no hydroelectricity. Similarly, firewood is used to cook food. Spirit lamps are used in laboratories as a source of heat. Charcoal is used to heat and melt metals while making utensils. All of these combustible substances contain carbon and hydrogen. These substances are obtained from plants and animals.

Those substances which are obtained from plants and animals and are combustible are called organic compounds.

The substances found in the human body like protein, hormone, carbohydrate, fat, enzyme, protoplasm, etc. all are organic compounds.

Organic compounds

Generally, the compounds of carbon covalently bonded to other carbon atoms or hydrogen atoms are called organic compounds. Besides hydrogen, the carbon may also form covalent bonds with other elements like oxygen, nitrogen, halogens, sulphur, and phosphorus. However, CO_2, CO, HCO_3-, CO_3- - , are not organic compounds although they contain carbon atoms. Generally organic compounds are composed of elements like carbon, hydrogen, oxygen, nitrogen, halogen, sulphur, and phosphorus. Some organic compounds may also contain metal bonded to them. The examples of organic compounds are methane, ethane, ethene, acetylene, methanol, chloroform, urea, insulin, protein, oil, etc. The branch of chemistry which deals with the study of these compounds is called carbonic chemistry or organic chemistry.

Petroleum is the main source of hydrocarbons. The hydrocarbons are classified as saturated and unsaturated on the basis of types of bonds between the carbon atoms.

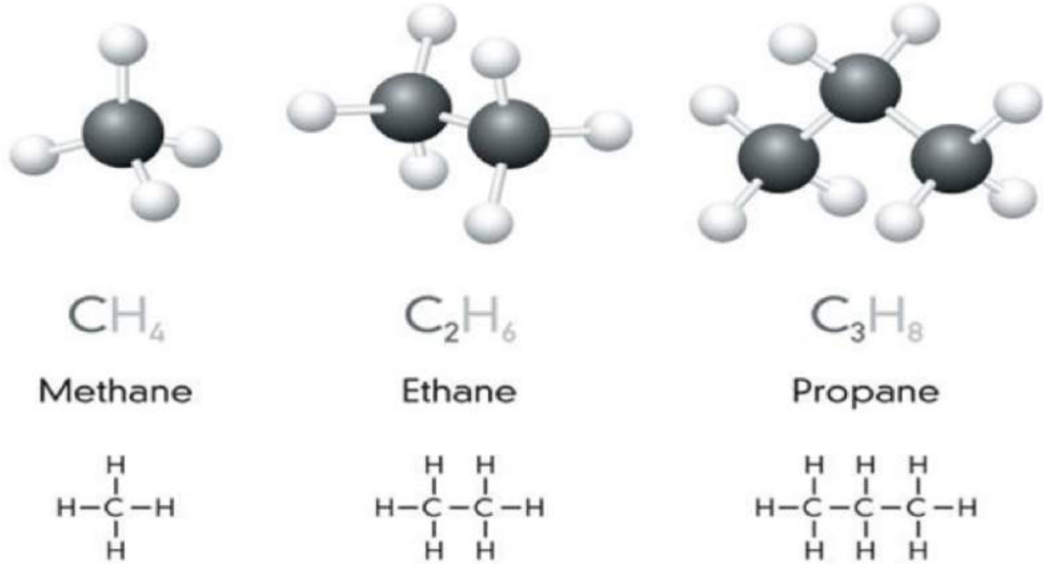
Activity 18.2 Model of a hydrocarbon molecule

Objective: To make a model of a hydrocarbon molecule

Materials required: clay dough or flour dough, colour, matchstick or toothpick

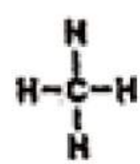
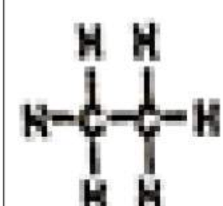
Method/ Procedure:

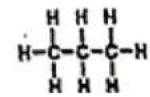
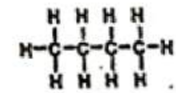
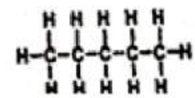
1. Make some spherical shapes from the clay or flour dough of different sizes.
2. Paint bigger spherical shapes red and assume them to be carbon atoms and paint smaller spherical shapes white and assume them to be hydrogen atoms.
3. Then prepare a model of hydrocarbon as shown in figure with the help of toothpick or matchstick. Now, have a discussion in your classroom.



Saturated hydrocarbon

The hydrocarbons having a single covalent bond between the carbon atoms are called saturated hydrocarbons. They are very stable and less reactive so they are known as paraffin. They are also called alkanes. The general formula of these compounds is $C_nH_2n + 2$ where 'n' is the number of carbon atoms. Here n= 1, 2,3,4............

Name	**Molecular formula**	**Condensed formula**	**Structural formula**
Methane	CH_4	CH_4	
Ethane	C_2H_6	H_3CCH_3	

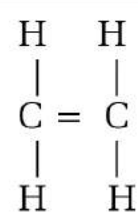
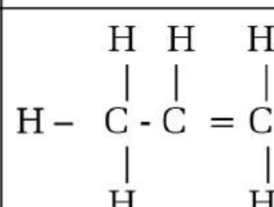
Propane	C_3H_8	$H_3CCH_2CH_3$	
Butane	C_4H_{10}	$H_3C(CH_2)_2CH_3$	
Pentane	C_5H_{12}	$H_3C(CH_2)_3CH_3$	

Unsaturated hydrocarbon

The hydrocarbons having double or triple covalent bond between the carbon atoms are called unsaturated hydrocarbons. They are less stable and are very reactive so they are known as olefins.They are also known as alkene and alkyne.

Alkene

The hydrocarbons having a double covalent bond between the carbon atoms are called alkene. Example ethene, propene, butene, etc. The general formula of these compounds is C_nH_{2-n} where 'n' is the number of carbon atoms.

Name	Molecular formula	Condensed formula	Structural formula
Ethene	C_2H_4	$H_2C = CH_2$	
propene	C_3H_6	$H_3C\text{-}CH= CH_2$	

Butene	C_4H_8	$H_3C-CH_2-CH=CH_2$	$\begin{array}{ccccccccc} & & H & & H & & H & & H \\ & & \mid & & \mid & & \mid & & \mid \\ H & - & C & - & C & - & C & = & C \\ & & \mid & & \mid & & & & \mid \\ & & H & & H & & & & H \end{array}$

Alkyne

The hydrocarbons having a triple covalent bond between the carbon atoms are called alkyne. Example ethyne, propyne, butyne, etc. The general formula of these compounds is C_nH_{2n-2} where 'n' is the number of carbon atoms.

Name	Molecular formula	Condensed formula	Structural formula
Ethyne	C_2H_2	HC ◦ CH	H - C◦C – H
Propyne	C_3H_4	H_3C- C ◦ CH	$\begin{array}{ccccccc} & & H & & & & \\ & & \mid & & & & \\ H & - & C & - & C \circ C & - & H \\ & & \mid & & & & \\ & & H & & & & \end{array}$
Butyne	C_4H_6	H_3C- CH_2 – C◦CH	$\begin{array}{ccccccccc} & & H & & H & & & & \\ & & \mid & & \mid & & & & \\ H & - & C & - & C & - & C \circ C & - & H \\ & & \mid & & \mid & & & & \\ & & H & & H & & & & \end{array}$

The process of making Vanaspati ghee from vegetable oil is called hydrogenation. In hydrogenation, the unsaturated fatty acids change to saturated fatty acids.

$$H_2C=CH_2 \quad + \quad H_2 \quad \longrightarrow \quad C_2H_6$$

Alkene Alkane

Differences between saturated and unsaturated hydrocarbons

Saturated Hydrocarbon	Unsaturated Hydrocarbon
1. The Hydrocarbon having a single covalent bond between the carbon atoms is called saturated hydrocarbon.	1. 1. The Hydrocarbon having double or triple covalent bond between the carbon atoms is called unsaturated hydrocarbon.
2. Saturated hydrocarbons are stable.	2. Unsaturated hydrocarbons are unstable or they are chemically reactive.
3. They are also known as alkane (C_nH_{2n+2}). For example, CH_4, C_2H_6, C_3H_8	They are also known as alkene (C_nH_2n) and alkyne (C_nH_{2n-2}). For example, C_2H_4, C_2H2, C_3H_4

Homologous series

The series of hydrocarbons which can be represented by the same general formula is called a homologous series. Each member of this series is called a homologue. All the members of the series can be represented by a common formula and the adjacent homologue of the series differs by CH2 group. Similarly, the molecular weight of adjacent members of the series or homologue differs by 14.

Name	Molecular Formula
Methanol	CH_3OH
Ethanol	CH_3CH_2OH
Propanol	$CH_3CH_2CH_2OH$

Alkyl radical

The group of atoms formed by removing one hydrogen atom from an alkane molecule is called an alkyl radical. It can be represented by a general formula C_nH_{2n+1}. For example $-CH_3+$, $-C_2H_5^+$, etc.

for example : CH_3^+, $CH_3CH_2^+$

Functional group

An atom or a group of atoms which determines the structure and chemical reactivity of a certain group of organic compounds is called a functional group. The functional groups get attached to the alkyl groups to form different groups of organic compounds.

Example of functional groups -O-, -CHO, -COOH

Nomenclature of hydrocarbons

IUPAC means International Union of Pure and Applied Chemistry. It is a system established by scientists to make uniformity in the names of organic and inorganic compounds all over the world. According to this system, a compound has the same or only one name. This removes the mistake while naming or understanding the compounds.

Common system of nomenclature of hydrocarbons

i. Find the word rooton the basis of number of carbon atoms as:

No of carbon atoms	Word root	notation
C-1	Meth	C_1
C-2	Eth	C_2
C-3	Prop	C_3
C-4	But	C_4
C-5	Pent	C_5
C-6	Hex	C_6
C-7	Hept	C_7
C-8	Oct	C_8
C-9	Non	C_9
C-10	Dec	C_{10}

ii. In this way after finding the word root, add the suffixes like ane, ene and yne according to the number of bonds between the carbon atoms.

For example,

$CH_3 - CH_3$

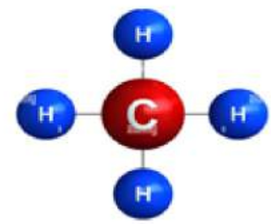
There are two carbon atoms so the word root is eth and there is only one covalent bond between the carbon atoms, so we should add ane as the suffix.

So, its name is eth+ane = ethane

Some important hydrocarbons and their compounds.

Methane

This gas is found in marshy places so it is also known as marsh gas. Its molecular formula is CH_4. This gas is generally found above the minerals oil. It is also found in gobar gas or bio gas, and sewage gases. It is colourless, odourless, and tasteless. It is not soluble in water but soluble in organic solvents like ether, alcohol, etc.



Methane CH_4

Uses of methane

1. Methane is used for cooking food as gobar gas or biogas and as a fuel in industries.
2. It is used to prepare carbon black which is used to make printing ink, shoe polish and paint.
3. Methane is also used to prepare chloroform, carbon tetrachloride, methyl alcohol, formaldehyde, etc.
4. It is also used in the industrial preparation of hydrogen gas.

Ethane

Ethane is a saturated hydrocarbon having two carbon atoms bonded with a single covalent bond. Its molecular formula is C_2H_6. It is found along with methane gas in natural gas, coal gas, and petroleum mines. It is also colourless, odourless, and tasteless as methane. It is also insoluble in water but soluble in organic solvents like ether, alcohol, etc.

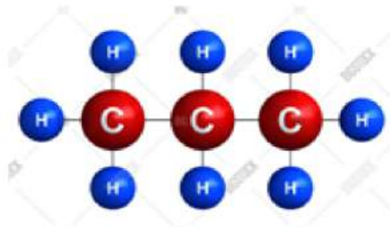
Uses of ethane

1. It produces heat on combustion so it is used in metal welding.

2. It is also used to prepare carbonic compounds like ethyl chloride, nitro ethane, etc.

Propane

Propane is also a saturated hydrocarbon. Its molecule consists of three carbon atoms and its molecular formula is C3H8. This gas is also found in natural gas and petroleum mines. It is a colourless and odourless gas. It is insoluble in water but soluble in organic solvents.



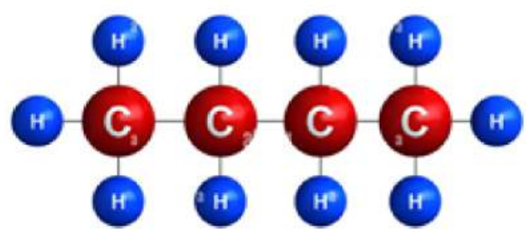
Propane C_3H_8

Uses of propane

1. It is a highly flammable gas so it is used as a fuel.
2. It is used to make different types of carbonic compounds.
3. It is used as a coolant in petroleum industries.

Butane

Butane is also a saturated hydrocarbon. Its molecule consists of four carbon atoms and its molecular formula is C4H10. This gas is also found in natural gas and petroleum mines. It is a colourless and odourless gas. It is insoluble in water but soluble in organic solvents.



Butane C_4H_{10}

Uses of Butane

1. It is used as a raw material for making synthetic rubber.
2. It is mixed with methane in LPG (Liquefied Petroleum Gas) which is used as fuel. It easily changes to liquid on applying pressure.

Alcohol

Do you know?

Generally, alcohol refers to ethyl alcohol (C_2H_5OH) in our daily life. It has the functional group -OH and it is also known as ethanol. It is colourless liquid and soluble in water.

The compounds of alcohol are produced from alkanes. The compounds formed by the replacement of one or more hydrogen atoms of alkanes by the -OH group are alcohols. Its general formula is $C_nH_{2n+1}OH$. Hydroxyl group (-OH) is the functional group of alcohols. The alcohol with only one hydroxyl group is known as monohydric alcohol. The alcohol with two hydroxyl groups is known as a dihydric alcohol. Similarly, the alcohol that consists of three hydroxyl groups is known as a trihydric alcohol.

Some important alcohol compounds

Methyl Alcohol

Methyl alcohol is a monohydric alcohol. Its IUPAC name is methanol. Its molecular formula is CH_3OH, and it is represented by the following structural formula:

```
      H
      |
  H – C – OH
      |
      H
```

Uses of methyl alcohol

1. It is used to prepare methylated spirit.
2. It is used as a solvent for paints and varnishes.
3. Methanol is also used to prepare perfumes, paints, medicines and synthetic clothes.

4. It is also used to manufacture formaldehyde.

5. It is also used in dry cleaning.

Ethyl alcohol

Ethyl alcohol is also a monohydric alcohol. Its IUPAC name is ethanol. Its molecular formula is C_2H_5OH, and its molecular structure is as follows:

$$
\begin{array}{ccccccc}
 & & H & & H & & \\
 & & | & & | & & \\
H & - & C & - & C & - & OH \\
 & & | & & | & & \\
 & & H & & H & &
\end{array}
$$

Uses of ethyl alcohol

1. Ethyl alcohol is used to prepare hard drinks like whisky, wine, beer, etc.

2. It is used to sterilize syringes and wounds in hospitals, health posts, and nursing homes.

3. It is used to preserve biological specimens in laboratories.

4. It is also used in thermometers.

5. It is used in the manufacture of polyethylene, terylene, soaps, paints, dyes, etc.

6. It is also used as an organic solvent.

Activity 18.3

Ask a person in your locality who could prepare alcohol and observe the alcohol making process and prepare a report. Present your report in the class.

Glycol

It is a dihydric alcohol. in which two hydroxyl groups are attached to each of the carbon atoms of hydrocarbons. In glycol, each carbon contains one hydroxyl group. Different types of glycols are used in industrial and food stuff. One of the common glycols is ethane diol. Its IUPAC name is ethane-1, 2-diol. Its molecular formula is CH_2OHCH_2OH and its structural formula is:

$$
\begin{array}{ccccccc}
 & & H & & H & & \\
 & & | & & | & & \\
H & - & C & - & C & - & H \\
 & & | & & | & & \\
 & & OH & & OH & &
\end{array}
$$

Glycerol

The compound formed by replacing three hydrogen atoms of propane with three hydroxyl groups is called glycerol. Glycerol is a trihydric alcohol which is also known as glycerine. Its name is derived from a Greek word glycerol which means sweet. It is a colourless and sweet viscous liquid. It is soluble in water and alcohol but insoluble in ether. Its IUPAC name is propane-1, 2, 3- triol. Its molecular formula is $C_3H_5(OH)_3$ and its structural formula is

$$
\begin{array}{ccccccccc}
 & & H & & H & & H & & \\
 & & | & & | & & | & & \\
H & - & C & - & C & - & C & - & H \\
 & & | & & | & & | & & \\
 & & OH & & OH & & OH & &
\end{array}
$$

Uses or glycerol

1. It is used to protect skin by trapping moisture and prevent its dryness.

2. It is used as a sweetening agent in food.
3. It is used to make good quality soap, lotion, cosmetics, shaving creams, etc.
4. It is used to keep the tobacco moist and it also prevents the dryness of fruits and foods as well as prevents them from decaying.

Project work

Enlist the hydrocarbons and their compounds used in your house. Also write how they are used at your home.Present your report in the class.

Exercise

1. Choose the best option for the following questions.

a. Which hydrocarbon is included in the alkane group?

i. Methane ii. Ethene

iii. Acetylene iv. Propyne

b. Which one is the correct formula of glycerol?

i. $C_3H_6(OH)_2$ ii. $C_3H_5(OH)_2$

iii. $C_3H_4(OH)_4$ iv. $C_3H_5(OH)_3$

c. Which of the following is the IUPAC name of the alcohol used as a beverage?

i. Methanol ii. Ethanol

iii. Propanol iv. Butanol

d. Which of the following is used to protect skin from dryness?

i. Methyl alcohol ii. Ethyl alcohol

iii. Glycerol iv. Glucose

e. Which hydrocarbon is used to prepare glycerol?

i. Methane ii. Ethane

iii. Propane iv. Glucose

2. Write differences between

a. Saturated and unsaturated hydrocarbon

b. Alkane and alkene

c. Monohydric alcohol and dihydric alcohol

3. Give reason

a. Ethane is known as a saturated hydrocarbon.

b. Glycerol is called a trihydric alcohol.

4. Answer the following questions:

a. What are hydrocarbons? Write any four examples.

b. What do you mean by a saturated hydrocarbon? Write with examples.

c. Introduce methane gas along with its two uses.

d. What is alcohol? Write its types on the basis of the hydroxyl group? Also write their examples along with their molecular formula and the structural formula.

e. Write the molecular formula, condensed formula, and the structural formula of the following compounds.

Ethylene, propene, acetylene, ethyl alcohol, glycerol

f. Name the alcohol used for following purposes:

i. to make formaldehyde

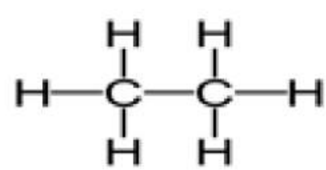
ii. used in thermometer

iii. used as an antiseptic

iv. to prepare alcoholic beverages

g. Write the structural formula of ethylene. What type of bond is found between its hydrogen and carbon? Why is the bond between its carbon atoms weak?

h. Study the following structural formula of a hydrocarbon and answer the given questions.



i. Write the name of this compound.

ii. Is it a saturated hydrocarbon?Write with reason.

iii. Which compound will form if one of the hydrogen atoms is replaced with a -OH group in the given compound?

i. Write any three uses of methane gas.

j. Write major uses of each of ethane and propane.

k. Define the following terms.

   i. Saturated hydrocarbon

   ii. Unsaturated hydrocarbon

   iii. Alkane

   iv. Alkene

   v. Alkyne

   vi. Functional group

   vii. Homologous series

l. Write the molecular formula of the following compounds

   Glycerol, methane, ethanol, butane, propane, acetylene, ethene, ethane, propyne, methyl alcohol

m. Write the name and structural formula of the alcohol used in spirit lamps.

n. Name the compound formed by the replacement of three hydrogen atoms with three hydroxyl groups (-OH) from propane. Also write its IUPAC name along with its structural formula. Write its three uses.

o. Rama has a problem of dry skin in her hands, feet, and face. Which compound can be used to solve her problem? Write the IUPAC name and the structural formula of that compound.

19

Chemicals used in Daily Life

Different types of chemicals are used in our daily life. Among them some are natural and some are manufactured in industries. For example, chemicals used for cleaning purposes, food preservatives, pesticides, chemicals used for the preservation of fruits and vegetables, chemical fertilizers, etc. are the chemicals used in our daily life. The branch of chemistry in which we study about the different aspects of transformationof matter to manufacture materials useful to mankind through chemical processes is called industrial chemistry.

Picture 19.1 materials used in our daily life

Some of the chemicals given above are used for cleaning, some are used to kill harmful pests, while some are used as food and food preservatives. Prepare a list of other chemicals used in our daily life and fill the given table and then, discuss in the classroom.

Chemicals used as food	**Chemicals used as food preservatives**	**Chemicals used for cleaning**	**Chemicals used as pesticides**
Salt, sugar	Salt, sugar	Soap	Rat poison (Rodenticides)

Food preservatives

Activity 19.1

Topic: Use of salt and oil in pickle

Objective: To observe the effect of salt and oil in pickle

Materials required: seasonal vegetables like carrot, radish, cabbage or fruits and vegetables which can be used to make pickle, two plastics or glass bottles, salt, oil

Method

1. Cut the vegetables or fruits into small pieces.
2. Dry them in sunlight for some time.
3. Divide them into two parts.
4. Mix oil and salt in one part and put in one of the bottles with little pressing. Put the next part into another bottle without mixing salt and oil.
5. Observe the pickles in both bottles after a week.

Conclusion

The pickle made by mixing oil and salt would be preserved whereas the pickle in another bottle would be decayed. Salt and oil prevent food from decaying so they are known as food preservatives.

The food gets decayed due to the growth of bacteria, yeast, mold, etc. on it. In this way, the substances used to protect food from decaying are called food preservatives. They are used to prevent food from decaying for a long time like cereals, legumes, vegetable products, fruits and vegetables, and animal products like meat, milk and milk products, etc. These food preservatives check the growth of bacteria, yeast and mold in the food stuff.

Preservatives are classified as first class and second class.

First Class preservatives: They belong to natural sources and can be used in necessary amounts in food. Sugar, salt, vinegar, honey, spices, edible oils, etc. are the examples of first class preservatives.

Second Class preservatives:

They are obtained by chemical derivation of compounds and can be used in a certain or limited amount only. For example, sodium or potassium nitrate, benzoic acid and its salts, sulphur dioxide, etc. We should not use more than one type of second class preservatives in any food.

Different traditional and modern methods are used to preserve food materials, like drying, keeping them in the fridge, mixing with salt and sugar solution, etc. Similarly, different chemicals are used to ripen the fruits quickly. But such chemicals used in food are very harmful to human health and the environment. We should wear masks and gloves while using them. Similarly, we should wash our hands with soap and water after using them. They should not be used in excess and we should use natural preservatives as much as possible instead of them.

Discuss the traditional and modern methods of preservation of food materials.

Food preservatives are used to preserve the nutrients of fruits, vegetables, milk, curd, meat, and fish, and prevent food spoilage. Food preservatives are of three types: chemical food preservatives, natural food preservatives, and the preservatives which induce ripening of fruits.

1. Chemical food preservatives

figure 19.2 a

figure 19.2 b

Salt and oil are the chemicals which control the growth of microscopic germs and organisms. Similarly, the chemicals like sodium benzoate sorbate, Sulphur dioxide, nitrates and nitrites,

butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), calcium propionate, sodium metabisulfite are used as food preservatives.

2. Natural food preservatives

Food materials are being used continuously and within a short interval of time in our daily life. Natural food preservatives come from organic matter and they prevent food materials from decaying. We can get the natural preservatives from plants, animals, fungi and algae. Use of mugwort (Titepati), neem oil, lemon concentrate (Chuk) etc. are some examples of natural food preservation. Similarly, the traditional methods of food preservation like drying in sun, keeping in cold places or above water, use of wood ash, mixing of turmeric and oil, etc. are the natural methods to preserve food. Nowadays new methods of food preservation have been developed in both urban and rural areas like pasteurization, freezing, keeping food in cold stores, etc. All of these technologies control the elements required for the growth of microbes and preserve food materials.

3. Food preservatives as inducing ripening of fruits/ Artificial ripening food preservative

Fruits like mango, banana take a long time to ripen even after maturation. So to induce the ripening of these fruits, different chemicals are used. The chemicals used for fast ripening of fruits are called ripening agents. Calcium carbide, ethylene gas, ethephon, etc. are the ripening agents.

Picture 19.3Chemicals used to ripen the mango

There are many traditional methods of fruit ripening like wrapping the fruits in a jute sac, using leaves of Asuro (Malabar nut), keeping the sac of fruits inside a pit or hole and covering with soil from top, wrapping them inside a thick layer of husk or hay, etc.

But nowadays calcium carbide is used excessively to ripen the fruits as it is an easier and cheaper method. We should be careful while using this chemical and while consuming the fruit ripened with it. Different health problems like skin irritation, skin burning, appearance of red blisters in skin, lung effusion, eye irritation may appear due to the overuse of these chemicals. So we must be very careful while consuming these fruits. Similarly, these chemicals should not be used in excess.

Introduction and use of chemicals used in cleansing

Natural materials used in cleansing

We use different types of natural substances for cleansing. Reetha (soapberry), mustard seed cake (Peena), wood ash, lemon juice, Sajiban, etc. are the natural materials used for cleansing purposes.

Picture 19.4Natural materials used in cleansing

Reetha (Soapberry)

Reetha contains saponin which acts as a foaming agent so it can be regarded as a soft natural soap. It has been in use for centuries to clean our body and wash clothes. It is a traditional medicinal tree found in Nepal, India, and China. It is generally used to make ayurvedic medicine. The powdered form of its fruit is used in shampoo as a foaming agent.

Peena (Mustard seed cake)

Peena (Mustard seed cake) has been in use in our country for a long time to wash hair and make it soft and strong. It consists of necessary nutrients for the healthy growth of hair and make it strong like folate, niacin, thymine and vitamin B6 which are the forms of vitamin B complex. Its use can control hair fall to a large extent. It also makes hair soft and healthy.

Wood ash

Wood ash is being used for cleaning purposes. It can be mixed with a small amount of water to form a paste, this paste can then be used as an abrasive cleaner. It can brighten metals and clean dirty utensils.It even removes sticky residue and adhesive. Wood ash is also a good source of potassium, phosphorus, and magnesium for the plants so it can also be used as a fertilizer.

Sajiban

Sajiban is a very useful plant found naturally in different regions of Nepal. It has been used in various ways. Animals do not eat this plant, so it can be used as a fence in our fields. Its leaves are used to make compost manure and its juice is used to cure the burns. Similarly, it can be used as an anticancer medicine and its twigs can be used for brushing teeth. It is also a good source of nitrogen, phosphorus, and potash.Therefore, it is also used as an organic fertilizer.

Let's know the importance of Sajiban

The juice and oil of Sajiban can be applied on cattle to kill lice on their body. Its oil can also be applied to cure skin diseases and infections and to relieve muscular and joint pains. Its oil can also be used to make soaps and lit lamps. Its twig can be used to clean teeth. Its oil can also be used to produce glycerin. Its leaves are used to make compost and its seed cake can be used as manure. The oil obtained can be refined to get bio diesel.

Jatropha curcas or Sajiban found in Nepal has been referred to as an excellent source of biodiesel by scientists. Generally, a seed of Sajiban consists of about 30 to 48% of oil. About one liter of oil can be produced from 3 kilograms of Sajiban seeds.

Lemon Juice

Lemon juice consists of citric acid in high concentration. It is a good natural cleaner due to its low pH value and antibacterial properties. It also works as a natural bleach. It has a good smell and does not destroy materials like wood and clotheswhen used to clean them. It also cleans copper surfaces efficiently and makes them shiny. Lemon juice has been used as a medicine for decades.

Chemicals used in cleansing

Soap

The sodium or potassium salts of long chain fatty acids are called soap. Generally, animal fat or vegetable oil, sodium hydroxide, and sodium chloride are the raw materials for making soap. For making soap, vegetable oil (olive, coconut or cotton seeds) or animal fat is heated with sodium hydroxide and sodium chloride. This process of making soap by the hydrolysis of vegetable oil or animal fat with alkali is known as saponification. Soap produces insoluble scum with the hard water so it is not an efficient cleaner in hard water. However, it is biodegradable so it does not cause chemical pollution.

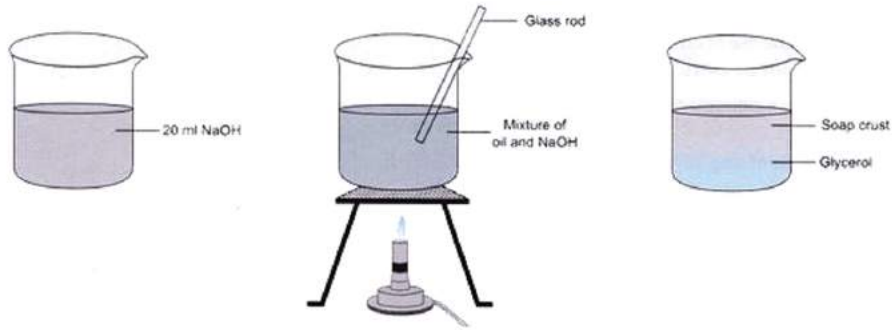
Activity 19.2

Objective: To make soap

Materials required: vegetable oil or animal fat, sodium hydroxide solution, edible salt or sodium chloride, a beaker, funnel, filter paper, source of heat

Method/ procedure

1. Take about 40 ml of vegetable oil in a beaker.
2. Make about 50 ml mixture of sodium hydroxide by dissolving 15 grams of sodium hydroxide in50 ml water.
3. Mix both of them and heat the mixture. On heating for some time, it forms a thick paste. Add a little soda and common salt. The salt helps to separate soap from the mixture.



Picture 19.5: Soap making process

4. Now filter the mixture by using a filter paper. The residue left on the filter paper is the soap. Now pour the soap in a desired shape vessel.

5. Keep the soap untouched for a day and we would get a soap of desired shape. The remaining solution or the filtrate contains glycerin.

Detergent

Picture 19.6: ditergent

Detergent is a substance used to clean clothes. It is more soluble than soap. It is a chemical obtained from hydrocarbons which is more soluble in water than soap. It is also known as soapless soap. It cleans clothes like soap.However, its chemical nature is different from that of soap. It can be used with hard water as well. Sodium lauryl sulphate, alkyl benzene sulphonate, sodium pyrophosphate, etc. are some examples of detergents. It is a chemical so it is non-biodegradable. Due to which it can cause chemical pollution.

They are found in powder or liquid form. Most of the perfumed soaps in the market are also made from petroleum rather than natural oils. However, its use can cause problems like skin irritation or skin burn. Similarly, it can cause soil and water pollution. It can also fade the colour of clothes on its long use.

Chemical pesticides

Activity 19.3

What type of insecticides are being used in the agricultural land and garden of your locality? observe and search,and then discuss on the following questions:

a) What are the advantages of using insecticides?

b) What local methods have been used to control pests and insects in your area?

c) Are there any negative effects of using insecticides?

Let's study a case

Picture 19.7Spraying insecticide in crops

According to the news published on 15th Shrawan 2079 BS, in the 'The Kathmandu Post', a farmer in Haripur Municipality was burnt badly at his back due to the leakage of insecticide, which he was carrying while spraying the chemical in his field. Similarly a study shows that 22 persons had already died of cancer in Ghurkauli, a main area of growing vegetables in Hariban Municipality. The number of people suffering from blood and skin cancer is also more in that area. These are only some examples in the case of Nepal. In fact, there is an excessive and unscientific use of pesticides in vegetables, fruits, and agricultural products in different regions of Nepal.

Discuss the following questions in groups in your classroom based onyour experience, observation, or the news you might have heard about.

a. What effects are seen on the health of people and the environment due to the excessive and unscientific use of pesticides?

b. What situation have you seen or felt in your family or locality due to the overuse of pesticides?

c. Is it right to spray pesticides as shown in the above figure?

The poisonous substances used to remove, destroy, kill, and control harmful pests from seeds, plants, trees, birds, animals, human health, and construction areas are called pesticides. According to the 'Pesticide Management Act 2076 (B.S.)',"pesticide" means any organic, vegetation, biological and chemical material which is used to protect plants, agricultural products, forest and forest products, living beings, livestock, human health, storage, packaging, and construction works from any harmful disease, insect, mite, nematode, weed grass, and rodents.

DDT was at first imported to Nepal in 1952 AD to control malaria. Currently the average use of pesticides in our country is 396 grams per hectare. About 80% of the used pesticides get mixed to the soil which takes a long time to get diffused. Due to this, the microorganisms in soil are destroyed and there is a high risk of pollution of surface and underground sources of water.

Types of pesticides

On the basis of effect on the environment, the pests they affect, and mode of action, the pesticides are classified to different groups as follows.

1. Pesticides on the basis of effect on the environment

According to the nature of effect on the environment, pesticides are of two types as:

a) Environmentally biodegradable or non-persistent

Biodegradable pesticides are those that can be broken down into harmless compounds by microbes and other living organisms within a shorter period of time when they come in contact with water, air, light, or heat. For example: dimethoate (Nugor, Rugor, Dimet), Malathion, etc.

b) Environmentally non-biodegradable or persistent

These types of pesticides do not decompose easily in the environment and remain in our food chain for a long time. This type of pesticides are banned in most of the countries. In Nepal also, the use, export, and import of these pesticides are banned. For example: DDT, Aldrin, etc.

2. Pesticides on the basis of the pests they affect

a) Insecticides:

Pesticides used to kill and control harmful insects, example: Malathion, Cypermethrin, Fenvalerate, Nitenpyram, etc.

b) Fungicides:

They are used against fungi and the diseases caused due to them. For example: Dimethomorph, Sectin, Mancozeb, Carbendazim, etc.

c) Herbicides:

They are used to destroy or control unwanted herbs and plants in our crop fields. For example: Butachlor, isoproturon, atrazine, etc.

d) Rodenticides:

The pesticides used to kill rats and rodents like mice, squirrels, hamsters, porcupines, etc. are rodenticides. For example: Zinc phosphide, bromadiolone, Coumatetralyl, etc.

e) Miticides:

They are used to kill mites. For example: bifenazate, fenazaquin, propargite, fenpyroximate, etc.

3. Pesticides on the basis of mode of action

a) Contact pesticides:

They kill pests like aphids (lahi), larva, thrips, white house fly, etc. when their body comes in direct contact with these pesticides. Malathion, Chlorpyrifos, etc. are the contact pesticides.

b) Internal pesticides:

When the pests consume the leaves, flowers and fruits of plants with these pesticides, then they are killed due to the effect of poison. Pesticides like Malathion, Cypermethrin, Fenvalerate, etc. lie in this group.

c) Systemic pesticides:

The parts of plants like roots, leaves, etc. absorb the pesticides due to which the plant itself becomes poisonous. So when insects suck its juice or eat the plant part, they are also killed. For example pesticides used to kill aphids, larva, thrips, white house fly, leaf miner, stem borer, such as ;Thiamethoxam, Dinotefuran, etc. are some systemic pesticides.

d. Fumigants pesticides:

These pesticides produce poisonous gases or fumes when they come in contact with air due to which pests are killed. These pesticides are generally used to kill pests during the storage of agricultural products. For example: Aluminium phosphide, Methyl bromide, etc.

Activity 19.4

What alternative methods are used to control pests in your house or locality besides using excessive chemical pesticides? Discuss in groups. Then preparea list of suggestions to give to your family members or people of your locality and present it in the class.

Safety precautions in the use and storage of pesticides

figure19.8

Following precautions must be followed strictly during the storage and use of chemical pesticides:

a) Only the pesticides permitted by 'Pesticides Management Act, 2076' must be imported, produced, traded, or used.

b) The pesticides should be bought under the suggestion of agricultural technicians only. Similarly, the remaining pesticides after use must be stored and managed in a safe place.

c) The labels of pesticides must be clear and intact.

d) Pesticides should not be stored in the places where children could easily reach or near the food storage.

e) The pesticides must be stored in an airtight container with no leakage.

f) The carelessness or a small mistake of the user can cause accident and harm so, the instructions given in the label should be read and followed strictly.

g) Only less harmful, but effective pesticides should be used. And while using them, protective suits which cover the whole body, along with masks to cover nose and mouth, goggles to cover eyes, andthe gloves should be used.

h) The utensils used for spraying pesticides should be cleaned immediately after their use and stored in a safe place. However, they should not be cleaned near the water sources.

i) We should wash our hands and take a bath immediately after spraying the pesticides.

j) We should follow the integrated pest management method as far as possible.

k) The vegetables, fruits and crops should not be sold or consumed immediately after using pesticides.

l) The most dangerous pesticides enlisted as Group IB pesticides must be bought only under the direction of the crop protection officer.

m) We should not forget the saying that,"all pesticides are poisons, they are not medicines".

Project work

Ask an expert to find the pesticides which could be used in Nepal and the time to be awaited after using them. Prepare a report and present it in class for discussion.

Chemical pollution

figure 19.9 Pollutants produced from the industry

Environment pollution is the problem which causes trouble for humans and all living beings in their survival. It causes the degradation in quality of components of the environment like air, water, soil thereby causing imbalance in the ecosystem. It causes negative impacts to all living beings such as the transmission of airborne disease due to air pollution, transmission of waterborne diseases due to water pollution, etc. The amount of carbon dioxide in the atmosphere is also increasing as a result of air pollution due to which the average temperature of the earth is increasing. It has a direct impact on all living beings.

Different pesticides are used to kill insects, pests, and rodents. They contain poison in different amounts. They not only kill the harmful insects but also kill the useful insects. It creates imbalance in the ecosystem of that place. The use of DichloroDiphenylTrichloroethane (DDT) powder causes physical and biological environment pollution. The polluted water causes negative impacts on aquatic and terrestrial animals. It also affects the reproductive system of the organisms. Similarly, it causes different respiratory diseases. The reproductive capacity and growth of fishes and birds are also affected. Birds lay less eggs and all of them will not be fertile. Similarly, some of the fertile eggs will not hatch to babies as their shells will be very thin and will get destroyed. Similarly, pesticides like benzene hexachloride (BHC), methoxychloride, aldrin, dieldrin, etc. also cause similar effects on the organisms.

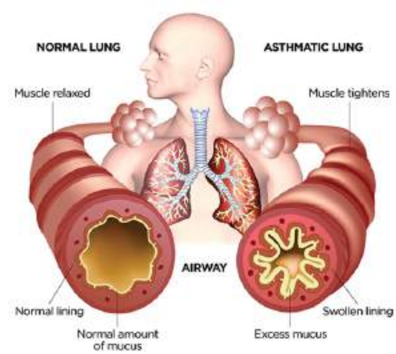


Figure 19.10

Different types of insecticides like DDT, BHC, aldrin, dieldrin, etc. are being used in the name of modernization in agriculture. Similarly, chemical fertilizers are also being used excessively. These insecticides and fertilizers reach the sources of water on getting mixed with the rain water and affect the ecosystem there. This destroys aquatic animals.

The agricultural products are destroyed by different harmful pests thus pesticides must be used in order to kill and control them. Although they protect agricultural products from harmful pests, they pollute soil. Chemicals like insecticides, fungicides, or weedicides are regarded as a main source of pollution. Substances like DDT, aldrin, dieldrin, and parathion like chemicals degrade the quality of soil.

Let's know

Aldrin,Dieldrin, DDT, BHC, Chlordane, Lindane, Endosulfan, etc. are the insecticides which are all banned in Nepal. The production, buying, selling, export, and import of Dichlorvos insecticide has been restricted in Nepal.

The haphazard use and disposal of industrial chemicals like cement, ceramics, glass, plastic, fiber, chemical fertilizers, soap, detergent has degraded the quality of different components of the environment like air, water, soil, etc. which causes imbalance in the ecosystem. So, this type of pollutants must be used and managed properly. They should not be disposed directly in the sources of water and agricultural land.

Figure19.11Ceramics, glass, plastic, fiber etc. in Sisdole dumping site

Observe the above picture and answer the following questions:

a) What effects are seen in the environment due to the haphazard disposal of such waste materials?

b) In your opinion, what measures can be taken to control such pollution?

Following measures can be adopted for the proper management of industrial chemicals like cement, glass, ceramics, plastic, fiber, chemical fertilizers, soap, detergents, pesticides, etc.

a) Glass, ceramics, plastic and fiber pieces should not be thrown haphazardly and should be managed in proper places.

b) Cement sacs should be tied and covered properly to prevent the dust blow.

c) Organic or compost fertilizer should be used instead of the chemical fertilizers.

d) Chemical fertilizers and pesticides should be used only as suggested by the agriculture expert.

e) The waste water after the use of soap and detergent should not be directly mixed to water sources or agricultural land but should be collected in separate places.

Project work

Get divided into into four groups (A, B, C and D).Each group will be assigned one topic given below. Visit the related places and do the project work on that basis to present in your class.

Group A : Chemical pollution due to soap and detergent and diseases caused by it.

Group B : Chemical pollution due to pesticides and diseases caused by it.

Group C : Effects of chemical fertilizers and ways to manage them.

Group D : Pollution due to cement, glass, ceramics, fiber, plastic, and chemical fertilizer, their effects and management.

According to the feedback you receive after the presentation in class, write a report onthe project.Include a proper conclusion with suggestions. Submit it to your subject teacher.

Exercise

1. Choose the correct optionfor the following questions:

a. Why is detergent called a soapless soap?

   i. It does not give lather with hard water as a soap.

   ii. It has the same chemical composition as of soap.

   iii. It has cleaning properties like soap and it can be used with hard water.

   iv. It has cleaning properties like soap but its chemical nature is different.

b. Identify the group of insecticides?

   i. Potassium chloride, aldrin, benzene hexa chloride

   ii. DDT, sodium chloride, aldrin

   iii. Dieldrin, DDT, methoxychloride

   iv. Potassium chloride, aldrin, malathion

c. In which group does sodium stearate lie?

   i. Soap　　ii. Detergent

   iii. Insecticide　　iv. Food preservative

d. What is the main use of detergents?

   i. To clean hands and foot　　ii. To take bath

   iii. To wash clothes　　iv. Tocleantoilet

e. Which of the following compounds is used to ripen fruits?

   i. Calcium carbide　　ii. Calcium carbonate

   iii. Sodium sulphate　　iv. Sodium carbonate

2. Write differences between:

a. Chemical pesticides and biological pesticides

b. Chemical food preservative and organic food preservative

c. Soap and detergent

3. Give reason

a. Use of DDT powder causes imbalance in the ecosystem.

b. The use of chemical pesticides should be decreased.

c. Salt is used in the process of making soap.

d. Pickles can be preserved for a long time.

4. Answer the following questions:

a. Write the full forms of DDT and BHC.

b. What do you mean by food preservatives? Why are they used?

c. What chemicals are used as food preservatives?

d. What are the natural methods used to preserve the nutrients of food?

e. What do you mean by natural food preservatives? Why are they good in comparison to the chemical food preservatives? Analyze it.

f. How can fruits be ripened artificially? Write methods and processes for it.

g. What precautions should be taken while using chemical pesticides?

h. Make a list of chemicals used for cleaning purposes in your house and locality? Write the effects of these substances in the environment.

i. Explain the soap making process.

j. What is detergent? Write its two examples. What effects are seen on the human health and environment due to the use of detergent? Present your argument.

k. There has been an excessive use of chemical pesticides in Hari's village due to which complex problems have been observed in the health of people and the environment. What may be the alternatives to solve these problems? Give some suggestions.

l. What do you mean by chemical pollution? What are its effects? Write practical ways to minimize it.

m. Write about the pollution caused by industrial products like cement, glass, ceramics, plastic, fiber, chemical fertilizers, soap, detergent,etc. in your locality. Write its causes and suggest proper ways for management.