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 Ms. 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 phenomenonis 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 $kgm\ -^1s^{-2}$. 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

acceleration	$\frac{\text{velocity}}{\text{time}}$	$\frac{\text{meter}}{\text{second} \times \text{second}}$	m/s^2	m/s^2
force	mass × acceleration	$\frac{\text{kilogram} \times \text{meter}}{\text{second} \times \text{second}}$	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^2s^{-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:

Bacteria *Euglena* *Mushroom* *Fern* *Frog*

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.

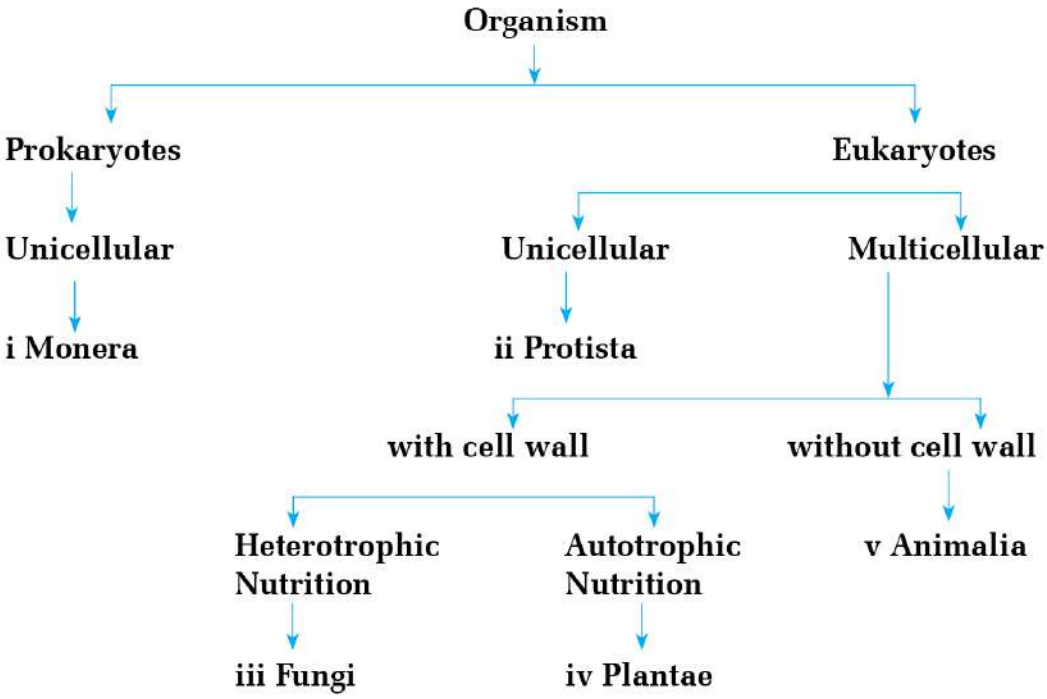


Figure 2.2 Five kingdom classification system

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.

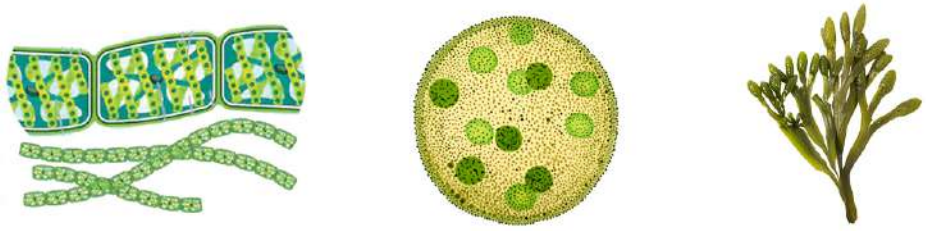
iv. Observe the slide undermicroscope.

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

Fern *Cycas* *Banana* *Peepal*

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

Mustard Soybean Orange Bean Pea

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.

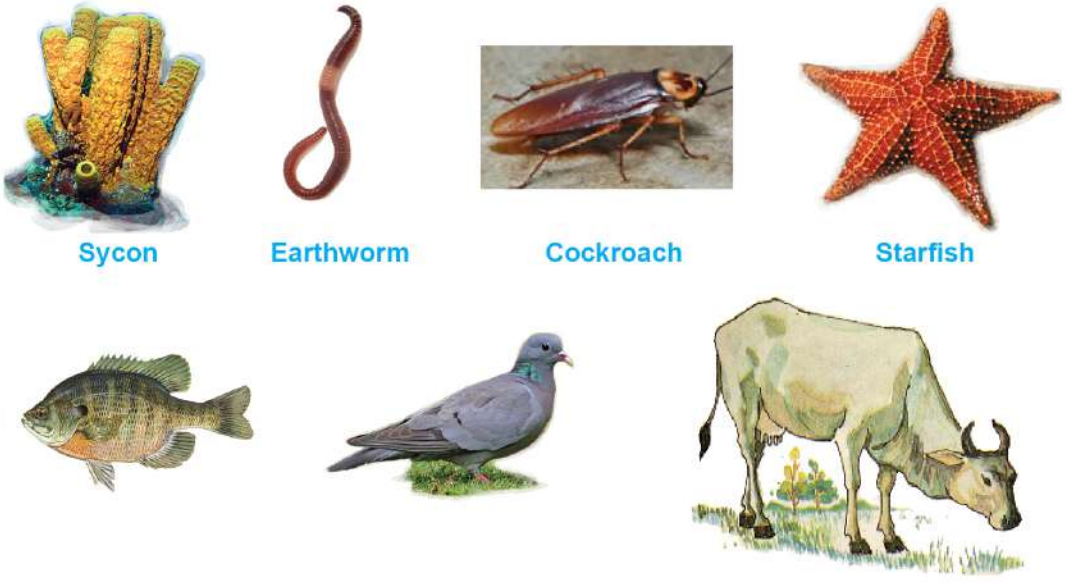


Figure 2.12

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.

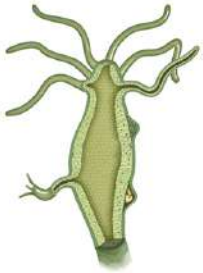
h. They reproduce both asexually and sexually. Asexual reproduction takes place by budding and regeneration, and sexual reproduction takes place by the formation of gametes.

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:



Hydra

Jellyfish

Coral

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.

Earthworm *Leech* *Nereis*

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.

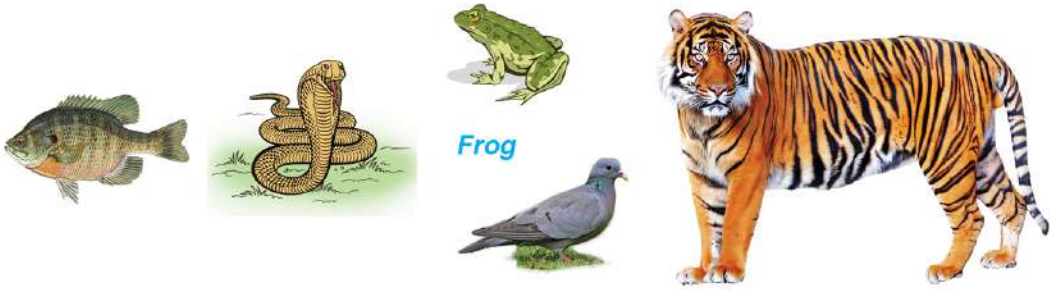
c. A hollow, tubular nervous tissue is found in the vertebral canal.

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



Fish Snake Frog Pigeon Tiger

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.

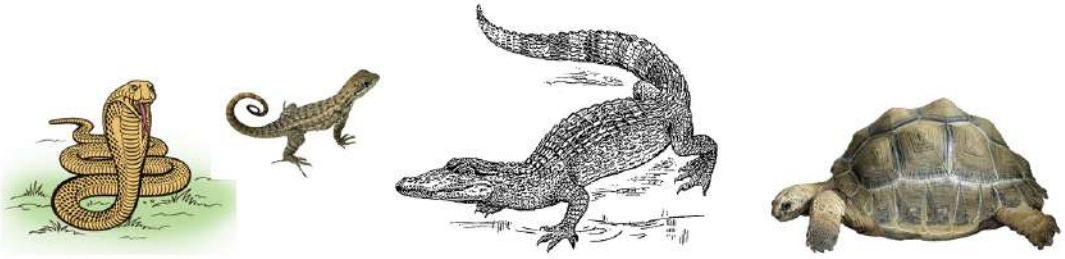
f. They have a three-chambered heart.

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



Snake *Lizard* *Crocodile* *Tortoise*

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

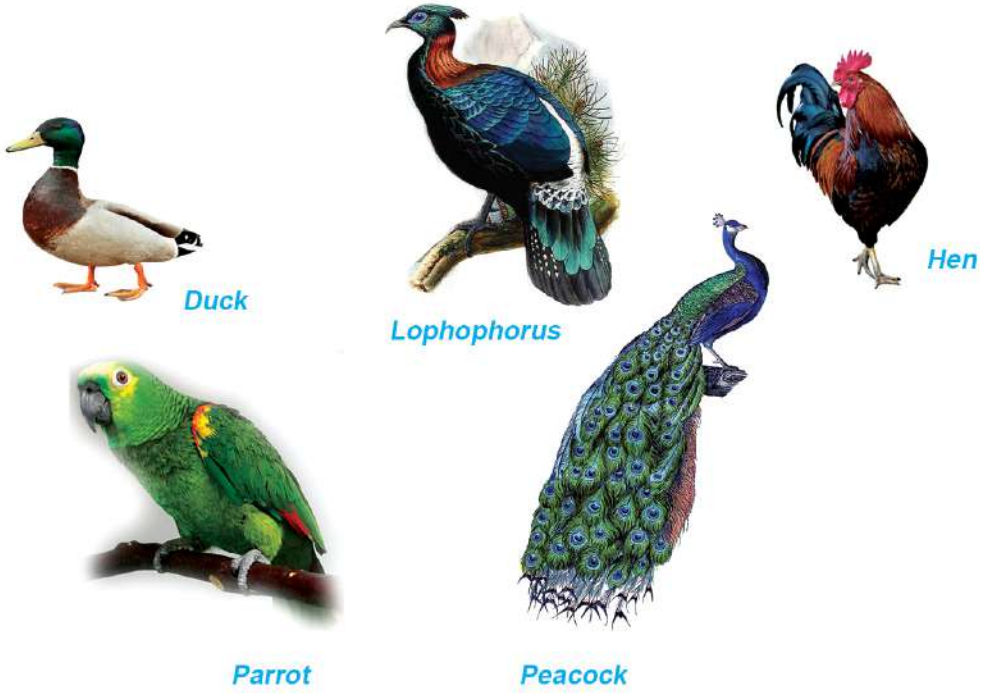


Figure 2.25

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.

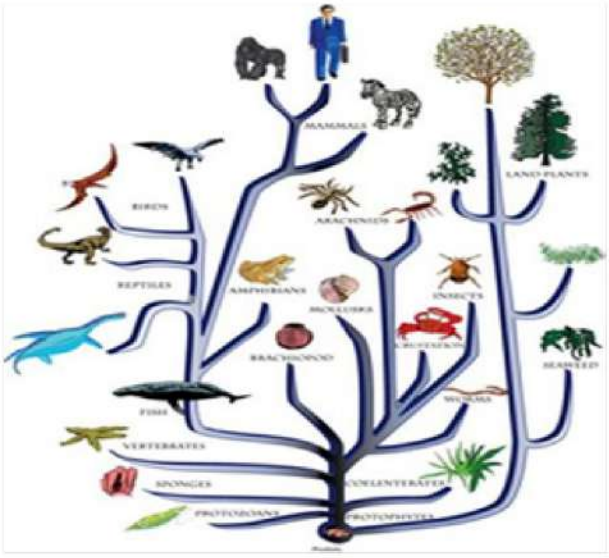


Fig. 2.27 Evolution of organism and classification

Relation of classification of living beings and evolution

Look at the given picture and discuss the following questions.

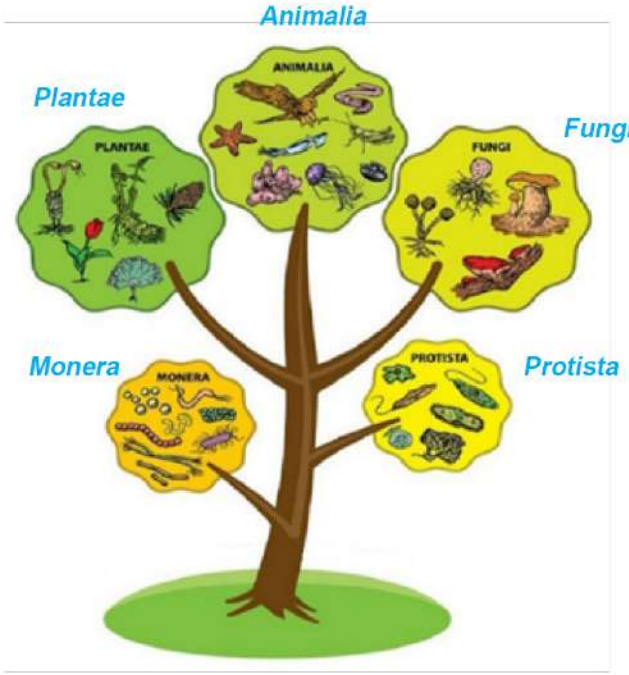


Figure 2.28 Classification of living being

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?

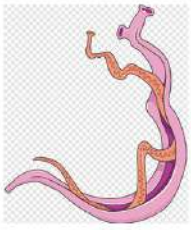
i. Bears flowers, produces seed.

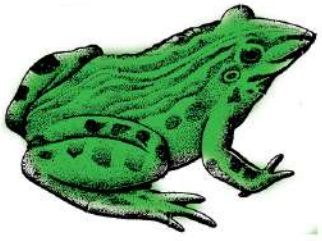
ii. Bears flowers, leaves are needle-like.

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.

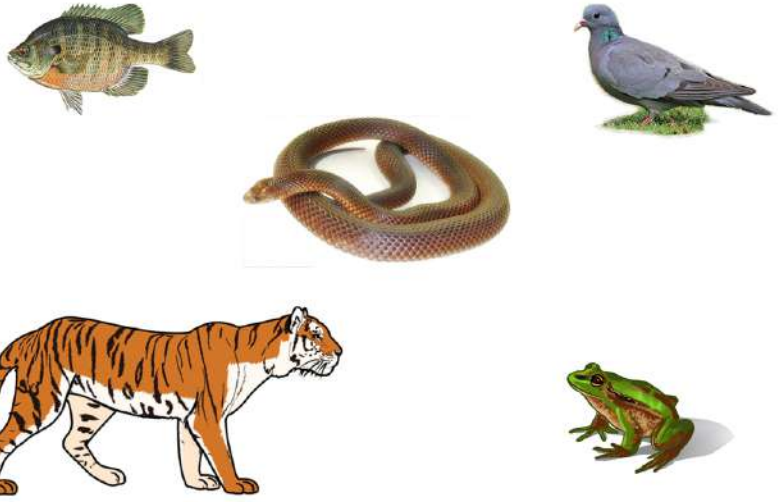
iii. How does the study of these animals clarify the concept of evolution?

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.

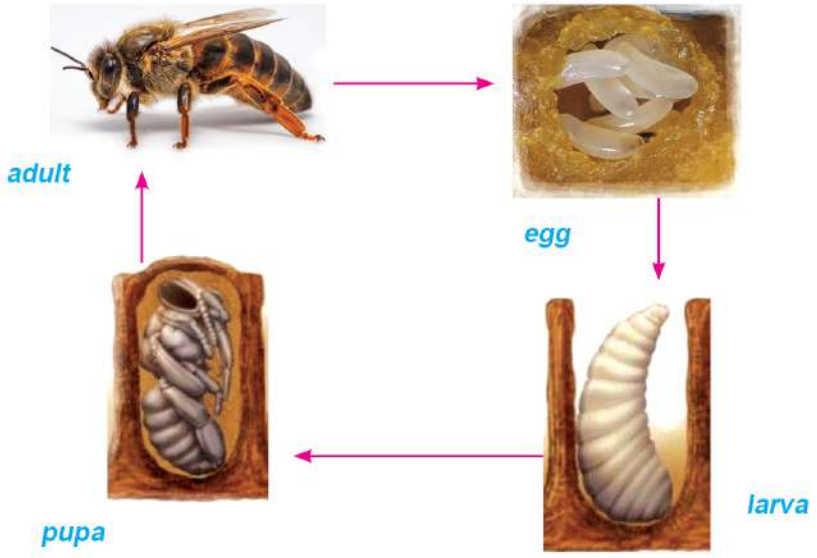
Conclusion: Conclude the discussion on life cycle of the honey bee based on the presentation.

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.

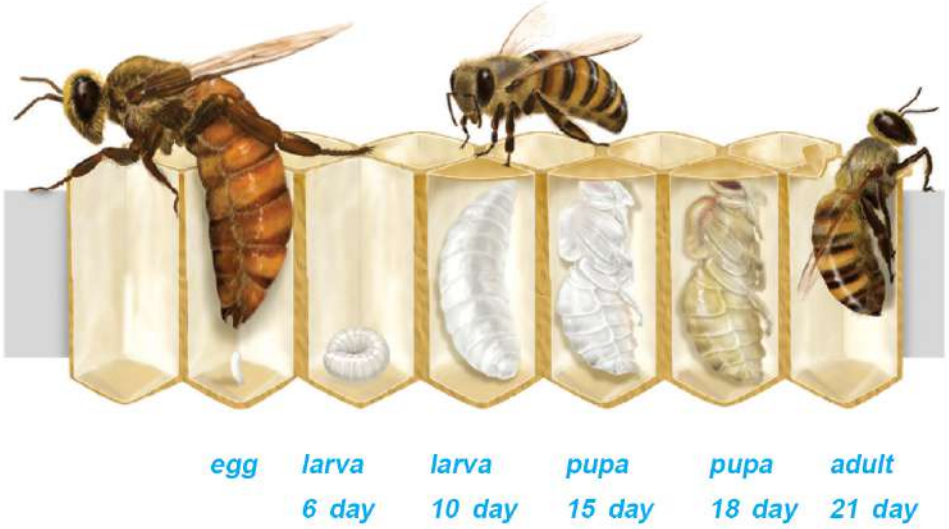


Figure 3.4 Various stages of bees

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.

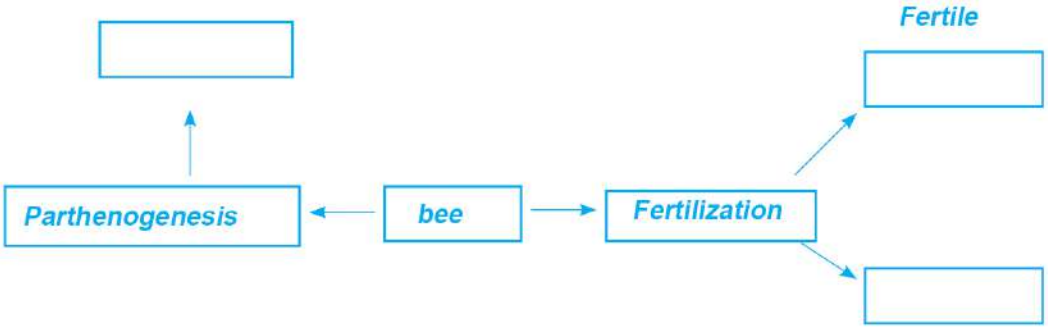
i. Explain the life cycle ofhoney bee with diagram.

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.

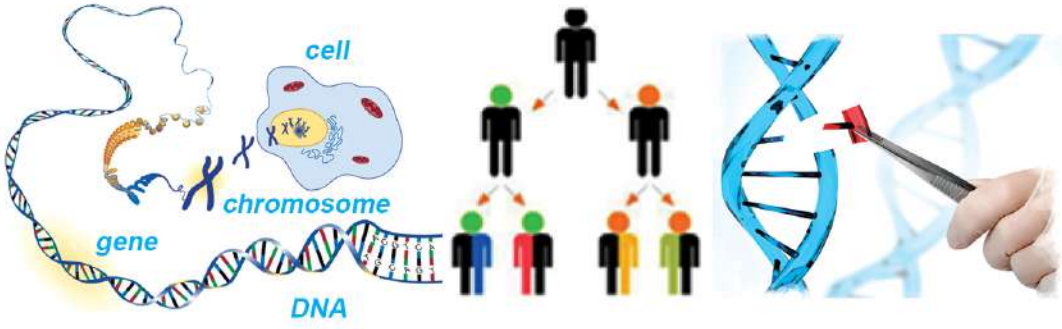


Figure 4.1 Gene, Sex determination, Genetic Technology

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:

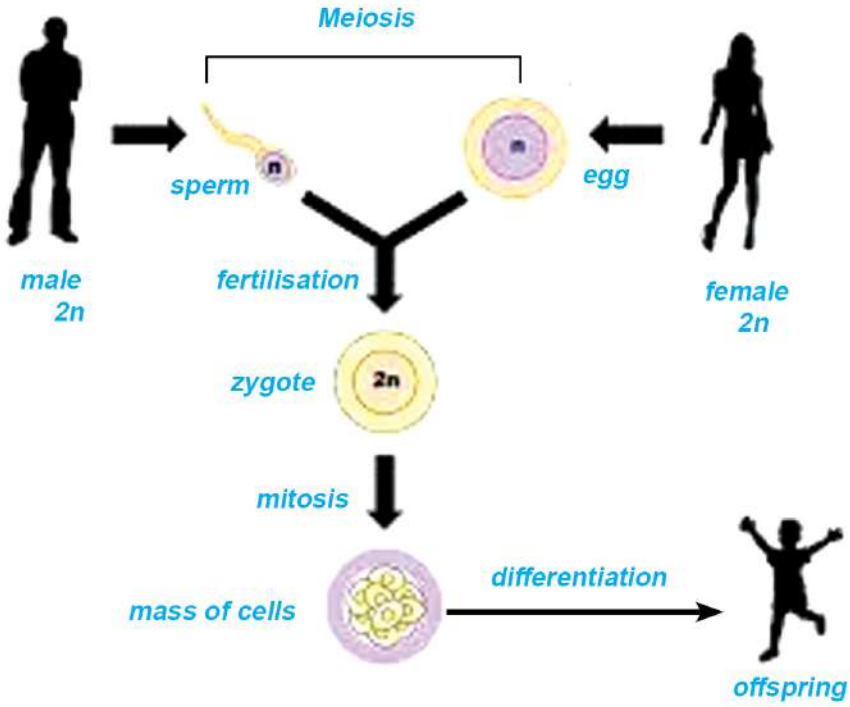


Figure 4.2 Cell division for the growth and development of living beings

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.

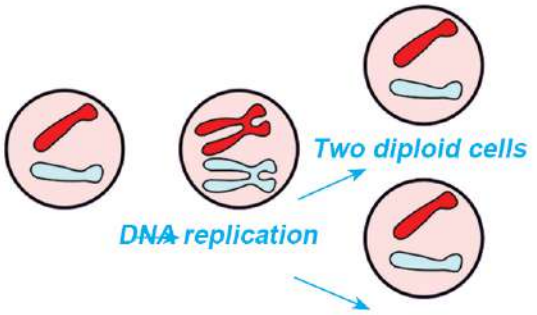


Figure 4.3 Model of mitotic cell division

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.

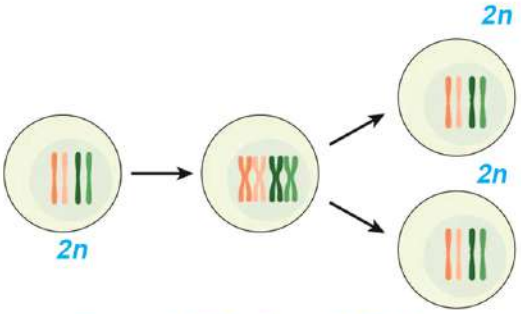


Figure 4.4 Mitotic cell division

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.

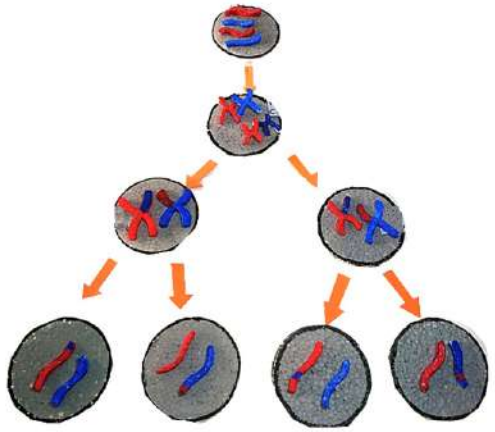


Figure 4.5 Model of meiosis cell division

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.

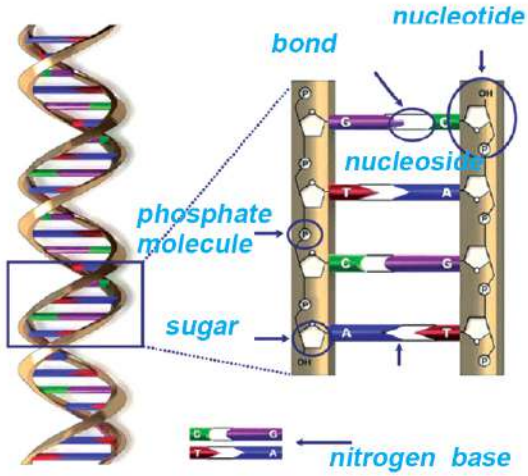


Figure 4.6 Structure of DNA

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.

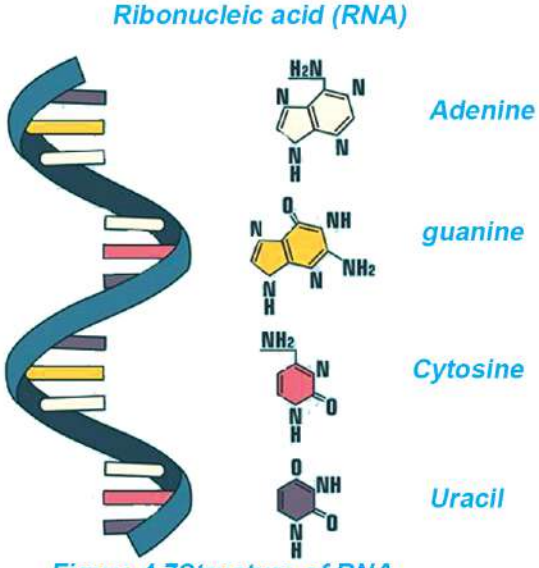


Figure 4.7Structure of RNA

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.

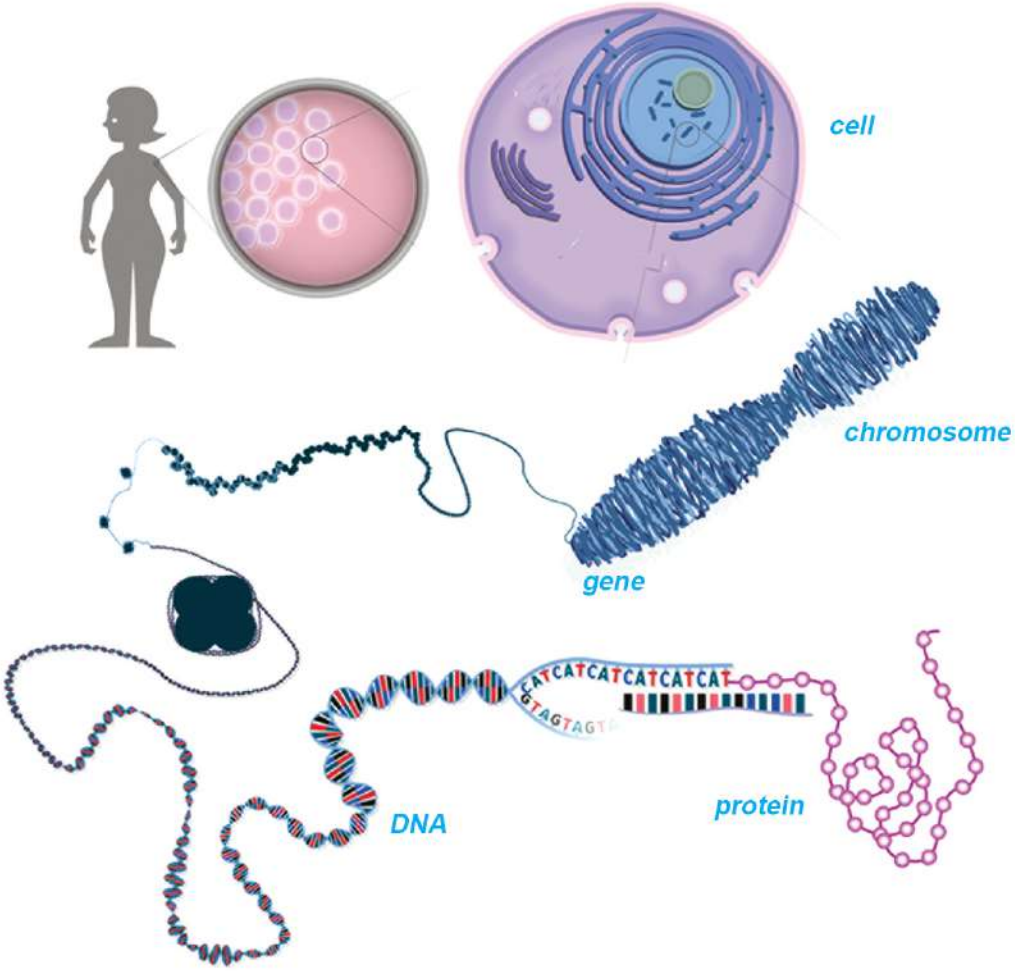


Figure 4.8 Cells, Chromosome, and Gene location

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.

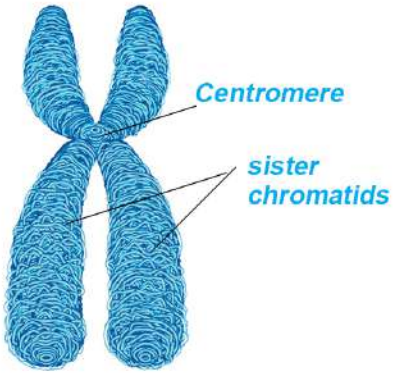


Figure 4.9 Structure of chromosome

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.

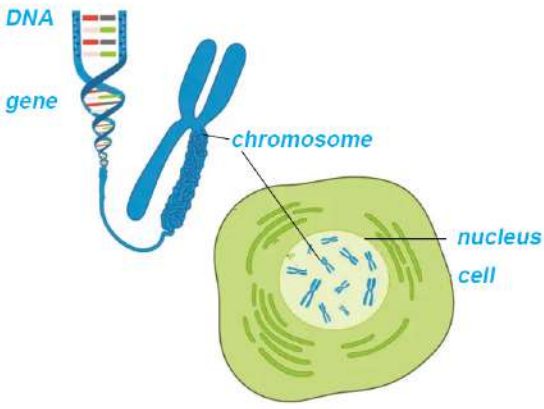


Figure 4.10 Location of gene

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

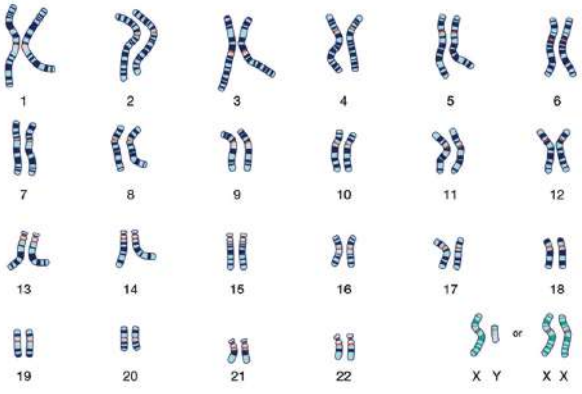


Figure 4.11 Number of chromosomes in humans

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.

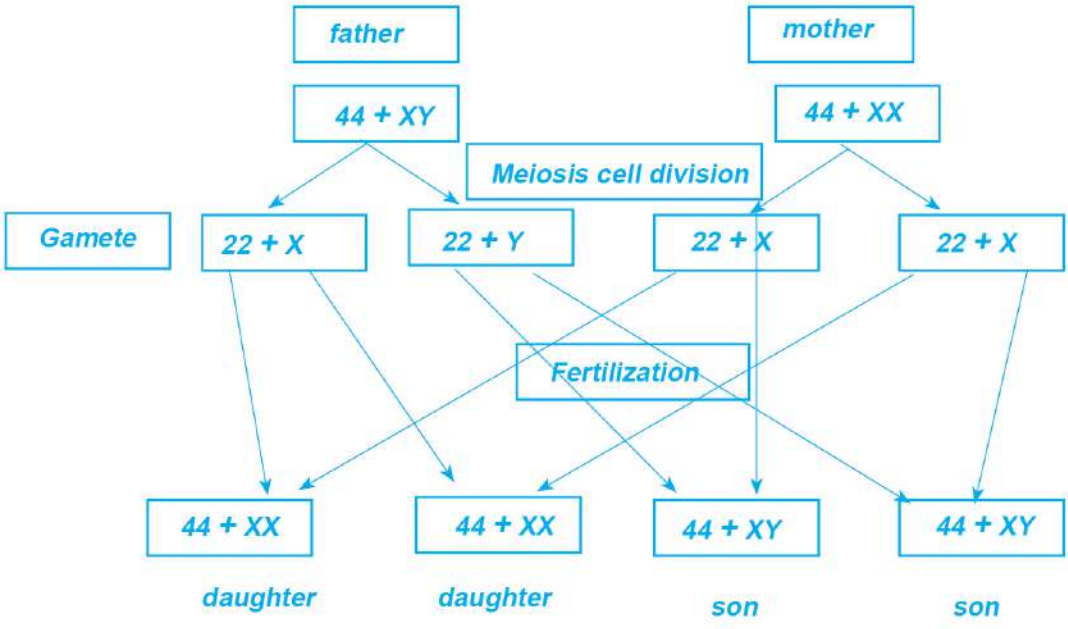


Figure 4.13 Sex determination chart

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.

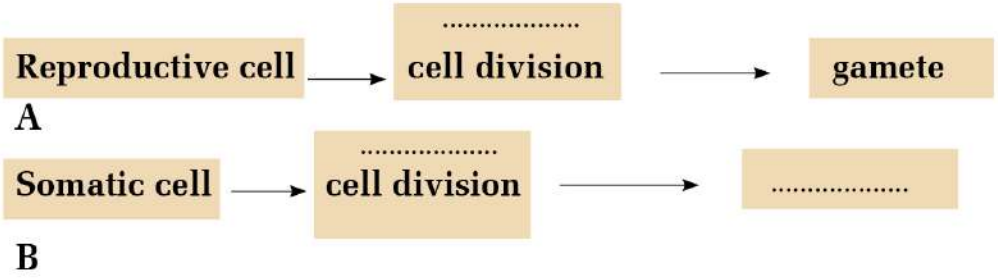
f. Clearly explain the role of genes in the transmission of hereditary characteristics in organisms.

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.



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.

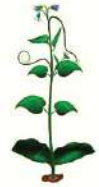
	Flower color	Seed shape	Seed color	Pod color	Pod shape	Plant height	Flower position
DOMINANT	 Purple	 Round	 Yellow	 Green	 Inflated	 Tall	 Axial
RECESSIVE	 White	 Wrinkled	 Green	 Yellow	 Constricted	 Short	 Terminal

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:

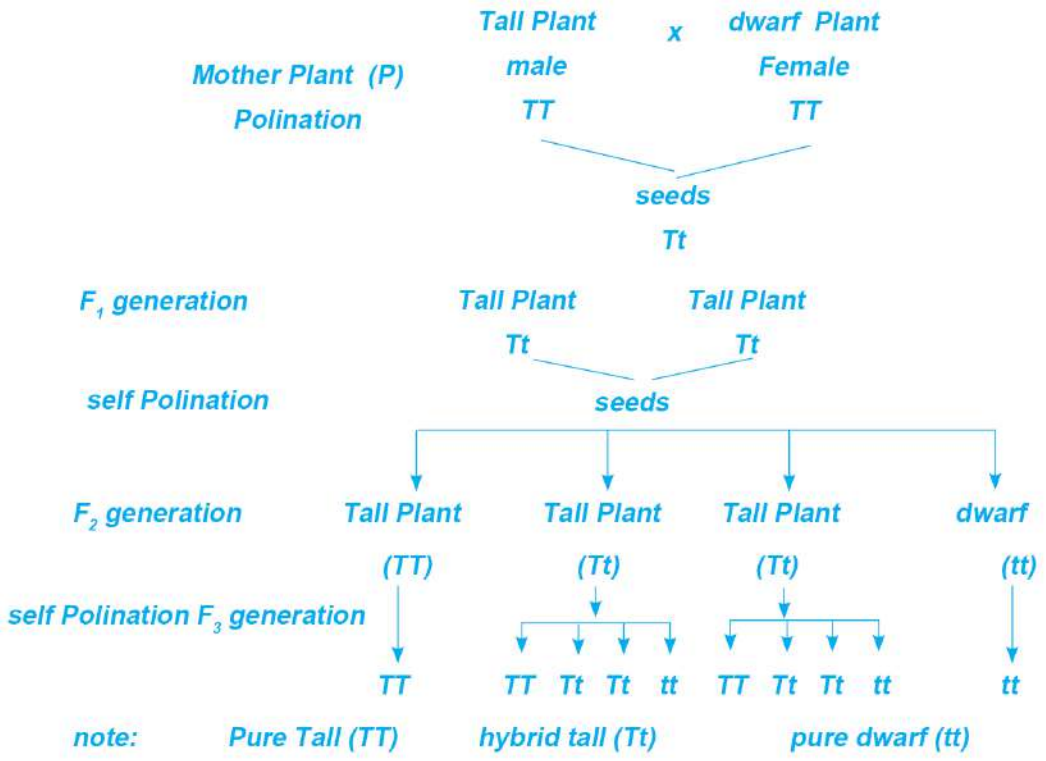


Figure 4.14

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.

In Mendel's experiment, a cross pollination between pure tall pea plant and pure dwarf pea plant

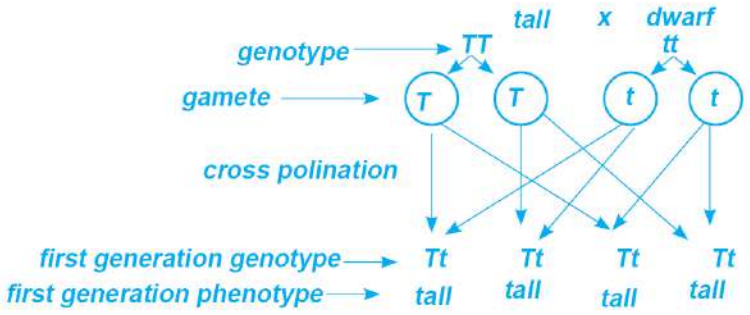


Figure 4.15 Chart showing Mendel's law of dominance

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.

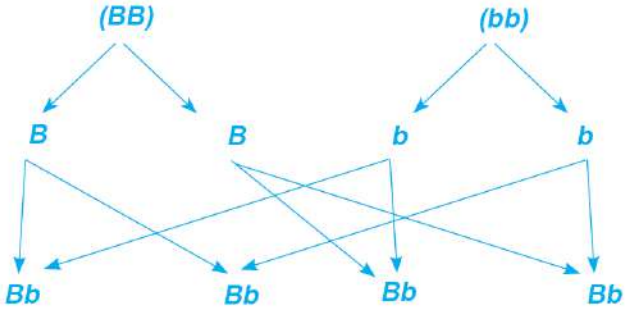


Figure 4.16 Cross breeding of pure black guinea pig and pure white guinea pig

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.

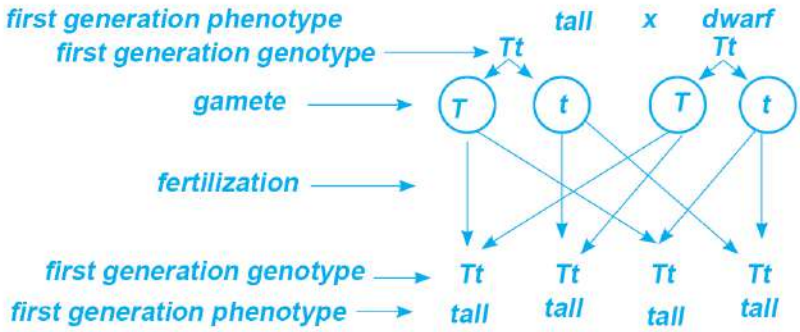


Figure 4.17: Second generation produced from self-pollination between hybrids of first generation

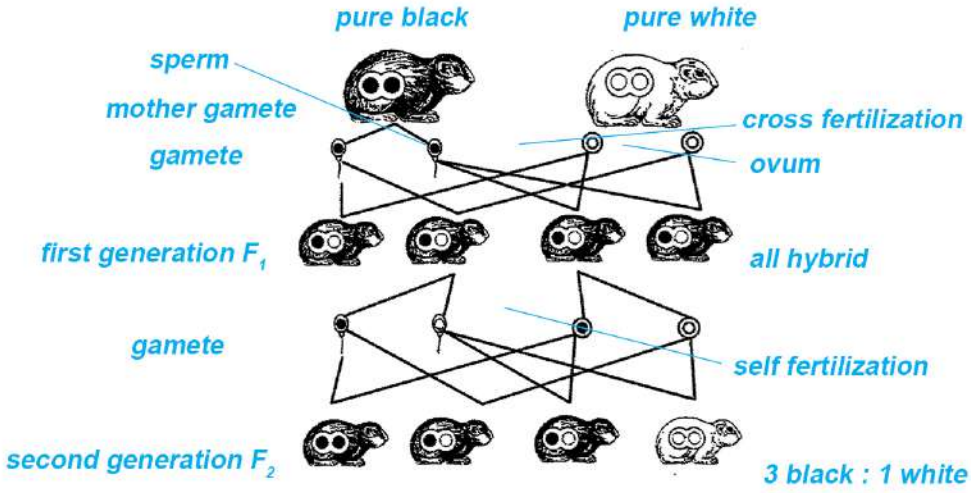


Figure 4.18 Second generation produced by self-breeding of hybrid black guinea pig

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

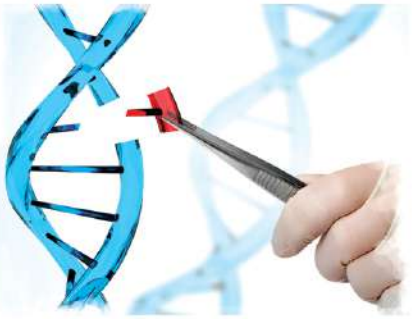


Figure 4.19 A fragment of DNA of an organism is added to the DNA of another organism

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.

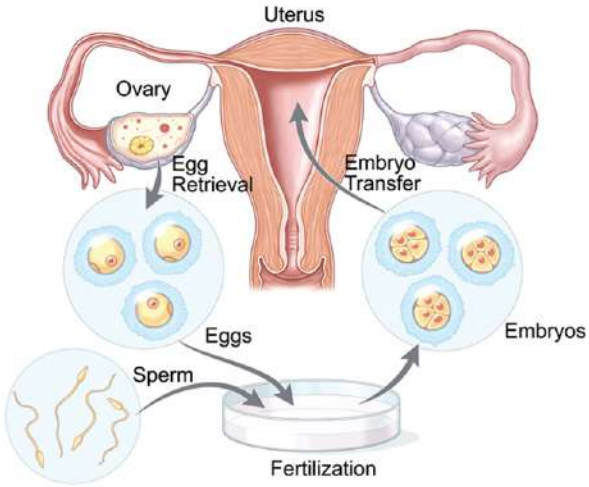


Figure 4.26 Method of In Vitro fertilization

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.

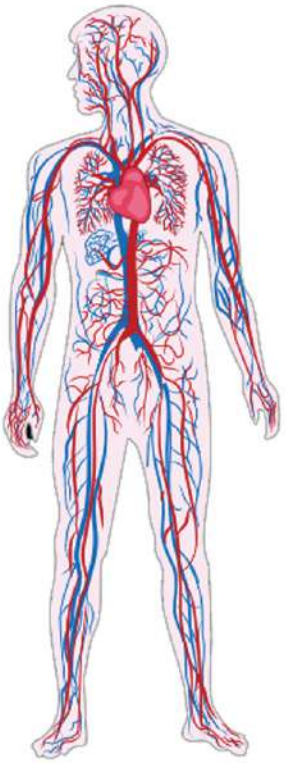


Figure 5.2 Human blood circulatory system

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

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.

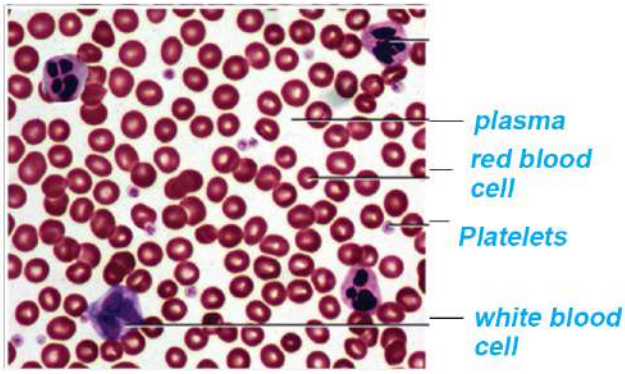


Figure 5.3 Composition of blood

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.

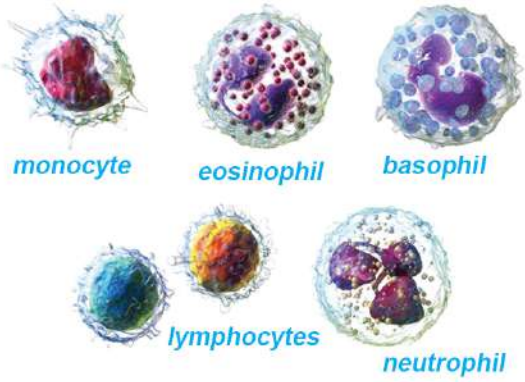


Figure 5.5 White blood cells

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.

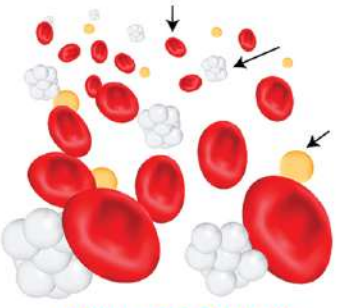


Figure 5.6 Platelets

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.		

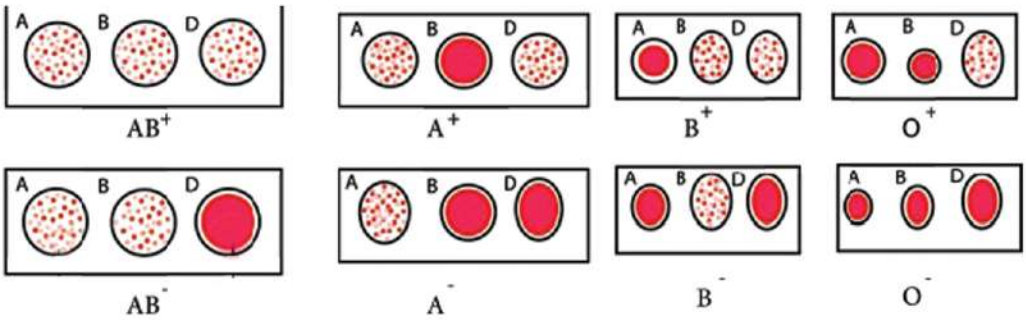


Figure 5.7 Test of human blood group

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.

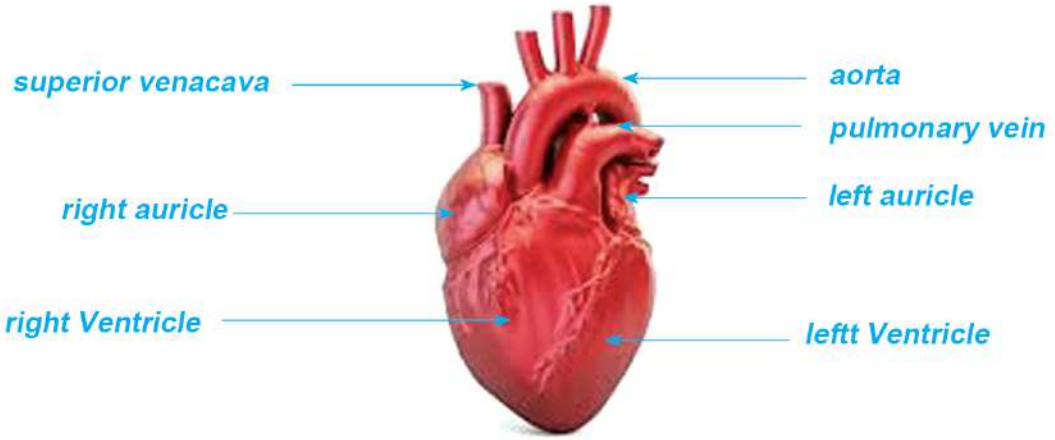


Figure 5.8 External structure of human heart

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.

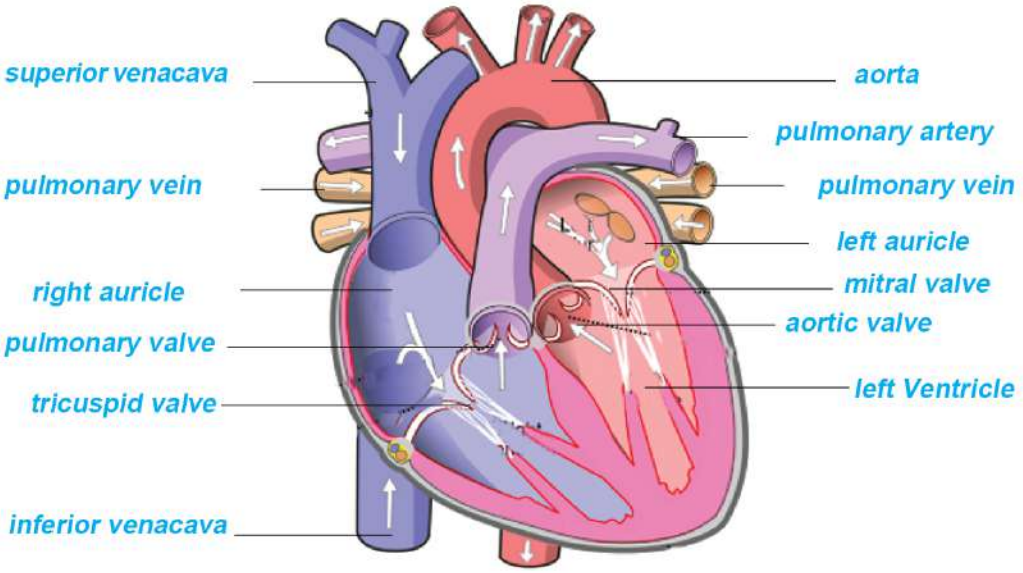


Figure 5.9 Internal structure of the human heart

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.

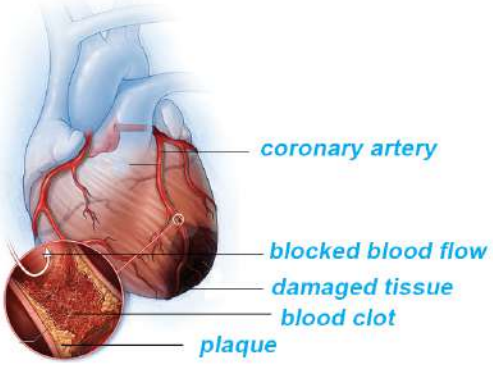


Figure 5.10 Condition of a heart attack

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.

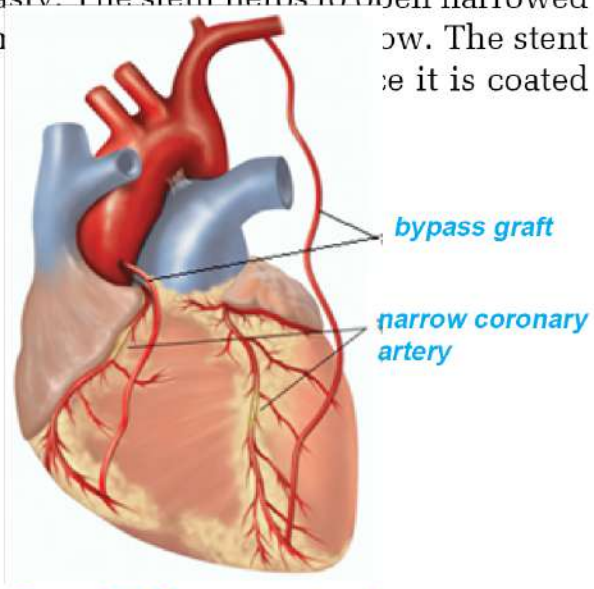


Figure 5.11 Coronary artery bypass surgery

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.

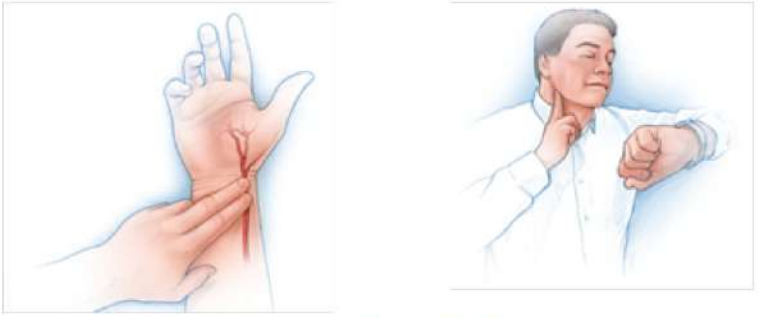


Figure 5.12

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.

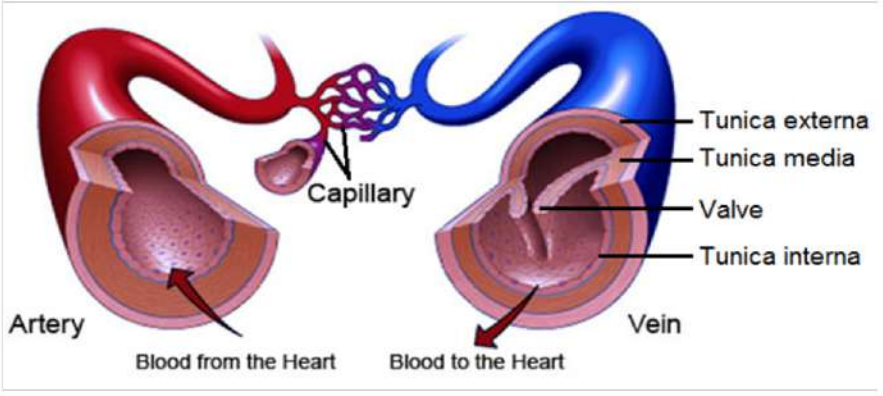


Figure 5.13 Types of blood vessels

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.

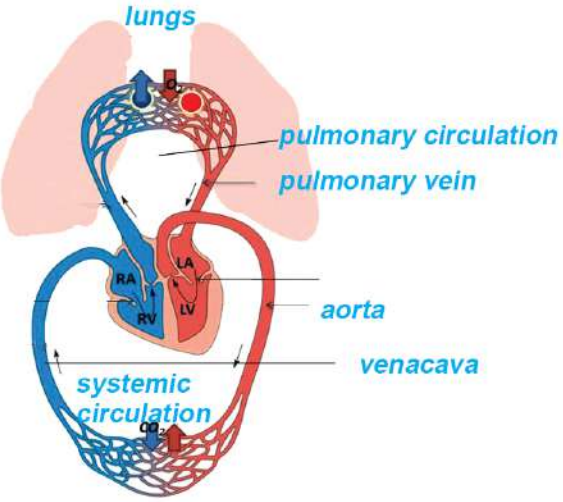


Figure 5.14 Blood circulation

left Ventricle —(artery)→ **different parts of body** —(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 —(pulmonary artery)→ **lungs** —(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?

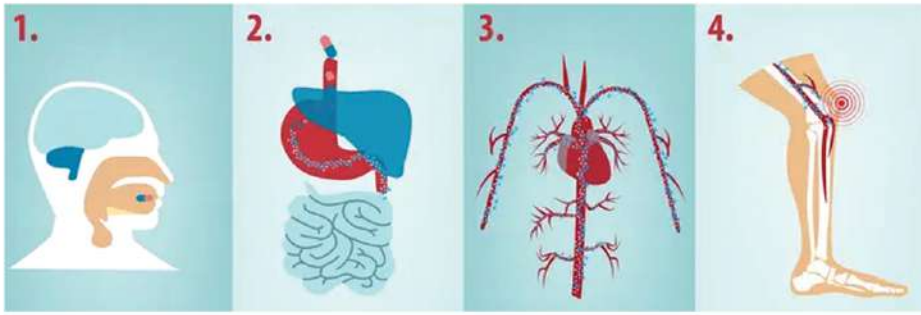
h. Sarita's grandmother shows the symptoms like frequent urination, tiredness, muscular spasm and numbness in hands and legs, and thirst. What is the problem with her?

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.

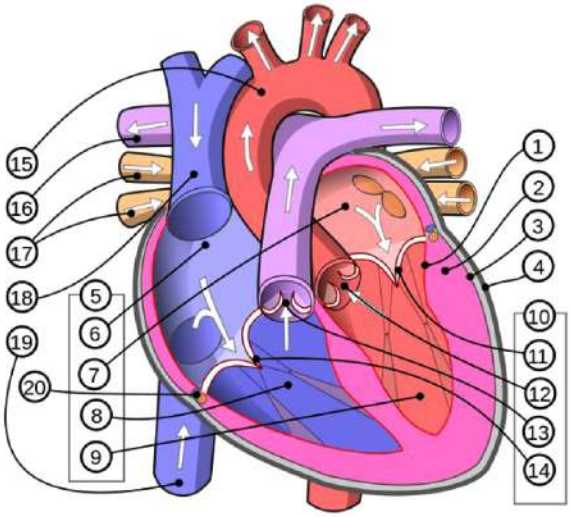
x. Study the concept map given below and answer the following questions.

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

Figure 6.2 Volcano

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.

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.

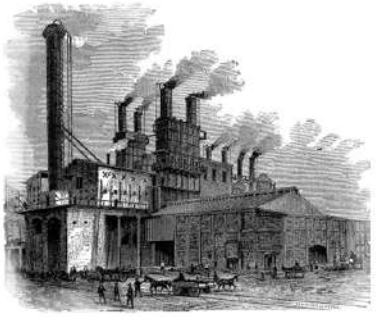


Figure 6.4 Factory

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.

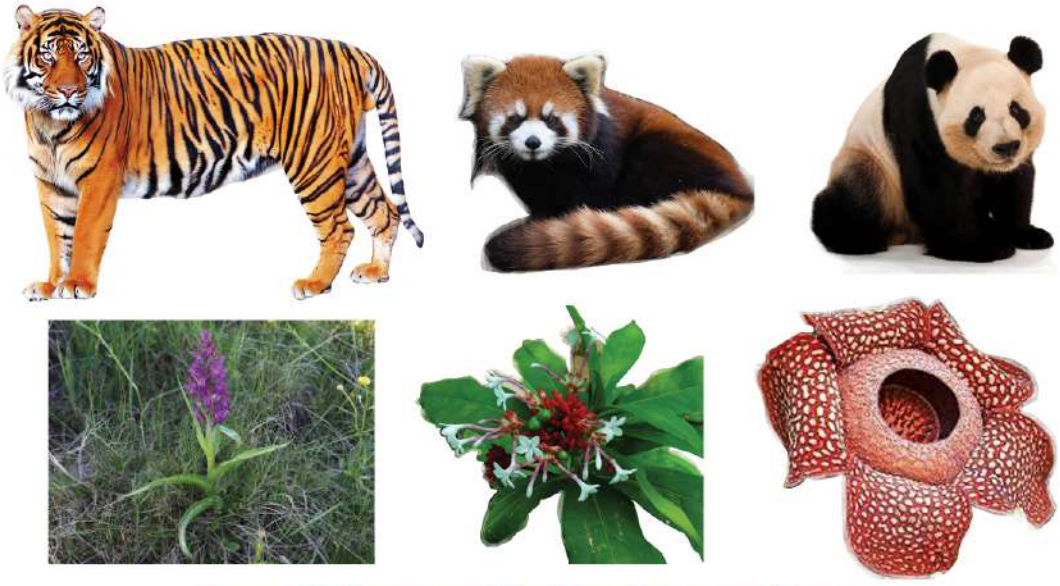


Figure 6.7 Endangered plants and animals of Nepal

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 2. Red Panda 3. Black buck 4. Gaur Bison 5. Wild yak 6. Wild water buffalo 7. Grey Wolf 8. Hispid hare 9. Swamp deer 10. Asiatic wild elephant 11. Lynx 12. Striped Hyena 13. Assamese Monkey 14. Indian Pangolin 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	1. Great hornbill 2. Cheer pheasant 3. White stork 4. Black stork 5. Sarus crane 6. Bengal florican 7. Impeyan pheasant 8. Lesser florican 9. Crimson horned pheasant **Reptiles** 1. Gharial 2. Asiatic rock Python 3. Golden monitor lizard

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

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.

Figure 6.13 Turmeric

Malaber nut (Asuro)

Figure 6.14 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.

Calamus (Bojo)

Figure 6.15 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.

Caterpiller fungus (Yarsagumba or Yarchagumba)

Figure 6.16 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.

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)

Figure 6.18 Aloe vera

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.

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?

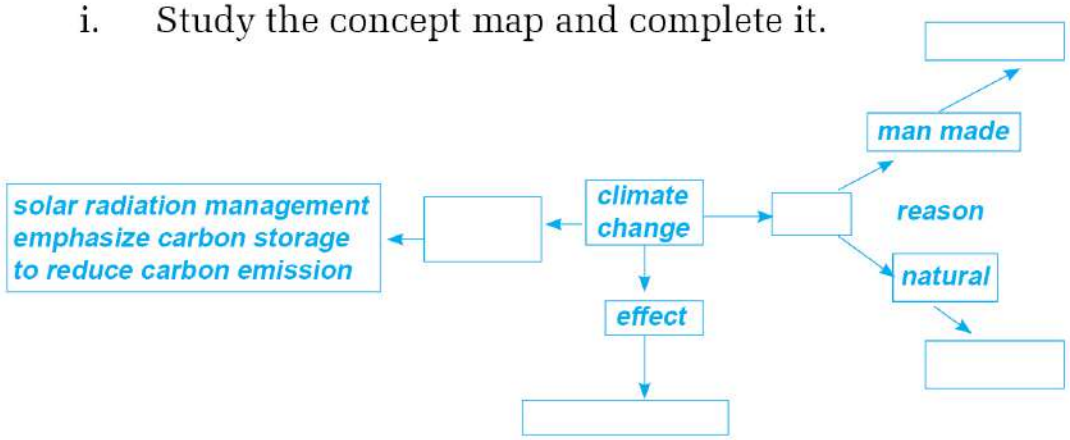
e. What measures can be adopted to protect rare animals?

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.

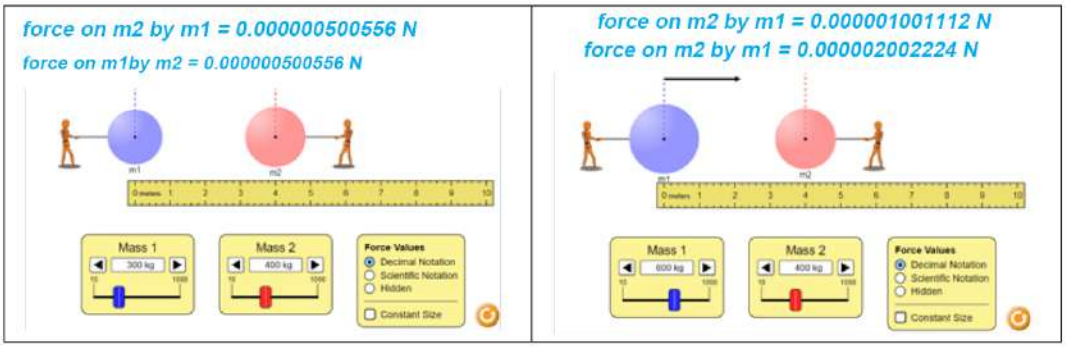


Figure 7.5 Difference in gravitational force between two objects when their mass is changed

(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.

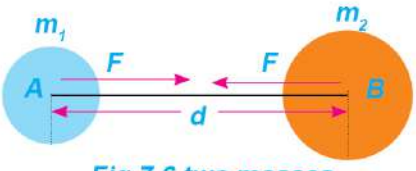


Fig 7.6 two masses

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,

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),

$$F \propto \frac{m_1 m_2}{d^2}$$

$$F = G\frac{m_1 m_2}{d^2} \quad \ldots\ldots\ldots\ldots \text{(iii)}$$

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.

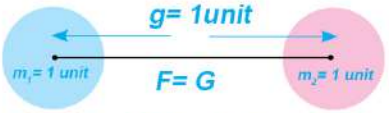


Figure 7.7 Definition of G

As shown in the figure, when $m_1 = m_2 = 1$ kg and d=1 m

$$F = \frac{Gm_1 m_2}{d^2} = \frac{G \times 1 \times 1}{1^2} = G$$

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 x 10^{24} kg and 7.34 x 10^{22} kg respectively. The distance between the Moon and the Earth is 3.84 x 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) = 3.84×10^5 km = 3.84×10^8 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) $F_2 = \frac{Gm_1 2m_2}{d^2} = 2\frac{Gm_1 m_2}{d^2}$ $F_2 = 2F_1$	Putting, $m_1 = 2\ m_1$, $m_2 = 2\ m_2$ in equation (i) $F_2 = \frac{G2m_1 2m_2}{d^2} = 4\frac{Gm_1 m_2}{d^2}$ $F_2 = 4F_1$

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) $F' = \frac{Gm_1 m_2}{\left(\frac{d}{2}\right)} = 4\frac{Gm_1 m_2}{d^2}$ $F' = 4F$	Putting, $d = 2\ d$ in equation (i) $F' = \frac{Gm_1 m_2}{(2d)^2} = \frac{1}{4}\frac{Gm_1 m_2}{d^2}$ $F' = \frac{1}{4}F$

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.

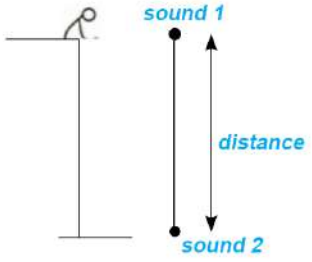


Figure 7.8 Measurement of acceleration due to gravity.

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	$v=\sqrt{(2\,ah)}$	Result
First time	...	...	$a_1=\cdots$	$=\frac{a_1+a_2+a_3}{3}$	$v_1=\sqrt{(2\,ah_1)}$	.....
Second time	...	...	$a_2=....$		$v_2=\sqrt{(2\,ah_2)}$	
Third time	...	...	.....		$v_3=\sqrt{(2\,ah_3)}$	

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).

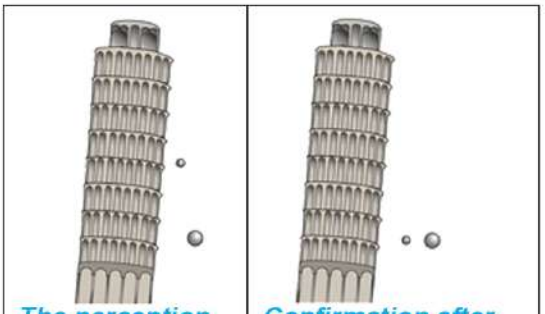
Question to think

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.



The perception beforeGalileo's experiment | Confirmation after Galileo's experiment

Figure 7.8 Falling of objects with different masses

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

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,

$$F = \frac{GMm}{R^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

If this force produces acceleration 'g' in mass 'm', then from the Second law of motion,

$$F = mg \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

From the equations (i) and (ii),

$$mg = \frac{GMm}{R^2}$$

$$g = \frac{GM}{R^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

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.

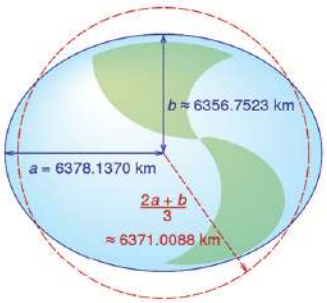
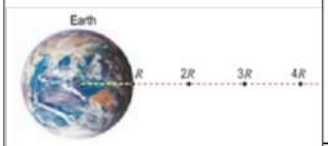


Figure 7.10 Earth's radius

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.

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.

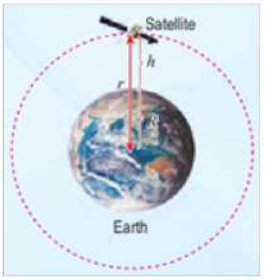


Figure 7.12

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,

$$g = \frac{GM}{(R+h)^2}$$

$$\text{or, } g = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(6.371000 + 400000)^2}$$

$$\text{or, } g = \frac{39.82 \times 10^{13}}{(6771000)^2} = \frac{39.82 \times 10^{13}}{4.60 \times 10^{13}}$$

$$\therefore \quad g_1 = 8.66\ m/s^2$$

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.

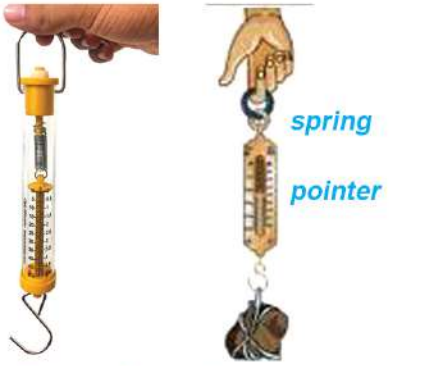


Figure 7.13: Measurement of weight by a spring balance

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/s² and weight (W = mg) in newton on different heavenly bodies									
50 kg	moon		mercury		mars		venus		earth	
	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) = 9.8m/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?

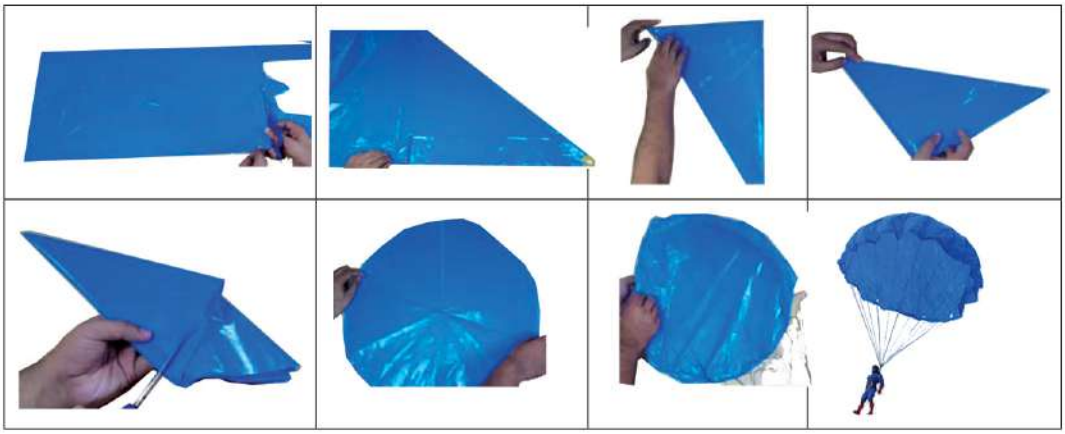


Figure 7.14 Construction of a model of a parachute

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

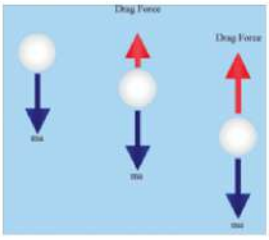


Figure 7.16 Resistance during a hail

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.

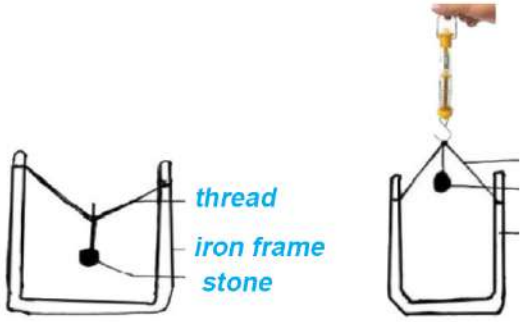


Figure 7.18 Observation of free fall

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 $2m/s^2$. 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