GOVERNMENT OF TAMILNADU

STANDARD NINE

TERM - III

VOLUME 3

SCIENCE

Untouchability is Inhuman and a Crime

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JOB / Post Graduation

PREFACE

This book is developed in a holistic approach which inculcates comprehending and analytical skills. It will be helpfull for the students to understand higher secondary science in a better way and to prepare for competitive exams in future. This textbook is designed in a learner centric way to trigger the thought process of students through activities and to make them excel in learning science.

HOW TO USE THE BOOK?

- This term-III science book has 9 units.
- Each unit has simple activities that can be demonstrated by the teacher and also few group activities are given for students to do under the guidance of the teacher.
- Infographics and info-bits are added to enrich the learner's scientific perception.
- The "Do you know?" and "More to know" placed in the units will be an eye opener.
- Glossary has been introduced to learn scientific terms.
- ICT corner and QR code are introduced in each unit for the digital native generation.

How to get connected to QR Code?

- Download the QR code scanner from the google play store/
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- Open the QR code scanner application
- Once the scanner button in the application is clicked, camera opens and then bring it closer to the QR code in the textbook.
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UNIT

1

Fluids

Learning Objectives

G8JNLI

After completing this lesson, students will be able to

- define pressure in terms of weight.
- explain the variation of pressure with respect to depth in a fluid.
- learn the fact that water exerts an upward force on objects immersed in it.
- recall and state the Archimedes' principle.
- calculate density when pressure and altitude are given.
- learn the formula for finding the relative density of an object and apply the same.
- understand the behaviour of floating bodies.

Introduction

A small iron nail sinks in water, whereas a huge ship of heavy mass floats on sea water. Astronauts have to wear a special suit while traveling in space. All these have a common reason called 'pressure'. The intermolecular forces in solids are strong, so that the shape and size of solids do not easily change. But this force is less in liquids and gases (together known as fluids) so that their shape is easily changed. If the pressure increases in a solid, based on its inherent properties it experiences tension and ultimately deforms or breaks. In the case of fluids it however causes it to flow rather than to deform. Although liquids and gases share some common characteristics, they have many distinctive characteristics on their own. It is easy to compress a gas whereas liquids are incompressible. Learning of all these facts helps us to understand pressure better. In this lesson you will study about the pressure in fluids, density of fluids and their application in practical life.

1.1 Thrust and Pressure

Try to fix a paper with the help of a drawing pin. Push the pin into the board by its head. Did you succeed? Try now to push the pin by the pointed end. Could you do it this time? Have you ever wondered why a camel can run in a desert easily? Why a truck or a motorbus has wider tyre? Why cutting tools have sharp edges? In order to answer these questions and understand the phenomena involved, we need to learn about two interrelated physical concepts called thrust and pressure.

Activity 1

Stand on loose sand. Your feet go deep into the sand. Now, lie down on the sand. What happens? You will find that your body will not go that deep into the sand.

In both the cases of the above activity, the force exerted on the sand is the weight of your body which is the same. This force acting perpendicular to the surface is called thrust. When you stand on loose sand, the force is acting on an area equal to the area of your feet. When you lie down, the same force acts on an area of your whole body, which is larger than the area of your feet. Therefore the effect of thrust, that is, pressure depends on the area on which it acts. The effect of thrust on sand is larger while standing than lying.

The net force in a particular direction is called thrust. The force per unit area acting on an object concerned is called pressure. Thus, we can say thrust on an unit area is pressure.

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area of contact}}$$

For the same given force, if the area is large pressure is low and vice versa. This is shown in Figure 1.1.

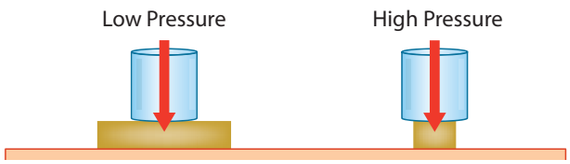


Figure 1.1 Pressure depends on area of application

Bed of nail

If a single nail pricks our body it is very painful. How is it possible for people to lie down on a bed of nails, still remain unhurt?

In SI units, the unit of thrust is newton denoted as N. The unit of pressure is newton per square metre or newton metre^{-2} denoted as Nm^{-2}. In the honour of the great French scientist, Blaise Pascal, 1 newton per square metre is called as 1 pascal denoted as Pa. 1 Pa = 1 N m^{-2}

In CGS system force is measured in dyne and area in square cm. Thus the unit of pressure in CGS system is dyne per square cm (dyne cm^{-2}). The relation between the two units is,

$$1 \text{ N m}^{-2} = 10 \text{ dyne cm}^{-2}.$$

Example 1.1

A man whose mass is 90 kg stands on his feet on a floor. The total area of contact of his two feet with the floor is 0.036 m^2. (Take, g = 10 ms^{-2})

a. How much is the pressure exerted by him on the floor?

b. What pressure will he exert on the floor if he stands on one foot?

Solution

The weight of the man (thrust),

F = mg = 90 kg × 10 m s^{-2} = 900 N

a) Pressure, $P = \frac{F}{A} = \frac{900 \text{ N}}{0.036 \text{ m}^2} = 25000$ Pa

b) Area of one foot, $A_{1foot} = \frac{A}{2} = 0.018$ m^2

Pressure, exerted by 1foot

$$= \frac{F}{A_{1foot}} = \frac{900 \text{ N}}{0.018 \text{ m}^2} = 50000 \text{ Pa}$$

DO YOU KNOW?

- Cutting edges of knife and axes are sharpened, because as the area decreases the pressure increases. Hence, small force is enough to cut an object.
- Heavy trucks are fitted with six to eight wheels. As area increases pressure decreases. So weight of the truck exerts less pressure on the road.
- Animals' jaws can exert a pressure of more than 750 pounds per square inch as they are very sharp.

1.2 Pressure in fluids

All the flowing substances, both liquids and gases are called fluids. Like solids, fluids also have weight and therefore exert pressure. When filled in a container, the pressure of the fluid is exerted in all directions and at all points of the fluid. Since the molecules of a fluid are in constant, rapid motion, particles are likely to move equally in any direction. Therefore the pressure exerted by the fluid acts on an object from all directions. It is shown in Figure 1.2. Pressure in fluids is calculated as shown below.

$$\text{Fluid Pressure} = \frac{\text{Total force exerted by the fluid}}{\text{Area over which the force is exerted}} = \frac{F}{A}$$

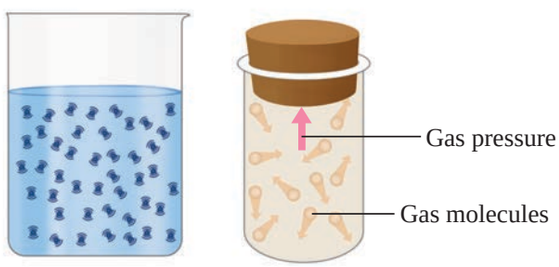


Figure 1.2 Collision of molecules gives rise to pressure

We shall first learn about the pressure exerted by liquids and then learn about the pressure exerted by gases.

1.2.1 Pressure due to liquids

The force exerted due to the pressure of a liquid on a body submerged in it and on the walls of the container is always perpendicular to the surface. In Figure 1.3, we can see the pressure acting on all sides of the vessel.

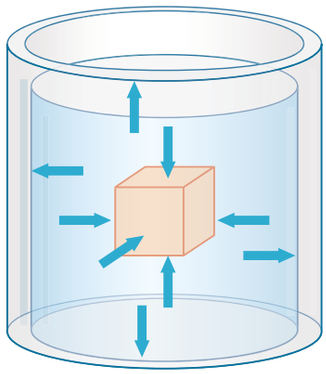
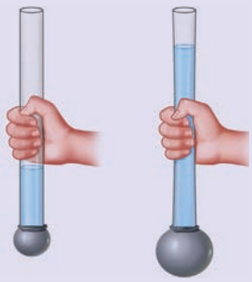


Figure 1.3 Force due to pressure of a liquid

When an air filled balloon is immersed inside the water in a vessel it immediately comes up and floats on water. This shows that water (or liquid) exerts pressure in the upward direction. It is shown in Figure 1.4.

Figure 1.4 Liquid pressure exerts force upwards

Activity 2



Take a transparent plastic pipe. Also take a balloon and tie it tightly over one end of the plastic pipe. Keep the pipe in a vertical position with its closed end at the bottom. Pour some water in the pipe from the top. What happens?

We will find that on pouring water in the pipe, the balloon tied at the bottom stretches and bulges out. The bulging out of balloon demonstrates that the water poured in the pipe exerts a pressure on the bottom of its container.

Similarly, liquid pressure acts in lateral sides also. When a bottle having water is pierced on the sides we can see water coming out with a speed as in Figure 1.5. This is because liquid exerts lateral pressure on the walls the container.

Figure 1.5 Liquid pressures on lateral sides of the container

1.2.2 Factors determining liquid pressure in liquids

Pressure exerted by a liquid at a point is determined by,

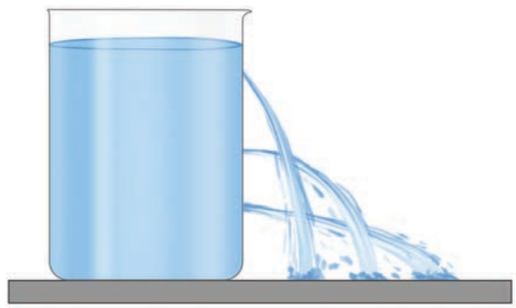
(i) depth (h)

(ii) density of the liquid (ρ)

(iii) acceleration due to gravity (g).

Activity 3

Take a large plastic can. Punch holes with a nail in a vertical line on the side of the can as shown in figure. Then fill the can with water. The water may just dribble out from the top hole, but with increased speed at the bottom holes as depth causes the water to squirt out with more pressure.



From this activity we can see that pressure varies as depth increases. But, it is same at a particular depth independent of the direction. In Figure 1.6, we see the gauge reads the same value because the pressure is being measured at the same depth (red line).

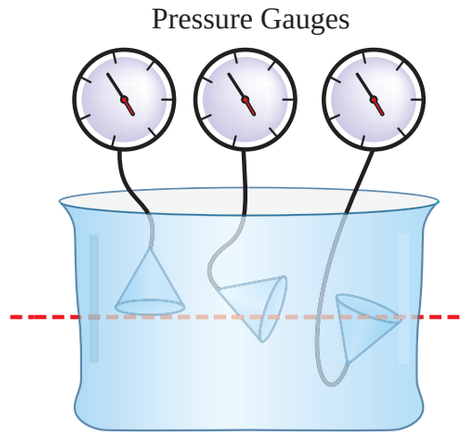


Figure 1.6 Pressure at a depth is same independent of directions

Activity 4

Take two liquids of different densities say water and oil to a same level in two plastic containers. Make holes in the two containers at the same level. What do you see? It is seen that water is squirting out with more pressure than that of oil. This indicates that pressure depends on density of the liquid.

Water Cooking oil

1.2.3 Pressure due to a liquid column

A tall beaker is filled with liquid so that it forms a liquid column. The area of cross section at the bottom is A. The density of the liquid is ρ. The height of the liquid column is h. In other words the depth of the water from the top level surface is 'h' as shown in Figure 1.7.

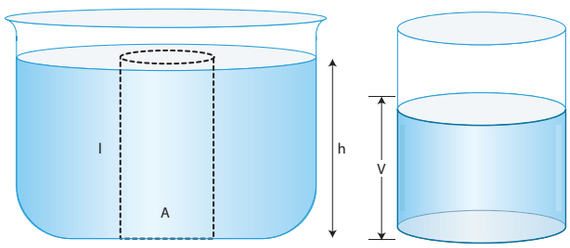


Figure 1.7 Pressure due to a liquid column

We know that thrust at the bottom of the column (F) = weight of the liquid.

Therefore, F = mg (1)

We can get the mass of the liquid by multiplying the volume of the liquid and its density.

Mass, m = ρ V (2)

Volume of the liquid column, V = Area of cross section (A) × Height (h) = Ah (3)

Substituting (3) in (2)

Hence, mass, m = ρAh (4)

Substituting (4) in (1)

Force = mg = ρAhg

$$\text{Pressure, } P = \frac{\text{Thrust (F)}}{\text{Area (A)}} = \frac{mg}{A} = \frac{\rho(Ah)g}{A} = \rho hg$$

∴ Pressure due to a liquid column, P = hρg

This expression shows that pressure in a liquid column is determined by depth, density of the liquid and the acceleration due to gravity. Interestingly, the final expression for pressure does not have the term area A in it. Thus pressure at a given depth does not depend upon the shape of the vessel containing the liquid or the amount of liquid in the vessel. It only depends on the depth. In Figure 1.8, the pressure is the same even though the containers have different amounts of liquid in them, and are of different shapes.

Figure 1.8 Pressure does not depend on shape and size of the container

Example 1.2

Calculate the pressure exerted by a column of water of height 0.85 m (density of water, ρ_w = 1000 kg m^{-3}) and kerosene of same height (density of kerosene, ρ_k = 800 kg m^{-3})

Solution:

Pressure due to water

= $h\rho_w g$ = 0.85 m × 1000 kg m^{-3} × 10 m s^{-2}

= 8500 Pa.

Pressure due to kerosene

= $h\rho_k g$ = 0.85 m × 800 kg m^{-3} × 10 ms^{-2}

= 6800 Pa.

1.3 Atmospheric pressure

Earth is surrounded by a layer of air up to certain height (nearly 300 km) and this layer of air around the earth is called atmosphere of the earth. Since air occupies space and has weight, it also exerts pressure (Fig. 1.9). This pressure is called atmospheric pressure. The atmospheric pressure we normally refer is the air pressure at sea level.

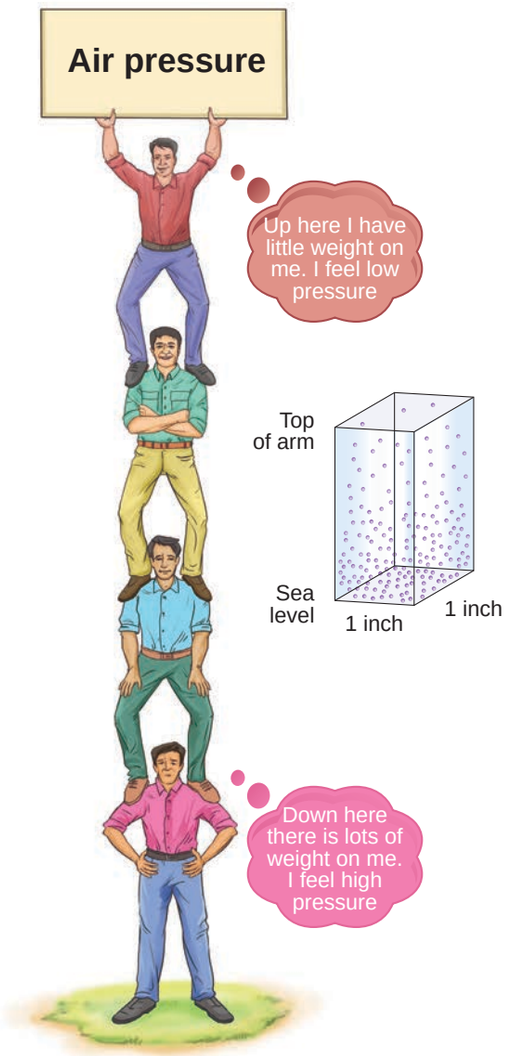


Figure 1.9 Atmospheric pressure

Figure 1.10 shows that air gets 'thinner' with increasing altitude. Hence, the atmospheric pressure decreases as we go up in mountains. On the other hand air gets heavier as we go down below sea level like mines. Table 1.1 gives the value of atmospheric pressure at some places above and below sea level.

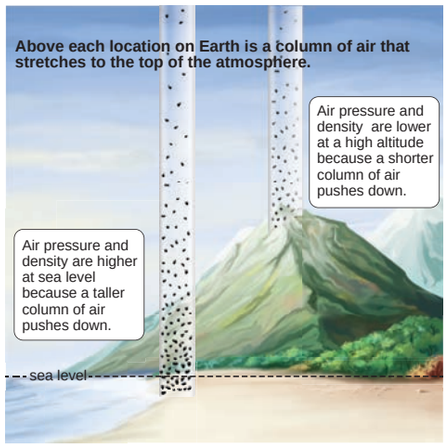


Figure 1.10 Atmospheric pressure acts like a column

DO YOU KNOW?

Human lung is well adapted to breathe at a pressure of sea level (101.3 k Pa). As the pressure falls at greater altitudes, mountain climbers need special breathing equipments with oxygen cylinders.

Similar special equipments are used by people who work in mines where the pressure is greater than that of sea level.

Table 1.1 Atmospheric pressure at different places

Atmospheric pressure	k Pa
Mount Everest summit	33.7
Earth sea level	101.3
Dead sea (below sea level)	*106.7*

1.3.1 Measurement of atmospheric pressure

The instrument used to measure atmospheric pressure is called barometer. A mercury barometer, first designed by an Italian Physicist Torricelli, consists of a long glass tube (closed at one end, open at the other) filled with mercury and turned upside down into a container of mercury. This is done by closing the open end of the mercury filled tube with the thumb and then opening it after immersing it in to a trough of mercury (Fig. 1.11). The barometer works by balancing the mercury in the glass tube against the outside air pressure. If the air pressure increases, it pushes more of the mercury up into the tub and if the air pressure decreases, more of the mercury drains from the tube. As there is no air trapped in the space between mercury and the closed end, there is vacuum in that space. Vacuum cannot exert any pressure. So the level of mercury in the tube provides a precise measure of air pressure which is called atmospheric pressure. This type of instrument can be used in a lab or weather station.

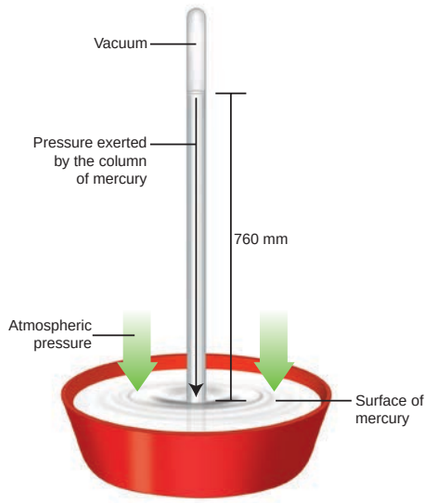


Figure 1.11 Mercury barometer

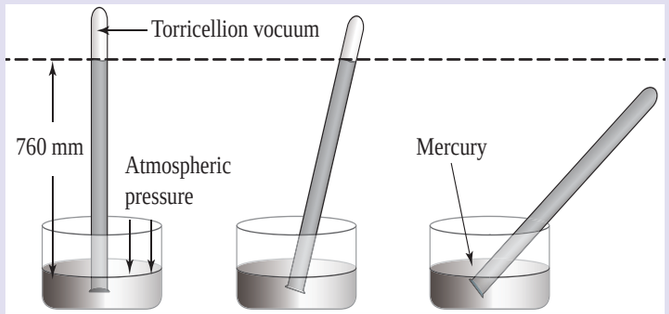
More to Know

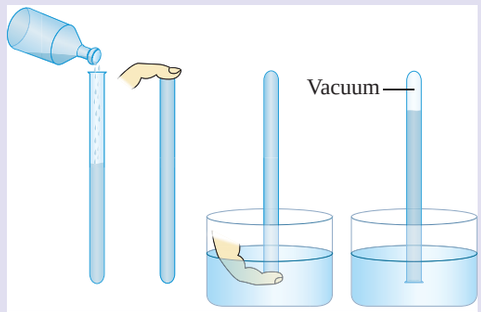
Two puzzling questions accidentally led to the discovery of the idea of air pressure and an instrument barometer, to measure it. During the time of Galileo, in Italy many were perplexed that a suction pump could not pump water from rivers and wells if the depth of the water was more than 11 meter. Another question that troubled philosophers in Europe was if there is an actual vacuum.

Galileo incorrectly suggested that the limit of the suction pump was imposed by the weight of water. The idea was put to test by Gasparo Berti around 1640. He took a glass tube of about 12 metres in length. He placed it vertically. Then he covered the bottom of the tube. Filled it with water and he sealed the top. Now he opened the top at the bottom. The water fell down and when it reached the level of 11 meter high the flow stopped. There was an empty space at the top above the water column. Was it really empty? Vacuum? Without examining the question, Berti died soon. The dramatic demonstration caught the attention of another Italian scientist, Evangelista Torricelli.

Torricelli took several glass tubes, each with different diameters, but all about one meter length, sealed at one end. He filled them with mercury. After placing a finger over the opening, they were upturned into a basin containing more mercury. When the finger was removed and the mercury was released, the level fell and stopping at the height of about 76 centimetre. This occurred irrespective of the diameter of the tube.

Above the 76 cm level the glass tube looked empty. Was it really empty? Torricelli tilted the tubes. As the tubes were tilted the mercury rushed into the empty space. If that space was filled with say air, bubbles should come out. None came. Therefore Torricelli reasoned that the empty space above the mercury column is real vacuum. But why the column remained at 76 cm?





In 1647, Marin Mersenne and Blaise Pascal, two scientists from France performed an interesting experiment. They made two identical barometers and placed them parallel at the base of a mountain in France, the Puy de Dôme. Both of them showed the same level of mercury. They carried one to the summit of the mountain. To their astonishment as they climbed the mountain, the level of the mercury dropped. They reasoned that air exerts pressure and as we go higher the air column above our head, the air pressure drops. The barometer helps to measure the invisible air pressure.

On a typical day at sea level, the height of the mercury column is 760 mm. Let us calculate the pressure due to the mercury column of 760 mm which is equal to the atmospheric pressure. The density of mercury is 13600 kg m^{-3}.

Pressure, P = hρg

= (760 × 10^{-3}m) × (13600 kgm^{-3}) × (9.8 ms^{-2})

= 1.013 × 10^5 Pa.

This pressure is called one atmospheric pressure (atm). There is also another unit called (bar) that is also used to express such high values of pressure.

1 atm = 1.013 × 10^5 Pa.

1 bar = 1 × 10^5 Pa.

Hence, 1 atm = 1.013 bar.

Expressing the value in kilopascal gives 101.3 k Pa. This means that, on each 1 m^2 of surface, the force acting is 1.013 k N.

1.3.2 Types of barometers

As the mercury is not in a closed vessel in the mercury barometer, moving the instrument without spilling the mercury is difficult. Hence, we have other sophisticated instruments which are handy. They also work on the same principle like a mercury barometer but instead of mercury they use diaphragms and other precise components which respond for variation in atmospheric pressure. Table 1.2 shows some of the barometers used frequently.

Example 1.3

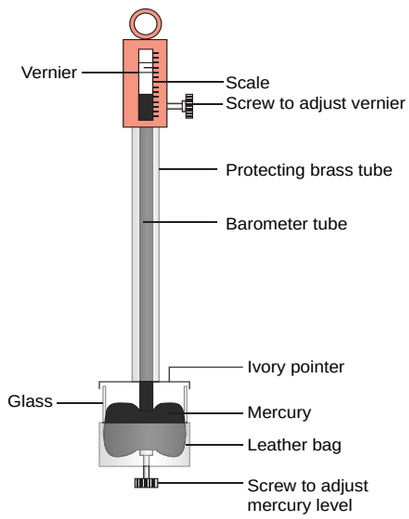
A mercury barometer in a physics laboratory shows a 732 mm vertical column of mercury. Calculate the atmospheric pressure in pascal. [Given density of mercury, $\rho = 1.36 \times 10^4$ kg m^{-3}, g = 9.8 m s^{-2}]

Solution:

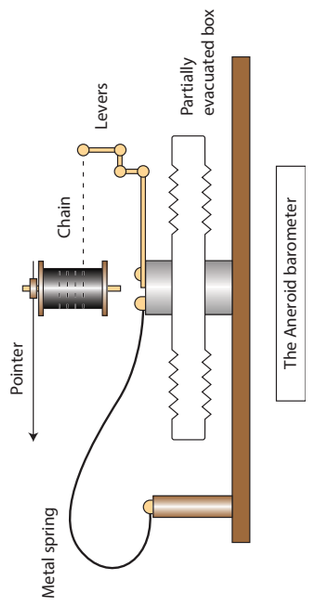
Atmospheric pressure in the laboratory, $P = h\rho g = 732 \times 10^{-3} \times 1.36 \times 10^4 \times 9.8$
$= 9.76 \times 10^4$ Pa (or) 0.976×10^5 Pa

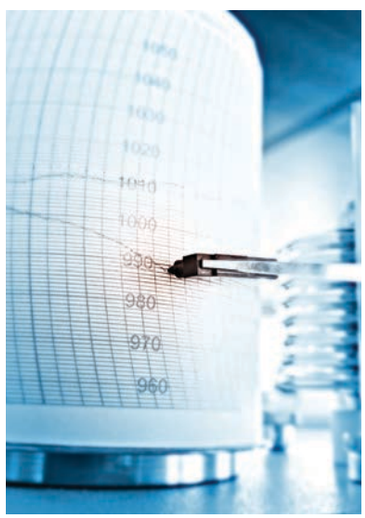
Table 1.2 Types of barometers

Fortin's barometer	Aneroid barometer	Barograph
It is a mercury barometer in which the mercury bath along with mercury and barometer tube is covered with a flexible leather case so that spilling of mercury during transport is averted. The amount of movement of a screw at the bottom to maintain the mercury level same is a measure of the atmospheric pressure.	It is a device for measuring atmospheric pressure without the use of liquids. It consists of a partially evacuated metal chamber and a thin corrugated lid which is displaced by variations in the external air pressure. A lever connected to the diaphragm of the chamber moves a pointer.	It is a barometer that records the atmospheric pressure variations over time. One or more aneroid cells sense the pressure changes. The variations are recorded through a lever and pen arrangement on a moving graph sheet attached to a rotating drum.



Fortin barometer





1.3.3 Gauge pressure and absolute pressure

Our daily activities are happening in the atmospheric pressure. We are so used to it that we do not even realise. When tyre pressure and blood pressure are measured using instruments (gauges) they show the pressure over the atmospheric pressure. Hence, absolute pressure is zero-referenced against a perfect vacuum and gauge pressure is zero-referenced against atmospheric pressure.

For pressures higher than atmospheric pressure,
absolute pressure = atmospheric pressure + gauge pressure

For pressures lower than atmospheric pressure,
absolute pressure = atmospheric pressure – gauge pressure

Example 1.4

Find the absolute pressure on a scuba diver (deep sea diver) when the diver is 12 metres below the surface of the ocean. Assume standard atmospheric conditions. [Take density of water as 1030 kg m^{-3}, g = 9.8 m s^{-2}]

Solution:

Pressure due to sea water, $P_{water} = h \rho g$

$= (12\ m) \times (1.03 \times 10^3\ kgm^{-3}) \times (9.8\ m\ s^{-2})$

$= 1.21 \times 10^5$ Pa

$P_{absolute} = P_{atmosphere} + P_{water}$

$= (1.01 \times 10^5) + (1.21 \times 10^5)$

$P_{absolute} = 2.22 \times 10^5$ Pa

This is more than twice the atmospheric pressure. Parts of our body, especially blood vessels and soft tissues cannot withstand such high pressure. Hence, scuba divers always wear special suits and equipment to protect them (Fig. 1.12).

Figure 1.12 Scuba divers with special protecting equipment

DO YOU KNOW?

In petrol bunks, the tyre pressure of vehicles is measured in a unit called psi.

It stands for pascal per inch, an old system of unit for measuring pressure.

1 psi = 6895 Pa

1 psi = 0.06895×10^5 Pa

A tire pressure of 30 psi means 2.0685×10^5 Pa. It is almost twice the atmospheric pressure.

More to Know

Mass of the Atmosphere

The global mean pressure at the surface of the Earth (P_S = 984 hPa) is slightly less than the mean sea-level pressure because of the elevation of land. We can deduce the total mass of the atmosphere (m_a) as shown below.

$$Pa = \frac{F}{A} = \frac{(m_a g)}{4\pi R^2};\ m_a = \frac{(P_a 4\pi R^2)}{g} = 5.2 \times 10^{18}\ kg$$

where R = 6400 km is the radius of the Earth.

Activity 5

Press a good quality rubber sucker hard on a plane smooth surface. It sticks to the surface. Now pull it off the surface. When you press the sucker, most of the air between its cup and the plane surface escapes out. The sucker sticks to the plane surface since the pressure due to the atmosphere pushes on it. The sucker can be removed off the plane surface by applying a large external force that overcomes the atmospheric pressure. By this principle only, lizards and monitor lizards (udumbu) are able to get good grip over surfaces.

1.4 Pascal's Law

Pascal's principle is named after Blaise Pascal (1623-1662), a French mathematician and physicist. The law states that the external pressure applied on an incompressible liquid is transmitted uniformly throughout the liquid. Pascal's law can be demonstrated with the help of the glass vessel having holes all over its surface. Fill it with water. Push the piston. The water rushes out of the holes in the vessel with the same pressure. The force applied on the piston exerts pressure on water. This pressure is transmitted equally throughout the liquid in all directions (Fig. 1.13). This principle is applied in various machines used in our daily life.

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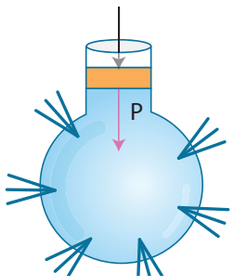


Figure 1.13 Demonstration of Pascal's Law

Activity 6

Take a tooth paste available in your home. Squeeze it. What happens? When any part of the tube is squeezed toothpaste squirts out through the open end. The pressure applied at one part of the tooth paste (through tube) is transmitted equally throughout the toothpaste. When the pressure reaches the open end, it forces toothpaste out through the opening.

1.4.1 Hydraulic press

Pascal's law became the basis for one of the important machines ever developed, the hydraulic press. It consists of two cylinders of different cross-sectional areas as shown in Figure 1.14. They are fitted with pistons of cross-sectional areas "a" and "A". The object to be compressed is placed over the piston of large

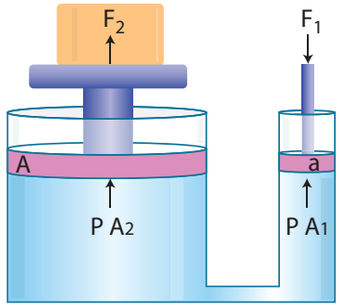


Figure 1.14 Hydraulic press

cross-sectional area A. The force F_1 is applied on the piston of small cross-sectional area a. The pressure P produced by small piston is transmitted equally to large piston and a force F_2 acts on A which is much larger than F_1. Pressure on piston of small area 'a' is given by,

$$P = \frac{F_1}{A_1} \quad (1)$$

Applying Pascal's law, the pressure on large piston of area A will be the same as that on small piston. Therefore, $P = \frac{F_2}{A_2}$ (2)

Comparing equations (1) and (2),we get $\frac{F_1}{A_1} = \frac{F_2}{A_2}$. or $F_2 = F_1 \times \frac{A_2}{A_1}$

Since, the ratio $\frac{A_2}{A_1}$ is greater than 1, the force F_2 that acts on the larger piston is greater than the force F_1 acting on the smaller piston. Hydraulic systems working in this way are known as *force multipliers*.

Example 1.5

A hydraulic system is used to lift a 2000 kg vehicle in an auto garage. If the vehicle sits on a piston of area 0.5 m^2, and a force is applied to a piston of area 0.03 m^2, what is the minimum force that must be applied to lift the vehicle?

Given: Area covered by the vehicle on the piston $A_1 = 0.5\ m^2$

Weight of the vehicle, $F_1 = 2000\ kg \times 9.8\ m\ s^{-2}$

Area on which force F_2 is applied, $A_2 = 0.03\ m^2$

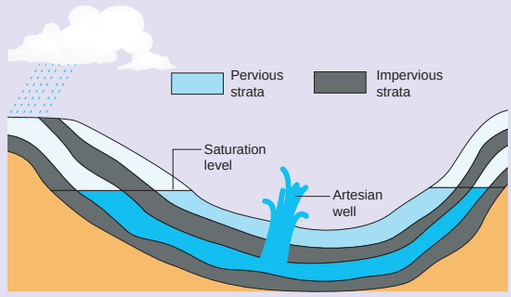
Solution:

$P_1 = P_2$; $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ and $F_2 = \frac{F_1}{A_1} A_2$;

$F_2 = (2000 \times 9.8) \frac{0.03}{0.5} = 1176\ N$

Info bits

An artesian aquifer is a confined aquifer containing groundwater that will flow upwards out of a well without the need for pumping. In recharging aquifers, this happens because the water table at its recharge zone is at a higher elevation than the head of the well.



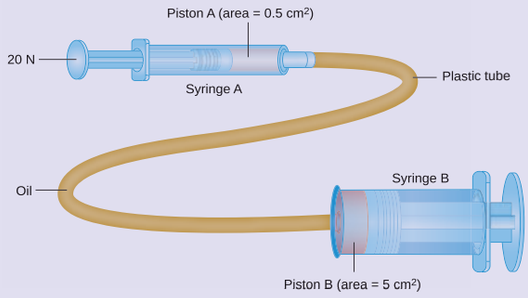
Example 1.6

Two syringes are connected together as shown in the diagram below.

A force of 20 N is applied to the piston in syringe A.

(a) Calculate the pressure that the piston in syringe A exerts on the oil.

(b) Calculate the force needed to just prevent the piston in syringe B from moving out.



Solution:

(a) A force of 20 N is applied to the piston in syringe A.

The pressure that the piston in syringe A exerts on the oil,

$P = \frac{F}{A} = \frac{20N}{0.5\ cm^2} = 40\ N\ cm^{-2}$

(b) $P = \frac{F}{A}$. So $F = PA$

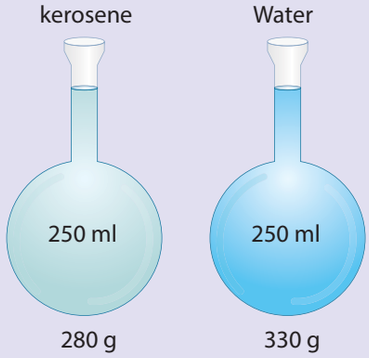
The force needed to just prevent the piston in syringe B from moving out,

$F = 40\ N\ cm^{-2} \times 5\ cm^2 = 200\ N$

1.5 Density

Activity 7

Take two identical flasks and fill one flask with water to 250 cm^3 mark and the other with kerosene to the same 250 cm^3 mark. Measure them in a balance. The flask filled with water will be heavier than the one filled with kerosene. Why? The answer is in finding the mass per unit volume of kerosene and water in respective flasks.



To understand density better, let us assume that the mass of the flask be 80g. So, the mass of the flask filled with water is 330g and the mass of flask filled with kerosene is 280g. Mass of water only is 250g and kerosene only is 200g. Mass per unit volume of water is 250/250cm^3. This is 1g/cm^3. Mass per unit volume of kerosene is 200g/250cm^3. This is 0.8g/cm^3. The result 1g/cm^3 and 0.8gcm^3 are the densities of water and kerosene respectively. *Therefore the density of a substance is the mass per unit volume of a given substance.*

The SI unit of density is kilogram per meter cubic (kg/m^3) also gram per centimeter cubic (g/cm^3). The symbol for density is rho (ρ).

Example 1.7

A silver cylindrical rod has a length of 0.5 m and radius of 0.4 m. Find the density of the rod if its mass is 2640 kg.

Solution:

Mass of the cylinder = 2640 kg

Volume of the cylinder = $\pi r^2 h = 3.14 \times (0.4)^2 \times 0.5 = 0.2512\ m^3$

Density = mass/volume = 2640 kg/0.2512 m^3 = 10509 kg m^{-3}

1.5.1 Relative Density

We can compare the densities of two substances by finding their masses. But generally density of a substance is compared with the density of water at 4°C because density of water at that temperature is 1g/cm^3. Density of any other substance with respect to the density of water at 4°C is called the relative density. Thus relative density of a substance is defined as ratio of density of the substance to density of water at 4°C. Mathematically, relative density (R.D)

$$= \frac{\text{Density of the substance}}{\text{Density of water at 4°C}}$$

We know that, Density $= \frac{\text{Mass}}{\text{Volume}}$

$\therefore$ Relative density

$$= \frac{\text{Mass of the substance/Volume of the substance}}{\text{Mass of water/Volume of water}}$$

Since the volume of the substance is equal to the volume of water,

Relative density

$$= \frac{\text{Mass of certain volume of substance}}{\text{Mass of equal volume of water}}$$

Thus, the ratio of the mass of a given volume of a substance to the mass of an equal volume of water at 4°C also denotes relative density.

1.5.2 Measurement of relative density

Relative density can be measured using Pycnometer (Fig. 1.15) also called density bottle. It consists of ground glass stopper with a fine hole through it. The function of the hole in a stopper is that, when the bottle is filled and the stopper is inserted, the excess liquid rises through the hole and runs down outside the bottle. By this way the bottle will always contain the same volume of whatever the liquid is filled in, provided the temperature remains constant. Thus the density of a given volume of a substance to the density of equal volume of referenced substance is called relative density or specific gravity of the given substance. If the referenced substance is water then the term specific gravity is used.

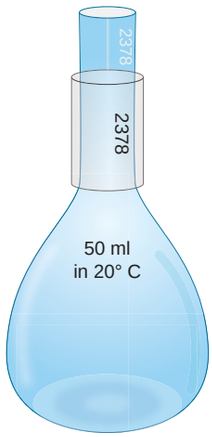


Figure 1.15 Specific gravity bottle

1.5.3 Floating and sinking

Whether an object will sink or float in a liquid is determined by the density of the object compared to the density of the liquid. If the density of a substance is less than the density of the liquid it will float. For example a piece of wood which is less dense than water will float on it. Any substance having more density than water (for example, a stone), will sink into water.

Example 1.8

You have a block of a mystery material, 12 cm long, 11 cm wide and 3.5 cm thick. Its mass is 1155 grams. (a) What is its density? (b) Will it float in a tank of water, or sink?

Solution:

(a) $\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{1155\text{g}}{12\text{ cm} \times 11\text{ cm} \times 3.5\text{ cm}}$

$= \frac{1155\text{ g}}{462\text{ cm}^3} = 2.5\text{ g cm}^{-3}$

(b) The mystery material is denser than the water, so it sinks.

1.5.4 Application of principle of flotation

Hydrometer

A direct-reading instrument used for measuring the density or relative density of the liquid is called hydrometer. Hydrometer is based on the principle of flotation, i.e., the weight of the liquid displaced by the immersed portion of the hydrometer is equal to the weight of the hydrometer.

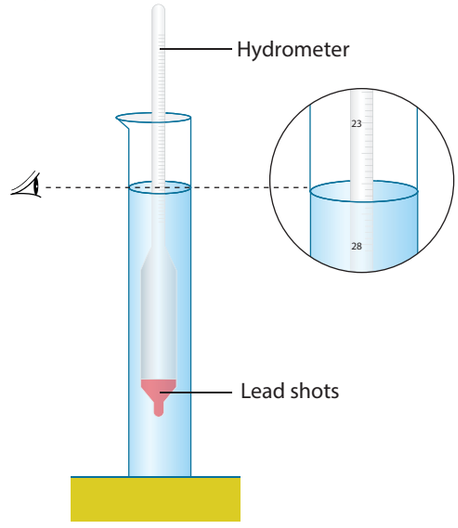


Figure 1.16 Hydrometer

Hydrometer consists of a cylindrical stem having a spherical bulb at its lower end and a narrow tube at is upper end. The lower spherical bulb is partially filled with lead shots or mercury. This helps hydrometer to float or stand vertically in liquids. The narrow tube has markings so that relative density of a liquid can be read directly.

The liquid to be tested is poured into the glass jar. The hydrometer is gently lowered in to the liquid until it floats freely. The reading against the level of liquid touching the tube gives the relative density of the liquid.

Hydrometers may be calibrated for different uses such as lactometers for measuring the density (creaminess) of milk, saccharometer for measuring the density of sugar in a liquid and alcoholometer for measuring higher levels of alcohol in spirits.

Lactometer

One form of hydrometer is a lactometer, an instrument used to check the purity of milk. The lactometer works on the principle of gravity of milk.

The lactometer consists of a long graduated test tube with a cylindrical bulb with the graduation ranging from 15 at the top to 45 at the bottom. The test tube is filled with air. This air chamber causes the instrument to float. The spherical bulb is filled with mercury to cause the lactometer to sink up to the proper level and to float in an upright position in the milk.

Inside the lactometer there may be a thermometer extending from the bulb up into the upper part of the test tube where the scale is located. The correct lactometer reading is obtained only at the temperature of 60°C. A lactometer measures the cream content of milk. More the cream, lower the lactometer floats in the milk. The average reading of normal milk is 32. The lactometers are used highly at milk processing units and at dairies.

1.6 Buoyancy

We already saw that a body experiences an upward force due to the fluid surrounding, when it is partially or fully immersed in to it. We also saw that pressure is more at the bottom and less at the top of the liquid. This pressure difference causes a force on the object and pushes it upward. This force is called buoyant force and the phenomenon is called buoyancy (Fig.1.17).

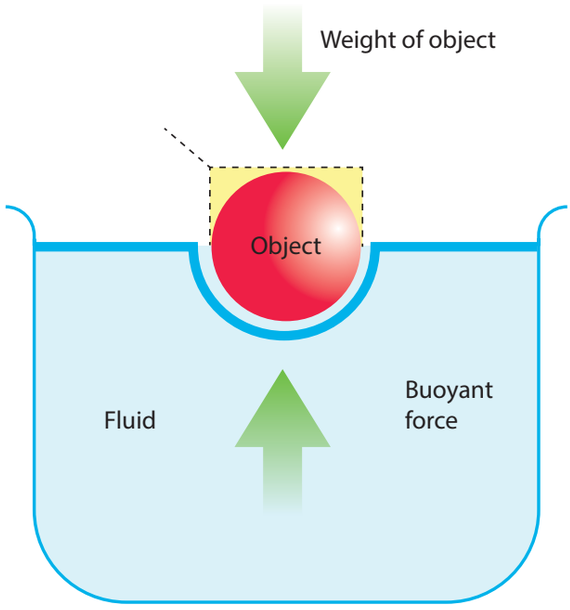


Figure 1.17 Buoyant force

Most buoyant objects are those with a relatively high volume and low density. If the object weighs less than the amount of water it has displaced (density is less), buoyant force will be more and it will float (such object is known as positively buoyant). But if the object weighs more than the amount of water it has displaced (density is more), buoyant force is less and the object will sink (such object is known as negatively buoyant).

More to Know

- ✓ Salt water provides more buoyant force than fresh water. Because buoyant force depends as much on the density of fluids as on the volume displaced.
- ✓ Hydrogen, helium and hot air are much less dense than ordinary air and this gives them buoyancy.

Cartesian diver

Cartesian diver is an experiment that demonstrates the principle of buoyancy. It is a pen cap with clay. The Cartesian diver contains just enough liquid that it barely floats in a bath of the liquid; its remaining volume is filled with air. When pressing the bath, the additional water enters the diver, thus increasing the average density of the diver, and thus it sinks.

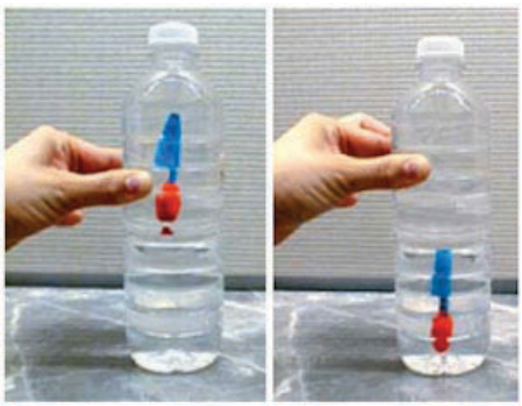


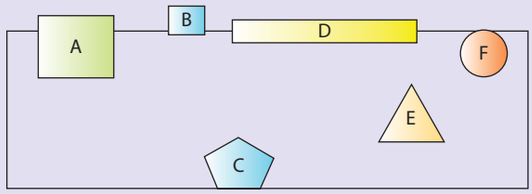
Figure 1.18 Cartesian diver

DO YOU KNOW?

- Fish has an internal swim bladder which is filled with gas. When it needs to rise or descend, it changes the volume and its density.
- Human swimmers, icebergs and ships stay afloat due to buoyancy.
- Petroleum-based products typically float on the surface of water, because their specific gravity is low.

Examples 1.9

Six objects (A-F) are in a liquid, as shown below. None of them are moving. Arrange them in order of density, from lowest to highest.



Solution:

The more of an object's volume is above the water surface, the less dense it is. Object B must therefore be the least dense, followed by D, A, and F. Object E is next, because it is neutrally buoyant and equal in density to the liquid. Object C is negatively buoyant because it is denser than the fluid.

Therefore the order of density from lowest to highest is B,D,A,F, E,C.

1.6.1 Mathematical representation of Buoyant force

For an object submerged in a fluid, there is a net force on the object, because the pressure at the top and bottom of it are different.

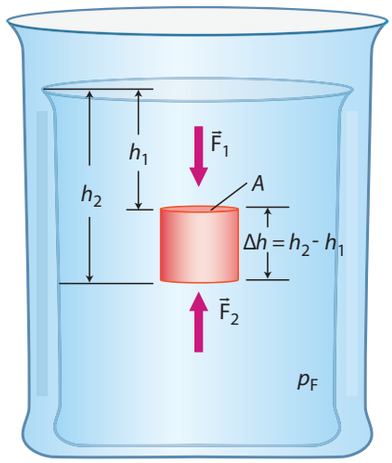


Figure 1.19 Net force acting on an object

We know that pressure, $P = \frac{F}{A}$

$$F = P\,A$$

$F_{buoyancy} = F_2 - F_1 = P_2A_2 - P_1A_1$

Since area is same, $A_2 = A_1 = A$

Therefore,

$$F_{buoyancy} = P_2A - P_1A$$
$$= A(P_2 - P_1)$$

Since, $P = h\rho g$,

$$F_{buoyancy} = A(\rho g h_2 - \rho g h_1)$$
$$= A\rho g(h_2 - h_1) = \rho g A(h_2 - h_1)$$
$$F_{buoyancy} = \rho g(A\Delta h) = (\rho_{fluid})\, g\, (V_{displaced})$$

Example 1.10

A golden crown has been placed in a tub of water. The volume of water displaced is measured to be 1.50 liters. The density of water is 1000 kg m^{-3}, or 1.000 kg L^{-1}. What is the buoyant force acting on the crown?

Solution:

The buoyant force is, $F_b = \rho gV$

First, we ensure that the units used for volume are the same.

If 1 m^3 = 1000 L, then 1.50 L = 0.00150 m^3.

$F_b = (1000 \text{ kg } m^{-3})(9.80 \text{ m } s^{-2})(0.00150 \text{ } m^3)$
$= 14.7 \text{ kg m } s^{-2} = 14.7 \text{ N}$

The buoyant force acting on the golden crown is 14.7 N.

1.7 Archimedes' Principle

Archimedes principle is the consequence of Pascal's law. According to legend, Archimedes devised the principle of the "hydrostatic balance" after he noticed his own apparent loss in weight while sitting in his bath. The story goes that he was so enthused with his discovery that he jumped out of his bath and ran through the town, shouting "eureka". Archimedes principle states that 'a body immersed in a fluid experiences a vertical upward buoyant force equal to the weight of the fluid it displaces'.

Figure 1.20 Archimedes and eureka

When a body is partially or completely immersed in a fluid at rest, it experiences an upthrust which is equal to the weight of the fluid displaced by it. Due to the upthrust acting on the body, it apparently loses a part of its weight and the apparent loss of weight is equal to the upthrust.

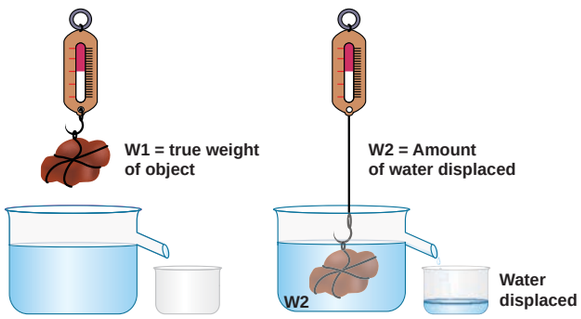


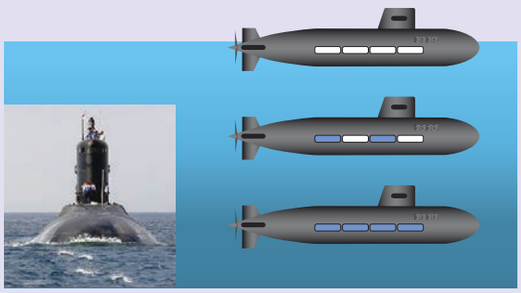
Figure 1.21 Upthrust is equal to the weight of the fluid displaced

Thus, for a body either partially or completely immersed in a fluid,

Upthrust = Weight of the fluid displaced
= Apparent loss of weight of the body.

Apparent weight of an object =
True weight of an object in air
– Upthrust (weight of water displaced)

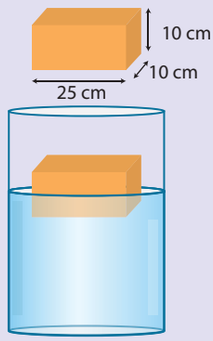
Info bits



Submarines change the level of floating by pumping in and pumping out water in to its compartments.

Example 1.11

What is the mass of the object floating in the given diagram?



Solution:

Weight of the object = Buoyant force

$\rho = 1000 \text{ kg m}^{-3}$

$V = (25 \times 10 \times 10) \text{ cm}^3 = 2500 \times 10^{-6} \text{ m}^3$

$m = \rho V = 1000 \times 2500 \times 10^{-6} = 2.5 \text{ kg}$

1.8 Laws of flotation

Laws of flotation are,

1. The weight of a floating body in a fluid is equal to the weight of the fluid displaced by the body.
2. The centre of gravity of the floating body and the centre of buoyancy are in the same vertical line.

The point through which the force of buoyancy is supposed to act is known as centre of buoyancy. It is shown in Figure 1.22.

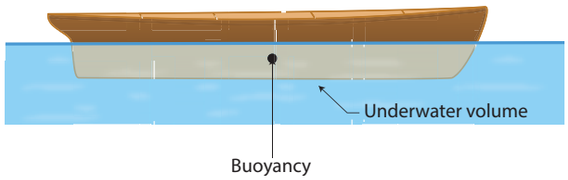


Figure 1.22 Centre of buoyancy

Info bits

Flotation therapy uses water that contains Epsom salts rich in magnesium. As a floater relaxes, he or she is absorbing this magnesium through the skin. Magnesium helps the body to process insulin, which lowers a person's risk of developing Type 2 Diabetes.

Points to Remember

- The force which produces compression is called thrust. Its S.I. unit is newton.
- Thrust acting normally to a unit area of a surface is called pressure. Its S.I. unit is pascal.
- The pressure exerted by the atmospheric gases on its surroundings and on the surface of the earth is called atmospheric pressure. 1 atm is the pressure exerted by a vertical column of mercury of 76 cm height.
- Barometer is an instrument used to measure atmospheric pressure.
- The upward force experienced by a body when partly or fully immersed in a fluid is called upthrust or buoyant force.
- Cartesian diver is an experiment which demonstrates the principle of buoyancy and the ideal gas law.
- Pascal's law states that an increase in pressure at any point inside a liquid at rest

is transmitted equally and without any change, in all directions to every other point in the liquid.

- Archimedes' Principle states that when a body is partially or wholly immersed in a fluid, it experiences an up thrust or apparent lose of weight, which is equal to the weight of the fluid displaced by the immersed part of the body.
- Density is known as mass per unit volume of a body. Its S.I. unit is kg m^{-3}.
- Relative density is the ratio between the density of a substance and density of water. Relative density of a body is a pure number and has no unit.
- Relative density of a liquid

$$= \frac{\text{Apparent loss of weight of a body in liquid}}{\text{Apparent loss of weight of the same body in water}}$$

- Hydrometer is a device used to measure the relative density of liquids based on the Archimedes' principle.
- Lactometer is a device used to check the purity of milk by measuring its density using Archimedes' Principle.
- Laws of flotation are given as: i) Weight of a floating body = Upthrust or buoyant force = Apparent loss of weight of the body in the fluid. ii) The centre of gravity and the centre of buoyancy lie in the same vertical line.

A-Z GLOSSARY

Altitude	Vertical distance in the up direction.
Astronaut	Person who is specially trained to travel into outer space.
Axes	Simple machine to cut, shape and split wood.
Deformation	Changes in an object's shape or form due to the application of a force or forces.
Fossils water	Preserved water.
Iceberg	Large piece of ice floating in water.
Hydraulic systems	Device that uses fluids and work under the fluid pressure to control valves.
Incompressible	No change in volume if a pressure is applied.
Meteorological	Weather condition.
Piston	Movable disc fitted inside a cylinder.
Propellers	Fan that transmits power in the form of thrust by rotation.
Syringe	Simple pump made of plastic or glass to inject or withdraw fluid.
Therapy	Treatment.
Velocity	Speed with direction.

TEXTBOOK EVALUATION

G93FPT

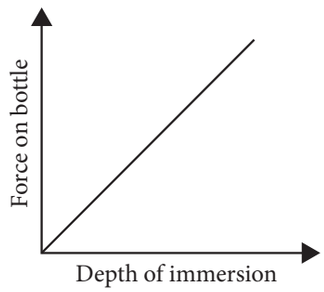
I. Choose the correct answer.

1. The size of an air bubble rising up in water
   (a) decreases
   (b) increases
   (c) remains same
   (d) may increase or decrease

2. Clouds float in atmosphere because of their low
   (a) density (b) pressure
   (c) velocity (d) mass

3. In a pressure cooker, the food is cooked faster because
   (a) increased pressure lowers the boiling point
   (b) increased pressure raises the boiling point
   (c) decreased pressure raises the boiling point
   (d) increased pressure lowers the melting point

4. An empty plastic bottle closed with an airtight stopper is pushed down into a bucket filled with water. As the bottle is pushed down, there is an increasing force on the bottom as shown in graph. This is because



   (a) more volume of liquid is dispaced
   (b) more weight of liquid is displaced
   (c) pressure increases with depth
   (d) all the above

II. Fill in the blanks.

1. In a fluid, buoyant force exists because pressure at the _____ of an object is greater than the pressure at the top.
2. The weight of the body immersed in a liquid appears to be _____ than its actual weight.
3. The instrument used to measure atmospheric pressure is _____.
4. The magnitude of buoyant force acting on an object immersed in a liquid depends on _____ of the liquid.
5. A drinking straw works on the existence of _____.

III. True or False.

1. The weight of fluid displaced determines the buoyant force on an object.
2. The shape of an object helps to determine whether the object will float.
3. The foundations of high-rise buildings are kept wide so that they may exert more pressure on the ground.
4. Archimedes' principle can also be applied to gases.
5. Hydraulic press is used in the extraction of oil from oil seeds.

IV. Match the following.

Density	-	hρg
1 gwt	-	Milk
Pascal's law	-	$\frac{\text{Mass}}{\text{Volume}}$
Pressure exerted by a fluid	-	Pressure
Lactometer	-	980 dyne

V. Answer in brief.

1. On what factors the pressure exerted by the liquid depends on?
2. Why does a helium balloon float in air?

3. Why it is easy to swim in river water than in sea water?
4. What is meant by atmospheric pressure?
5. State Pascal's law.

VI. Answer in detail.

1. With an appropriate illustration prove that the force acting on a smaller area exerts a greater pressure.
2. Describe the construction and working of mercury barometer.
3. How does an object's density determine whether the object will sink or float in water?
4. Explain the construction and working of a hydrometer with diagram.
5. State the laws of flotation.

VII. Assertion and Reason.

Directions: In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If assertion is false but reason is true.

1. **Assertion:** To float, body must displace liquid whose weight is equal to the actual weight.

   Reason: The body will experience no net downward force in that case.

2. **Assertion:** Pascal's law is the working principle of a hydraulic lift.

   Reason: Pressure is thrust per unit area.

3. **Assertion:** The force acting on the surface of a liquid at rest, under gravity, in a container is always horizontal.

   Reason: The forces acting on a fluid at rest have to be normal to the surface.

4. **Assertion:** A sleeping mattress is so designed that when you lie on it, a large area of your body comes in its contact.

   Reason: This reduces the pressure on the body and sleeping becomes comfortable.

5. **Assertion:** Wide wooden sleepers are kept below railway lines to reduce pressure on the railway tracks and prevent them from sinking in the ground.

   Reason: Pressure is directly proportional to the area in which it is acting.

VIII. Comprehension type.

1. While passing nearby a pond, some students saw a drowning man screaming for help. They alerted another passerby, who immediately threw an inflated rubber tube in the pond. The man was saved. Respond to the given questions using the information provided above.
   a. Why the passerby did use inflated rubber tube to save the drowning man?
   b. Write the principle involved herein.
   c. Which qualities shown by the students and the passerby do you identify that helped in saving the drowning man.
2. A balloon displaces air and it results in buoyant force. This buoyant force is more than the weight of the balloon and hence the balloon moves up.
   a. As the balloon moves up what happens to the density of it?
   b. Write the condition for floating of balloon.
   c. Buoyant force depends on the density of _____.

3. Two different bodies A and B are completely immersed in water and undergo the same loss in weight.
   a. Will the weight of the body A and body B in air be the same?
   b. If 4 kg of material occupy 20 cm^3 and 9 kg of material be occupy 90 cm^3, which has greater density A or B?
   c. What vertical height of mercury will exert a pressure of 99960 Pa? (Density of mercury = 136000 kg m^{-3}).

IX. Numerical Problems.

1. A block of wood of weight 200 g floats on the surface of water. If the volume of block is 300 cm^3 calculate the upthrust due to water.
2. Density of mercury is 13600 kg m^{-3}. Calculate the relative density.
3. A body of voloume 100 cc is immersed completely in water contained in a jar. The weight of water and the jar before immersion of the body was 700 g. Calculate the weight of water and jar after immersion.
4. The density of water is 1 g cm^{-3}. What is its density in S.I. units?
5. Calculate the apparent weight of wood floating on water if it weighs 100g in air.

X. HOTS

1. How high does the mercury barometer stand on a day when atmospheric pressure is 98.6 kPa?
2. How does a fish manage to rise up and move down in water?
3. If you put one ice cube in a glass of water and another in a glass of alcohol, what would you observe? Explain your observations.
4. You have a bag of cotton and an iron bar, each indicating a mass of 100 kg when measured on a weighing machine. In reality, one is heavier than other. Can you say which one is heavier and why?
5. Why does a boat with a hole in the bottom would eventually sink?

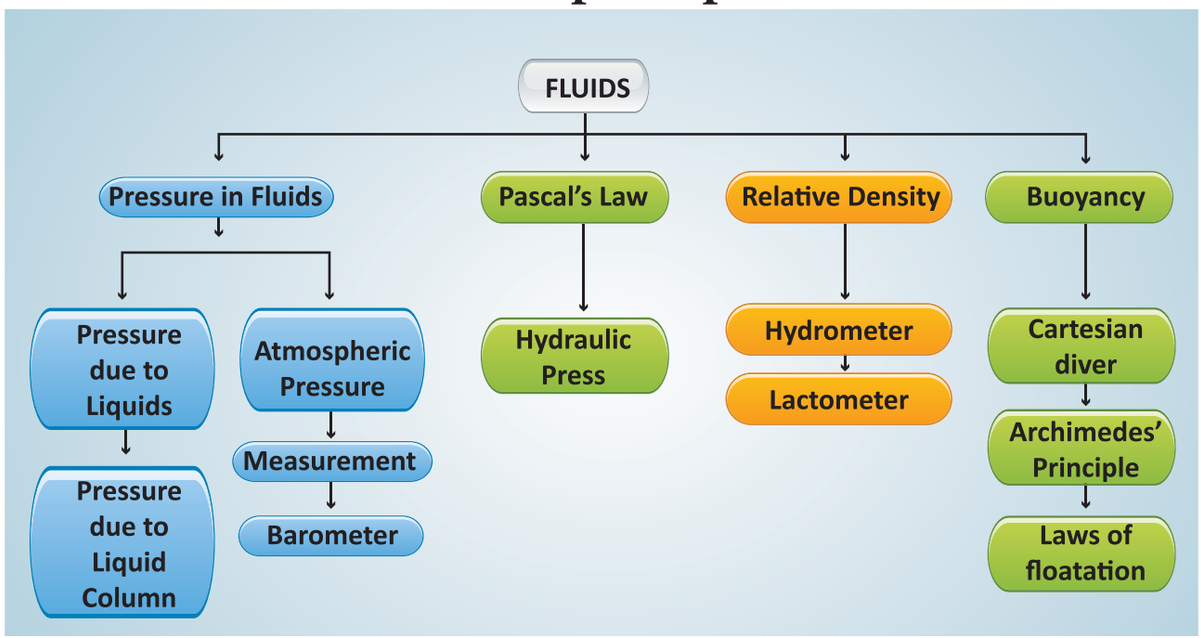
REFERENCE BOOKS

1. Fundamentals of Physics - By David Halliday and Robert Resnick.
2. I.C.S.E Concise Physics - By Selina publisher.
3. Physics - By Tower, Smith Tuston & Cope.

INTERNET RESOURCES

https://www.sciencelearn.org.nz/resources/390-rockets-and-thrust
https://www.teachengineering.org/lessons/view/cub_airplanes_lesson04
http://www.cyberphysics.co.uk/topics/earth/atmosphr/atmospheric_pressure.htm
http://discovermagazine.com/2003/mar/featscienceof
http://northwestfloatcenter.com/how-flotation-can-help-your-heart/

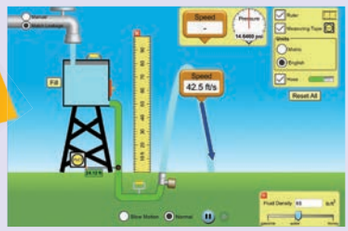
Concept Map



ICT CORNER

Experiment with Fluid Pressure and Flow using virtual simulator.

Fluid



Steps

- Type the given URL to reach "pHET Simulation" page and download the "java" file of "Fluid Pressure and Flow".
- Open the "java" file. Open the water tap and observe the "Pressure" fluctuations by increasing "Fluid density" and "Gravity".
- Select the third picture and drop down a weight scales to transform weight into pressure.
- Switch to "Flow" tab from the top to simulate fluid motion under a given shape and pressure. Click the "red" button to drop dots into the fluid and alter the pipe shape by dragging the yellow holders.


Step1


Step2


Step3


Step4

Fluid Pressure and Flow Simulator

URL: https://phet.colorado.edu/en/simulation/fluid-pressure-and-flow or Scan the QR Code.

*Pictures are indicative only

B567_9_SCI_EM_T3

UNIT 2

Sound

Learning Objectives

After completing this lesson, students will be able to

- understand that sound is produced due to vibration of objects.
- know that sound requires a medium to travel.
- understand that sound waves are longitudinal in nature.
- explain the characteristics of sound.
- understand the parameters on which speed of sound depends.
- explain ultrasonic sound and understand the applications of ultrasonic sound.

Introduction

Sound is a form of energy which produces sensation of hearing in our ears. Some sounds are pleasant to hear and some others are not. But, all sounds are produced by vibrations of substances. These vibrations travel as disturbances in a medium and reach our ears as sound. Human ear can hear only a particular range of frequency of sound that too with a certain range of energy. We are not able to hear sound clearly if it is below certain intensity. The quality of sound also differs from one another. What are the reasons for all these? It is because sound has several qualities. In this unit we are going to learn about production and propagation of sound along with its various other characteristics. We will also study about ultrasonic waves and their applications in our daily life.

2.1 Production of sound

In your daily life you hear different sounds from different sources. But have you ever thought how sound is produced? To understand the production of sound, let us do some activities.

Activity 1

Take a tuning fork and strike its prongs on a rubber pad. Bring it near your ear. Do you hear any sound? Now touch the tuning fork with your finger. What do you feel? Do you feel vibrations?

When you strike the tuning fork on the rubber pad, it starts vibrating. That's what you feel with your fingers. These vibrations cause the nearby molecules to vibrate.

Activity 2

Take a steel tumbler and fill it with water. Take a spoon and gently tap the tumbler. What do you observe? Can you hear some sound? Do you see any vibration on the surface of the water?

From the above activities we see that vibrations are produced when some mechanical work is done. Vibration is nothing but to and fro movement of a particle. Thus, mechanical energy vibrates an object and when these vibrations reach our ear we hear the sound. At the end of this chapter, we will study how our ear senses sound.

2.2 Propagation of sound waves

2.2.1 Sound needs a medium for Propagation

In the activities given above we saw that sound needs a material medium like air, water, steel etc., for its propagation. It cannot travel through vacuum. This can be demonstrated by the Bell – Jar experiment.

An electric bell and an airtight glass jar are taken. The electric bell is suspended inside the airtight jar. The jar is connected to a vacuum pump, as shown in Figure 2.1. If the bell is made to ring, we will be able to hear the sound of the bell. Now when the jar is evacuated with the vacuum pump, the air in the jar is pumped out gradually and the sound becomes feebler and feebler. We will not hear any sound, if the air is fully removed (if the jar has vacuum).

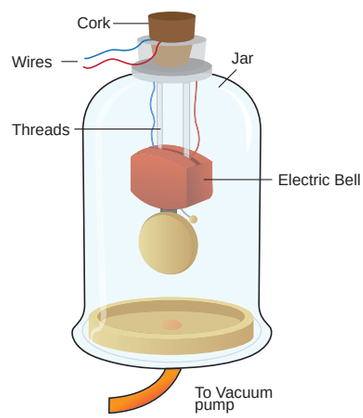


Figure 2.1 Bell-Jar experiment

2.2.2 Sound is a wave

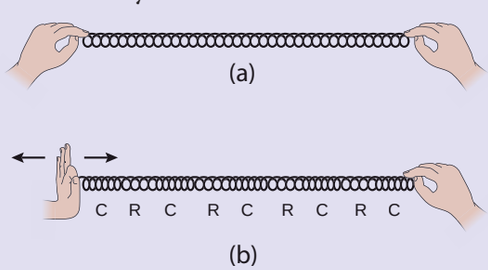
Sound moves from the point of generation to the ear of the listener through a medium. When an object vibrates, it sets the particles of the medium around to vibrate. But, the vibrating particles do not travel all the way from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is displaced from its equilibrium position. It then exerts a force on an adjacent particle. As a result of which the adjacent particle gets displaced from its position of rest. After displacing the adjacent particle the first particle comes back to its original position. This process continues in the medium till the sound reaches our ears. It is to be noted that only the disturbance created by a source of sound travels through the medium and not the particles of the medium. All the particles of the medium restrict themselves with only

a small to and fro motion called vibration which enables the disturbance to be carried forward. This disturbance which is carried forward in a medium is called wave.

2.2.3 Longitudinal nature of sound waves

Activity 3

Take a coil or spring and move it forward and backward. What do you observe? You can observe that in some parts of the coil the turns will be closer and in some other parts the turns will be far apart. Sound also travels in a medium in the same manner. We will study about this now.



In the above activity you noticed that in some parts of the coil, the turns are closer together. These are regions of compressions. In between these regions of compressions we have regions where the coil turns are far apart called rarefactions. As the coil oscillates, the compressions and rarefactions move along the coil. The wave that propagates with compressions and rarefactions are called longitudinal waves. In longitudinal waves the particles of the medium move to and fro along the direction of propagation of the wave.

Sound is also a longitudinal wave. Sound can travel only when there are particles which can be compressed and rarefied. Compressions are the regions where particles are crowded together. Rarefactions are the regions of low pressure where particles are

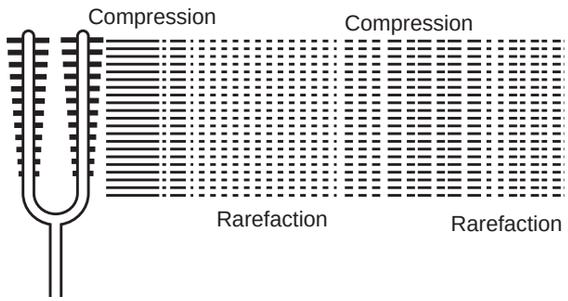


Figure 2.2 Sound is a wave

spread apart. A sound wave is an example of a longitudinal mechanical wave. Figure 2.3 represents the longitudinal nature of sound wave in the medium.

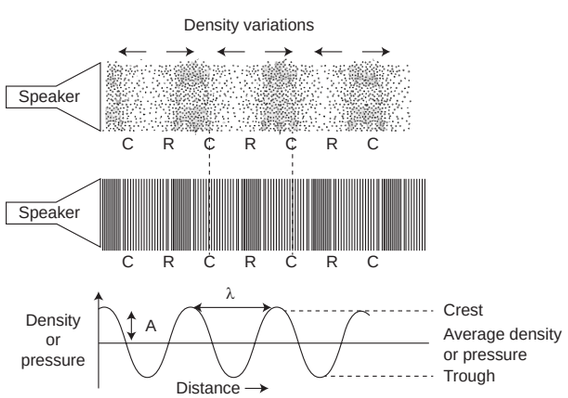


Figure 2.3 Longitudinal nature of sound

2.3 Characteristics of a sound wave

Activity 4

Listen to the audio of any musical instrument like *flute, nathaswaram, tabla, drums, veena* etc., Tabulate the differences between the sounds produced by the various sources.

A sound wave can be described completely by five characteristics namely amplitude, frequency, time period, wavelength and velocity or speed.

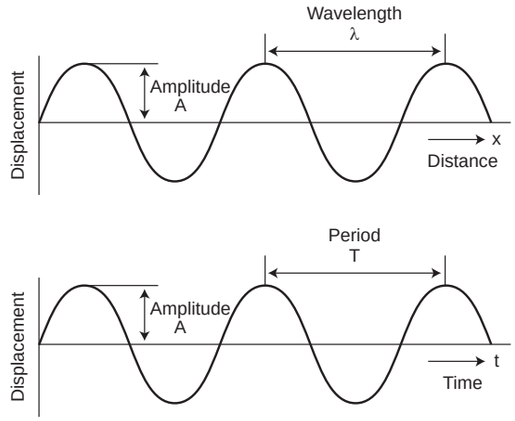


Figure 2.4 Characteristics of sound wave

Amplitude (A)

The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium is called amplitude of the wave. If the vibration of a particle has large amplitude, the sound will be loud and if the vibration has small amplitude, the sound will be soft. Amplitude is denoted as A. Its SI unit is meter (m).

Frequency (n)

The number of vibrations (complete waves or cycles) produced in one second is called frequency of the wave. It is denoted as n. The SI unit of frequency is s^{-1} (or) hertz (Hz). Human ear can hear sound of frequency from 20 Hz to 20,000 Hz. Sound with frequency less than 20 Hz is called infrasonic sound. Sound with frequency greater than 20,000 Hz is called ultrasonic sound. Human beings cannot hear infrasonic and ultrasonic sounds.

Time period (T)

The time required to produce one complete vibration (wave or cycle) is called time period of the wave. It is denoted as T. The SI unit of time period is second (s). Frequency and time period are reciprocal to each other.

DO YOU KNOW?

Heinrich Rudolph Hertz was born on 22 February 1857 in Hamburg, Germany and educated at the University of Berlin. He confirmed J. C. Maxwell's electromagnetic theory by his experiments. He laid the foundation for future development of radio, telephone, telegraph and even television. He also discovered the photoelectric effect which was later explained by Albert Einstein. The SI unit of frequency was named as hertz in his honour.

Wavelength (λ)

The minimum distance in which a sound wave repeats itself is called its wavelength. In a sound wave, the distance between the centers of two consecutive compressions or two consecutive rarefactions is also called wavelength. The wavelength is usually denoted as λ (Greek letter lambda). The SI unit of wavelength is metre (m).

Velocity or speed (v)

The distance travelled by the sound wave in one second is called velocity of the sound. The SI unit of velocity of sound is m s^{-1}.

2.4 Distinguishing different sounds

Sounds can be distinguished from one another in terms of the following three different factors.

1. Loudness
2. Pitch
3. Timbre (or quality)

1. Loudness and Intensity

Loudness is a quantity by virtue of which a sound can be distinguished from another one, both having the same frequency. Loudness or softness of sound depends on the amplitude of the wave. If we strike a table lightly, we hear a soft sound because we produce a sound wave of less amplitude. If we hit the table hard we hear a louder sound. Loud sound can travel a longer distance as loudness is associated with higher energy. A sound wave spreads out from its source. As it move away from the source its amplitude decreases and thus its loudness decreases. Figure 2.5 shows the wave shapes of a soft and loud sound of the same frequency.

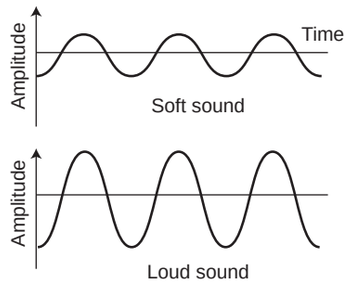


Figure 2.5 Soft and loud sound

The loudness of a sound depends on the intensity of sound wave. Intensity is defined as the amount of energy crossing per unit area per unit time perpendicular to the direction of propagation of the wave.

The intensity of sound heard at a place depends on the following five factors.

i. Amplitude of the source.
ii. Distance of the observer from the source.
iii. Surface area of the source.
iv. Density of the medium.
v. Frequency of the source.

The unit of intensity of sound is decibel (dB). It is named in honour of the Scottish-born scientist Alexander Graham Bell who invented telephone.

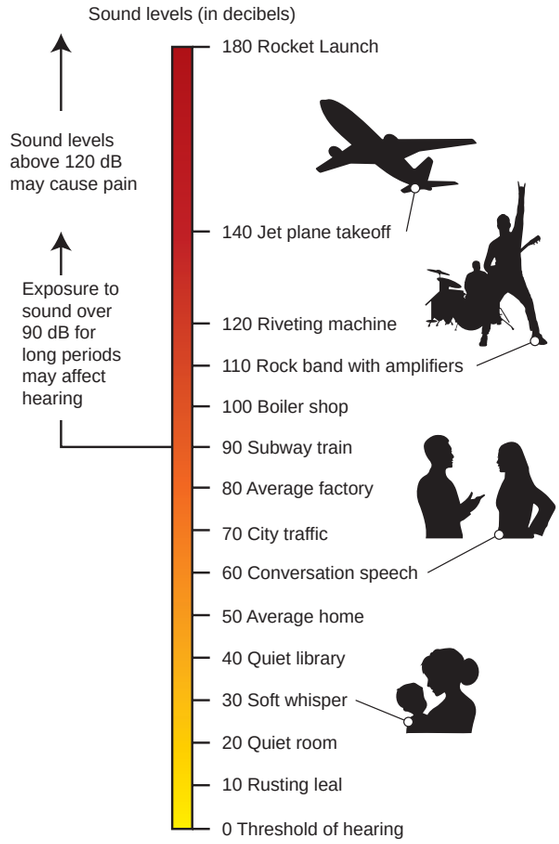


Figure 2.6 Intensity level of sound

2. Pitch

Pitch is the characteristics of sound by which we can distinguish whether a sound is shrill or base. High pitch sound is shrill and low pitch sound is flat. Two music sounds produced by the same instrument with same amplitude, will differ when their vibrations are of different frequencies. Figure 2.7 consists of two waves representing low pitch and high pitch sounds.

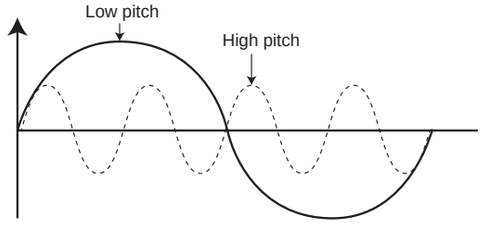


Figure 2.7 Longitudinal nature of sound

3. Timbre or Quality

Timbre is the characteristic which distinguishes two sounds of same loudness and pitch emitted by two different instruments. A sound of single frequency is called a tone and a collection of tones is called a note. Timbre is then a general term for the distinguishable characteristics of a tone.

2.5 Speed of sound

The speed of sound is defined as the distance travelled by a sound wave per unit time as it propagates through an elastic medium.

$$\text{Speed (v)} = \frac{\text{Distance}}{\text{Time}}$$

If the distance traveled by one wave is taken as one wavelength (λ), and the time taken for this propagation is one time period (T), then

$$\text{Speed (v)} = \frac{\text{one wavelength } (\lambda)}{\text{one time period (T)}} \quad \text{(or)} \quad v = \frac{\lambda}{T}$$

As, $T = \frac{1}{n}$ the speed (v) of sound is also written as, $v = n\lambda$

The speed of sound remains almost the same for all frequencies in a given medium under the same physical conditions.

Example 1

A sound wave has a frequency of 2 kHz and wavelength of 15 cm. How much time will it take to travel 1.5 km?

Solution:

Given, Frequency, n = 2 kHz = 2000Hz

Wavelength, λ = 15 cm = 0.15 m

Speed, $v = n\lambda$

$= 0.15 \times 2000 = 300\ m\ s^{-1}$

The time taken (t) by the wave to travel a distance (d) of 1.5 km is calculated as, d = 1.5 km = 1500 m

$$\text{Time (t)} = \frac{\text{Distance (d)}}{\text{Velocity (v)}}$$

$$t = \frac{1500}{300} = 5\ s$$

The sound will take 5 s to travel a distance of 1.5 km.

Example 2

What is the wavelength of a sound wave in air at 20° C with a frequency of 22 MHz?

Solution:

The speed of sound at 20° C is $v = 344\ m\ s^{-1}$.

The frequency of sound $n = 22\ MHz$

$= 22 \times 10^6\ Hz$

To find the wavelength λ, we use the wave equation with speed of sound.

$\lambda = v/n$

$\lambda = 344/22 \times 10^6$

$\lambda = 15.64 \times 10^{-6}\ m$

Ans. $\lambda = 15.64\ \mu m$.

2.5.1 Speed of sound in different media

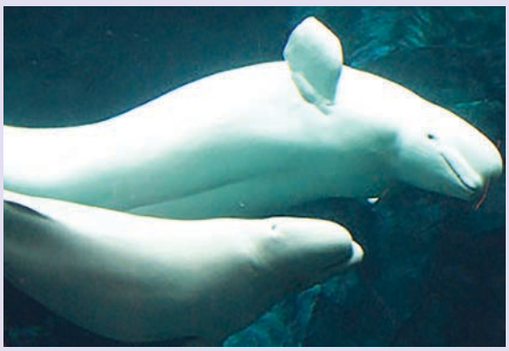
Sound propagates through a medium at a finite speed. The sound of thunder is heard a little later than the flash of light is seen. So we can make out that sound travels with a speed which is much less than the speed of light. The speed of sound depends on the properties of the medium through which it travels.

The speed of sound in a gaseous medium depends on,

- pressure of the medium
- temperature of the medium
- density of the medium
- nature of gas

More to Know

Sound travels about 5 times faster in water than in air. Since the speed of sound in sea water is very large (being about 1530 m s^{-1} which is more than 5500 km h^{-1}), two whales in the sea which are even hundreds of kilometres away from each other can talk to each other very easily through the sea water.



The speed of sound in solid medium depends on,

- elastic property of the medium
- temperature of the medium
- density of the medium

The speed of sound is less in gaseous medium compared to solid medium. In any medium the speed of sound increases if we increase the temperature of the medium. For example the speed of sound in air is 330 m s^{-1} at 0°C and 340 m s^{-1} at 25°C. The speed of sound at a particular temperature in various media is listed in Table 2.1.

Table 2.1 Speed of sound in different media at 25° C.

State	Medium	Speed in m s^{-1}
Solids	Aluminum	6420
	Nickel	6040
	Steel	5960
	Iron	5950
	Brass	4700
	Glass	3980
Liquids	Water (Sea)	1531
	Water (distilled)	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965
	Air	340
	Oxygen	316
	Sulphur dioxide	213

More to Know

Sonic boom: When the speed of any object exceeds the speed of sound in air (330 m s^{-1}) it is said to be travelling at supersonic speed. Bullets, jet, aircrafts etc., can travel at supersonic speeds. When an object travels at a speed higher than that of sound in air, it produces shock waves. These shock waves carry a large amount of energy. The air pressure variations associated with this type of shock waves produce a very sharp and loud sound called the 'sonic boom'. The shock waves produced by an aircraft have energy to shatter glass and even damage buildings.

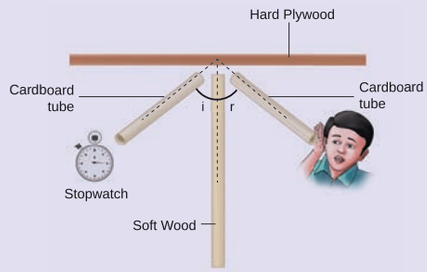
2.6 Reflection of sound

Sound bounces off a surface of solid or a liquid medium like a rubber ball that bounces off from a wall. An obstacle of large size which may be polished or rough is needed for the reflection of sound waves. The laws of reflection are:

- The angle in which the sound is incident is equal to the angle in which sound is reflected.
- Direction of incident sound, direction of the reflected sound and the normal are in the same plane.

Activity 5

Take two identical pipes as shown in below. You can make the pipes using chart paper. The length of the pipes should be sufficiently long as shown in figure. Arrange them on a table near wall. Keep a clock near the open end of one of the pipes and try to hear the sound of the clock through the other pipe. Adjust the position of the pipes so that you can best hear the sound of the clock. Now, measure the angle of incidence and reflection and see the relationship between the angles. Lift the pipes on the right vertically to a small height, and observe what happens.



2.6.1 Uses of multiple reflections of sound

Musical instruments

Megaphones, loud speakers, horns, musical instruments such as nathaswaram, shehnai and trumpets are all designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.

Figure 2.8 Megaphone or horn

Stethoscope

Stethoscope is a medical instrument used for listening to sounds produced in the body. In stethoscopes these sounds reach doctor's ears by multiple reflections that happen in the connecting tube.

Figure 2.9 Stethoscope

DO YOU KNOW?

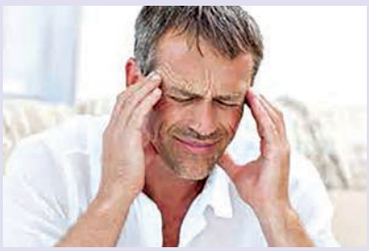
Noise pollution: Noise is an unwanted sound. Sounds with loudness of 120 dB (decibel) and higher can be painful to the ear. Even brief exposures to higher sound levels can rupture eardrum and can cause permanent hearing loss. However, long exposure to relatively lower sound level can also cause hearing problems. Such exposures may lead to psychological damages too. For some jobs, ear protectors must be worn in work places. You may have experienced a temporary hearing loss after being exposed to a loud band for long time or a loud bang for a short time. Ear protectors are commercially available at medical stores and hardware stores.

2.7 Echo

When we shout or clap near a suitable reflecting surface such as a tall building or a mountain, we will hear the same sound again a little later. This sound which we hear is called an echo. The sensation of sound persists in our brain for about 0.1s.

More to Know

Use of ear phones for long hours can cause infection in the inner parts of the ears, apart from damage to the ear drum. Your safety is in danger if you wear ear phones while crossing signals, walking on the roads and travelling. Using earphones while sleeping is all the more dangerous as current is passing in the wires. It may even lead to mental irritation. Hence, you are advised to deter from using earphones as far as possible.



Hence, to hear a distinct echo the time interval between the original sound and the reflected sound must be at least 0.1s. Let us consider the speed of sound to be 340 m s^{-1} at 25° C. The sound must go to the obstacle and return to the ear of the listener on reflection after 0.1 s. Thus, the total distance covered by the sound from the point of generation to the reflecting surface and back should be at least 340 m s^{-1} × 0.1 s = 34 m.

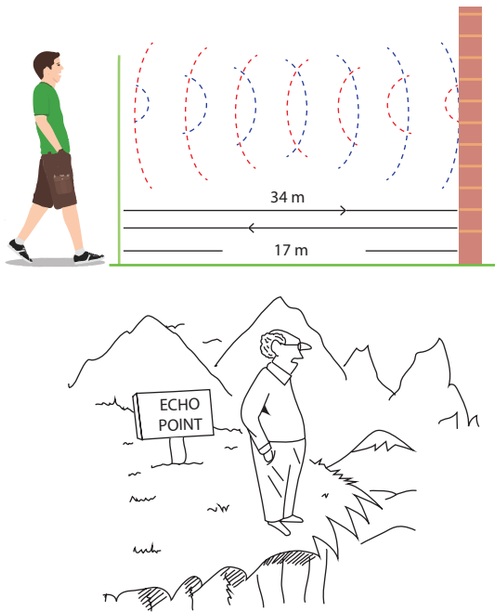


Figure 2.10 Echo

Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance i.e. 17 m. This distance will change with the temperature of air. Echoes may be heard more than once due to successive or multiple reflections. The roaring of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds at different heights and the land.

Example 3

A person claps his hands near a cliff and hears the echo after 5 s. What is the distance of the cliff from the person if the speed of the sound is taken as 330 m s^{-1}?

Solution:

Speed of sound, v = 330 m s^{-1}

Time taken to hear the echo, t = 5 s

Distance travelled by the sound, d = v × t

= 330 × 5

= 1650 m (or) 1.65 km

In 5s sound travels twice the distance between the cliff and person. Hence the distance between the cliff and the person = $\frac{1650}{2}$ = 825 m.

Example 4

A man fires a gun and hears its echo after 5 s. The man then moves 310 m towards the hill and fires his gun again. If he hears the echo after 3 s, calculate the speed of sound.

Solution:

Distance (d) = velocity (v) × time (t)

Distance travelled by sound when gun fires first time, $2d = v \times 5$ (1)

Distance travelled by sound when gun fires second time, $2d - 620 = v \times 3$ (2)

Rewriting equation (2) as,
$2d = (v \times 3) + 620$ (3)

Equating (1) and (3), $5v = 3v + 620$

$2v = 620$

Velocity of sound, $v = 310\ m\ s^{-1}$

2.8 Reverberation

A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. In an auditorium or big hall excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound absorbing materials like compressed fiberboard, flannel cloths, rough plaster and draperies. The seat materials are also selected on the basis of their sound absorbing properties.

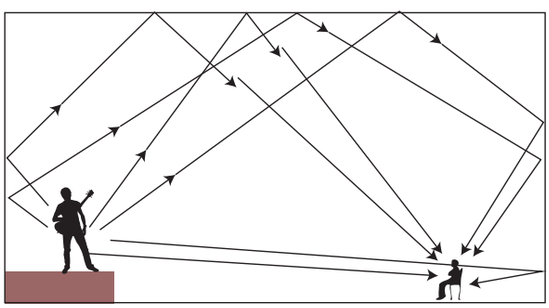


Figure 2.11 Reverberation of sound in a auditorium

There is a separate branch in physics called acoustics which takes these aspects of sound in to account while designing auditoria, opera halls, theaters etc. (You will study about acoustics in class X).

2.9 Ultrasonic sound or Ultrasound

Ultrasonic sound is the term used for sound waves with frequencies greater than 20,000 Hz. These waves cannot be heard by the human ear, but the audible frequency range for other animals includes ultrasound frequencies. For example dogs can hear ultrasonic sound. Ultrasonic whistles are used on cars to alert deer to oncoming traffic so that they will not leap across the road in front of cars.

An important use of ultrasound is in examining inner parts of the body. Thus ultrasound is an alternative to X-rays. The ultrasonic waves allow different tissues such as organs and bones to be 'seen' or distinguished by bouncing of ultrasonic waves by the objects examined. The waves are detected, analysed and stored in a computer. An echogram is an image obtained by the use of reflected ultrasonic waves. It is used as a medical diagnostic tool. Ultrasonic sound is having application in marine surveying also.

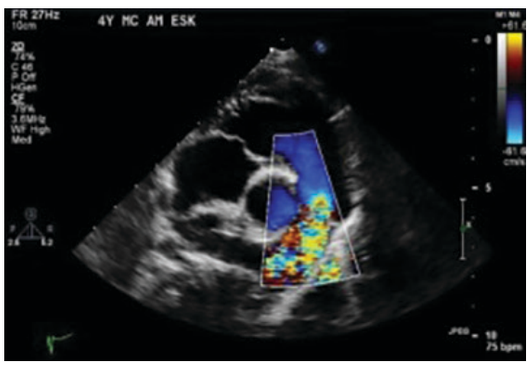
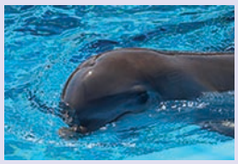


Figure 2.12 Echogram using ultra sound

More to Know

Animals, such as bats, dolphins, rats, whales and oil birds, use ultrasound to navigate or communicate. Bats, dolphins and some toothed whales use echolation, an ultrasound technique that uses echoes to identify and locate objects. Echolation allows bats to navigate through dark caves and find insects for food. Dolphins and whales emit a rapid series of underwater clicks in ultrasonic frequencies to locate their prey and navigate through water. Many nocturnal insects including moths, grasshoppers, praying mantis, beetles and lacewings, have sharp ultrasonic hearing, which helps them escape predators. While oil birds use ultrasound to fly safely and hunt at night, they use lower echolation frequencies compared to bats and other nocturnal insects.






2.9.1 Applications of ultrasonic waves

- Ultra sound can be used in cleaning technology. Minute foreign particles can be removed from objects placed in a liquid bath through which ultrasound is passed.
- Ultrasounds can also be used to detect cracks and flaws in metal blocks.
- Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echo cardiography'.
- Ultrasound may be employed to break small 'stones' formed in the kidney into fine grains. These grains later get flushed out with urine.

2.10 SONAR

SONAR stands for Sound Navigation And Ranging. Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects. Sonar consists of a transmitter and a detector and is installed at the bottom of boats and ships.

The transmitter produces and transmits ultrasonic waves. These waves travel through water and after striking the object on the seabed, get reflected back and are sensed by the detector. The detector converts the ultrasonic waves into electrical signals which are appropriately interpreted. The distance of the object that reflected the sound wave can be calculated by knowing the speed of sound in water and the time interval between transmission and reception of the ultrasound.

Let the time interval between transmission and reception of ultrasound signal be 't' and

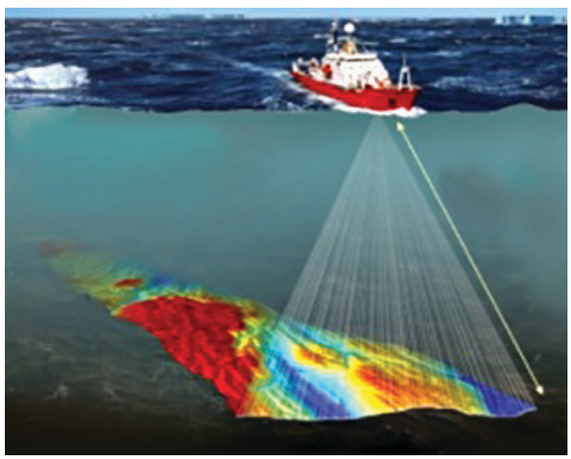


Figure 2.13 Sonar

the speed of sound through sea water be $2d = v \times t$. This method is called echo-ranging. Sonar technique is used to determine the depth of the sea and to locate underwater hills, valleys, submarine, icebergs etc.

Example 5

A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of ultrasound through sea water is 1531 m s^{-1}, what is the distance of the seabed from the ship?

Solution

Time between transmission and detection, t = 3.42 s.

Speed of ultrasound in sea water, v = 1531 m s^{-1}

Distance travelled by the ultrasound = 2 × depth of the sea

We know, distance = speed × time

2d = speed of ultrasound × time

$$2d = 1531 \times 3.42$$

$$\therefore d = \frac{5236}{2} m$$

$$d = 2618 \text{ m}$$

Thus, the distance of the seabed from the ship is 2618 m or 2.618 km.

2.11 Electrocardiogram (ECG)

The electrocardiogram (ECG) is one of the simplest and oldest cardiac investigations available. It can provide a wealth of useful information and remains an essential part of the assessment of cardiac patients. In ECG the sound variation produced by heart is converted into electric signals. Thus, an ECG is simply a representation of the electrical activity of the heart muscle as it changes with time. Usually it is printed on paper for easy analysis. The sum of this electrical activity, when amplified and recorded for just a few seconds is known as an ECG (Fig. 2.14).

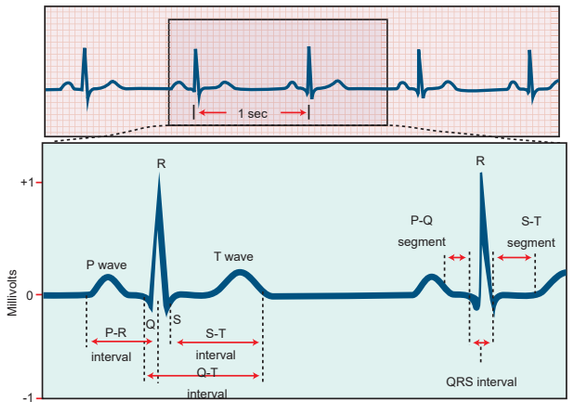


Figure 2.14 ECG diagram

2.12 Structure of human ear

How do we hear? We are able to hear with the help of an extremely sensitive device called the ear. It allows us to convert pressure variations in air with audible frequencies into electric signals that travel to the brain via the auditory nerve. The auditory aspect of human ear is discussed below.

The outer ear is called 'pinna'. It collects the sound from the surroundings. The collected sound passes through the auditory canal. At the end of the ear is eardrum or tympanic membrane. When a compression of the medium reaches the eardrum the pressure on the outside of the membrane increases and forces the eardrum inward. Similarly the eardrum moves outward when a rarefaction reaches it. In this way the eardrum vibrates. The vibrations are amplified several times by three bones (the hammer, anvil and stirrup) in the middle ear. The middle ear transmits the amplified pressure variations received from the sound wave to the inner ear. In the inner ear, the pressure variations are turned into electrical signals by the cochlea. These electrical signals are sent to the brain via the auditory nerve and the brain interrupts them as sound.

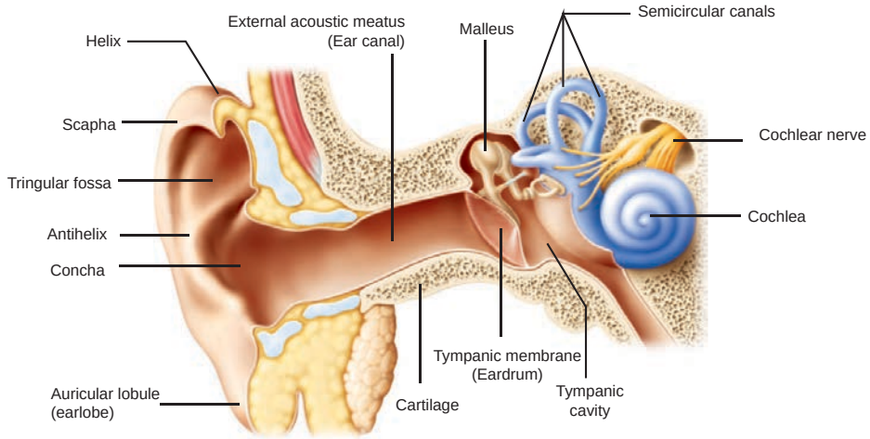


Figure 2.14 Human ear

More to Know

Hearing Aid

People with hearing loss may need a hearing aid. A hearing aid is an electronic, battery operated device. The hearing aid receives sound through a microphone. The microphone converts the sound waves into electrical signals. These electrical signals are amplified by an amplifier. The amplified electrical signals are given to a speaker of the hearing aid. The speaker converts the amplified electrical signals to sound and sends to the ear for clear hearing.

Points to Remember

- Sound is produced due to vibration.
- Sound travels as a longitudinal wave through a material medium.
- Sound travels as successive compressions and rarefactions in the medium.
- In sound propagation, it is the energy of the sound that travels and not the particles of the medium.
- Sound cannot travel through vacuum.
- The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength.
- The time taken by the wave to complete one oscillation.
- The number of oscillations per unit time is called the frequency. $n = 1 / T$
- The speed v, frequency n, and wavelength λ, of sound are related by the equation. $v = n \lambda$
- The speed of sound depends primarily on the nature and the temperature of the transmitting medium.
- The law of reflection of sound: (i) The angle of incidence ray, the angle of reflection and normal drawn at the point of incidence all lie in the same plane (ii) The angle of incidence i and the angle of reflection r are always equal.
- For hearing distinct echo sound, the time interval between the original sound and the reflected sound must be at least 0.1 s.
- The persistence of hearing sound in an auditorium is the result of repeated reflections of sound and is called reverberation.
- The amount of sound energy passing each second through unit area is called the intensity of sound.
- The audible range of hearing for average human being is in the frequency range of 20 Hz to 20000 Hz

- Sound waves with frequencies below audible range are termed as 'Infrasonics' and those above audible range are termed as 'Ultrasonics'.
- The SONAR technique is used to determine the depth of the sea and to locate under water hills, valleys, submarines, icebergs, etc.

GLOSSARY

Amplitude	The maximum displacement of a particle.
Compressions	The region of increased pressure.
ECG	Electrocardiogram.
Echo	The repetition of sound caused by the reflection of sound.
Frequency	Number of waves produced in one second.
Longitudinal wave	The wave that propagates with compressions and rarefactions are called longitudinal waves.
Loudness	Loudness or softness of sound depends on the amplitude of the wave.
Pitch	Characteristics of sound based on frequency.
Rarefactions	The region of decreased pressure.
Reverberation	The repeated reflection that results in persistence of sound is called reverberation.
SONAR	Sound Navigation And Ranging.
Speed of sound	Distance travelled by a sound wave per unit time.
Timbre (or quality)	Characteristic which distinguishes the two sounds of same loudness and pitch emitted by two different instruments.
Time period	Time taken to produce one wave.
Ultrasonic sound	Sound waves with frequencies greater than 20,000 Hz.
Velocity (or) Speed	Distance travelled by the wave in one second.
Wave	The propagating disturbance that travels in a medium is called a wave.
Wavelength	The minimum distance in which a sound wave repeats itself.

TEXTBOOK EVALUATION

G9L7T4

I. Choose the correct answer:

1. Which of the following vibrates when a musical note is produced by the cymbals in a orchestra?
   a) stretched strings
   b) stretched membranes
   c) air columns
   d) metal plates

2. Sound travels in air:
   a) if there is no moisture in the atmosphere.
   b) if particles of medium travel from one place to another.
   c) if both particles as well as disturbance move from one place to another.
   d) if disturbance moves.

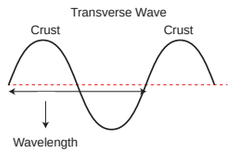
3. A musical instrument is producing continuous note. This note cannot be heard by a person having a normal hearing range. This note must then be passing through
   a) wax b) vacuum
   c) water d) empty vessel

4. If the speed of a wave is 340 $m s^{-1}$ and its frequency is 1700 Hz, then wavelength λ for this wave in cm will be
   a) 34 b) 20 c) 15 d) 0.2

5. Which of the following statement best describes frequency?
   a) the number of complete vibrations per second.
   b) the distance travelled by a wave per second.
   c) the distance between one crest of wave and the next one.
   d) the maximum disturbance caused by a wave.

6. The maximum speed of vibrations which produces audible sound will be in
   a) seawater b) ground glass
   b) dry air d) Human blood

7. In the sound wave produced by a vibrating turning fork as shown in the diagram, half the wave length is represented by:



   a) BD b) AB c) AE d) DE

8. The sound waves travel faster
   a) in liquids b) in gases
   c) in solids d) in vacuum

9. When the pitch of note by a harmonium is lowered, then the wave length of the note
   a) first decreases and then increases
   b) decreases
   c) remains the same
   d) increases

10. The speeds of sound in four different media are given below. Which of the following is the most likely speed in $m s^{-1}$ with which the two under water whales in a sea can talk to each other when separated by a large distance?
   a) 5170 b) 1280
   c) 340 d) 1530

11. Which of the following can produce longitudinal waves as well as transverse waves under different conditions?
   a) TV transmitter b) tuning fork
   c) water d) slinky

12. The velocities of sound waves in four media P, O, Q, R and S are 18,00 km/h, 900 km/h, 0 km/h, and 1200 km/h respectively. Which could be a liquid medium?
   a) R b) Q c) P d) S

II. Fill in the blanks.

1. Vibration of object produces _____ .
2. Sound is a _____ wave and needs a material medium to travel.
3. Number of vibrations produced in one second is _____ .
4. The velocity of sound in solid is _____ than the velocity of sound in air.
5. Loudness is proportional to the square of the _____ .
6. A sound wave has a frequency of 4 k hz and wavelength 2 m. Then the velocity of sound is _____ .
7. _____ is a medical instrument used for listening to sounds produced in the body.
8. The repeated reflection that results in persistence of sound is called _____ .
9. Ultrasounds can also be used to detect cracks and flows in _____ .
10. In the inner ear, the pressure variations are turned into electrical signals by the _____ .

III. Match the following.

Tuning fork	The point where density of air is maximum
Sound	Maximum displacement from the equilibrium position
Compressions	The sound whose frequency is greater than 20,000 Hz
Amplitude	Longitudinal wave
Ultasonics	Production of sound

IV. Matrix matching.

Loudness	Number of vibrations produced in unit time	decibel
Time period	The amount of sound produced / received	Metre
Amplitude	Distance travelled by sound in unit time	Hertz
Velocity of sound	The time required to produce one complete wave	Metre per second
Frequency	The maximum displacement from the mean position	second

V. Answer in brief.

1. Name the device which is used to produce sound in laboratory experiments.
2. Through which medium sound travels faster, iron or water? Give reason.
3. What should an object do to produce sound?
4. Can sound travel through vacuum?
5. Name the physical quantity whose SI unit is 'hertz'. Define.
6. What is meant by supersonic speed?
7. How does the sound produced by a vibrating object in a medium reach your ears?
8. You and your friend are on the moon. Will you be able to hear any sound produced by your friend?

VI. Answer in detail.

1. Describe with diagram, how compressions and rarefactions are produced.
2. Verify experimentally the laws reflection of sound.
3. List the applications of sound.
4. Explain how does SONAR work?
5. Explain the working of human ear with diagram.

VII. Numerical problems.

1. The frequency of a source of sound is 600 Hz. How many times does it vibrate in a minute?
2. A stone is dropped from the top of a tower 750 m high into a pond of water at the base of the tower. When is the splash heard at the top? (Given g = 10 m s^{-2} and speed of sound = 340 m s^{-1})

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1. An Introduction to Physical Science- James T-Shipman, Jerry D. Wilson and Aaron W. Todd.—Houghton Miffin Company, Boston, Newyark.
2. Applied Physics – Rajasekaran S and others – Vikas Publishing House Pvt Ltd.
3. Fundamentals of Physics – Halliday, Resnick and Walker- Sixth Edition – Wiley India Pvt Ltd. NewDelhi.

INTERNET RESOURCES

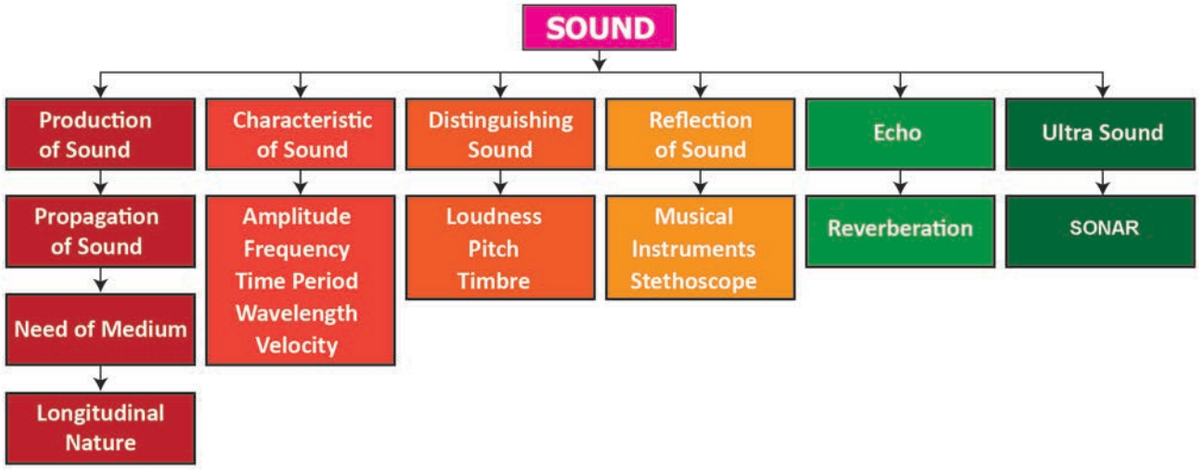
www.britannica.com/science/ultrasonics

www.reference.com/pets-animals/animals-use-ultrasound

https://www.searchencrypt.com

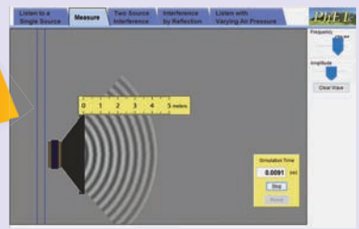
https://www.soundwaves.com/

Concept Map



ICT CORNER

Experiment with *sound waves* using virtual simulator.



Steps

- Type the given URL to reach "pHET Simulation" page and download the "java" file of Sound.
- Open the "java" file and plug in your headphone. Click "Audio enabled" box from right side to hear the sound waves.
- Switch the tabs from the top to simulate various properties of sound waves. Watch the longitudinal sound waves from different interfaces by altering "Frequency" and "Amplitude".
- Alter "Air Density" and observe its effect on the sound waves. Use "Reset" to repeat the experiment.

Step1

Step2

Step3

Step4

Sound Simulator

URL: https://phet.colorado.edu/en/simulation/legacy/sound or Scan the QR Code.

*Pictures are indicative only

B567_9_SCI_EM_T3

UNIT 3

Universe

Learning Objectives

G9V3UR

After completing this lesson, students will be able to

- understand the evolution of the universe.
- explain the vastness of the universe.
- interpret Kepler's laws of motion and solve related problems.
- calculate the orbital velocity and the time-period of satellites.
- know more about International Space Station.

Introduction

If you look at the sky, you can see the Sun during daytime; moon and numerous stars during night time. In the earlier days, before the invention of astronomical instruments, people were able to see the Sun, moon and stars only. Based on their observation, they thought that Earth is the centre of all the objects in the space. This was known as the geocentric model, held by Greek astronomer Ptolemy (2nd Century), Indian astronomer Aryabhatta (5th Century) and many astronomers around the world. Later Polish astronomer Nicolaus Copernicus observed the space more keenly and proposed the heliocentric model (helios = Sun), with Sun at the centre of the solar system. The invention of the telescope in the Netherlands, in 1608, created a revolution in astronomy. The improvement of telescopes led astronomers to realize that our Sun is one of hundreds of billions of stars in a galaxy, what we call the Milky Way. We have millions of galaxies in space. The collection of all the things that exist in space is known as the universe. In this lesson we will study how the universe came into existence and all the things in it, how satellites are put into orbit and also about international space station.

3.1 Building Block of the Universe

The basic constituent of the universe is luminous matter i.e., galaxies which are really the collection of billions of stars. The universe contains everything that exists including the Earth, planets, stars, space, and galaxies. This includes all matter, energy and even time. No one knows how big the universe is. It could be infinitely large. Scientists, however, measure the size of the universe by what they can see. This is called the 'observable universe'. The observable universe is around 93 billion light years (1 light year = the distance that light travels in one year, which is 9.4607×10^{12} km) across.

One of the interesting things about the universe is that it is currently expanding. It is growing larger and larger all the time. Not only is it growing larger, but the edge of the universe is expanding at a faster and faster rate. However, most of the universe what we think of is empty space. All the atoms together only make up around four percent of the universe. The majority of the universe consists of something scientists call dark matter and dark energy.

Activity 1

Form a team of three to four students. Prepare a poster about the astronomers.

3.1.1 Age of the universe

Scientists think that the universe began with the start of a massive explosion called the Big Bang. According to Big Bang theory, all the matter in the universe was concentrated in a single point of hot dense matter. About 13.7 billion years ago, an explosion occurred and ejected all the matter in all directions in the form of galaxies. Nearly all of the matter in the universe that we understand is made of hydrogen and helium, the simplest elements, created in the Big Bang. The rest, including the oxygen that we breathe, the carbon, calcium, and iron in our bodies, and the silicon in our computer chips are formed in the cores of stars.

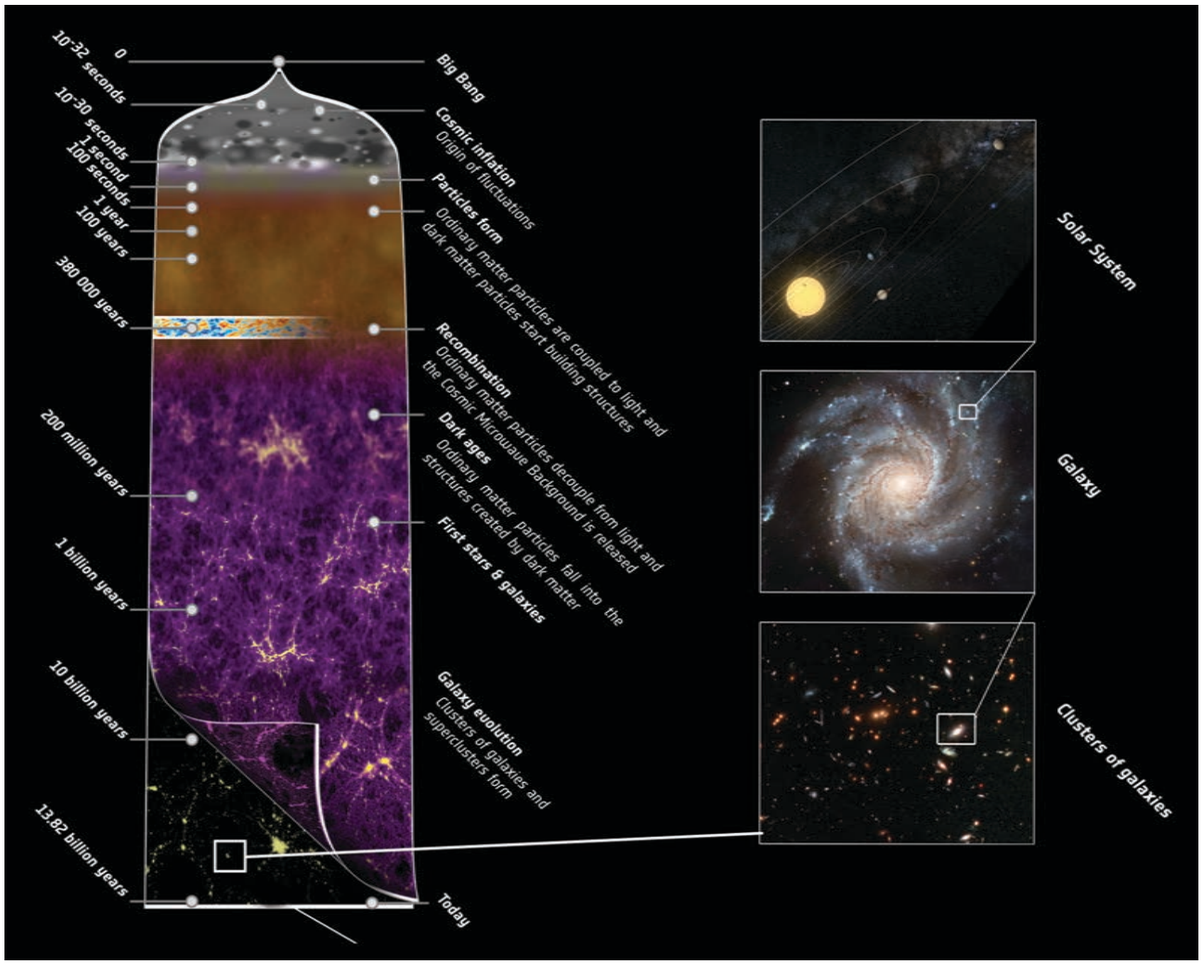


Figure 3.1 Formation of the universe

The gravity that holds these stars together generally keeps these elements deep inside their interiors. When these stars explode, these fundamental building blocks of planetary systems are liberated throughout the universe.

More to Know

DARK MATTER AND DARK ENERGY

Scientists are not sure exactly what dark matter is. Dark matter gets its name because it cannot be seen with any type of instrument that we have today. Around 27% of the universe is made up of dark matter. Dark energy is something that fills all space. The theory of dark energy helps us to explain why the universe is expanding. Around 68% of the universe is dark energy.

3.1.2 Galaxies

According to astronomers galaxies were formed shortly after the Big Bang that happened 10 billion to 13.7 billion years ago. Immediately after the Big Bang, clouds of gases began to compress under gravity to form the building blocks of galaxies. A galaxy is a massive collection of gas, dust, and billions of stars and their solar systems. Scientists believe that there are one hundred billion (10^{11}) galaxies in the observable universe. The size of the galaxies ranges having a few hundred million (10^{8}) stars to one hundred trillion (10^{14}) stars. Galaxies are also in different shapes. Depending on their appearance galaxies are classified as spiral, elliptical, or irregular. Galaxies occur alone or in pairs, but they are more often parts of groups, clusters, and super clusters. Galaxies in such groups often interact and even merge together.

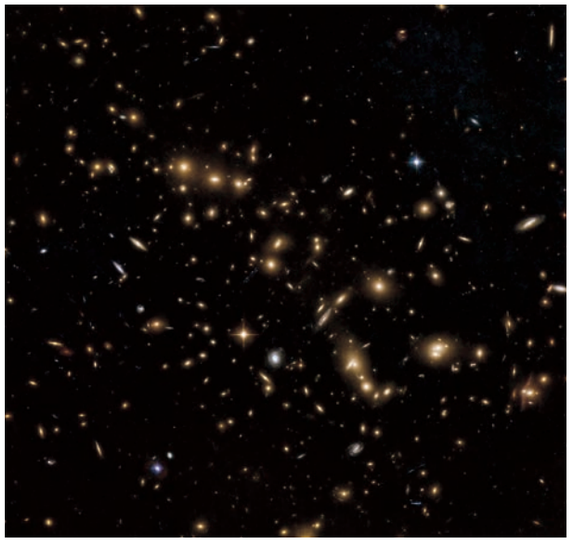


Figure 3.2 Galaxies
(Image from Hubble Space Telescope)

Our Sun and all the planets in the solar system are in the Milky Way galaxy. There are many galaxies besides our Milky Way. Andromeda galaxy is our closest neighboring galaxy. The Milky Way galaxy is spiral in shape. It is called Milky Way because it appears as a milky band of light in the sky. It is made up of approximately 100 billion stars and its diameter is 1,00,000 light years. Our solar system is 25,000 light years away from the centre of our galaxy. Just as the Earth goes around the Sun, the Sun goes around the centre of the galaxy and it takes 250 million years to do that.

Figure 3.3 Milky Way Galaxy

DO YOU KNOW?

The distance of Andromeda, our nearest galaxy is ≈ 2.5 million light-years. If we move at the speed of the Earth (30 km/s), it would take us 25 billion years to reach it!

3.1.3 Stars

Stars are the fundamental building blocks of galaxies. Stars were formed when the galaxies were formed during the Big Bang. Stars produce heat, light, ultraviolet rays, x-rays, and other forms of radiation. They are largely composed of gas and plasma (a superheated state of matter). Stars are built by hydrogen gases. Hydrogen atoms fuse together to form helium atoms and in the process they produce large amount of heat. In a dark night we can see nearly 3,000 stars with the naked eye. We don't know how many stars exist. Our universe contains more than 100 billion galaxies, and each of those galaxies may have more than 100 billion stars.

Figure 3.4 Stars

Though the stars appear to be alone, most of the stars exist as pairs. The brightness of a star depends on their intensity and the distance from the Earth. Stars also appear to be in different colours depending on their temperature. Hot stars are white or blue, whereas cooler stars are orange or red in colour. They also occur in many sizes. Some stars have radii a thousand times larger than that of our own Sun.

A group of stars forms an imaginary outline or meaningful pattern on the space. They represent an animal, mythological person or creature, a god, or an object. This group of stars is called constellations. People in different cultures and countries adopted their own sets of constellations outlines. There are 88 formally accepted constellations. Aries, Gemini, Leo, Orion, Scorpius and Cassiopeia are some of the constellations.

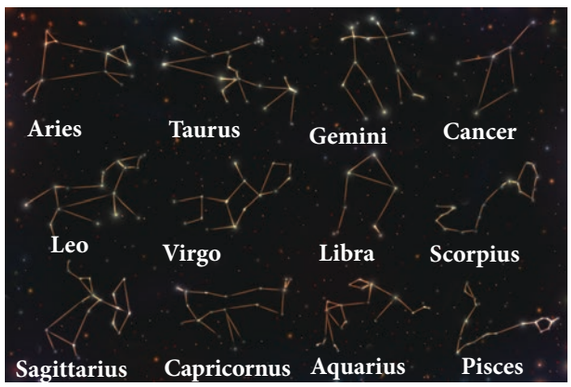


Figure 3.5 Constellations

Activity 2

Observe the sky keenly during night. Can you see a group of stars? Can you figure out any shape? Discuss with your teachers and find out their name.

3.2 The Solar System

The Sun and celestial bodies which revolve around it form the solar system. It consists of large number of bodies such as planets, comets, asteroids and meteors. The gravitational force of attraction between the Sun and these objects keep them revolving around it.

3.2.1 The Sun

The Sun is sometimes referred to by its Latin name Sol or by its Greek name Helios. The ancient Greeks grouped the Sun together with the other celestial bodies which moved across the sky, calling them all planets. But the Sun is a medium sized star, a very fiery spinning ball of hot gases. Three quarters of the Sun has hydrogen gas and one quarter has helium gas. It is over a million times as big as the Earth. Hydrogen atoms combine or fuse together to form helium under enormous pressure. This process, called nuclear fusion releases enormous amount of energy as light and heat. It is this energy which makes Sun shine and provide heat. The Sun is situated at the centre of the solar system. The strong gravitational fields cause other solar matter, mainly planets, asteroids, comets, meteoroids and other debris, to orbit around it. The Sun is believed to be more than 4.6 billion years old.

More to Know

Sun	
Diameter (across equator):	about 1,392,000 km (1 million 392 thousand km)
Volume:	1.3 million times that of Earth
Distance from the Earth:	About 150 million (15 crore) km
Sun's gravity:	28 times that of the Earth
Surface temperature:	From 5500˚C to 6000˚C
Core temperature:	1.5 million˚C
Composition:	75% Hydrogen + 25% helium + 70 elements

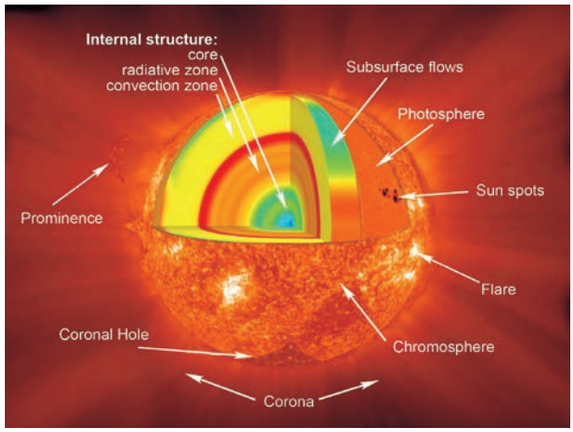


Figure 3.6 Internal view of the Sun

Formation of the Sun

At the time of the Big Bang, hydrogen gas condensed to form huge clouds, which later concentrated and formed the numerous galaxies. Some of the hydrogen gas was left free and started floating around in our galaxy. With time, due to some changes, this free-floating hydrogen gas concentrated and paved way for the formation of the Sun and solar system. Gradually, the Sun and the solar system turned into a slowly spinning molecular cloud, composed of hydrogen and helium molecules, along with dust. The cloud started to undergo the process of compression, as a result of its own gravity. Its excessive and high-speed spinning ultimately resulted in its flattening into a giant disc.

Rotation

The Sun rotates on its axis. Since the Sun is primarily made of very hot gas, the surface at the equator rotates once every 25.4 days. The rotation near the poles takes around 36 days.

Energy output

Most of the energy emitted by the Sun is visible light and a form of radiation known as infrared rays, which we feel as heat.

DO YOU KNOW?

- The Sun travels around the galaxy once every 200 million years – a journey of 100,000 light years.
- The Sun provides our plant with 126,000,000,000,000 horsepower of energy every day!
- For 186 days one cannot see the Sun in the North Pole.
- The amount of energy reaching the Earth's surface from the Sun is 6,000 times the amount of energy used by all human beings worldwide.
- The Sun is one among the 6000 stars which is visible to the naked eye from the Earth.

Colour

It is a common misconception that Sun emits yellow color radiation and it is not true. The radiation coming from the Sun contains all the colors. But the yellow is most intense among all the colors. Sunlight is scattered by the molecules when it passes through the Earth's atmosphere. The scattering of light depends on the color. Blue and violet are scattered more and red is scattered less.

3.2.2 Planets

A planet revolves around the Sun along a definite curved path which is called an orbit. It is elliptical. The time taken by a planet to complete one revolution is called its period of revolution. The period of revolution increases as the distance of the planet from the Sun increases. Thus the period of revolution of the Earth is 365.30 days whereas that of Neptune is 164.80 years.

Besides revolving around the Sun, a planet also rotates on its own axis like a top. The time taken by a planet to complete one rotation is called its period of rotation. The period of rotation of the Earth is 23 hours and 56 minutes and so the length of a day on Earth is taken as 24 hours. Table 3.1 tells about the length of a day on each planet. A day on the planet mercury is 59 Earth days, i.e., 59 × 24 = 1416 hours. Jupiter rotates so fast that a day lasts only less than 10 hours.

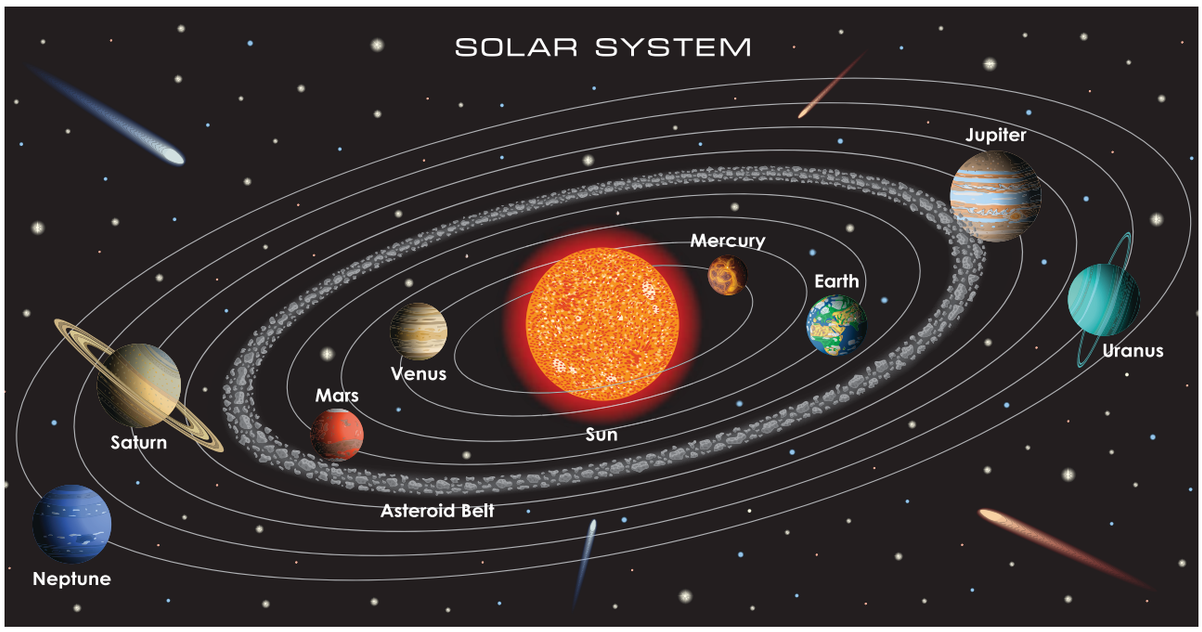


Figure 3.7 Planets in Orbit

Table 3.1 Length of a day on each planet

Planets	Length of a day
Mercury	58.65 days
Venus	243 days
Earth	23.93 hours
Mars	24.62 hours
Jupiter	9.92 hours
Saturn	10.23 hours
Uranus	17 hours
Neptune	18 hours

The planets are spaced unevenly. The first four planets are relatively close together and close to the Sun. They form the inner solar system. Farther from the Sun is the outer solar system, where the planets are much more spread out. Thus the distance between Saturn and Uranus is much greater (about 20 times) than between the Earth and the Mars.

The four planets grouped together in the inner solar system are Mercury, Venus, Earth and Mars. They are called inner planets. They have a surface of solid rock crust and so are called terrestrial or rocky planets. Their insides, surfaces and atmospheres are formed in a similar way and form similar pattern. Our planet, Earth can be taken as a model of the other three planets.

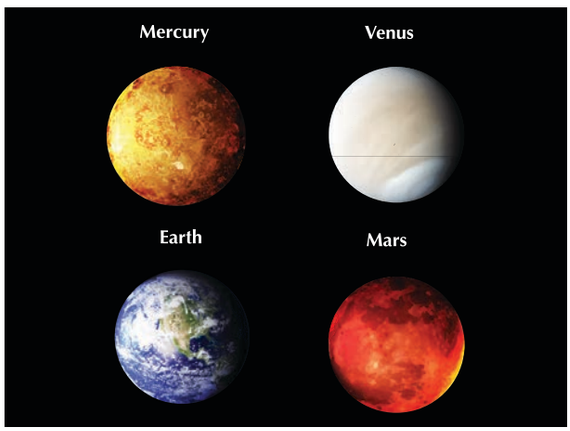


Figure 3.8 Inner Planets

The four large planets Jupiter, Saturn, Uranus and Neptune spread out in the outer solar system that slowly orbit the Sun are called outer planets. They are made of hydrogen, helium and other gases in huge amounts and have very dense atmosphere. They are known as gas giants and are called gaseous planets. The four outer planets Jupiter, Saturn, Uranus and Neptune have rings whereas the four inner planets do not have any rings. The rings are actually tiny pieces of rock covered with ice. Now let us learn about each planet in the solar system.

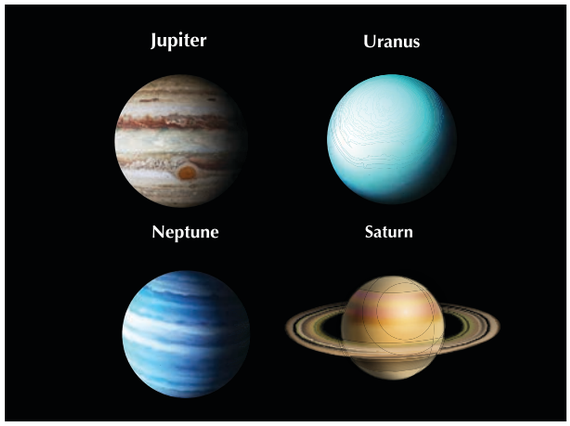


Figure 3.9 Outer Planets

Mercury

Mercury is a rocky planet nearest to the Sun. It is very hot during day but very cold at night. It moves around the Sun faster than any other planet – one year being only 87.97 Earth days and rotates very slowly. One day is equal to 58.65 days. Mercury can be easily observed thorough telescope than naked eye since it is very faint and small. It always appears in the eastern horizon or western horizon of the sky.

Venus

Venus is a special planet from the Sun, almost the same size as the Earth. It is the hottest planet in our solar system. After our moon, it is the brightest heavenly body in our night sky. A day on this planet is longer than its year. A day on this planet

is 243 Earth days, and a year is only 224.7 Earth days. This planet spins in the opposite direction to all other planet and so unlike Earth, the Sun rises in the west and sets in the east here. Venus can be seen clearly through naked eye. It always appears in the horizon of eastern or western sky.

Activity 3

Watch the sky in the early morning. Do you see any planet? What is its name? Find out with the help of your teachers.

The Earth

The Earth where we live is the only planet in the solar system which supports life. Due to its right distance from the Sun it has the right temperature, the presence of water and suitable atmosphere and a blanket of ozone. All these have made continuation of life possible on the Earth. It moves around the Sun in 365.25 days and rotation period is 23.93 hours. The axis of rotation of the Earth is not perpendicular to the plane of its orbit. The tilt is responsible for the change of seasons on the Earth. From space, the Earth appears bluish green due to the reflection of light from water and land mass on its surface.

The Earth rotates on its axis from west to east (Fig. 3.10), so the Sun appears to move in its opposite direction that is from east to west. Life on Earth as we know would not be possible without the Sun. The solar energy from the Sun has supported and sustained terrestrial existence on Earth since the beginning of time.

DO YOU KNOW?

More than 1 million Earth would fit inside the Sun! A man weighing 60 kg in the Earth will weigh 1680 kg in the Sun.

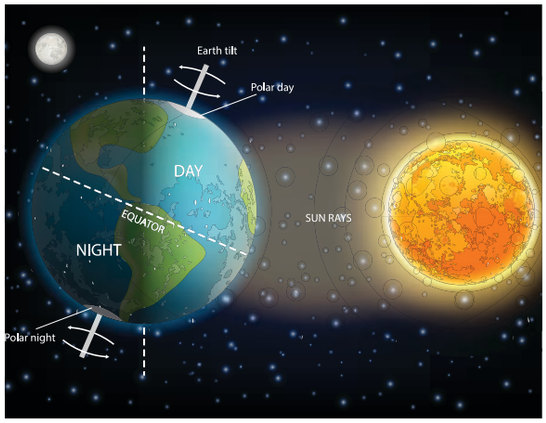
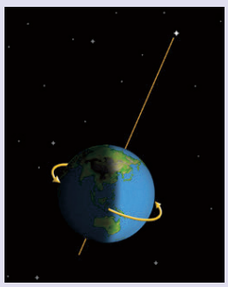


Figure 3.10 The rotation of the Earth on its axis

DO YOU KNOW?

All stars appear to us as moving from east to west, whereas there is one star which appears to us stationary in its position. It has been named as Pole star. The pole star appears to us as fixed in space at the same place in the sky in the north direction because it lies on the axis of rotation of the Earth which itself is fixed and does not change its position in space. It may be noted that the pole star is not visible from the southern hemisphere.



Mars

The first planet outside the orbit of the Earth is Mars. It appears slightly reddish and therefore it is also called the red planet. It has two small natural satellites (Deimos and Phobos). A natural satellite of any planet is called moon. One day on this planet is of 24 hours 37 minutes 22 seconds, and one year is 686.98 days, i.e., 687 Earth days.

Jupiter

Jupiter is called as Giant planet. It is the largest of all planets (about 11 times larger and 318 times heavier than Earth). It has 3 rings and 65 moons. Its moon Ganymede is the largest moon of our solar system. Rotating faster than any other planet, Jupiter has the shortest days - one day lasting only 9 hours 55 minutes 30 seconds. One year in Jupiter equals our 11.862 years.

Saturn

Known for its bright shiny rings, Saturn appears yellowish in colour. It is the second biggest and a giant gas planet in the outer solar system. It rotates very fast - the rotation period being 10.7 hours but revolves slowly around the Sun - the revolution period being 29.46 Earth years. At least 60 moons are present - the largest being Titan. Titan is the only moon in the solar system with clouds. Having least density of all (30 times less than Earth), this planet is so light.

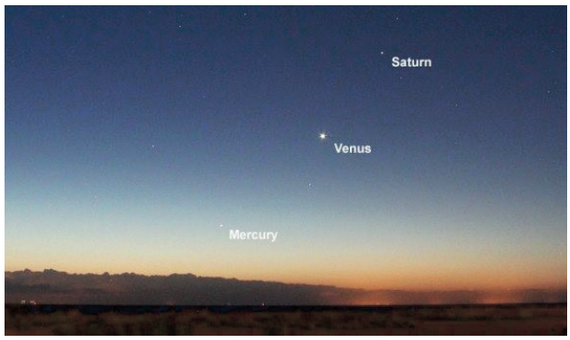


Figure 3.11 Planets seen from Earth

Uranus

Uranus is a cold gas giant and it is the seventh planet from the Sun in the solar system. It can be seen only with the help of large telescope. It has a greatly tilted axis of rotation. As a result, in its orbital motion it appears to roll on its side. Its revolution period is 84 Earth years and the rotation period is 17.2 hours. Due to its peculiar tilt, it has the longest summers and winters each lasting 42 years.

Neptune

It appears as Greenish star. It is the eighth planet from the Sun and is the windiest planet. Every 248 years, Pluto crosses its orbit. This situation continues for 20 years. It has 13 moons – Triton being the largest. Triton is the only moon in the solar system that moves in the opposite direction to the direction in which its planet spins.

3.2.3 Other bodies of the solar system

Besides the eight planets, there are some other bodies which revolve around the Sun. They are also members of the solar system.

Asteroids

There is a large gap in between the orbits of Mars and Jupiter. This gap is occupied by a broad belt containing about half a million pieces of rocks that were left over when the planets were formed and now revolve around the Sun. These are called asteroids. The biggest asteroid is Ceres – 946 km across. Every 50 million years, the Earth is hit by an asteroid nearing 10 km across. Asteroids can only be seen through large telescope.

Figure 3.12 Asteroids

Comets

Comets are lumps of dust and ice that revolve around the Sun in highly elliptical orbits. Their period of revolution is very long.

When approaching the Sun, a comet vaporizes and forms a head and tail. Some of the biggest comets even seen had tails 160 million (16 crores) km long. This is more than the distance between the Earth and the Sun. Many comets are known to appear periodically. One such comet is Halley's Comet, which appears after nearly every 76 years. It was last seen in 1986. It will next be seen in 2062.

Figure 3.13 Comet

Cosmic year

The Sun travelling at a speed of 250 km per second (9 lakh km/h) takes about 225 million years to complete one revolution around the Milky Way. This period is called a cosmic year.

Meteors and Meteorites

Meteors are small piece of rocks scattered throughout the solar system. Traveling with high speed, these small pieces come closer to the Earth's atmosphere and are attracted by the gravitational force of Earth. Most of them are burnt up by the heat generated due to friction in the Earth's atmosphere. They are called meteors. Some of the bigger meteors may not be burnt completely and they fall on the surface of Earth. These are called meteorites.

Figure 3.14 Meteors and Meteorites

Satellites

A body moving in an orbit around a planet is called satellite. In order to distinguish them from the man made satellites (called as artificial satellites), they are called as natural satellites or moons. Satellite of the Earth is called Moon (other satellites are written as moon). It moves around the Earth once in 27.3 days in an approximate circular orbit of radius 3.85×10^5 km. Natural satellites do not make their own light. We can see the Earth's satellite Moon, because it reflects the light of the Sun. Satellite moves around the planets due to gravity, and the centripetal force. Among the planets in the solar system all the planets have moons except Mercury and Venus.

Figure 3.15 Moon revolving around Earth

3.3 Orbital Velocity

We saw that there are natural satellites moving around the planets. There will be gravitational force between the planet and satellites. Nowadays many artificial satellites are launched into the Earth's orbit. The first artificial satellite Sputnik was launched in 1956. India launched its first satellite Aryabhatta on April 19, 1975. Artificial satellites are made to revolve in an orbit at a height of few hundred kilometres. At this altitude, the friction due to air is negligible. The satellite is carried by a rocket to the desired height and released horizontally with a high velocity, so that it remains moving in a nearly circular orbit.

The horizontal velocity that has to be imparted to a satellite at the determined height so that it makes a circular orbit around the planet is called orbital velocity.

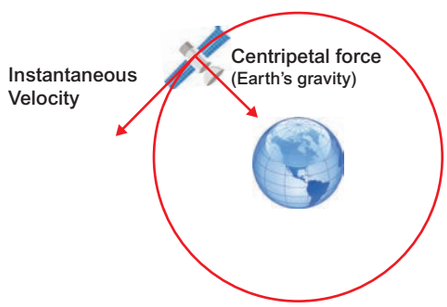


Figure 3.16 Orbital velocity

The orbital velocity of the satellite depends on its altitude above Earth. Nearer the object to the Earth, the faster is the required orbital velocity. At an altitude of 200 kilometres, the required orbital velocity is little more than 27,400 kph. That orbital speed and distance permit the satellite to make one revolution in 24 hours. Since Earth also rotates once in 24 hours, a satellite stays in a fixed position relative to a point on Earth's surface. Because the satellite stays over the same spot all the time, this kind of orbit is called 'geostationary'. Orbital velocity can be calculated using the following formula.

$v = \sqrt{\frac{GM}{(R+h)}}$ where

G = Gravitational constant ($6.673 \times 10^{-11} Nm^2kg^{-2}$)

M = Mass of the Earth (5.972×10^{24} kg)

R = Radius of the Earth (6371 km)

h = Height of the satellite from the surface of the Earth.

Example 1

Can you calculate the orbital velocity of a satellite orbiting at an altitude of 500 km?

Data: $G = 6.673 \times 10^{-11}$ SI units;

$M = 5.972 \times 10^{24}$ kg; R = 6371000 m;

h = 500000 m.

Solution:

$$v = \sqrt{\frac{6.67 \times 10^{-11} \times 5.972 \times 10^{24}}{(6371000 + 500000)}}$$

Ans: $v = 7613\ ms^{-1}$ or $7.613\ kms^{-1}$

Microgravity is the condition in which people or objects appear to be weightless. The effects of microgravity can be seen when astronauts and objects float in space. Micro- means very small, so microgravity refers to the condition where gravity 'seems' to be very small. Many things seem to act differently in microgravity. Fire burns differently. Without the pull of gravity, flames are mere round. NASA performs science experiments in microgravity. These experiments help NASA to learn things that would be hard or perhaps impossible to learn on Earth.

3.4 Time period of a Satellite

Time taken by the satellite to complete one revolution round the Earth is called time period.

$$\text{Time period, } T = \frac{\text{Distance covered}}{\text{Orbital velocity}}.$$

$$T = \frac{2\pi r}{v}$$

Substituting the value of v, we get

$$T = \frac{2\pi(R+h)}{\sqrt{\frac{GM}{(R+h)}}}.$$

Example 2

At an orbital height of 500 km, find the orbital period of the satellite.

Solution

$h = 500\text{x}10^3\text{m}$, $R = 6371\text{x}10^3\text{m}$,

$v = 7616\text{x}10^3\ \text{kms}^{-1}$.

Substituting the values,

$$T = \frac{2\pi(R+h)}{v} = 2 \times \frac{22}{7} \times \frac{(6371+500)}{7616}$$

$= 5.6677\text{x}10^3\text{s} = 5667$ s.

This is $T \approx 95$ min

Activity 2

Prepare a list of Indian satellites from Aryabhatta to the latest along with their purposes.

3.5 Kepler's Laws

In the early 1600s, Johannes Kepler proposed three laws of planetary motion. Kepler was able to summarize the carefully collected data of his mentor - Tycho Brahe - with three statements that described the motion of planets in a Sun-centered solar system. Kepler's efforts to explain the underlying reasons for such motions are no longer accepted; nonetheless, the actual laws themselves are still considered an accurate description of the motion of any planet and any satellite. Kepler's three laws of planetary motion can be described as below.

First Law – The Law of Ellipses

The path of the planets about the Sun is elliptical in shape, with the center of the Sun being located at one of the foci.

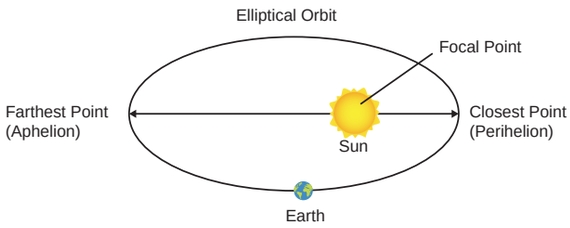


Figure 3.17 The Law of Ellipses

Second Law – The Law of Equal Areas

An imaginary line drawn from the center of the Sun to the center of the planet will sweep out equal areas in equal intervals of time.

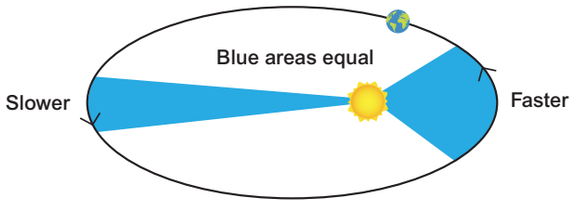


Figure 3.18 The Law of Equal area

Third Law – The Law of Harmonies

The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their semi major axis from the Sun.

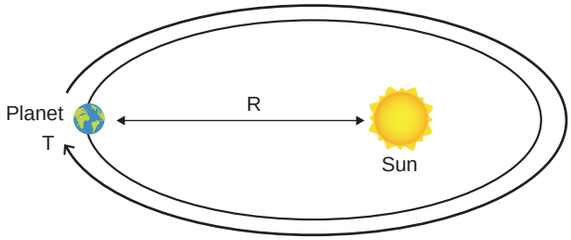


Figure 3.19 The Law of Harmonics

3.6 International Space Station

ISS is a large spacecraft which can house astronauts. It goes around in low Earth orbit at approximately 400 km distance. It is also a science laboratory. Its very first part was placed in orbit in 1998 and its core construction was completed by 2011. It is the largest man-made object in space which can also be seen from the Earth through the naked eye. The first human crew went to the ISS in 2000. Ever since that, it has never been unoccupied by humans. At any given instant, at least six humans will be present in the ISS. According to the current plan ISS will be operated until 2024, with a possible extension until 2028. After that, it could be deorbited, or recycled for future space stations.

Figure 3.20 International Space Station

3.6.1 Purpose of International Space Station

The ISS is intended to act as a scientific laboratory and observatory. Its main purpose is to provide an international lab for conducting experiments in space, as the space environment is nearly impossible to reproduce here on Earth. The microgravity environment present in the ISS provides ideal conditions for doing many scientific researches especially in biology, human biology, physics, astronomy and meteorology.

More to Know

Some facts about ISS

Mass/Power	420 000 kg / 75 kW to 90 kW
Length/Width/ Height	73 m / 108 m / 31 m
Operating Altitude	407 km
Orbital velocity/ Period	7.67 km s^{-1} (27 600 km hr^{-1}) / 93 min
Humans visited	227 (as of July 2018)
Food needed to support three for six months	3,630 kg
Total length of wire for electrical connections	13 km
Most no. of days spent in ISS	665 days by astronaut Peggy Wilson

3.6.2 Benefits of ISS

According to NASA, the following are some of the ways in which the ISS is already benefitting us or will benefit us in the future.

Supporting water-purification efforts

Using the technology developed for the ISS, areas having water scarcity can gain access to advanced water filtration and purification systems. This could very well be a life-saving difference for the people in such hazardous locations. The water recovery system (WRS) and the oxygen generation system (OGS) developed for the ISS have already saved a village in Iraq from being deserted due to lack of clean water.

Eye tracking technology

The Eye Tracking Device, built for a microgravity experiment, has proved ideal to be used in many laser surgeries. This device tracks the eye's position very accurately without interfering with the surgeon's work. Also, eye tracking technology is helping disabled people with limited movement and speech. For example, a kid who has severe disability in body movements can use his eye-movements alone and do routine tasks and lead an independent life.

Robotic arms and surgeries

Robotic arms developed for research in the ISS are providing significant help to the surgeons in removing inoperable tumours (e.g., brain tumours) and taking biopsies with great accuracies. The same technology designed for huge robotic arms that help astronauts in space is being brought back to Earth to do some heavy lifting in cancer treatment - in the form of a surgical robot. Its inventors say that the robot could take biopsies with remarkable precision and consistency.

Figure 3.21 Robotic arm

Apart from the above-mentioned applications there are many other ways in which the researches that take place in the ISS are helpful. They are: development of improved vaccines, breast cancer detection and treatment, ultrasound machines for remote regions etc,.

3.6.3 ISS and international cooperation

As great as the ISS' scientific achievements are, no less in accomplishment is the international co-operation which resulted in the construction of the ISS. An international collaboration of five different space agencies of 16 countries provides, maintains and operates the ISS. They are: NASA (USA), Roskosmos (Russia), ESA (Europe), JAXA (Japan) and CSA (Cananda). Belgium, Brazil, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the UK are also part of the consortium. In fact, in the late 1950s, the idea of international space missions was unthinkable. The first part of the ISS was launched by the Russian Zarya module, which was funded by America. The first crew sailed on board was Russian Soyuz spaceship. Even as the ISS has sections split into US Orbital Segment, Russian Orbital Segment etc., on the whole it is jointly-owned by all the participating agencies and their nations. Cooperative international agreements between the world powers have made the largest international scientific undertaking a possibility. The many significant researches and functions of the ISS could only have been possible with the full co-operation of these nations.

DO YOU KNOW?

The Indian Space Research Organisation (ISRO) had proposed its Indian Human Spaceflight Programme to be done by 2021/2022 according to ISRO Chairman, K. Sivan. The first crew is to consist of three astronauts to be taken to space with a spacecraft called *Gaganyaan* on a GSLV-III rocket. V.R. Lalithambika, a specialist in advanced launcher technologies, will help the project as Director of the Human Space Flight Project.

Points to Remember

- The basic constituent of universe is galaxies which are really the collection of billions of stars.
- Scientists think that the universe began with the start of a massive explosion called the Big Bang.
- The universe contains everything that exists including the Earth, planets, stars, space, and galaxies.
- Depending on their appearance, galaxies are classified as spiral, elliptical, or irregular.
- Our Sun and all the planets in the solar system are in the Milky Way galaxy.
- Stars are the fundamental building blocks of galaxies.
- A group of stars forms an imaginary outline or meaningful pattern on the space, called constellations.
- The Sun and celestial bodies which revolve around it form the solar system.
- The first four planets are relatively close together and close to the Sun. They form the inner solar system. Farther from the Sun is the outer solar system, where the planets are much more spread out.
- Due to its right distance from the Sun, Earth has the right temperature, the presence of water and suitable atmosphere and a blanket of ozone.
- Million pieces of rocks that were left over when the planets were formed and now revolve around the Sun are called asteroids.
- Comets are lumps of dust and ice that revolve around the Sun in a highly elliptical orbits.
- A body moving in an orbit around a planet is called satellite.
- The ISS is intended to act as a scientific laboratory and observatory. Its main purpose is to provide an international lab for conducting experiments in space.

A-Z GLOSSARY

Asteroid	Small, rocky object orbiting the Sun.
Astronomy	The scientific study of the universe and the objects in it.
Big Bang Theory	A theory which states that the universe began in an enormous explosion.
Comet	A chunk of dirty, dark ice, mixed with dust and grit which revolves around the Sun in an oval orbit.
Constellation	A group of stars that can be seen as a pattern from Earth. There are 88 constellations.
Galaxy	A group of stars, nebulae, star clusters, globular clusters and other matter. There are millions of galaxies in the universe.
Meteor	A meteoroid that travels through the Earth's atmosphere. As it falls toward Earth, it burns up, making a streak of light. Also known as a shooting star.
Meteorite	A meteor that hits the Earth's surface.
Milky Way	A broad band of light that looks like a trail of spilled milk in the night sky. Created by the millions of faint stars that form part of our galaxy.
Moon	Any natural object which orbits a planet.

Orbit	The path of one object as it revolves around another
Planet	A relatively large object that revolves around a star, but which is not itself a star.
Satellite	Any object in outer space that orbits another object. Manmade satellites are launched into space to orbit a planet or moon.
Solar System	The Sun and all the objects that orbit it.
Space station	A large, manned satellite in space used as a base for space exploration over a long period of time.
Star	A ball of constantly exploding gases, giving off light and heat. The Sun is a star.
Universe	The word used to describe everything that exists in space, including the galaxies and stars, the Milky Way and the Solar System.

GADUY2

TEXTBOOK EVALUATION

I. Choose the correct answer.

1. Which of the following statements is correct?

   A. There are eight planets in our Solar System.

   B. Except Mars, all other planets revolve around the Sun in elliptical orbits

   (a) A only (b) B only
   (c) Both A and B (d) None

2. Who proposed the heliocentric model of the universe?
   (a) Tycho Brahe (b) Nicolaus Copernicus
   (c) Ptolemy (d) Archimedes

3. Which of the following is not a part of outer solar system?
   (a) Mercury (b) Saturn
   (c) Uranus (d) Neptune

4. Ceres is a _____.
   (a) Meteor (b) Star
   (c) Planet (d) Astroid

5. The period of revolution of planet A around the Sun is 8 times that of planet B. How many times is the distance of planet A as great as that of planet B?
   (a) 4 (b) 5
   (c) 2 (d) 3

6. The Big Bang occurred _____ years ago.
   (a) 13.7 billion (b) 15 million
   (c) 15 billion (d) 20 million

II. Fill in the blanks.

1. The speed of Sun in km/s is _____.
2. The rotational period of the Sun near its poles is _____.
3. India's first satellite is _____.
4. The third law of Kepler is also known as the Law of _____.
5. _____ is the only moon in the solar system that moves in the opposite direction to the direction in which its planet spins.
6. The number of planets in our Solar System is _____.

III. True or false.

1. The distance between Saturn and Uranus is about 10 times as that between Earth and Mars.
2. ISS is a proof for international cooperation.

3. Halley's comet appears after nearly 67 hours.
4. Satellites nearer to the Earth should have lesser orbital velocity.
5. Mars is called the red planet.

IV. Match the following.

1. Jupiter	a. 17.2 hours
2. Mercury	b. 10.7 hours
3. Venus	c. 87.97 days
4. Saturn	d. 9 hours 55 min
5. Mars	e. 243 days
	f. 87.97 days
	g. 24 hours 37 min

V. Answer very briefly.

1. What is solar system?
2. What is a cosmic year?
3. Define orbital velocity.
4. Define time period of a satellite.
5. What is a satellite? What are the two types of satellites?

VI. Answer in brief.

1. Write a note on the inner planets.
2. Write about comets in brief.
3. State Kepler's laws.
4. Write short notes on Gaganyaan.
5. What factors have made life on Earth possible?

VII. Answer in detail.

1. Give an account of all the planets in the solar system.
2. Discuss the benefits of ISS.
3. Write a note on orbital velocity.

VIII. Conceptual questions

1. Why do some stars appear blue and some red?
2. Why are we able to see the Moon even though it is not a luminous body?
3. How is a satellite maintained in nearly circular orbit?
4. Why are some satellites called geostationary?
5. A man weighing 60 kg in the Earth will weigh 1680 kg in the Sun. Why?

IX. Numerical problems

1. Calculate the speed with which a satellite moves if it is at a height of 36,000 km from the Earth's surface and has an orbital period of 24 hr (Take R = 6370 km)
   [Hint: Convert hr into seconds before doing calculation]
2. At an orbital height of 400 km, find the orbital period of the satellite.

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3. An introduction to Astronomy - By Baidyanath Basu.

INTERNET RESOURCES

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Concept Map

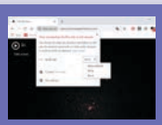
ICT CORNER

Building Blocks of Universe

Explore the universe in an interactive nutshell

Steps

- Type the given URL to reach interactive universe and allow the browser to play "JAVA Script", if asked.
- Click and drag the "Scale Pointer" present in the right side of the page or scroll the mouse to zoom into the universe.
- Click and drag the mouse pointer to North-South (up-down) axis to observe the fabricating structure of the galaxy.
- Zoom in on to extreme close up to view the solar system and to view the name of the objects present in the galaxy.


Step1


Step2


Step3


Step4

Interactive Universe's

URL: http://stars.chromeexperiments.com/ or Scan the QR Code.

*Pictures are indicative only

B567_9_SCI_EM_T3

UNIT

4

Carbon and its Compounds

GAMQZP

Learning Objectives

After completing this lesson, students will be able to

- explain the special features of carbon.
- know the isomerism of carbon compounds.
- know the three allotropic forms of carbon.
- differentiate between the properties of graphite and diamond.
- recognise the various inorganic carbon compounds with their uses.
- know the few common properties of carbon compounds.
- identify the codes of various plastics.
- understand the effects of plastics on human life and environment.
- know the legal measures to prevent plastic pollution.

Introduction

Carbon is an inseparable chemical entity associated with living things of the earth. The food we eat, the clothes we wear, the cosmetics we use and the fuels by which we run the automobiles all contain carbon compounds. When we burn the materials like cotton, wood, paper, plastics and rubber, they burn with smoky flame and leave some amount of solid or ash at the end. This is nothing but carbon.

Carbon is one of the most important **non-metallic** element. Antoine Lavoisier named Carbon from the Latin word **'Carbo'** meaning coal. This is because carbon is the main constituent of coal. Coal is a fossil fuel developed from prolonged decomposition of buried plants and animals. So it is clear that all the life forms contain carbon. The earth's crust contains only 0.032% of carbon (i.e.320 parts per million by weight) in the form of minerals like carbonates, coal and petroleum and the atmosphere has only 0.03% of carbon dioxide (i.e.300 parts per million by weight). In spite of this availability of small amount of carbon in nature, carbon compounds have an immense importance in everyday life. For example, we ourselves are made of carbon compounds. About 18 % of the weight of human body is carbon.

- ❖ Carbon is present in our muscles, bones, organs, blood and other components of living matter. Carbohydrates (compounds formed primarily of carbon and hydrogen) provide fuel for living organisms, underlie the structure of plants, animals and bacteria and are essential components of DNA and RNA, the molecular blueprints of life.
- ❖ A large number of things which we use in our daily life are made up of carbon compounds.
- ❖ The most vital photochemical reaction of plants involve carbon compounds (CO_2 and Chlorophyll)

So without carbon, there is no possibility for the existence of plants and animals including human. Thus **Carbon Chemistry** is also called as **Living Chemistry**.

4.1 Discovery of Carbon-Milestones

Carbon has been known since ancient times in the form of soot, charcoal, graphite and diamonds. Ancient cultures did not realize, of course, that these substances were different forms of the same element.

In 1772, French scientist **Antoine Lavoisier** pooled resources with other chemists to buy a diamond, which they placed in a closed glass jar. They focused the Sun's rays on the diamond with a remarkable giant magnifying glass and saw the diamond burn and disappear. Lavoisier noted that the overall weight of the jar was unchanged and that when it burned, the diamond had combined with oxygen to form carbon dioxide. He concluded that diamond and charcoal were made of the same element – carbon.

In 1779, Swedish scientist **Carl Scheele** showed that graphite burned to form carbon dioxide and so it must be another form of carbon.

In 1796, English chemist **Smithson Tennant** established that diamond is pure carbon and not a compound of carbon and it burned to form only carbon dioxide. Tennant also proved that when equal weights of charcoal and diamonds were burned, they produced the same amount of carbon dioxide.

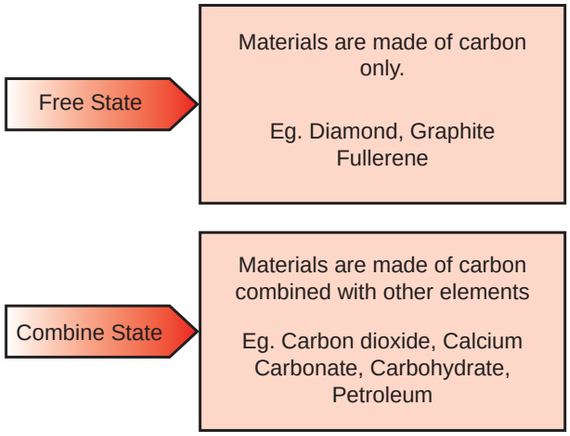
In 1855, English chemist **Benjamin Brodie** produced pure graphite from carbon, proving graphite is a form of carbon.

Although it had been previously attempted without success, in 1955 American scientist **Francis Bundy** and co-workers at 'General Electric' company finally demonstrated that graphite could be transformed into diamond at high temperature and high pressure.

In 1985, **Robert Curl, Harry Kroto and Richard Smalley** discovered fullerenes, a new form of carbon in which the atoms are arranged in soccer-ball shapes. The most recently discovered allotrope of carbon is **graphene**, which consists of a single layer of carbon atoms arranged in hexagons. Graphene's discovery was announced in 2004 by **Kostya Novoselov and Andre Geim**, who used adhesive tape to detach a single layer of atoms from graphite to produce the new allotrope. If these layers were stacked upon one other, graphite would be the result. Graphene has a thickness of just one atom.

4.2 Compounds of Carbon – Classification

Carbon is found both in free state as well as combined state in nature.



In the pre-historic period, ancients used to manufacture charcoal by burning organic materials. They used to obtain carbon compounds both from living things as well as non-living matter. Thus in the early 19th century, Berzelius classified carbon compounds based on their source as follows:

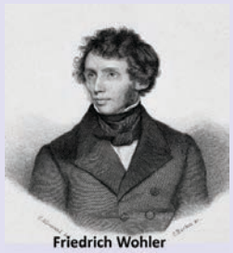
i. **Organic Carbon Compounds:** These are the compounds of carbon obtained from living organisms such as plants and animals. e.g. Ethanol, cellulose, Starch.

ii. **Inorganic Carbon Compounds:** These are the compounds containing carbon but obtained from non-living matter. e.g. Calcium Carbonate, Carbon Monoxide, Carbon dioxide.

4.2.1 Organic Compounds of Carbon

There are millions of organic carbon compounds available in nature and also synthesized manually. Organic carbon compounds contain carbon connected with other elements like hydrogen, oxygen, nitrogen, sulphur etc. Thus depending on the nature of other elements and the way in which they are connected with carbon, there are various classes of organic carbon compounds such as hydrocarbons, alcohols, aldehydes and ketones, carboxylic acids, amino acids, etc. You will study about organic carbon compounds in your higher classes.

More to Know


Friedrich Wohler
(1800 – 1882)

Until the mid – nineteenth century, scientists believed organic compounds came only from live plants and animals. They reasoned that organisms possessed a vital force that enabled them to produce organic compounds. This concept was known as **Vital Force Theory.** In 1829, **Friedrich Wohler** synthesized urea, an organic compound, from inorganic compounds lead cyanate and aqueous ammonia.

$$Pb(OCN)_2 + 2NH_4OH \rightarrow 2\,(NH_2)_2CO + Pb(OH)_2$$

Lead cyanate Aq. Ammonia Urea Lead hydroxide

Wohler was actually attempting to synthesize ammonium cyanate from the foresaid reaction. But he obtained the crystals of urea and thus urea is the first organic compound synthesized in laboratory. This synthesis was a blow to vital force theory. Following Wohler, chemists synthesized many organic compounds like acetic acid, methane, dyes, etc. in laboratory. Hence Friedrich Wohler is called '**Father of Modern Organic Chemistry**'.

4.2.2 Inorganic Compounds of Carbon

As compared to organic compounds, the number of inorganic carbon compounds are limited. Among them oxides, carbides, sulphides, cyanides, carbonates and bicarbonates are the major classes of inorganic carbon compounds. Formation, properties and uses of some of the compounds are given in Table 4.1.

Table 4.1 Inorganic carbon compounds

Compounds	Formation	Properties	Uses
Carbon monoxide (CO)	Not a natural component of air. Mainly added to atmosphere due to incomplete combustion of fuels.	Colourless Odourless Highly toxic Sparingly soluble in water.	Main component of water gas ($CO+H_2$). Reducing agent.
Carbon dioxide (CO_2)	Occurs in nature as free and combined forms. Combined form is found in minerals like limestone, magnesite. Formed by complete combustion of carbon or coke.	Colourless Odourless Tasteless Stable Highly soluble in water Takes part in photosynthesis.	Fire extinguisher Preservative for fruits Making bread To manufacture urea Carbonated water Nitrogenous fertilizers Dry ice in refrigerator
Calcium Carbide (CaC_2)	Prepared by heating CaO and Coke	Greyish black solid	To manufacture graphite and hydrogen To prepare acetylene gas for welding.
Carbon disulphide (CS_2)	Directly prepared from C and S	Colourless Inflammable Highly poisonous gas	Solvent for sulphur To manufacture rayon Fungicide Insecticide
Calcium Carbonate ($CaCo_3$)	Prepared by passing CO_2 into the solution of slaked lime	Crystalline solid Insoluble in water	Antacid
Sodium bicarbonate ($NaHCO_3$)	Formed by NaOH with carbonic acid (H_2CO_3)	White Crystalline substance Sparingly soluble in water	Preparation of sodium carbonate. Backing powder Antacid

Activity 1

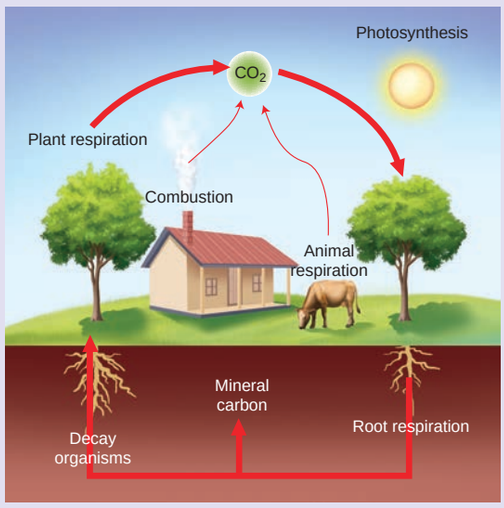
With the help of your teacher, try to classify the following compounds and materials and, fill in the table accordingly.

HCN, CO_2, Propane, PVC, CO, Kerosene, LPG, Coconut oil, Wood, Perfume, Alcohol, Na_2CO_3, $CaCO_3$. MgO, Cotton, Petrol.

Inorganic	Organic

Carbon cycle

The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, geosphere, hydrosphere and atmosphere of the Earth. Carbon is the main component of biological compounds as well as a major component of many minerals such as limestone. Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to make Earth capable of sustaining life.



4.3 Special Features of Carbon

The number of carbon compounds known at present is more than 5 million. Many newer carbon compounds are being isolated or prepared every day. Even though the abundance of carbon is less, the number of carbon compounds alone is more than the number of compounds of all the elements taken together. Why is it that this property is seen in carbon and in no other elements? Because carbon has some unique features such as:

- Catenation
- Tetra valency
- Multiple bonds
- Isomerism
- Allotropy

GAHM2C

4.3.1 Catenation

Catenation is **binding of an element to itself or with other elements through covalent bonds** to form open chain or closed chain compounds. Carbon is the most common element which undergoes catenation and forms long chain compounds. Carbon atom links repeatedly to itself through covalent bond to form linear chain, branched chain or ring structure.

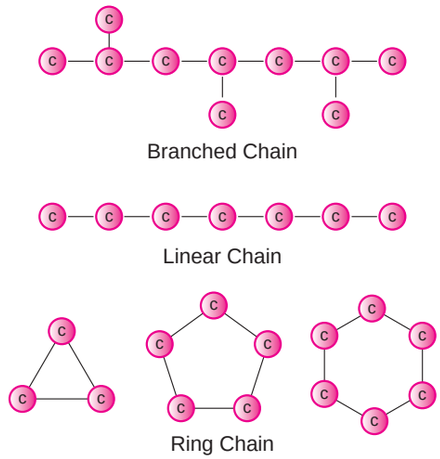


Figure 4.1 Catenation in carbon

This property of carbon itself is the reason for the presence of large number of organic carbon compounds. So organic chemistry essentially deals with catenated carbon compounds.

For example, Starch and Cellulose contain chains of hundreds of carbon atoms. Even plastics what we use in our daily life are macromolecules of catenated carbon compounds.

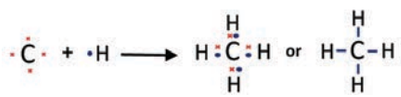
Activity 2

Ask the students to form human chain like catenated carbon compounds of linear, branched and ring structure.

4.3.2 Tetravalency

Another versatile nature of carbon is its tetravalency. The shell electronic configuration of carbon is 2,4 (Atomic no: 6). It has four electrons in its outermost orbit. According to Octet Rule, carbon requires four electrons to attain nearest noble gas (Neon) electronic configuration. So carbon has the tendency to share its four electrons with other atoms to complete its octet. This is called its **tetravalency.** Thus carbon can form four covalent bond with other elements.

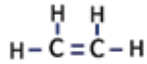
For example, in methane, carbon atom shares its four valence electrons with four hydrogen atoms to form four covalent bonds and hence tetravalent.



4.3.3 Multiple Bonds

As seen above, the tetravalent carbon can form four covalent bonds. With this tetravalency, carbon is able to combine with other elements or with itself through **single bond, double bond and triple bond**. As we know, the nature of bonding in a compound is the primary factor which determines the physical and chemical characteristics of a compound. So the ability of carbon to form multiple bonds is the main reason for the formation of various classes of carbon compounds. Table 4.2 shows one of such classes of compounds called **'hydrocarbons'** and the type of bonding in them.

Table 4.2 Hydrocarbon

Type of bond	Example	Class of the compound
Single Bond	 Methane	**Alkane**
Double Bond	 Ethene	**Alkene**
Triple Bond	H-C ≡ C-H Ethyne	**Alkyne**

When one or more hydrogen in hydrocarbons is replaced by other elements like O, N, S, halogens, etc., a variety of compounds having different functional groups are produced. You will study about them in your higher class.

4.3.4 Isomerism

Isomerism is another special feature of carbon compounds especially found in catenated organic compounds. Let us consider the molecular formula of an organic compound C_2H_6O. Can you name the compound? You can't. Because the molecular formula of an organic compound represents only the number of different atoms present in that compound. It does not tell about the way in which the atoms are arranged and hence its structure. Without knowing the structure, we can't name it.

A given molecular formula may lead to more than one arrangement of atoms. Such compounds are having different physical and chemical

properties. This phenomenon in which the **same molecular formula may exhibit different structural arrangement** is called isomerism. Compounds that have the same molecular formula but different structural formula are called isomers (Greek, isos = equal, meros = parts).

Illustration:

The given formula C_2H_6O is having two kinds of arrangement of atoms as shown below.

(a) CH_3-CH_2-OH (b) CH_3-O-CH_3

Both the compounds have same molecular formula but different kind of arrangements. In compound 'a', the oxygen atom is attached to a hydrogen and a carbon. It is an alcohol. Whereas in compound 'b', the oxygen atom is attached to two carbon atoms and it is an **ether**. These compounds have different physical and chemical properties. You will study about isomerism in detail in higher classes.

4.3.5 Allotropy

Allotropy is a property by which an element can exist in more than one form that are physically different and chemically similar. The different forms of that element are called its allotropes. Look at the materials given below. They are charcoal, graphite and diamond.

Are they equally hard? Are they cost same? Definitely not. Diamond is shiny, costliest and hardest of all. Charcoal and graphite are soft and dark. But chemically they are all similar. Yes. They are made of only carbon. They are called allotropes of carbon.

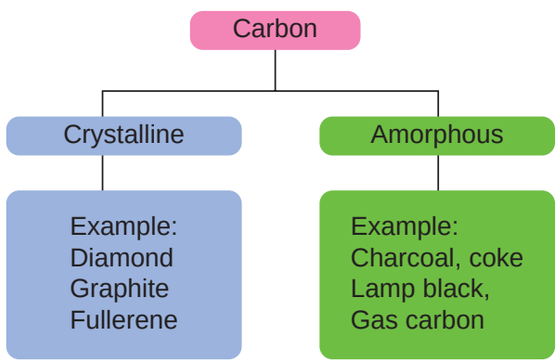
Think yourself:

One gram of diamond costs in thousands where as a kilogram of charcoal costs less than hundred. Even though both are chemically similar, why does diamond cost more?

Why do elements show allotropy?

The main reason for the existence of allotropes of an element is its method of formation or preparation.

Carbon exists in different allotropic forms and based on their physical nature they are classified as below.




Charcoal


Graphite


Diamond

Figure 4.2 Allotropes of carbon

(a) Crystalline forms of Carbon

Diamond:

- In diamond, each carbon atom shares its four valence electrons with four other carbon atoms forming four covalent bonds.
- Here the atoms are arranged in repeated **tetrahedral** fashion which leads to a t**hree dimensional structure accounting** for its hardness and rigidity.

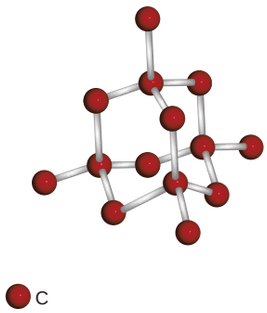


Figure 4.3 Structure of Diamond

Graphite:

- In graphite, each carbon atom is bonded to three other carbon atoms through covalent bonds in the same plane.

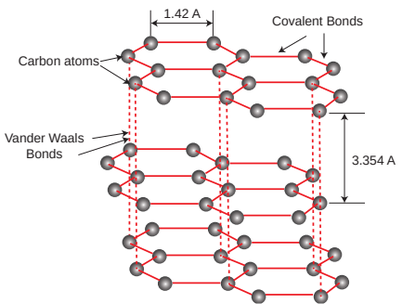


Figure 4.4 Structure of Graphite

- This arrangement forms hexagonal layers which are held together one over other by weak Vander Waals forces.
- Since the layers are held by weak forces, graphite is softer than diamond.

More to Know

Graphene is most recently produced allotrope of carbon which consists of honeycomb shaped hexagonal ring repeatedly arranged in a plane. Graphene is the thinnest compound known to man at one atom thick. It is the lightest material known (with 1 square metre weighing around 0.77 milligrams) and the strongest compound discovered (100-300 times stronger than steel). It is a best conductor of heat at room temperature. Layers of graphene are stacked on top of each other form graphite, with an inter planar spacing of 0.335 nanometres. The separate layers of graphene in graphite are held together by Vander Waals forces.

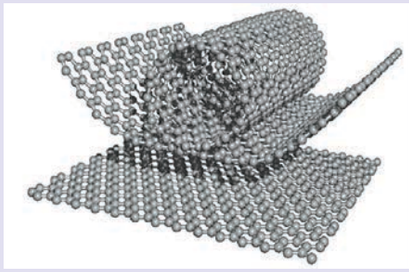


Table 4.3 Difference between Diamond and Graphite

Diamond	Graphite
Each carbon has four covalent bonds.	Each carbon has three covalent bonds.
Hard, heavy and transparent.	Soft , slippery to touch and opaque.
It has tetrahedral units linked in three dimension.	It has planar layers of hexagon units.
It is non-conductor of heat and electricity.	It is conductor of heat and electricity.

Fullerene:

❖ The third crystalline allotrope of carbon is fullerene. The best known fullerene is **Buckminster fullerene,** which consists of 60 carbon atoms joined together in a series of 5- and 6- membered to form spherical molecule resembling a soccer ball. So its formula is C_{60}.

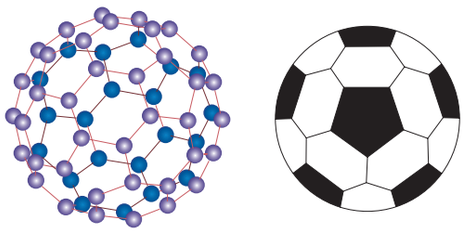


Figure 4.5 Structure of Fullerene

❖ This allotrope was named as **Buckminster fullerene** after the American architect Buckminster **fuller**. Because its structure remembered the framework of **dome shaped halls** designed by Fuller for large international exhibitions, it is called by the pet name **Bucky Ball**. A large family of fullerenes exists, starting at C_{20} and reaching up to C_{540}.

(b) Amorphous forms of carbon

In amorphous form of carbon, carbon atoms are arranged in random manner. These form of carbon are obtained when wood is heated in the absence of air. Table 4.4 enlists some amorphous forms of carbon and their features.

Table 4.4 Preparation, nature and uses of amorphous form of carbon

Amorphous Form	Preparation	Nature	Uses
Charcoal	Prepared from various sources like wood, bone and sugar. Types: wood charcoal bone charcoal, sugar charcoal.	Porous black solid Huge surface area due to porosity	Wood charcoal: Excellent household fuel, as gun powder, reducing agent in metallurgy Bone charcoal: To remove colour in sugarcane juices Sugar charcoal: Extracting metal from oxides
Lamp black	Prepared by burning mustard oil, turpentine oil and petroleum in the absence of oxygen	Greyish black porous solid	Household fuel As reducing agent in the extraction of metals like iron, copper and lead To manufacture graphite and calcium carbide. To manufacture water gas and producer gas.
Coke	Prepared by heating coal in the absence of air at 1300°C. Coal gas is obtained as a biproduct.	Greyish black porous solid.	Household fuel, As reducing agent in the extraction of metals like iron, copper and lead, To manufacture graphite and calcium carbide. To manufacture water gas and producer gas.
Gas Carbon	Prepared by destructive distillation of coal. Thermal vaporization of coal on condensation produces a grey solid.	Dull grey solid. Good conductor of electricity.	Making electrode in dry cell.

Activity 3

- Take a football since it resembles to Buckminster fullerene.
- Count how many hexagonal and pentagonal panels are in it. Every corner is considered as carbon.
- Compare your observation with fullerene and discuss with your friends.

4.4 Physical properties of Carbon and its compounds

- ❖ Carbon is a non-metal found in various allotropic forms from soft powder to hard solid.
- ❖ All the allotropic forms of carbon are solids whereas its compounds exist in solid, liquid and gaseous state.
- ❖ Amorphous forms of carbon and graphite are almost black in colour and opaque. Diamond is transparent and shiny.
- ❖ Its amorphous forms have low melting and boiling point compared to crystalline forms.
- ❖ Carbon is insoluble in water and other common solvents. But some of its compounds are soluble in water and other solvents. e.g., Ethanol, CO_2 are soluble in water.

4.5 Chemical Properties of Carbon and its compounds

Elemental carbon undergoes no reaction at room temperature and limited number of reactions at elevated temperatures. But its compounds undergo large number of reactions even at room temperature.

Oxidation – (Reaction with oxygen)

Carbon combines with oxygen to form its oxides like carbon monoxide (CO) and carbon dioxide (CO_2) with evolution of heat. Organic carbon compounds like hydrocarbon also undergo oxidation to form oxides and steam with evolution of heat and flame. This is otherwise called Burning.

$$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)} + \text{heat}$$

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + \text{heat}$$

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)} + \text{heat}$$

Reaction with steam

Carbon reacts with steam to form carbon monoxide and hydrogen. This mixture is called water gas.

$$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$$

DO YOU KNOW?

Carbon monoxide is a toxic oxide gas of carbon. When fuels undergo incomplete combustion (insufficient supply of oxygen), it results in the formation of carbon monoxide. It is released into the atmosphere from various sources like vehicle fuels, domestic fuels, industries, furnaces, etc. Cigarette smoking also is a source of carbon monoxide.

How toxic carbon monoxide is?

It is a colourless, odourless toxic gas. When people exposed to CO, it enters into human body through breathing and affects the function of haemoglobin. CO displaces oxygen from haemoglobin thereby stops its function (supply of oxygen to the parts of body) leading to death.

Reaction with sulphur

With sulphur, carbon forms its disulphide at high temperature.

$$C_{(s)} + S_{(g)} \rightarrow CS_{2(g)}$$

Reaction with metals

At elevated temperatures, carbon reacts with some metals like iron, tungsten, Titanium, etc. to form their carbides.

$$W_{(s)} + C_{(g)} \rightarrow WC_{(s)}$$

4.6 Carbon compounds in everyday life

It is impossible to think of our daily life without carbon compounds. Over time, a large number of carbon compounds have been developed for the improvement of our lifestyle and comfort. They include carbon-based fuels, carbon nanomaterials, plastics, carbon filters, carbon steel, etc.

Even though carbon and its compounds are vital for modern life, some of its compounds like CO, cyanide and certain types of plastics are harmful to humans. In the following segment, let us discuss the role of plastics in our daily life and how we can become aware of the toxic chemicals that some plastics contain.

4.7 Plastics – Catenated long chain carbon compounds

Plastics are a major class of catenated organic carbon compounds. They are made from long chain organic compounds called 'polymer resins' with chemical additives that give them different properties. Different kinds of polymers are used to make different types of plastics. Plastics are everywhere. They are convenient, cheap and are used in our everyday life. Plastics have changed the way we live. They have helped improve health care, transport and food safety. Plastics have allowed many breakthroughs in technology such as smartphones, computers and the internet. It is clear that plastic has given our society many benefits. But these benefits have come at a cost.

4.7.1 Drawbacks of plastics

- Plastics take a very long time to fully break down in nature.
- The microbes that break down plastic are too few in nature to deal with the quantity of plastics we produce.
- A lot of plastic does not get recycled and ends up polluting the environment.
- Some types of plastics contain harmful chemical additives that are not good for human health.
- Burning of plastics releases toxic gases that are harmful to our health and contribute to climate change.
- One-time use and throwaway plastics end up littering and polluting the environment.

In order to know which plastics are harmful, you will need to learn the secret 'language' of plastics (resin codes).

Plastics in the environment break down into pieces that are smaller than 5mm in diameter. Dangerous pollution in the ocean sticks to microplastics making them harmful to marine life (fish and shrimp) who mistake them as their food.

4.7.2 Identifying different types of plastics

(a) The resin codes

Look at the following pictures.

Figure 4.6 Plastic items used in daily life

One is a plastic sachet in which milk is distributed to consumers and the other is a plastic food container. Observe the code shown on it (circled). Do you know what this code means? It is called a '**resin code**'. The resin code represents the type of polymer used to make the plastic.

(b) Need for resin codes

Plastics should be recycled or disposed of safely. Certain types of plastics should be avoided so that they do not end up polluting the environment or harming our health. Each plastic is composed of a different polymer or set of molecules. Different molecules do not mix when plastics are recycled, it is like trying to recycle paper and glass together. For this reason, they need to be separated. The resin codes of plastics were designed in 1988 and are a uniform way of classifying the different types of plastic which help recyclers in the sorting process.

(c) How to find the resin code on plastic items

The secret resin codes are shown as **three chasing arrows in a triangle**. There is a **number in the middle or letters under the triangle** (an acronym of that plastic type). This is usually difficult to find. It can be found on the label or bottom of a plastic item.

Figure 4.7 Resin codes

The resin codes are numbered from 1 to 7. Resin codes #1 to #6 each identify a certain type of plastic that is often used in products. Resin code #7 is a category which is used for every other plastic (since 1988) that does not fit into the categories #1 to #6. The resin codes look very similar to the recycling symbol, but this does not mean all plastics with a code can be recycled. The Table 4.5 shows information of various resin codes.

Activity 4

- Collect various plastic materials we use in our day-to-day life and try to find the resin code.
- Once you have found an everyday plastic item with a resin code – ask yourself the following questions.

What plastic resin codes did you find?
Is this plastic item used to store or serve food or drinks?
Do these types of plastics contain harmful chemicals?
To find out these answers, please refer Table 4.5, Plastic Resin Code Chart. Prepare a report of your observations.

Table 4.5 Plastic Resin Code Chart

PLASTIC RESIN CODE CHART

Plastic resin codes can be found on the label or bottom of most plastic items.
It is a number or acronym found in the middle of a chasing arrow triangle.
There may be other numbers or letters on the plastic items, but these are not resin codes.

KNOW PLASTICS

RESIN CODE	OTHER NAMES	COMMON ITEMS	ABOUT
01 PET	PETE, Polyester	Mineral water or soft drink bottles and plastic jars.	This plastic is designed to be used only ONCE. Reusing PET plastic can release a chemical additive called antimony which is not good for your health.
02 HDPE	PEHD	Bottles (shampoo, detergent, etc.), toys, plastic bags and waste bins.	Considered one of the safer plastics. It is light, very strong and widely recycled.
03 PVC	V, Vinyl	Raincoats, ring binders, shoes, floating pool toys and shiny prints on backpacks.	The most toxic plastic. Do the smell test: some PVC has a new shoe or new car smell. Avoid this type of plastic where possible.
04 LDPE	PELD, LLDPE	Food packaging, plastic bags, food storage containers and plastic coating on the inside of paper cups.	Considered one of the safer plastics. It is very flexible and soft but strong.
05 PP		Bottle caps, straws, food containers, hard pencil cases and plastic chairs.	Considered one of the safer plastics. It feels waxy or greasy. It is light and hard but scratches easily.
06 PS	Thermocol, EPS, XPS and HIPS	Pens, rulers, foam, packaging, toys, disposable cups, plates and cutlery.	One of the unsafe plastics as it has harmful chemicals. Thermocol is very light weight (95% air) and often ends up polluting the oceans.
07 OTHER	Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS), acrylic (AC), bioplastics, nylon, polyurethane (PU), etc.	PC: baby bottles, water bottles and food containers. ABS: Lego, helmets, and kitchen appliances. Acrylic: phone screens and paints. Bioplastics: plastic bags and tableware. Nylon: clothes and toothbrush bristles. PU: mattress foam and shoe soles.	This code includes all plastic types that do not fit into the resin codes 1-6. PC and ABS are two of the unsafe plastics and are considered toxic. When you see a #7 plastic try to know more before buying and using it.
NO CODE	Does not have a resin code or an acronym	Can be any plastic item.	The company did not follow the rules and mark what type of plastic was used. It could be harmful but you do not have the information to know for sure. Avoid using plastic without a resin code.

(d) Where will the resin code be shown on plastic items?

Flip a plastic item to find the resin code on the bottom.

Sometimes the bottom of plastic item will only have an acronym or the full name of that plastic type.

If you do not find it on the bottom, search for the code on the label.

Some plastics do not have a code. The company did not follow the rules and you do not know if it is safe to use.

4.7.3 Harmful effects of plastics

Plastics in our everyday life can be harmful for two reasons. The first reason is that some types of plastic contain chemicals that are harmful to our health. The second reason is that a lot of plastics are designed to be used just one time. This use and throwaway plastic causes pollution to our environment.

(a) Harmful plastics

There are three types of plastic that use toxic and harmful chemicals. These chemicals are added to plastics to give them certain qualities such as flexibility, strength, colour or fire and UV resistance. The three unsafe plastics are PVC (resin code #3), PS (resin code #6 also commonly called Thermocol) and PC/ABS (resin code #7).

PVC – Polyvinyl Chloride plastics

- Heavy metals (cadmium & lead) are added to PVC.
- Phthalates (chemical additive) copy our hormones.
- Burning PVC releases dioxins (one of the most toxic chemicals known to humans).

PS – Polystyrene plastics

- Styrene is a building block of this plastic and may cause cancer.
- It takes very long time to break-down (100- 1 million years).
- Higher amounts of toxic styrene leak into our food and drinks when they are hot or oily.

PC – Polycarbonate plastics

- PC plastic contains Bisphenol A (BPA).
- BPA leaks out of PC products used for food and drinks.
- BPA increases or decreases certain hormones and changes the way our bodies work.

ABS – Acrylonitrile Butadiene Styrene

- Styrene causes problems for our eyes, skin, digestive system and lungs.
- Brominated Flame Retardants (BFRs) are often added.
- Studies show toxic chemicals leak from this plastic.

(b) One-time use plastic

Use and throwaway plastics cause short and long-term environmental damage. Half of all the plastic made today is used for throwaway plastic items. These block drains and pollute water bodies. One-time use plastic causes health problems for humans, plants and animals. Some examples are plastic carry bags, cups, plates, straws, water pouches, cutlery and plastic sheets used for food wrapping.

Figure 4.8 One-time use plastic items

These items take a few seconds to be made in a factory. You will use them for a very short time. Once you throw them away, they can stay in our environment for over a 1,000 years causing plastic pollution for future generations.

We need rules and laws to protect people and the environment from plastic pollution.

More to Know

The impacts of one-time use and throwaway plastics on animals

One-time use and throwaway plastics can cause harm to animals. In the past, restaurants and teashops used banana leaves as a plate and for takeaway food. This was a good source of food for cows that would eat the leftover food and banana leaves, making them the perfect recyclers. They recycled this waste and in return provided us with nutritious milk and valuable cow dung as a fertiliser. Since plastics have been introduced, the banana leaf has been replaced by a plastic sheet (commonly called a 'cut-piece') on top of plates for food. When these are thrown away animals such as cows smell the leftover food. When they try to eat it, they eat the plastic by accident. The chemical composition of plastic does not allow it to be broken down by the cow's digestive system. Instead the plastic gets stuck in the rumen (stomach) of a cow, occupying precious space and reducing the ability of a cow to digest nutrients and provide nutritious milk and valuable cow dung for society.

- How can you make sure that cows do not eat your leftover food in plastic packaging?
- How will the ban on one-time use and throwaway plastics as of 1st January 2019 in Tamil Nadu help animals such as cows?
- What can you do in your day-to-day life to protect animals from the dangers of plastics?

4.8 New rules to make Tamil Nadu plastic free

As we know, the Government of India is progressively taking various legal initiatives to stop plastic pollution by making some provisions and amendments in the Environment (Protection) Act 1988. With reference to this act, Government of Tamil Nadu has taken a step forward to ban the usage of some kind of plastic items (Environment and Forests Department, T.N. G.O. No: 84, dated 25/06/2018).

As per the government order cited above, the Tamil Nadu Government has banned the usage of one-time use and throwaway plastics from 1st January 2019. This excellent legislation is designed to protect Tamil Nadu from plastic pollution.

Rules which ban the production, storage, supply, transport, sale and distribution of one-time use plastics are extremely effective. They are successful because they target all sections of society– manufacturer, supplier, shopkeeper and customer. This progressive initiative taken by the State of Tamil Nadu leads by example for the rest of the nation.

Please find below some key aspects of the new rules along with science-based facts why these items have been banned in Tamil Nadu.

If we do not change our habits, one study estimates that our oceans will have more plastic than fish (in weight) by 2050.

4.8.1 Banned items

Plastic carry bags

- Globally we use 2 million plastic bags each minute.
- 97% of plastic bags do not get recycled.
- Animals eat plastic bags by accident as they contain food. A cow was found with over 70 kilos of plastic in its stomach.

Plastic plates

- Dirty plastics (like a used plate) are difficult to recycle.
- Most one-time use plates are made from Polystyrene (resin code # 6) which is harmful to your health.
- Plates will be used for just 20 minutes but stay in the environment for over a 1,000 years.

Water pouches

- Water pouches are often littered, increasing plastic pollution.
- The blue print (ink) on the clear plastic pouch decreases the recycling value.
- Once a water pouch is used, it is difficult to recycle as it contains leftover water and gets covered in dirt.

Plastic straws

- Plastic straws are too lightweight and small to be recycled.
- Straws are one of the top 10 items which are found in the plastic pollution in oceans.
- 90% of seabirds have ingested plastics such as straws.

Plastic sheets

- Plastic sheets used on top of plates get dirty and cannot be recycled.
- More chemicals leak from plastic into food when it is hot, spicy or oily.
- Animals such as cows, goats, and dogs eat plastic by accident because it smells like food.

DO YOU KNOW?

A study found that one-time use and throwaway plastic items such as cups, plates, spoons and straws were among the top 10 plastic items found in garbage washed up from the ocean.

4.9 Role of students in the prevention of plastic pollution

Plastics affect all of us. Change starts with you and your family. The first step to change something is to know why you need to change. Equipped with the right knowledge, you can start to take small steps to protect yourself, your family and beautiful Tamil Nadu.

You play a very important role and have the power to minimise plastic pollution. You can start today by reflecting on the plastic you use in your everyday life.

Ask yourself, is this plastic safe or harmful plastic? If it is not a harmful plastic type, is it a one-time use plastic item? These questions and the science-based knowledge will help you to reduce unnecessary plastic pollution.

4.9.1 What can you do to prevent plastic pollution?

- As a student, you can share your scientific knowledge on plastics and their effects with your parents, relatives and friends to make them aware of plastic pollution.
- You can help by teaching them how to avoid harmful plastics by searching for the resin codes.
- You can educate them about the new rules and how important it is to stop one-time use plastics.

4.9.2 Practice in your daily life

- Do not litter the environment by throwing plastic items.
- Do not use Thermocol (resin code #6 PS) for your school projects.
- Do not use one-time use or throwaway plastics like plastics bags, tea cups, Thermocol plates and cups, and plastic straws.
- Do not burn plastics since they release toxic gases that are harmful to our health and contribute to climate change.
- Burning PVC plastic releases dioxins which are one of the most dangerous chemicals known to humans.
- Do not eat hot or spicy food items in plastic containers.
- Segregate your plastic waste and hand this over to the municipal authorities so that it can be recycled.
- Educate at least one person per day about how to identify the resin codes and avoid unsafe plastics (resin code #3 PVC, #6 PS and #7 ABS/PC).

Let us join together to make our nation pollution free.

Points to Remember

- Carbon is an inseparable chemical entity associated with living things.
- Carbon chemistry is also called as living chemistry.
- Carbon is found both in free state as well as combined state in nature.
- Friedrich Wohler is called Father of Modern Organic Chemistry.
- Catenation, tetra valency, multiple bonds, isomerism and allotropy are the unique features of carbon.
- Carbon atom links repeatedly to itself through covalent bond to form linear chain, branched chain or ring structure.
- Carbon combines with other elements or with itself through single bond, double bond and triple bond.
- Charcoal, graphite and diamond are the allotropes of carbon.
- In diamond atoms are arranged in repeated tetrahedral fashion.
- In graphite, each carbon atom is bonded to three other carbon atoms through covalent bonds in hexagonal fashion.
- Buckminster fullerene consists of 60 carbon atoms joined together in series of 5- and 6- membered to form spherical molecule resembling a soccer ball.
- Buckminster fullerene is named after the American architect Buckminster fuller.
- All the allotropic forms of carbon are solids whereas its compounds exist in solid, liquid and gaseous state.
- Carbon monoxide is a toxic oxide gas of carbon. When fuels undergo incomplete combustion (insufficient supply of oxygen), it results in the formation of carbon monoxide.
- The resin code represents the polymer used in making of plastics. The resin codes are numbered from 1 to 7.
- The three unsafe plastics are PVC (Polyvinyl chloride), PS (Polystyrene) and PC (Polycarbonate) / ABS (Acrylonitrile Butadiene Styrene).
- One-time use plastic causes health problems for humans, plants and animals.
- Government of Tamil Nadu has taken a step forward to ban the usage of some kind of plastics items (Environment and Forests Department, T.N. G.O. No: 84, dated 25/06/2018).
- Plastic carry bags, cups, plates, straws, water pouches, cutlery and plastic sheets used for food wrapping are one – time use plastics.

A-Z GLOSSARY

Allotropes	Different forms of an element.
Allotropy	Property by which an element can exist in more than one form that are physically different and chemically similar.
Carbon cycle	It is the biogeochemical cycle by which carbon is exchanged among the biosphere, geosphere, hydrosphere and atmosphere of the Earth.

Catenation	It is binding of an element to itself or with other elements through covalent bonds to form open chain or closed chain compounds.
Harmful plastics	Plastic that use toxic and harmful chemicals.
Inorganic carbon compounds	Compounds of carbon obtained from non-living matter.
Isomerism	Phenomenon in which the same molecular formula may exhibit different structural arrangement.
Isomers	Compounds that have the same molecular formula but different structural formula.
One-time use plastic	Use and throwaway plastics.
Organic carbon compounds	Compounds of carbon obtained from living organisms.
Plastics	Major class of catenated organic carbon compounds made from liquid polymers called 'resins' added with some additives.
Tetravalency	Tendency of carbon to share its four electrons with that of other atoms to complete its octet.

TEXTBOOK EVALUATION

GB6I3Z

I. Choose the correct answer.

1 A phenomenon in which an element exists in different modification in same physical state is called

(a) Isomerism (b) Allotropy
(c) Catenation (d) Crystallinity

2 Number of free electron(s) in each carbon of graphite is

(a) one (b) Two
(c) Three (d) Four

3 The carbon atoms in fullerene are arranged in mixed

(a) Tetragon and Pentagon
(b) Pentagon and Hexagon
(c) Hexagon and Heptagon
(d) Heptagon and Octagon

4 Carbon forms large number of organic compounds due to

(a) Allotropy (b) Isomerism
(c) Tetravalency (d) Catenation

5 Diamond is not a good conductor of electricity because

(a) it is very hard
(b) it has no free electron
(c) its structure is uniform
(d) it is insoluble in water

6 Which of the following does not contain double bond

(a) CO_2 (b) C_2H_4
(c) HCl (d) O_2

7 Which of the following is highly toxic?

(a) Carbon dioxide
(b) Carbon monoxide
(c) Calcium carbonate
(d) Sodium bicarbonate

8 Raagav brings his lunch every day to school in a plastic container which has resin code number 5. The container is made of

(a) Polystyrene (b) PVC
(c) Polypropylene (d) LDPE

9 Plastics made of Polycarbonate (PC) and Acrylonitrile Butadiene Styrene (ABS) are made of resin code _____

(a) 2 (b) 5 (c) 6 (d) 7

10 Which of the following plastic items are banned by the Government of Tamil Nadu as of 1st January 2019?

(a) Plastic sheets
(b) Plastic tea cups
(c) Plastic water packets
(d) All the above

11 Graphite is used as lubricant in machines because

(a) it is good conductor of electricity
(b) it is made of slippery layers and has high melting point
(c) it has high density
(d) it is strong and soft

12 The lead pencil contains

(a) Graphite (b) Diamond
(c) Lead (d) Charcoal

13 Graphene is one atom thick layer of carbon obtained from

(a) Diamond (b) Fullerene
(c) Graphite (d) Gas Carbon

14 Plastic resin codes are shown as three chasing arrows in a_____ with a number in the middle or letters (an acronym of that plastic type).

(a) Logo (b) Recycling symbol
(c) Square (d) Triangle

15 The legal measures to prevent plastic pollution come under the _____ Protection Act 1988.

(a) Forest (b) Wildlife
(c) Environment (d) Human Rights

II. Fill in the blanks.

1. _____ named carbon.
2. Buckminster Fullerene contains _____ carbon atoms.
3. Compounds with same molecular formula and different structural formula are knows as _____.
4. Different methods of formation of carbon is the main reason for its _____.
5. There are _____ plastic resin codes.

III Match the following

Alkyne	-	Bucky Ball
Andre Geim	-	Oxidation
C_{60}	-	Graphene
Thermocol	-	Triple bond
Burning	-	Polystyrene

IV Answer very briefly.

1. How many valence electrons are there in carbon?
2. Who is called 'Father of Modern Organic Chemistry'?
3. Which three resin codes are unsafe?

IV. Answer in brief.

1. Differentiate graphite and diamond
2. What are saturated and unsaturated compounds called?

3. Carbon do not form ionic compounds. Why?
4. What is the valency of carbon in carbon monoxide?
5. Why are one-time use and throwaway plastics harmful?

V. Answer in detail.

1. What is catenation? How does carbon form catenated compounds?
2. What are the chemical reactions of carbon?
3. Name the three safer resin codes of plastics and describe their features.

VI. HOTS

1. Why do carbon exist mostly in combined state?
2. When a carbon fuel burns in less aerated room, it is dangerous to stay there. Why?
3. Explain how dioxins are formed, which plastic type they are linked to and why they are harmful to humans.
4. Yugaa wants to buy a plastic water bottle. She goes to the shop and sees four different kinds of plastic bottles with resin codes 1, 3, 5 and 7. Which one should she buy? Why?

VII. Answer the following by rearranging the jumbled letters.

1. It is the hardest allotrope of carbon.
   mnodaid Ans:_____
2. Organic compounds having double bond between carbon atoms are
   knelaes Ans: _____
3. Reaction of carbon with oxygen gives
   osdiexs Ans: _____
4. In this molecule, carbon is attached with four hydrogen atoms.
   emathen Ans: _____
5. Carbon combines with other elements through _____ bond.
   lnaocvet Ans: _____
6. It is used as gun powder.
   ocahrcla Ans: _____
7. Plastics made of _____ are represented by resin code #6.
   sytlopynere Ans: _____
8. One-time use plastics are also known as _____ plastics.
   awyrhotwa Ans: _____
9. One-time use plastics cause _____ damage.
   trnvomenialne Ans: _____
10. Expanded polystyrene is commercially known as
    mthreolco Ans: _____

REFERENCE BOOKS

1. Modern Inorganic Chemistry by R.D Madan
2. Fundamentals of Organic Chemistry by B.S.Bahl et.al
3. Organic Chemistry by Paula Bruise, 6th Edition

INTERNET RESOURCES

http://www.chemicool.com/elements/carbon.html

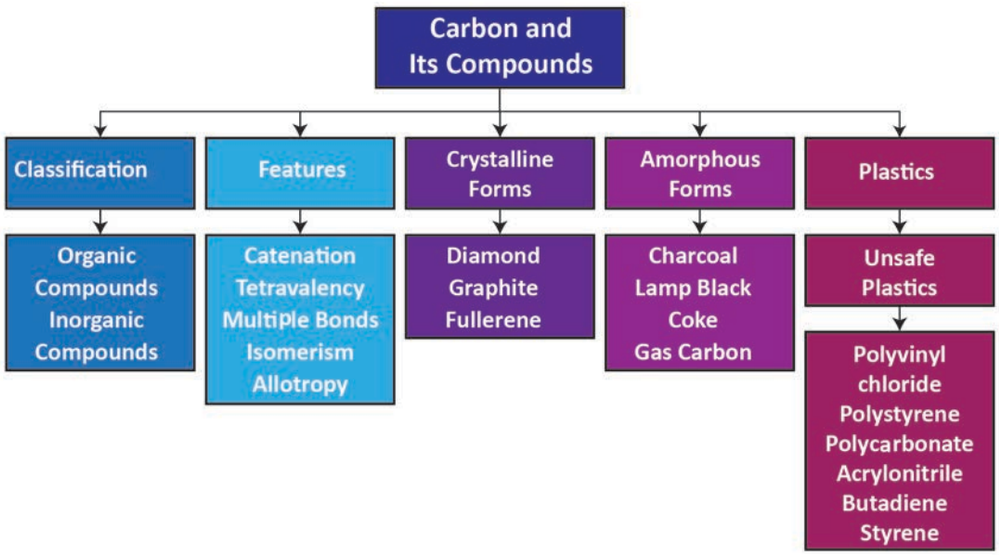
https://en.wikipedia.org/wiki/Carbon

https://courses.lumenlearning.com/introchem/chapter/allotropes-of-carbon/

https://plastics.americanchemistry.com/Plastic-Resin-Codes-PDF/

https://www.youtube.com/watch?v=8Obb982Sg84

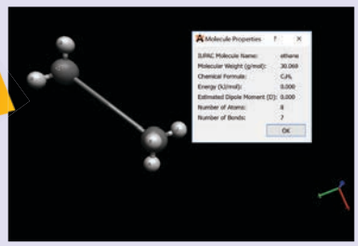
Concept Map



ICT CORNER

Carbon

Experiment carbon bonding with an intuitive molecular editor and visualization tool



Steps

- Reach the given URL to download and install the "Avogadro" cross platform application in your computer.
- Open the Avogadro application and select carbon from "Element" tab and select the available bond type "Single" or "Double" or "Triple".
- Place the mouse pointer on the black screen and click and drag the mouse to draw the carbon structure. Extend the bonding by dragging repeatedly. Build the structure of Ethane, Methane etc.
- Select "Auto Rotation" from the tools and rotate the molecular structure by dragging the mouse on the bond. To view various properties of the drawn bonding go to menu View -> Properties.


Step1


Step2


Step3


Step4

Avogadro

URL: https://avogadro.cc/ or Scan the QR Code.

*Pictures are indicative only

B567_9_SCI_EM_T3

UNIT 5

Applied Chemistry

Learning Objectives

After completing this lesson, students will able to:

- understand the various branches of applied chemistry.
- differentiate pure and applied chemistry.
- know latest technology of Nanochemistry.
- know the various types of drugs.
- understand the various uses of electrochemistry.
- understand the applications of radiochemistry.
- understand the various types of dyes and their application.
- acquire knowledge about food chemistry and agriculture chemistry.
- understand some basic ideas about forensic chemistry.

Introduction

We know that there are three major branches in chemistry namely: Organic chemistry, Inorganic chemistry and Physical chemistry. Organic chemistry deals with carbon and its compounds, inorganic chemistry is the study of minerals and the physical properties of these chemicals are dealt in physical chemistry. Then what is applied chemistry?

Food, medicines, cosmetics, dress materials and gold covering ornaments are some of the items used in our day to day life. They may differ in nature and applications. But all these are associated with chemistry. They are made of synthetic / natural chemicals or involve chemical principles and theories.

We face lot of difficulties in different means to lead our day to day life. Such difficulties make chemists to come out of new ideas and theories. For example, when people suffered by diseases, new chemical compounds were synthesized and used as drugs. New techniques were also developed to diagnose diseases. When farmers suffered due to low crop yield and pest- related problems in crop field, chemists developed new chemical fertilizers and pesticides to combat these issues. Thus chemical principles and theories are applied to various fields in order to achieve specific results or to solve real-world problems. This is called **applied chemistry.** In this lesson, let us discuss various branches of applied chemistry and their significance.

5.1 Nanochemistry

We know that the size and shape of materials influence their characteristics. Scientists found that materials having size about 1/1,000,000,000 metre show special characteristics. Then they started producing such kind of materials and studied the effect of size on properties. Thus a new branch of chemistry called 'Nanochemistry' was developed.

Nanochemistry is a branch of nanoscience, that deals with the chemical applications of nanomaterials in nanotechnology. It involves synthesis and manipulation of materials at atomic and molecular level and the study of their physical and chemical properties.

Nanotechnology is the application of science to manipulate matter to atomic or molecular scale and making use of them to develop specialized materials and devices for use in our day to day life. It deals with the materials which are smaller than 100 nanometres and hence it is so called.

5.1.1 Size of Nanoparticles

The word, Nano has been derived from the Greek word 'Nanos' which is designated to represent billionth fraction of a unit. For instance, 1 Nanometre = 1/ 1,000,000,000 metre. Can you imagine how small is a nanoparticle?

The following examples may help to illustrate how small the nanoscale is.

- One nanometre (nm) is 10^{-9} or 0.000,000,001 metre.
- A nanometre and a metre can be understood as the same size-difference as between golf ball and the Earth.
- Our nails grow 1 nm each second.
- The virus most usually responsible for the common cold has a diameter of 30 nm.
- One nanometre is about one twenty-five-thousandth the diameter of a human hair.
- A cell membrane is around 9 nm across.

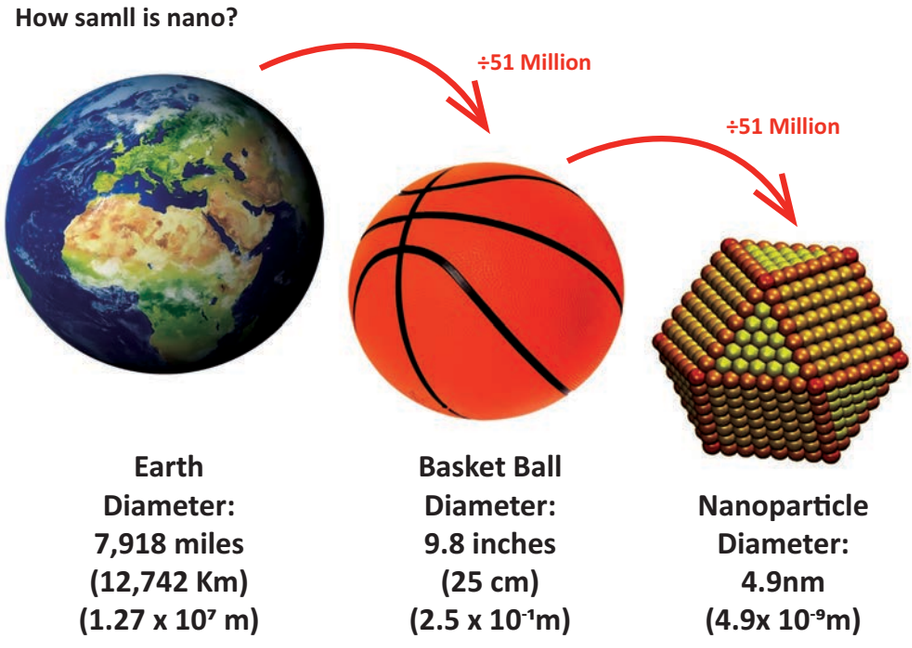


Figure 5.1 Comparisim of nanometre with metre

- The DNA double helix is 2 nm across.
- The diameter of one hydrogen atom is around 0.2 nm.

Activity 1

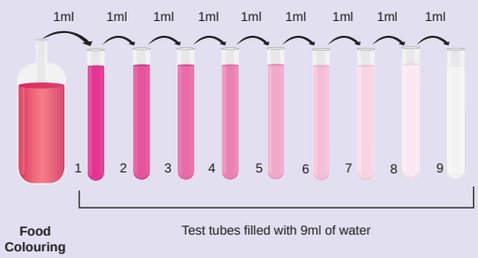
Let us try to understand the size at nanoscale through an example of Serial dilution.

Materials required:

Some scented food colouring materials, a Pasteur pipette, Nine test tubes, numbered 1-9.

Procedure

1. Fill each test tube carefully with 9 ml of water.
2. Using the Pasteur pipette, carefully add 1 ml of food colouring to Tube 1. Mix it thoroughly.
3. Smell the contents. What does it smell of? Does it smell the same as the original food colouring?
4. Now take 1 ml of liquid from Tube 1, add it to Tube 2 and mix thoroughly.
5. Continue the process by repeating steps 3 and 4: dilute Tube 2 into Tube 3, Tube 3 into Tube 4, and so on.



At what point you can no longer see any colour in the tubes?

At what point you can no longer smell anything in the tubes?

How can you explain the difference?

The method you have just used is called a **Serial dilution**. You can notice that in each tube, the food colouring is ten times more diluted than the previous tube. By the time they reach tube 9, the original food colouring would have been diluted to the level of one part of food colouring to a billion parts of water. At this stage, the intensity of colour and smell would be extremely low.

In such a way, when materials are broken down to nanoscale, they show some special surface properties which make them to be used for special kinds of applications. This type of manipulation of materials is done by nanotechnology.

How small is a nanoparticle? Visit the following link: https://www.youtube.com/watch?v=38Vi8Dm0kdY

Try it yourself

If you want to dilute 1 ml of the food dye to the same concentration as in Tube 9, in just one step, how much water would you need?

Figure 5.2 Nanometre sized changes

5.1.2 Properties of nanomaterials

Nanomaterials have the structural features in between those of atoms and the bulk materials. The properties of materials with nanometre dimensions are significantly different from those of atoms and bulk materials. This is mainly because the nanometre size of the materials render them, larger surface area, high surface energy, spatial confinement and reduced imperfections, which do not exist in the corresponding bulk materials. Due to their small dimensions, nanomaterials have extremely large surface area to volume ratio, resulting in more 'surface dependent' material properties. As the surface characteristics of nanoparticles are the main criteria to be considered for applications, highly sophisticated instruments like Scanning Electron Microscope (SEM), Tunneling Electron Microscope (TEM) and Atomic Force Microscope (AFM) are used to analyse the surface properties of a nanoparticle with high resolution.

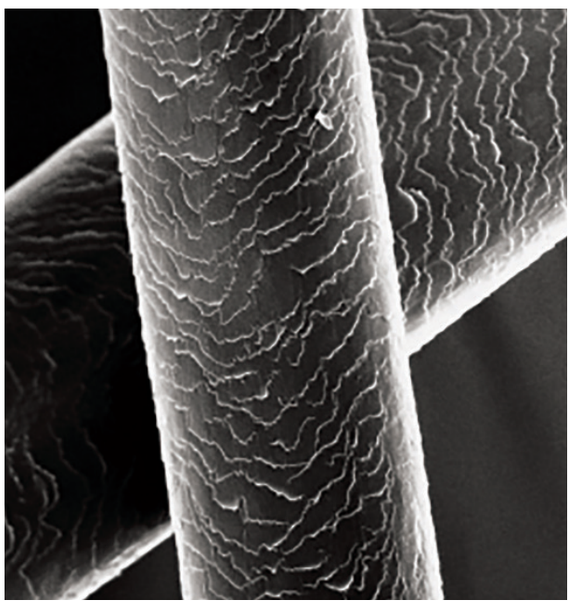


Figure 5.3 SEM image of human hair

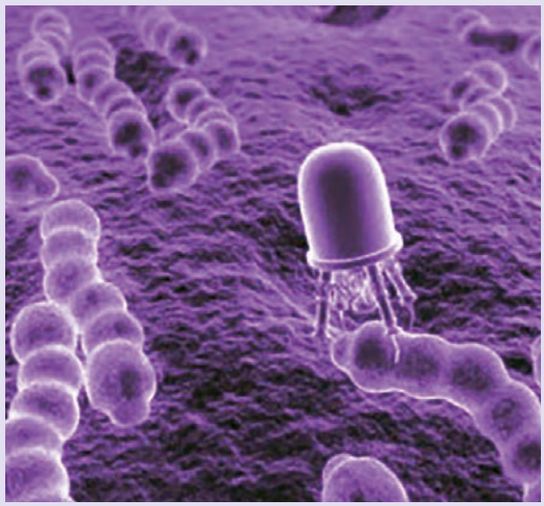
5.1.3 Applications of Nanochemistry

The range of commercial products available today is very broad, including stain-resistant and wrinkle-free textiles, cosmetics, sunscreens, electronics, paints and varnishes. Nanochemistry is applied in all these substance. Some of them are given below.

- The metallic nanoparticles can be used as very active catalysts.
- Chemical sensors from nanoparticles and nanowires enhance the sensitivity and sensor selectivity.
- Nano coatings and nanocomposites are found useful in making variety of products such as sports equipment, bicycles and automobiles etc.
- These are used as novel UV-blocking coatings on glass bottles which protect beverages from being damaged by sunlight.
- Nanotechnology is being applied in the production of synthetic skin and implant surgery.
- Nanomaterials that conduct electricity are being used in electronics as minute conductors to produce circuits for microchips.
- Nanomaterials have extensive applications in the preparation of cosmetics, deodorants and sun screen lotion and they are used to improve moisturizers without making them too oily.
- Nanoparticle substances are incorporated in fabrics to prevent the growth of bacteria.

- Biomedical devices like drug infusion pumps, microneedles and glucometer are made from nanomaterials.
- Nanochemistry is used in making space, defence and aeronautical devices

More to Know



Nanorobotics is an emerging branch of nanotechnology which involves creating machines or robots at nanoscale. These devices range from 0.1-10 micrometres and are made up of nano scale or molecular components. Nanorobots can be used in different application areas such as medicine and space technology. Nowadays, these nanorobots play a crucial role in the field of Bio-Medicine, particularly for the treatment of cancer, removal of kidney stones, elimination of defected parts in the DNA structure, and for some other treatments that need utmost support to save human lives. Nanorobots with embedded chemical biosensors are used for detecting the tumor cells in early stages of cancer development inside a patient's body.

Sunscreen lotion – Nanochemistry

Prolonged UV exposure causes skin-burns and cancer. Sun-screen lotions containing nano-TiO_2 provide enhanced sun protection factor (SPF). The added advantage of nano skin blocks such as ZnO and TiO_2 is that they protect the skin by sitting onto it rather than penetrating into the skin. Thus they block UV radiation effectively for prolonged duration. Additionally, they are transparent, thus retain natural skin colour while working better than conventional skin-lotions.

5.1.4 Drawbacks of nanomaterials in chemistry

- Nanoparticles are unstable when they contact with oxygen.
- Their exothermic combustion with oxygen can easily cause explosion.
- Because nanoparticles are highly reactive, they inherently interact with impurities as well.
- Nanomaterials are usually considered biologically harmful and toxic.
- It is difficulty to synthesis, isolate and apply them.
- There are no hard-and-fast safe disposal policies for nanomaterials.

5.2 Pharmaceutical chemistry

People always want to lead healthy life. But due to various reasons such as pollution, life style and natural calamities they are always prone to diseases. So they need to fight against diseases in order to lead healthy life. Do you know how our ancestors treated diseases? There is a long history of plants being used to treat various diseases. They figure in the records of early civilisations of Babylon, Egypt, India and China.

When modern organic chemistry evolved at the beginning of nineteenth century, chemists isolated various alkaloids like morphine, quinine and atropine from plants and used them for treatment of diseases. After 1860, many developments arose from synthesis of medicinally important chemicals and were used for treatment of numerous diseases.

When scientists started using synthetic chemicals as medicines, they started to analyse the effects of those chemicals in human and made necessary modifications. Then another new branch of chemistry was evolved. It is called **Pharmaceutical Chemistry.**

Pharmaceutical chemistry is the chemistry of drugs which utilizes the general laws of chemistry to study drugs. Pharmaceutical chemistry deals with the preparation of drugs and study of the chemical composition, nature, behavior, structure and influence of the drug in an organism, condition of their storage and the therapeutic uses of the drugs. Drug discovery is the core of pharmaceutical chemistry.

5.2.1 Drugs

Even though we use so many chemicals in our daily life, the chemicals used for treating diseases are termed as **drug.** The word drug is derived from the French word 'droque' which means a dry herb.

According to World Health Organisation, a drug is defined as follows: 'It is a substance or product that is used or intended to be used to modify or explore physiological systems or pathological states for the benefits of the recipient'.

Figure 5.4 Drug store

5.2.2 Characteristics of drugs

Can we use all chemicals as drugs? Definitely not. A drug must possess the following characteristics:

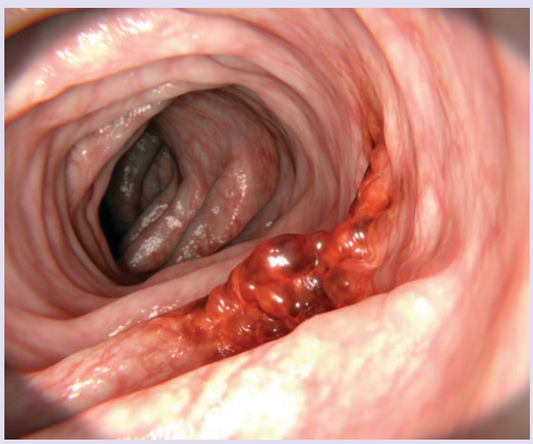
- It should not be toxic.
- It should not cause any side effects.
- It should not affect the receptor tissues.
- It should not affect the normal physiological activities.
- It should be effective in its action.

Chemicals which satisfy the above criteria only are preferred as drugs.

More to Know

Chemotherapy: Treatment of certain diseases by destroying the invading organism without damaging the cells of the host, by the use of certain organic compounds is known as **Chemotherapy.** It is widely used for treating cancer.

As part of the body's natural process, cells are constantly replaced through a process of dividing and growing. When cancer occurs, cells are reproduced in an uncontrolled manner. More and more cells are produced, and they start to occupy an increasing amount of space until they occupy the space previously inhabited by useful cells. Chemotherapy drugs interfere with the cancer cell's ability to divide and reproduce, and thereby prevent their growth. A single drug or a combination of drugs is used.



5.2.3 Sources of drugs

The main sources of drugs are animals and plants. The modern manufacturers adopt many chemical strategies to synthesize drugs for specialized treatments which are more uniform than natural materials**.** The following table shows various sources of drugs.

Table 5.1 Sources of drugs

Source or Process	Drug
Plants	Morphine, Quinine
Chemical Synthesis	Aspirin, Paracetamol
Animal	Insulin, Heparin
Minerals	Liquid Paraffin
Microorganism	Penicillin
Genetic Engineering	Human growth Hormone

5.2.4 Types of Drugs

Drugs fall into two general categories:

i) The drugs that are used in the treatment and cure of any specific disease.

ii) The drugs that have some characteristic effect on the animal organism, but do not have any remedial effect for a particular disease. This class includes, morphine, cocaine etc.

A. Anaesthetics

The drugs which cause loss of sensation are called **Anaesthetics.** They are given to patients when they undergo surgery.

(a) Types of Anaesthetics

When patients undergo a major surgery in internal organs, some anaesthetics are given so that the they lose sensation completely. But when they undergo a minor surgery in a specific part of the body, anaesthetic is given to loose sensation around that particular part. Based on this, there are two classes of anaesthetics as given below.

General anaesthetics: They are the agents, which bring about loss of all modalities of sensation, particularly pain along with 'reversible' loss of consciousness. For example, when a surgery is carried out on internal organs, this anaesthetics are given. The patient loses consciousness for specific period of time (depending on the duration of surgery) and get it back later.

Figure 5.5 General anaesthesia

Local anaesthetics: They prevent the pain sensation in localised areas without affecting the degree of consciousness. For example, dentist give patients this kind of anaesthetics when carry out a minor surgery in teeth.

Figure 5.6 Local anaesthesia

(b) Chemicals as Anaesthetics:

There are three major chemicals which are used as anaesthetics. They are:

Nitrous Oxide (N_2O): It is a colourless, non-irritating, inorganic gas. It is the safest of the anaesthetic agents. This is used after mixing general anaesthetics like ether.

Chloroform ($CHCl_3$): It is a volatile liquid. It has pleasant smell and sweet taste. With oxygen it forms a toxic carbonyl chloride. Hence it is not used now.

Ether: Diethyl ether or simply ether ($C_2H_5–O–C_2H_5$) is a volatile liquid. This is mixed with a stabilizer, 0.002% propyl halide. After absorption by tissues it attacks the central nervous system and makes the patient unconscious.

Discovery of anaesthesia

A young US dentist named William Morton inspired by the business opportunities afforded by technical advances in artificial teeth, searched for a way to relieve pain and boost dental profits. His efforts were soon rewarded. He discovered that when he or small animals inhaled sulfuric ether (now known as ethyl ether or simply ether) they became unresponsive. A few months after this discovery, on October 16, 1846, Morton anaesthetised a young male patient in a public demonstration at hospital.

The hospital's chief surgeon then removed a tumour on the left side of the jaw. This occurred without the patient apparently moving or complaining, much to the surgeon's and audience's surprise. So began the story of general anaesthesia, which for good reason is now widely regarded as one of the greatest discoveries of all time.

B. Analgesics

Analgesics are the compounds which relieve all sorts of pains without the loss of consciousness. These are also called as *pain killer*, or *pain relievers*. These are effective in headaches, myalgia and arthralgia.

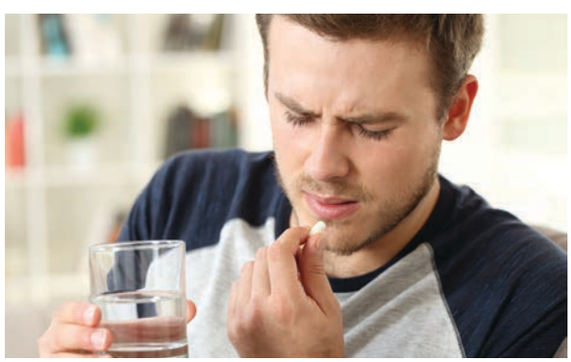


Figure 5.7 Analgesics

Aspirin and Novalgin are the commonly used analgesics. Aspirin acts both as antipyretic as well as analgesic. Certain narcotics (which produce sleep and unconsciousness) are also used as analgesics. The analgesics are given either **orally or applied externally**. In general, externally applicable pain killers come as "gels".

Figure 5.8 Pain relieving gel

C. Antipyretics

Antipyretics are the compounds which are used for the purpose of reducing fever (lowering the body temperature to the normal). They are taken orally as tablets and capsules. The most common antipyretics are, aspirin, antipyrine, phenacetin, and paracetamol.

Figure 5.9 Antipyretics

D. Antiseptics

Antiseptic is a substance that prevents infections caused by disease causing microorganisms or pathogens. Anticeptics either kill the microorganism or prevent their growth. Anticeptics are used externally to cleanse wounds and internally to treat infections of the intestine and bladder.

- Iodoform (CHI_3) is used as an antiseptic and its 1% solution is a disinfectant.
- 0.2 percent solution of phenol acts as an antiseptic and its 1% solution is a disinfectant.
- Hydrogen peroxide is a minor antiseptic mainly used for cleansing wounds.

Figure 5.10 Antiseptics

E. Antimalarial

Malaria is a vector borne disease which causes shivering and fever. It raises the body temperature to 103-106°F. It causes **physical weakness** with the side-effects in liver and also causes **aneamia**.

Extracts of roots and stems of certain plants are extensively used as antimalarial. Quinine is a natural antimalarial obtained from Cinchona bark. The last antimalarial discovered in 1961 is pyrimethamine. However, quinine, primaquine and chloroquine are some of the best antimalarials. Chloroquine is used specially to control malarial parasites such as plasmodium ovale, plasmodium vivax etc. It is not used in curing the disease. It is used as an additive with other antimalarial drugs.

Figure 5.11 Cinchona Bark

F. Antibiotics

Many microorganisms (bacteria, fungi and molds) produce certain chemicals which inhibit the growth or metabolism of some other disease causing microorganism. Such chemical compounds are known as *antibiotics*. These need to be present only in low concentration to be effective in their antibiotic action. The first antibiotic 'penicillin' was discovered by Alexander Fleming in1929, from the mould Penicillium notatum. Penicillin is extensively used for rheumatic fever, narrowing of heart wall, bronchitis, and pneumonia etc.

The first commercially available antibacterial was developed in 1932. But mold and plant extracts were used to treat infections by ancient Egyptians and Greeks over 2,000 years ago. Penicillin wasn't actually discovered until 1928, but the ancient Egyptians had the practice of applying moldy bread to infected wounds for treatment. Penicillin was an important antibiotic back in 1941, when it became more popular, because it helped to treat battle wounds for soldiers. It was named as the 'miracle drug'.

More to Know

Alexander Fleming was a doctor and scientist in London, England, in the early 1900s who was trying to figure out how to kill bacteria. Back in those days, many people got sick and died from infections caused by bacteria. In his lab, Fleming was experimenting with bacteria when some of his experiments accidentally got a kind of mold in them called **Penicillium** (pronounced pen-ih-SILL-ee-um). He noticed that the bacteria wasn't growing around the mold and studied it more. Eventually, he separated out small amounts of 'mold juice,' which is now knows as **penicillin.** Although Fleming first recognized how well it could kill dangerous bacteria, he wasn't able to make enough of it to turn it into a life-saving medicine.

There are three main sources of antibiotics: (i) Bacteria (ii) Fungi and (iii) Actinomycetes. The original antibiotics, like a lot of today's antibiotics, are derived from natural sources. Certain plant extracts, essential oils, and even foods have antibiotic properties. Example: Honey, garlic, ginger, clove, neem and turmeric.

Figure 5.12 Sources of Antibiotics

G. Antacids

Quite often, after eating oily and spicy food, one may feel uncomfortable due to some burning sensation in stomach / food pipe. This is due to imbalance in the acidity in the stomach. Certain drug formulations provide relief from such burning sensation. These are known as **antacids.** Antacids are available in tablet as well as gel / syrup forms. These antacids contain magnesium and aluminium hydroxides, in addition to flavouring agents and colour.

Figure 5.13 Tablet form of antacids

Activity 2

Complete the following table by suggesting suitable type of drug(s) for the given health conditions.

Condition	Type of drug(s)
Ramu's grandfather suffers from knee pain.	
Sudha had spicy food last night and got indigestion.	
When Kavin returned home from school, he got wet in rain. So he suffered from fever.	
Nimmy cut her hand when sharpening her pencil.	

Try to learn: Ask your mother or grandmother, to suggest some home remedies for the fore said situations.

5.3 Electrochemistry

We use so many electronic devices like mobile phone, and electrical devices like torch light in our daily life. Electricity produced by the battery is the key factor which makes these devices to function. But how does battery produce electricity? Because it contains some chemicals in it. The chemical reactions (chemical energy) that take place in the battery produce electricity (electrical energy). So, when scientists realized that chemical energy can be converted into electrical energy and vice versa, another branch of applied chemistry was developed. It is **Electrochemistry.**

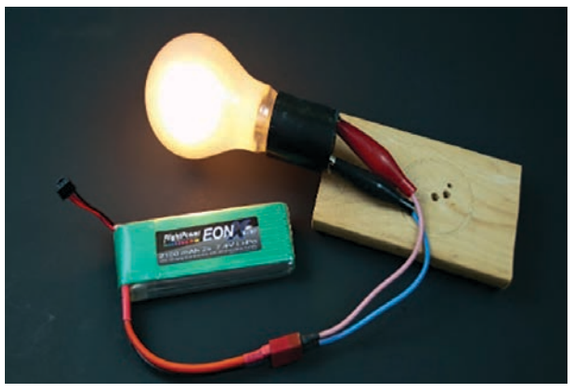


Figure 5.14 Battery-Source of Electric Energy

Thus **Electrochemistry** is a branch of chemistry which deals with the relation between electrical energy and chemical change. It is mainly concerned with the processes taking place between the electrode and solution having ions called **electrolyte**.

5.3.1 Electrochemical Cell

So many chemical reactions take place around us. Do all they produce electricity? No. Only redox reactions that take place in a specific device can produce electricity. The device that make use of a chemical change to produce electricity or electricity to produce chemical change is called **Electrochemical Cell.**

(a) Components of Electrochemical Cell

An electrochemical cell may comprise of the following two major components:

Electrode: It is a solid electrical conductor made of metal (sometimes non-metal like graphite). A cell consists of two electrodes. One is called **Anode** and the other is called **Cathode.**

Electrolyte: It is made up of solutions of ions or molten salts which can conduct electricity.

(b) Cell reactions

An electrochemical cell involves two reactions simultaneously.

Oxidation: As we know already, an oxidation is **loss of electron**. In electrochemical cells, oxidation takes place at anode.

Metal → Metal ion + electron (e^-)

Reduction: It involves gain of electron. Reduction takes place at cathode

Metal ion + electron (e^-) → Metal

Since both the reactions take place simultaneously, the inter conversion of electrical and chemical energy in electrochemical cells involves a **redox reaction.**

(c) Types of Electrochemical Cell

Based on the nature of the energy conversion, electrochemical cells are broadly classified as below.

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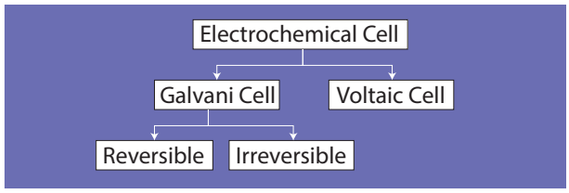


Galvanic Cell

- It is an electrochemical cell which converts chemical energy into electrical energy i.e. it produces electricity from chemical reactions.
- It consists of two half cells namely **anodic half-cell** and **cathodic half-cell.**
- In anodic half-cell, the anode is in contact with its electrolyte whereas in cathodic half-cell, the cathode is in contact with its electrolyte.
- The anode and cathode are connected by a conductor wire. The electrolytes of half-cells are connected through a tube containing a saturated salt solution. It is called **salt bridge**. Thus in galvanic cell, both the half-cells are kept separately but stay connected electrically.

How does a galvanic cell produce electricity?

At anode, oxidation takes place which releases electrons. These electrons are attracted by cathode and hence the electrons flowing from anode to cathode are gained in reduction reaction. As long as the redox reaction proceeds, there is a flow of electrons and hence electricity.

Daniel Cell

It is a type of galvanic cell in which zinc metal acts as anode and copper metal as cathode. Aqueous zinc sulphate solution makes the anodic electrolyte whereas aqueous copper sulphate solution makes the cathodic electrolyte. Saturated solution of potassium chloride (KCl) acts as salt bridge. The following figure depicts the construction of Daniel cell.

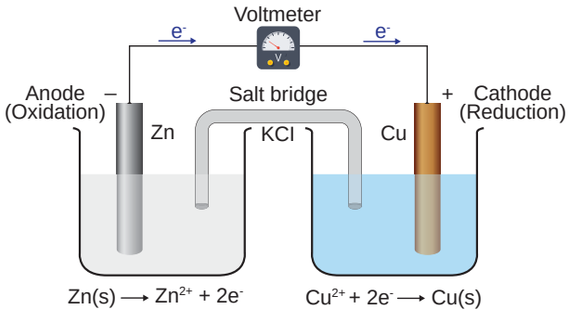


Figure 5.15 Daniel Cell

At anode, zinc undergoes oxidation losing its electrons.

$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$ (Oxidation)

At cathode, copper ions from cathodic electrolyte gain electrons at the surface of cathode and get reduced to copper metal.

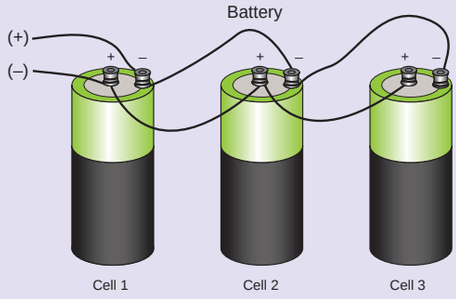
$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ (Reduction)

Net reaction: $Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+} + Cu_{(s)}$

Cell potential of Daniel cell is 1.1 V

Are cell and battery same or different?

A cell is a **single unit** consisting of an anode, cathode and electrolyte. Battery is the combination of two or more cells connected in series.



Activity 3

With the help of your teacher, construct the galvanic cell using lemon and potato. Identity their anode, cathode and electrolyte.

Electrolytic Cell

- It is an electrochemical cell which converts electrical energy into chemical energy i.e. in electrolytic cells, electricity is used to bring about chemical reactions.
- Here, both anode and cathode are in contact with same electrolyte and thus the half-cells are not separated. As seen in galvanic cells, electrolytic cell also involves redox reaction.

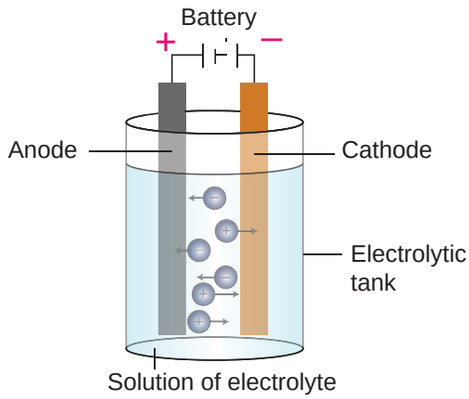


Figure 5.16 Electrolytic Cell

We get electricity from galvanic cells. But electrolytic cells use electricity. Then how are they useful?

In electrolytic cells, when electricity is passed to the electrolyte, it dissociates into its constituent ions. These ions undergo redox reaction forming the respective elements. This phenomenon is called **Electrolysis.** So electrolysis is a process by which an electrolyte is decomposed into its constituent elements by passing electricity through its aqueous solution or fused (molten) state.

(d) Applications of Electrolysis

Electrolysis has wide range of applications both in industry and research. The important applications are given below.

i. Electroplating

The process of depositing a thin layer of one metal over another metal by the process of electrolysis is called electroplating. Electroplating is one of the main processes applied in most of the industries. Some important applications of electroplating are given below.

Figure 5.17 Chromium plating on iron

Corrosion prevention: It is done to protect the metal from corrosion. For example, metals like iron are electroplated with tin, nickel or chromium to protect them from rusting.

Decoration: In some cases, electroplating is done to beautify the surface of a metal. For example, the metals like Au or Ag are deposited over metals like Cu to improve their beauty. Gold covering jewels are made by this method in which gold is electroplated over copper, silver or tin.

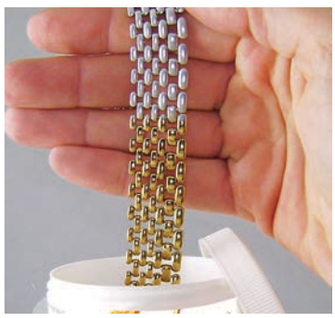
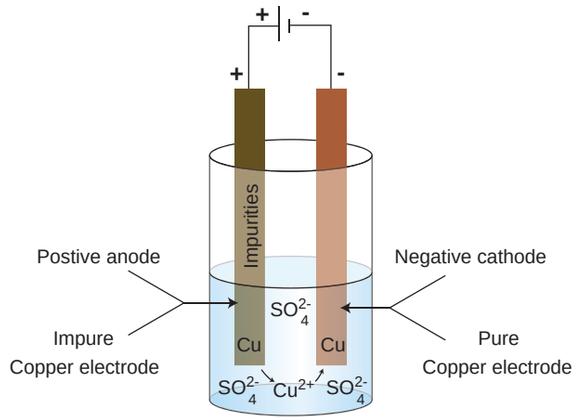


Figure 5.18 Gold Covering

Repairs: In some cases, broken parts of machinery may require electro- deposition of a metal between broken parts.

ii. Electro-refining of metals

It is a process of purifying metals by electrolysis. When metals of very high degree of purity are required, electro refining is done.



Electro-refining of Copper

Figure 5.19 Electro-refining of Copper

iii. Electro manufacturing

Electro manufacturing is a process of manufacturing metals, non-metals and compounds by electrolysis. For example a number of metals like Na, Al, Mg, Ca, Cu, etc., non-metal molecules like H_2, O_2, F_2, Cl_2 and compounds like NaOH, $KClO_3$ etc have been manufactured by this method.

(e) Significance of electrochemistry

The subject of electro chemistry is of great significance. Some of its applications are given below.

i. It has been used to discover important technical processes for the production and purification of non-ferrous metals, and for the electro- synthesis of organic compounds.

ii. Electrochemistry has been used to predict whether a particular reaction will occur or not.

iii. The detection of alcohol in drunken drivers is possible through the electrochemical redox reaction of ethanol.

iv. Production of metals like aluminum and titanium from their ores involve electrochemical reactions.

v. Diabetes blood sugar metres measure the amount of glucose in the blood through its redox potential.

vi. Lead acid batteries, lithium-ion batteries and fuel cells are based on electrochemical cells. Fuel cell is used to bring about direct conversion of chemical energy into electrical energy.

5.4 Radiochemistry

You have studied in previous chapters that elements can exist in nature as their isotopes. Isotopes are atoms with the same number of protons and electrons, but a different number of neutrons. Some isotopes are stable and stay forever. These are the elements that we see around us and find in nature. However, some isotopes are unstable and they undergo disintegration by losing their energy in the form of radiation. As we studied earlier, every element tries to attain stability by sharing, losing or gaining electrons (octet rule). Thus the unstable isotopes of elements lose their energy in the form of radiation to become stable.

This phenomenon is called **radioactive decay**. The isotope which undergoes radioactive decay is called **radioactive isotope** or **radioisotope**. This property of isotopes is known as **radioactivity**.

Uranium in the ground can decay into radon gas which can be very dangerous to humans. It is thought to be the second leading isotope to cause lung cancer.

Radiochemistry is the study of chemistry of radioactive and non-radioactive isotopes. It includes both natural and artificial isotopes. Radiochemistry mainly deals with application of radioisotopes to study the nature of chemical reactions of non-radioactive isotopes of elements and applications of radioisotopes to various fields.

5.4.1 Applications of Radiochemistry

Radioisotopes can easily be detected and estimated quantitatively. So they are used in radiochemistry for various applications. Radiochemistry mainly deals with study of chemical reactions of non-radioactive isotopes using radioisotopes. In addition to that it could find applications in medical field and environmental management also. Let us list important applications of radioisotopes.

Radiocarbon dating: It is a method by which the age of fossil wood or animal is determined using C-14 isotope.

Study of chemical reactions: The nature of some of the chemical reactions can be studied by mixing a radioisotope with non-radioactive isotope of the reactants. The radioisotope used for this purpose is called **radiotracer**. For example, by photosynthesis plants synthesize carbohydrate from carbon dioxide and water as shown in the following reaction.

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow{\text{Light}} \underset{\text{Sugar}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

Here a question arises that whether the oxygen evolved in this process comes from CO_2 or H_2O. By using radioisotope O-18 as tracer, it was found that the evolved oxygen comes from H_2O.

Diagnosis: Radioisotopes are found very useful to diagnose and understanded many diseases.

Table 5.2 Radioisotope in Diagnosis

Radioisotope	Diagnosis used for
Iodine-131	Location and detection of brain tumor, thyroid gland disorder
Sodium-24	Location of blood clot and circulation disorders, pumping action of heart
Iron-59	Diagnosis of anaemia, pregnancy disorder
Cobalt-60	Diagnosis of cancer
Hydrogen-3	Water content of the human body

Henry Becquerel (France) was awarded Nobel prize for his discovery of spontaneous radioactivity in 1903. In the same year Pierre Curie (France) and Marie Curie (France) were awarded for their research on radiation phenomenon. In 1911, Marie Curie (France) was awarded Nobel prize for the discovery of radium and polonium, and the isolation of radium. They only coined the word Radioactivity. In 1938, Enrico Fermi (Italy) was awarded Nobel Prize for the discovery of nuclear reactions induced by slow neutrons.

Pierre Curie & Marie Curie

Radiotherapy: Radioactive isotopes are used in the treatment of many diseases. This kind treatment is called radiotherapy.

Table 5.3 Radioisotope in Treatment

Radioisotope	Treatment used for
Gold-198	Cancer
Iodine-131	Hyperthyroidism and cancer
Phosphorous -30	Blood disorder and skin disease
Cobalt-60	Cancer

5.5 Dye Chemistry

Human is always fascinated by colours, because we are living in a colourful world. We could see so many colours in plants and their flowers. We eat coloured food stuffs and use numerous coloured materials in our daily life. Do you know how do they get coloured? Because they contain some kind of chemicals in them which are called colourants.

Figure 5.20 Dye in various colours

The uses of colourants by mankind for painting and dyeing dates back to the dawn of civilization. Until the middle of the 19th century, all colourants applied were from natural origin. For example, inorganic pigments such as soot, manganese oxide, hematite were used as colourants. Organic natural colourants have also a timeless history of application, especially for colouring textiles.

Figure 5.21 Coloured Textiles

The organic compounds that are used as colourants are called **dyes**. These dyes are all aromatic compounds, originating from plants and also from insects, fungi and lichens.

After the evolution of modern organic chemistry, many kinds of synthetic dyes were prepared and used by mankind. **Dye chemistry** is the study of such kind of dyes. It provides us information on theory, structure, synthesis and applications of synthetic dyes.

DO YOU KNOW?

Synthetic dye manufacturing started in 1856, when the English Chemist **W. H. Perkin** in an attempt to synthesize quinine, obtained instead a bluish substance with excellent dyeing properties that was latter known as aniline purple, Tyrian purple or mauveine. Perkin patented his invention and set up a production line. In the beginning of the 20th century, synthetic dyestuffs had almost completely supplanted natural dyes. Now days, such substances are synthesized in factories through simple chemical reactions.

5.5.1 Colour and Structure of Dyes

Not all the aromatic compounds are coloured. Aromatic compounds which absorb light of wavelength range 350 nm – 700 nm (visible light) only are coloured. This nature of absorption of visible light by aromatic compound depends on their structure. The relationship between the colour of an organic compound and its structure was explained by a German scientist **Otto Witt (1876)** through the **Chromophore and Auxochrome theory**. You will study about this theory in your higher classes.

Activity 4

With the help of your teacher, try to find the answer for the following questions:

As the tomato ripens, its starts to change colour from green to yellow and then red at last. Why?

Why does a banana ripen, it turns from green to yellow?

Why does chilly change colour from green to yellow orange and then eventually red?

Why do all these colour changes follow same sequence i.e. green to yellow or orange or red?

5.5.2 Characteristics of Dyes

All coloured compounds are not dyes. Dyes are those coloured compounds which can be firmly fixed in fabrics by chemical or physical bonding.

So, a dye should have the following characteristics:

- It should have a suitable colour.
- It should be able to fix itself or be capable of being fixed to the fabric.
- It should be fast to light.
- It should be resistant to the action of water, dilute acids and alkalies.

More to Know

Many natural dyes have been known for a long time. These were obtained from vegetable sources.

Henna: It is one of the natural dyes. It is a reddish brown dye obtained from plant *Lawsonia inermis* (Tamil: Maruthondri). Paste of these leaves is used as a hair dye and also for colouring palms (Mehandhi).

Turmeric: It is the traditional natural cosmetic in India. It is obtained from the plant *Curcuma longa* (Manjal). It also acts as an antiseptic. Turmeric is mostly used in India for colouring food.

5.5.3 Classification of dyes

Now a days, practically all the dyes are synthetic, and are prepared from aromatic compounds obtained from coal tar. Therefore, such dyes are sometimes called as coal tar dyes. But they may differ in their basic structure and the way of application. So dyes are classified in two ways, one, based on the method of application and other on their parent structure.

(a) Based on method of application

Acid dyes: These are acidic in nature and used for dyeing animal fibres and synthetic fibres. These can be used for protein fibre such as wool and silk. E.g. Picric acid, Naphthol yellow-s

Basic dyes: These are basic dyes containing basic group ($-NH_2$,- NHR, - NR_2). They are used for dyeing animal fibres and plant fibres.

Mordant dyes or Indirect dyes: These dyes have a poor affinity for cotton fabrics and hence do not dye directly. They require pretreatment of the fibre with a mordant. Mordant (latin : mordere = to bite) is a substance which can be fixed to the fibre and then can be combined with the dye to form an insoluble complex called lake. Aluminium, chromium, and iron salts are widely used as mordants. E.g. alizarin.

Direct dyes: They have high affinity for cotton, rayon and other cellulose fibre. So they are applied directly as they fix firmly on the fabric. E.g. Congo red

Vat dyes: It can be used only on cotton and, not on silk and wool. This dyeing is a continuous process and is carried out in a large vessel called vat. So it is called as vat dye. E.g. Indigo

Figure 5.22 Vat dyes

(b) Based on Structure

Based on the structure, dyes are classified as below:

- Azo dyes
- Diphenyl methane dye
- Triphenyl methane dye
- Phthalein dye
- Anthraquinone dye
- Indigo dyes
- Phthalo cyanine dye
- Nitro and nitroso dyes

5.6 Agricultural and Food Chemistry

5.6.1 Agricultural Chemistry

Agricultural chemistry involves the application of chemical and biochemical knowledge to agricultural production, processing of raw materials into foods and beverages, and environmental monitoring and remediation. It deals with scientific relation between plants, animals, bacteria and environment.

(a) Role of agricultural chemistry

India is predominantly an agricultural country. Its major source of food production is agriculture. Indian agriculture began in 7000 BC and followed a traditional practice. After independence, rapid growth of population and urbanization made threats to agricultural production and it led to food scarcity.

Figure 5.23 Spraying pesticides

40% of today's global population works in agriculture, making it the single largest employment in the world.

Indian chemists and biochemists applied their knowledge and developed modernized agricultural practices which involve use of synthetic fertilizers, genetically modified crops, and equipments.

(b) Goals of agricultural chemistry

The goals of agricultural chemistry are to expand the understanding of the causes and effects of biochemical reactions related to plant and animal growth, to reveal opportunities for controlling those reactions, and to develop chemical products that will provide the desired assistance or control. It aims at producing sufficient nutritious food and feed the population in a sustainable way while being responsible stewards of our environment and ecosystem. Based on the issues and challenges in agricultural production, agricultural chemistry mainly focusses to achieve the following:

- Increase in crop yield and livestock
- Improvement of food quality
- Reducing cost of food production

(c) Applications of Agricultural Chemistry

Chemical principles and reactions are most widely used in agriculture in order to increase yield, to protect crops from diseases and to simplify the practice of agriculture. Various applications are give below.

Soil Testing: Crop lands may have different kinds of soil with varying pH. Soil pH is one of the main criteria to be considered for the selection of crop or remediation of soil. Soil testing involve determination of pH, porosity and texture.

Chemical Fertilizers: Fertilizers are chemical compounds added to crop field for supplying essential micro and macro nutrients required for crop growth. Ammonium nitrate, calcium phosphate, urea, NPK (Nitrogen, Phosphorous and Potassium), etc. are some of the fertilizers. Depending on the nature of soil, these fertilizers are used singly or as mixtures.

Figure 5.24 Chemical Fertilizers

More to Know

According to World Health Organization (WHO), "Pesticides are chemical compounds that are used to kill pests, including insects,

rodents, fungi and unwanted plants (weeds). Pesticides are used to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed of properly."

Organic Farming: Even though chemical fertilizers and pesticides are used for plant growth and protection, they are harmful to human. So now a days, naturally prepared fertilizers and pesticides from herbs and microorganisms are used. This practice of agriculture is called Organic Farming. **Vermi compost** is one of such natural fertilizers produced from domestic wastes.

Pesticides and Insecticides: Crops are prone to diseases caused by pests and insects. Chemically synthesized pesticides and insecticides are used to solve these issues. Chlorinated hydrocarbons, organophosphates and carbamates are used as pesticides and insecticides.

5.6.2 Food Chemistry

Food is one of the basic needs of human and animal. The food we eat also are made of chemicals. Any human might require the following three kinds of food:

Body building foods: These are required for physical growth of body. E.g. Proteins

Energy giving foods: These the foods that supply energy for the functioning of parts human body. E.g. Carbohydrates

Protective foods: These protect us from deficiency diseases. E.g. Vitamins and Minerals

Every human requires all these three kind of foods in right proportion for the smooth functioning of the body. The diet that contain all these three foods in right proportion is called **Balanced diet**.

Food chemistry is chemistry of foods which involves the analysis, processing, packaging, and utilization of materials including bioenergy for food safety and quality.

(a) Goals of food chemistry

The main goal of food chemistry is to cater the needs of quality food to the population in a sustainable way. In basic research, food chemists study the properties of proteins, fats, starches, and carbohydrates, as well as micro components such as additives and flavourants, to determine how each works in a food system. In application research, they often develop new ways to use ingredients or new ingredients altogether, such as fat or sugar replacements.

(b) Chemicals in Food

Food we eat in our day to day life contains natural or synthetic chemicals. They serve different functions in human body.

Nutrients: They are the most essential chemicals present in food. They are required for the growth, physiological and metabolic activities of body. They are natural or synthetic. E.g. Carbohydrates, proteins, vitamins and minerals

Food additives: These are the chemicals added to food for specialized functions. The various types of additives of foods are given in Table 5.4.

Table 5.4 Food additives

Type of additive	Function of the additive	Example
Preservatives	They protect food from spoilage by microorganism in storage.	Vinegar, Sodium benzoate, benzoic acid, sodium nitrite
Colourants	They give pleasant colours to food	Carotenoids, Anthocyanin, Curcumin
Artificial Sweeteners	They add sweet taste to food	Saccharin, Cyclamate
Flavor enhancers	They are used to enhance the flavour of food items	Monosodium glutamate, Calcium diglutamate
Antioxidants	They prevent the oxidation of food. They protect us against cardiovascular disease.	Vitamin C, Vitamin E, Carotene

More to Know

There are several natural preservatives that you can use to preserve food.

Oil: When food comes into contact with air, it oxidises and starts to go bad. Oil slows down this oxidation process and keeps microorganisms from coming into contact with the food.

Common Salt: Microorganisms that spoil food tend to grow in water, but salt absorbs this water and prevents them from growing. Salt also prevents yeast and bacteria from decaying.

Sugar: Like salt, sugar also preserves food by absorbing the excess water and preventing microorganisms from growing. This is why jams, jellies and other fruits preserves don't go bad even after the jar has been opened. Sugar can even be added to the water in a flower vase – it feeds the flowers and keeps them from going bad.

Lemon juice: Lemon juice contains plenty of citric acid and ascorbic acid, also known as Vitamin C. Acidity prevents microorganisms from growing in the food and spoiling it. Vitamin C is also a powerful antioxidant that prevents food from oxidising.

Vinegar: Like lemon juice, vinegar is also extremely acidic, for it contains high amounts of acetic acid. Made of fermented sugar and water solutions, vinegar is commonly used to preserve pickles and canned foods, as it kills microbes and prevents the food from going bad.

Cloves: Cloves, have been used for thousands of years in Indian and Chinese medicines as a natural preservative. Containing high amounts of phenolic compounds, which have antioxidant properties, they keep food from going bad by preventing the growth of fungus and bacteria.

Cinnamon: Cinnamon, is an aromatic spice that is also used to preserve food. It does not protect food from all the bacteria and microbes that can decay it; it is more organism specific, meaning it kills only certain organisms.

Activity 5

With the help of your mother, know the food materials used in cooking. List out the chemicals present in them.

Food colouring or colour additives are pigments-synthetic or natural-added to food to create a certain colour, enhance a natural colour and improve the overall aesthetic appeal of a dish. Food colouring can make food fun. Food colouring contains one or more of the certified colour additives commonly known by their numbering system. Colour additives are blended to create a brightness or intensity to the base colour. The other basic ingredients of synthetic food colouring are propylparaben, propylene glycol and water.

Figure 5.25 Colour additives in cooldrinks

5.7 Forensic Chemistry

Forensic chemistry applies scientific principles, techniques, and methods to the investigation of crime. Our daily newspaper is carrying a lot of news on incidents of criminal activities such as robbery, murder, sexual harassment, etc. How the crime department investigate and analyse it? In real life the collection and analysis of evidence involve painstaking care and rigorous application of scientific principles.

Figure 5.26 Crime detection

5.7.1 Forensic Chemists in Criminal Investigation

In general, forensic chemists work in four steps in the investigation of crime.

Collection of Evidences: They collect physical evidences such as knife, instruments, materials, etc in a systematic way and uncover their information using chemistry.

Analysis of evidences: In criminal cases, chemists analyze substances such as blood and DNA to attempt to determine when and by whom the crime was committed.

Collaboration: To solve the crime, they discuss with other fellow investigators like police officers, detective and other forensic scientists.

Report of findings: Finally, they prepare a report of the conclusion of the analysis.

5.7.2 Method of Forensic Chemistry

The world of forensic chemistry, focusing on the theory and processes of chemistry in forensic analysis shows the role that chemistry plays in criminal investigations. The following are some methods used in crime investigation by a forensic chemitry lab.

Finger print: Finger print is one of the most important evidences in crime investigation. Fingerprints on smooth surfaces can often be made visible by the application of light or dark powder, but fingerprints on cheque or other documents are often occult (hidden). Occult fingerprints are sometimes made visible by the use of ninhydrin, which turns purple due to reaction with amino acids present in perspiration. Fingerprints or other marks are

also sometimes made visible by exposure to high-powered laser light. Cyanoacrylate ester fumes from glue are used with fluorescent dyes to make the fingerprints visible.

Figure 5.27 Finger print

Biometrics: The science that involves the study and analysis of human body prints is known as **biometrics**. The biometric system compares the body prints to the specimen data stored in the system to verify the identity of a person.

Figure 5.28 Biometrics

Activity 6

Find out the foot print of animals from the following:

DO YOU KNOW?

No two fingerprints are exactly alike! The ridges on your fingers start forming when you are still inside your mother's womb. Our fingers have sweat glands that ooze some oils and salt through tiny pores on the finger surface. This sticky film of sweat and oil trapped in the ridges leaves behind a print when we touch anything. It is difficult to get fingerprints on carpets and clothes as they absorb the oils. Just like fingerprints, our retinal print and tongue prints are also unique and cannot be forged by anyone. It is for this reason that these unique characteristics of the human body are used for authentication of a person's identity.

Alcohol test: Drinkers can be easily identified by the use of applied chemistry. The person being tested blows through a tube, which bubbles the breath through a solution of chemicals containing sulfuric acid, potassium dichromate, water, and silver nitrate. Oxidation of the alcohol results in the reduction of dichromate to chromic ion, with a corresponding change in colour from orange to green. An electrical device employing a photocell compares the colour of the test solution with a standard solution, giving a quantitative determination of the alcohol content. The test provides a quick and reproducible determination of the amount of alcohol in a person's breath and is a numerical measure of the amount of alcohol in the bloodstream.

Figure 5.29 Alcohol test

Forensic Toxicology: Toxicologists examine a wide range of materials such as blood stains, urine, and blood gases for traces of poisons or drugs. Even tiny samples of blood, saliva, or semen may be separated and subjected to enzymatic analysis.

Figure 5.30 Forensic Toxicology

5.8 Applications of Applied Chemistry

- Many of the advantages of applied chemistry are around us. It is inevitable.
- Applied chemistry has given us innumerous synthetic materials to lead our day to day life.
- The applied chemistry makes a most important contribution to our society.
- It makes a major contribution to the country's economic development, and plays vital role worldwide.
- The products of applied chemistry are so widespread that they are used in our daily.

Points to Remember

❖ Nanochemistry is a branch of nanoscience, that deals with the chemical applications of nanomaterials in nanotechnology.

1 Nanometre = 1/ 1,000,000,000 metre.

❖ Pharmaceutical chemistry deals with the preparation of drugs and study of the chemical composition, nature, behavior, structure and influence of the drug in an organism.

❖ Drug is a substance or product that is used or intended to be used to modify or explore physiological systems or pathological states for the benefits of the recipient.

❖ Electrochemistry is a branch of chemistry which deals with the relation between electrical energy and chemical change.

❖ Galvanic cell is an electrochemical cell which converts chemical energy into electrical energy .

❖ Radiochemistry is the study of chemistry of radioactive and non-radioactive isotopes.

❖ Dye chemistry is the study of dyes. It provides us information on theory, structure, synthesis and applications of synthetic dyes.

❖ Dyes are those coloured compounds which can be firmly fixed to fabrics by chemical or physical bonding.

❖ Agricultural chemistry involves the application of chemical and biochemical knowledge to agricultural production, the processing of raw products into foods and beverages, and environmental monitoring and remediation

❖ Food chemistry is chemistry of foods which involves the analysis, processing, packaging, and utilization of materials including bioenergy for food safety and quality.

❖ Forensic chemistry applies scienctific principles, techniques, and methods to the investigation of crime.

GLOSSARY

Anaesthetics	The drugs which cause loss of sensation.
Antipyretics	The compounds which are used for the purpose of reducing fever (lowering the body temperature to the normal).
Antiseptic	It is the substance that prevents infections caused by disease causing microorganisms or pathogens.
Antibiotics	It is a chemical compounds which was produced by many microorganisms (bacteria, fungi and moulds) which inhibit the growth or metabolism of some other disease causing microorganism.
Antacids	These are certain drug formulations which provide relief from burning sensation.
Balanced diet	The diet that contain all foods in right proportion.
Chemotherapy	Treatment of certain diseases by destroying the invading organism without damaging the cells of the host, by the use of certain organic compounds.
Drug	The chemicals used for treating diseases
Electrochemical Cell	The device that make use of a chemical change to produce electricity or electricity to produce chemical change.
Electrolyte	It is made up of solutions of ions or molten salts which can conduct electricity
Nanotechnology	It involves synthesis and manipulation of materials at atomic and molecular level and study of their physical and chemical properties.
Pharmaceutical Chemistry	It is the study of drugs and it involves drug development.

TEXTBOOK EVALUATION

GBY68X

I. Choose the correct answer.

1. One Nanometre is
   (a) 10^{-7} metre (b) 10^{-8} metre
   (c) 10^{-6} metre (d) 10^{-9} metre
2. The antibiotic Penicillin is obtained from _____
   (a) plant (b) microorganism
   (c) animal (d) sunlight
3. 1% solution of Iodoform is used as
   (a) antipyretic (b) antimalarial
   (c) antiseptic (d) antacid
4. The cathode of an electrochemical reaction involves _____
   (a) oxidation (b) reduction
   (c) neutralisation (d) catenation

5. The age of a dead animal can be determined by using an isotope of _____
   (a) carbon (b) iodine
   (c) phosphorous (d) oxygen
6. Which of the following does not contain natural dyes?
   (a) Potato (b) Beetroot
   (c) Carrot (d) Turmeric
7. This type of food protect us from deficiency diseases.
   (a) Carbohydrates (b) Vitamins
   (c) Proteins (d) Fats
8. Radiochemistry deals with
   (a) oxidants (b) batteries
   (c) isotopes (d) nanoparticles
9. The groups responsible for the colour of an organic compound is called
   (a) isotopes (b) auxochrome
   (c) chromogen (d) chromophore
10. Chlorinated hydrocarbons are used as
    (a) fertilizers (b) pesticides
    (c) food colourants (d) preservatives

II. Fill in the blanks.

1. _____ is an electrochemical cell which converts electrical energy into chemical change(Reaction).
2. Painkiller drugs are called _____
3. Aspirin is an _____
4. _____, _____ and _____ are macronutrients required for plant growth.
5. _____ is a chemical used in finger print analysis.

III. Match the following.

Antipyretics	-	Large surface area
Corrosion prevention	-	Iodine-131
Hyperthyroidism	-	Fever
Nanoparticle	-	Cancer cell identification
Nanorobotics	-	Electroplating

IV. Answer in brief.

1. What is Chemotherapy?
2. What are called Anaesthetics? How are they classified?
3. What is the need for chemical fertilizers in crop fields?
4. What is Forensic chemistry related to?

V. Answer in detail.

1. Draw the cell diagram of Daniel cell. Give its reactions.
2. Explain the types of dyes based on their method of application.
3. Name various food additives and explain their functions.

VI. HOTS

1. Batteries that are used in mobile phone can be recharged. Likewise, can you recharge the batteries used in watches? Justify your answer.
2. Sudha met with a fire accident. What kind of drug(s), she must take?
3. The soil pH of a crop land is 5. What kind of fertilizers should be used in that land?

REFERENCE BOOKS

1. Nanomaterials and Nanochemistry by Catherine Brechignac
2. Nuclear and Radiochemistry – Fundamentals and applications by Karl Heinrich Lieser
3. Food Chemistry (Third Edition) by Owen Fennema

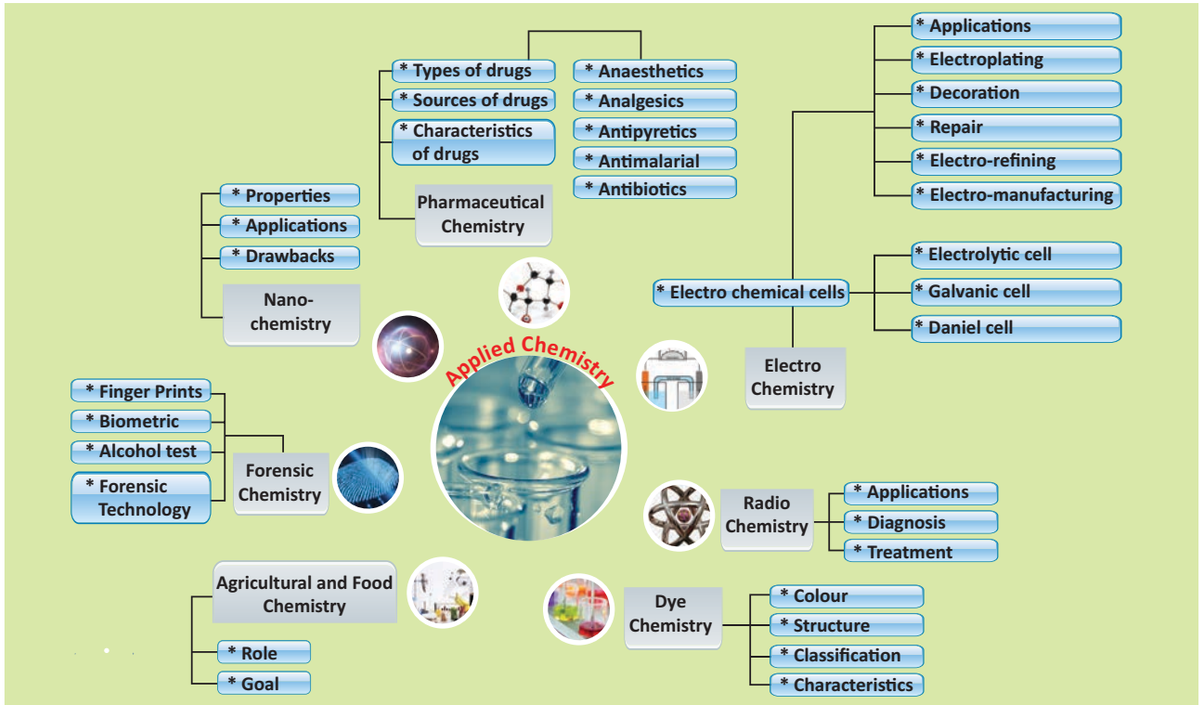
INTERNET RESOURCES

https://en.wikipedia.org/wiki/Agricultural_chemistry

https://www.medicalnewstoday.com/articles/321108.php

https://www.youtube.com/watch?v=kC1aPOqoYWc

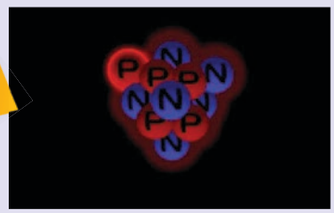
Concept Map



ICT CORNER

Applied Chemistry

Experiment with radioactive elements to know about its half-life



Steps

- Use the given URL to open the simulation page and allow the "javascript" to play, if asks. Read the given description on how to perform the half-life simulation.
- Click the "Years Passed" button to increase the years by 1000 and press "Count the Remaining Atom" to know how much of the atoms have become "Daughter atoms".
- Use the "Table/Graph" button situated below the description to record your observations.
- Press the "video" button to view the process of degradation of radioactive atoms and its calculation


Step1


Step2


Step3


Step4

Radioactive Atoms Half-Life

URL: http://www.glencoe.com/sites/common_assets/science/virtual_labs/E18/E18.html

*Pictures are indicative only

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UNIT 6

Environmental Science

GC82AK

Learning Objectives

After completing this lesson, students will be able to

- relate different aspects of environmental science.
- describe biogeochemical cycles.
- explain water cycle, nitrogen cycle and carbon cycle.
- analyse the impacts of human activities on water cycle, nitrogen cycle and carbon cycle.
- correlate the adaptations of plants with the habitat.
- explain the adaptations of bat and earthworm.
- explain recycling of water.
- discuss the importance of water conservation and water recycling method.

Introduction

"Nature has the power to refresh and renew"
- Helen Keller

Several environmental issues such as pollution, global warming, ozone layer depletion, acid rain, deforestation, land slide, drought and desertification have gained major focus across the world. Environmental science provides holistic knowledge about natural processes, effects of human intervention and solutions to overcome such environmental issues. Thus, it is defined as the study of patterns, processes in the natural world and their modifications by human activities. Elements of nature continuously undergo changes and transformations. They are recycled over and over again on earth and make themselves always available on earth. In the same way, all living organisms react with their environment and develop certain morphological, anatomical, physiological and reproductive features to withstand particular conditions. This lesson deals with biogeochemical cycles, adaptations by the plants and animals, water conservation and recycling of water.

6.1 Biogeochemical cycles (bio – life; geo – earth)

Biosphere is the part of the earth where life exists. All resources of biosphere can be grouped into two major categories namely:

(i) Biotic or living factors which include plants, animals and all other living organisms.

(ii) Abiotic or non-living factors which include all factors like temperature, pressure,

water, soil, air and sunlight which affect the ability of organisms to survive and reproduce.

There is a constant interaction between biotic and abiotic components in the biosphere and that make the biosphere a dynamic and stable system. Cyclic flow of nutrients between non-living and living factors of the environment are termed as biogeochemical cycles. Some of the important biogeochemical cycles are:

1. Water cycle 2. Nitrogen cycle 3. Carbon cycle

6.1.1 Water cycle

- Can you imagine life without water?
- Have you tried to find out how do we get rain?
- Why do lakes and ponds dry out during summer?
- What is the need for conserving and recycling water?

Water cycle has the answers for all these questions. Water cycle or hydrological cycle is the continuous movement of water on earth. In this process, water moves from one reservoir to another, from river to ocean or from ocean to the atmosphere by processes such as evaporation, sublimation, transpiration, condensation, precipitation, surface runoff and infiltration, during which water converts itself to various forms like liquid, solid and vapour (Fig. 6.1). Let's begin the process of water cycle with evaporation.

Evaporation

Evaporation is a type of vaporization, where liquid is converted to gas before reaching its boiling point. Water evaporates from the surface of the earth and water bodies such as the oceans, seas, lakes, ponds and rivers turn into water vapour.

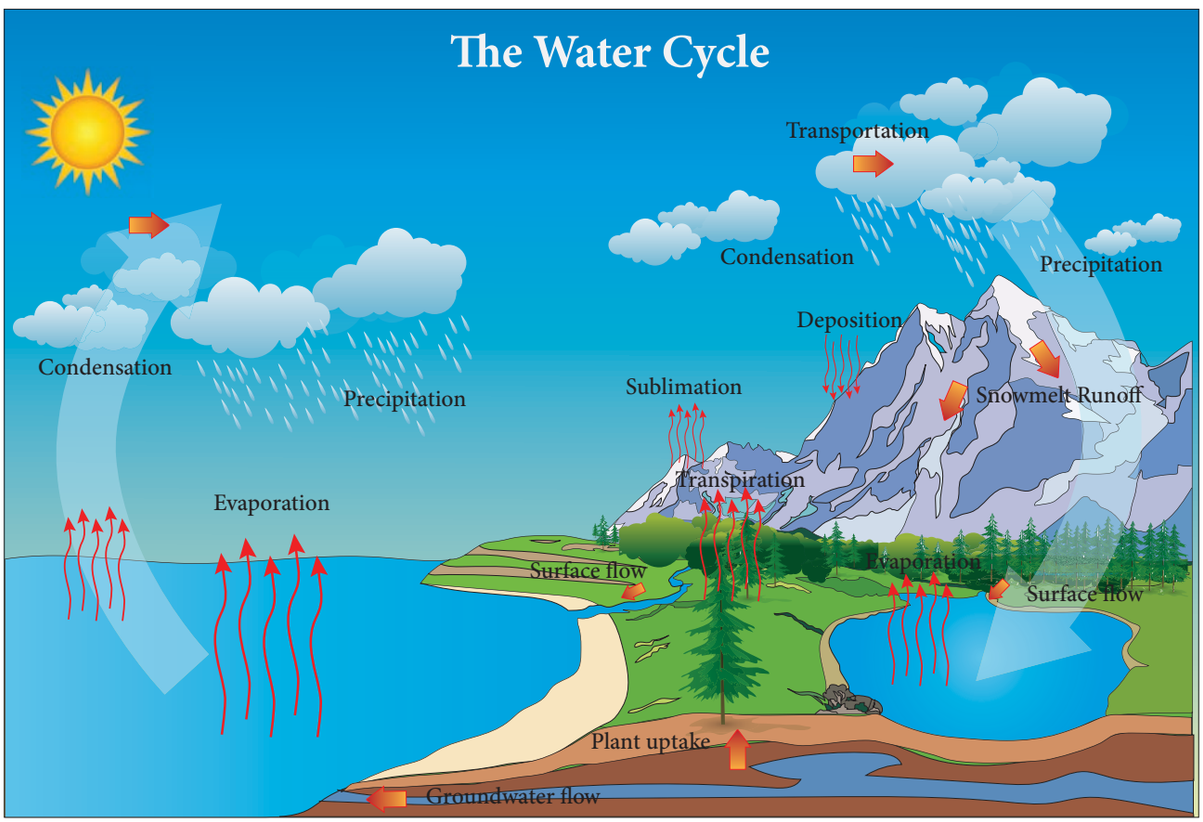

Figure 6.1 Water cycle

Sublimation

Sublimation is conversion of solid to gas, without passing through the intermediate liquid phase. Ice sheets and ice caps from north and south poles, and icecaps on mountains, get converted into water vapour directly, without converting into liquid.

Transpiration

Transpiration is the process by which plants release water vapour to atmosphere through small pores in leaves and stems.

Condensation

Condensation is the changing of gas phase into liquid phase and is the reverse of vaporisation. At higher altitudes, the temperature is low. The water vapour present there condenses to form very tiny particles of water droplets. These particles come close together to form clouds and fog.

Precipitation

Due to change in wind or temperature, clouds combine to make bigger droplets, and pour down as precipitation(rain). Precipitation includes drizzle, rain, snow and hail.

Run off

As the water pours down, it runs over the surface of earth. Runoff water combines to form channels, rivers, lakes and ends up into seas and oceans.

Infiltration

Some of the precipitated water moves deep into the soil. Then it moves down and increases the ground water level.

Percolation

Some of the precipitated water flows through soil and porous or fractured rock:

Infiltration and percolation are two related but different processes describing the movement of water through soil.

Human impacts on water cycle

Major human activities affecting the water cycle on land are urbanisation, dumping of plastic waste on land and into water, polluting water bodies and deforestation.

Activity 1

Create your own water cycle

Aim

To understand utilisation and recycling of water.

Materials

A large transparent bowl, plastic wrap, a stone, a smaller container and a rubber band.

Procedure

The small container is placed in the middle of the large bowl. Water is filled in the large container and it is covered with plastic wrap. The plastic wrap is fastened around the rim of the large container with the rubber band. The stone is placed on the top of the plastic wrap. This is placed under sun for few hours.

Observation

----------.

Inference

----------.

6.1.2 Nitrogen cycle

Nitrogen is primary nutrient important for survival of all living organisms. It is an essential component of proteins, DNA and chlorophyll. Atmosphere is a rich source of nitrogen and contains about 78% nitrogen. Plants and animals cannot utilize atmospheric nitrogen. They can use it only if it is in the form of ammonia, amino acids or nitrates.

Processes involved in nitrogen cycle are explained below.

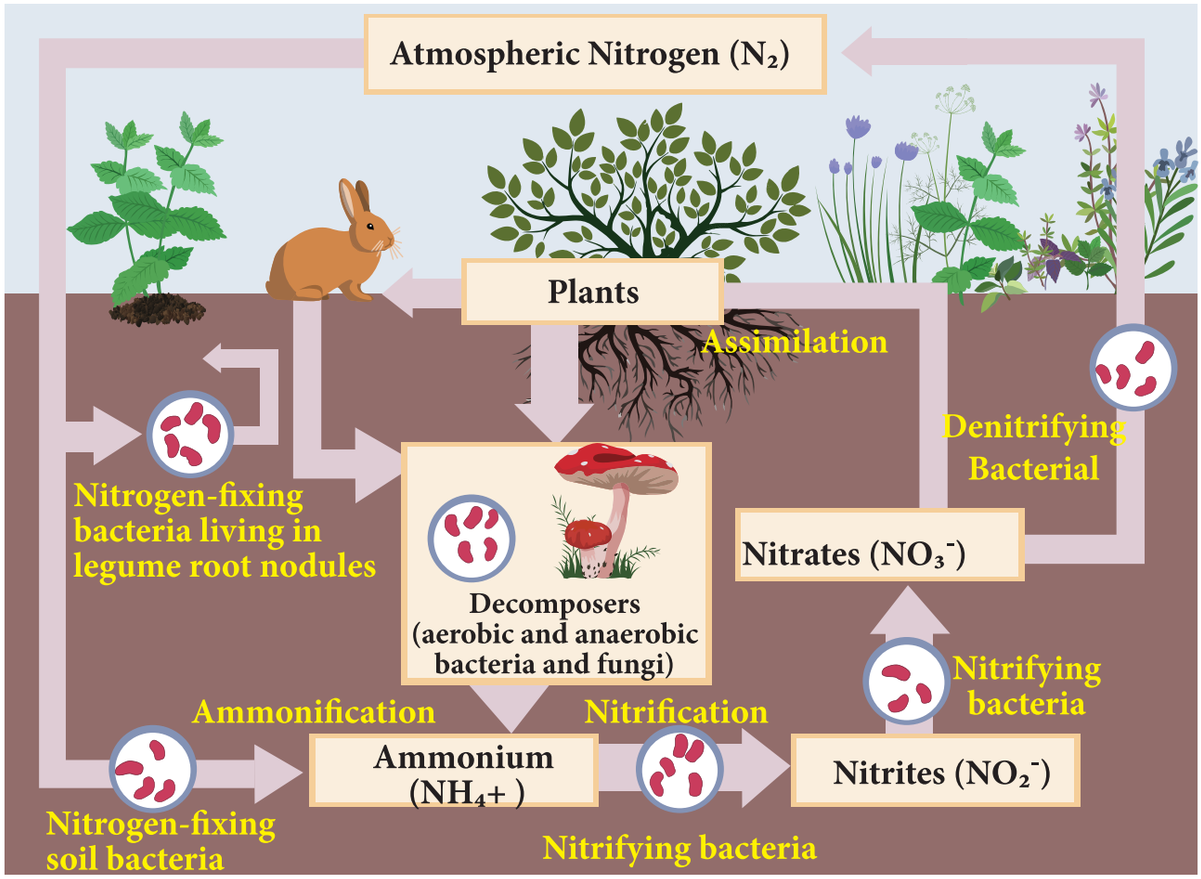

Figure 6.2 Nitrogen cycle

Nitrogen fixation

Nitrogen fixation is the conversion of atmospheric nitrogen, which is in inert form into reactive compounds available to living organisms. This conversion is done by a number of bacteria and blue green algae (Cyanobacteria). Leguminous plants like pea and beans have a symbiotic relationship with nitrogen fixing bacteria *Rhizobium*. Rhizobia occur in the root nodules of leguminous plants and fixes nitrogenous compounds.

Nitrogen assimilation

Plants absorb nitrate ions and use them for making organic matter like proteins and nucleic acids. Herbivorous animals convert plant proteins into animal proteins. Carnivorous animals synthesize proteins from their food.

Ammonification

The process of decomposition of nitrogenous waste by putrefying bacteria and fungi into ammonium compounds is called ammonification. Animal proteins are excreted in the form of urea, uric acid or ammonia. The putrefying bacteria and fungi decompose these animal proteins, dead animals and plants into ammonium compounds.

Nitrification

The ammonium compounds formed by ammonification process are oxidised to soluble nitrates. This process of nitrate formation is known as nitrification. The bacteria responsible for nitrification are called as nitrifying bacteria.

Denitrification

Free living soil bacteria such as *Pseudomonas sp.* reduce nitrate ions of soil into gaseous nitrogen which enters the atmosphere.

Human impacts on nitrogen cycle

Burning fossil fuels, application of nitrogen-based fertilizers and other activities can increase the amount of biologically available nitrogen in an

ecosystem. Nitrogen applied to agricultural fields enters rivers and marine systems. It alters the biodiversity, changes the food web structure and destroys the general habitat.

Table 6.1 Microorganisms involved in nitrogen cycle

Role played in nitrogen cycle	Name of the microorganisms
Nitrogen fixation	*Azotobacter* (in soil) *Rhizobium* (in root nodules) Blue green algae- *Nostoc*
Ammonification	Putrefying bacteria Fungi
Nitrification	Nitrifying bacteria *i. Nitrosomonas* *ii. Nitrobacter*
Denitrification	Denitrifying bacteria *Pseudomonas*

6.1.3 Carbon cycle

Carbon occurs in various forms on earth. Charcoal, diamond and graphite are elemental forms of carbon. Combined forms of carbon include carbon monoxide, carbon dioxide and carbonate salts. All living organisms are made up of carbon containing molecules like proteins and nucleic acids. The atmospheric carbon dioxide enters into the plants through the process of photosynthesis to form carbohydrates. From plants, it is passed on to herbivores and carnivores. During respiration, plants and animals release carbon into atmosphere in the form of carbon dioxide. Carbon dioxide is also returned to the atmosphere through decomposition of dead organic matter, burning fossil fuels and volcanic activities.

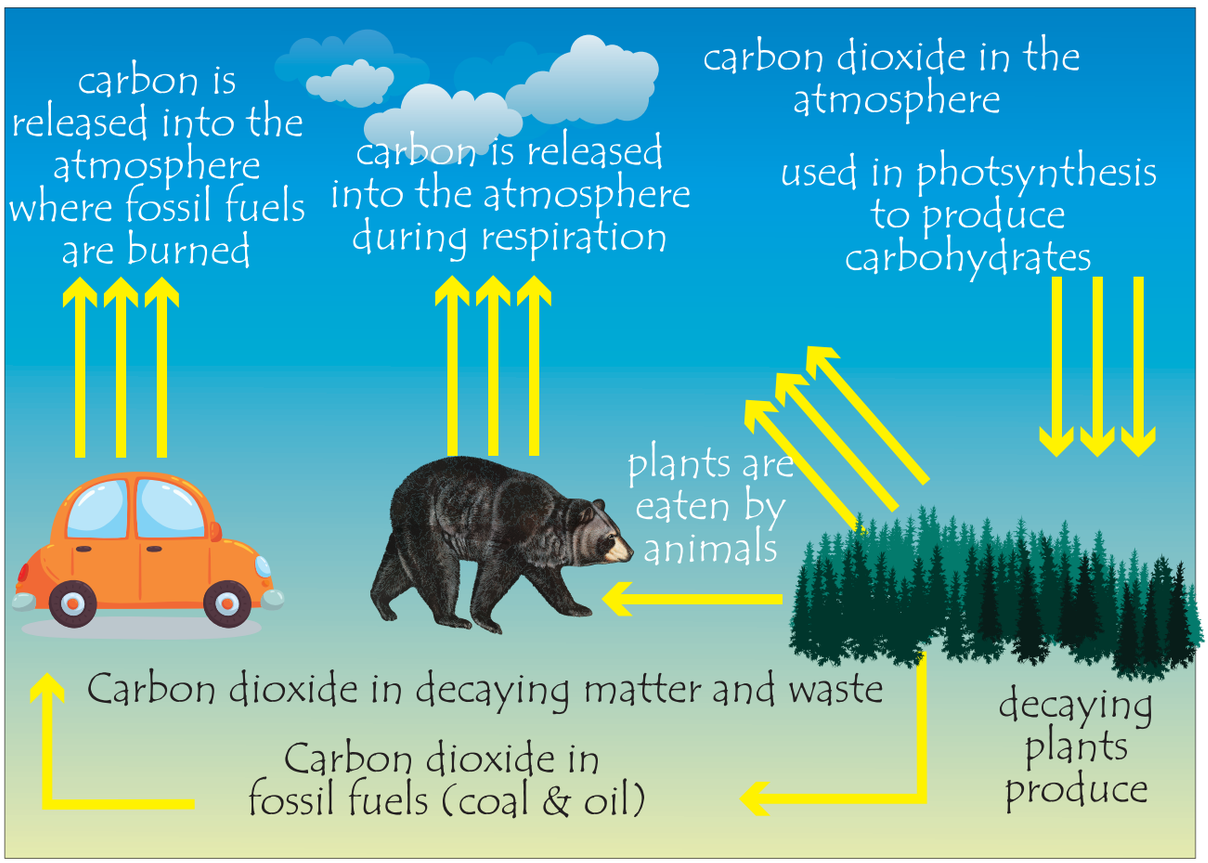

Figure 6.3 Carbon cycle

Human impacts on carbon cycle

More carbon moves into the atmosphere due to burning of fossil fuels and deforestation. Most of the carbon in atmosphere is in the form of carbon dioxide. Carbon dioxide is a greenhouse gas. By increasing the amount of carbon dioxide, earth becomes warmer. This leads to greenhouse effect and global warming.

It is really interesting to know how nature renews itself. At the same time, it also reminds us of our responsibility to reduce and restrain our activities that will affect the natural processes. Living organisms also try to adjust themselves according to their habitat and changes in the ecosystems. The adaptations help them to survive better.

6.2 Adaptations of plants

Any feature of an organism or its part that enables it to exist under conditions of its habitat is called adaptation. On the basis of water availability, plants have been classified as:

(i) Hydrophytes

(ii) Xerophytes

(iii) Mesophytes

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6.2.1 Hydrophytes

Plants growing in or near water are called hydrophytes. Hydrophytes may be free floating or submerged plants living in lakes, ponds, shallow water, marshy lands and marine habitat. Hydrophytes face certain challenges in their habitat. They are:

(i) Availability of more water than needed.

(ii) Water current may damage the plant body.

(iii) Water levels may change regularly.

(iv) Maintain buoyancy in water.

Adaptations of hydrophytes

1. Roots are poorly developed as in *Hydrilla* or absent as in *Wolffia*.
2. Plant body is greatly reduced as in *Lemna*.
3. Submerged leaves are narrow or finely divided. e.g. *Hydrilla*.
4. Floating leaves have long leaf stalks to enable the leaves move up and down in response to changes in water level. e.g. Lotus.
5. Air chambers provide buoyancy and mechanical support to plants as in *Eichhornia* (swollen and spongy petiole).

Hydrilla *Wolffia* *Lemna*

Eichhornia Lily Lotus

Figure 6.4 Hydrophytes

DO YOU KNOW?

Water hyacinth (*Eichhornia crassipes*) is a very charming plant. It is called as '***Cindrella of the plant kingdom***'. It covers entire surface of the water resources like ponds and lakes. It will not allow the light to penetrate into the water and increases the ***Biological Oxygen Demand*** leading to the death of aquatic plants and animals. It also alters the water clarity and decreases phytoplankton production, dissolved oxygen, nitrogen, phosphorus and heavy metals. During monsoon, it blocks the flow of water. During summer, the lake with water hyacinth evaporates nine times faster than the lake with no water hyacinth. Apart from its adverse effects, it is used as a green manure or converted as compost. It is also used as animal fodder. It can be processed to make paper, rope, handbags and even furniture.

Water Hyacinth

6.2.2 Xerophytes

Plants that grow in dry habitat are called xerophytes. These plants develop special structural and physiological characteristics to meet the following conditions:

(i) To absorb as much water as they can get from the surroundings.

(ii) To retain water in their organs for very long time.

(iii) To reduce the transpiration rate.

(iv) To reduce consumption of water.

Acacia

Calotropis

Opuntia

Figure 6.5 Xerophytes

Adaptations of xerophytes

1. They have well developed roots. Roots grow very deep and reach the layers where water is available as in *Calotropis*.
2. They store water in succulent water storing parenchymatous tissues. e.g. *Opuntia*, *Aloe vera*.
3. They have small sized leaves with waxy coating. e.g. *Acacia*. In some plants, leaves are modified into spines. e.g. *Opuntia*.
4. Some of the xerophytes complete their life cycle within a very short period when sufficient moisture is available

6.2.3 Mesophytes

Mesophytes are common land plants which grow in situations that are neither too wet nor too dry. They do not need any extreme adaptations.

Adaptations of mesophytes

1. The roots of mesophytes are well developed and are provided with root caps.

2. The stem is generally straight and branched.
3. The leaves are generally broad and thin.
4. The presence of waxy cuticle in leaves traps the moisture and lessens water loss.
5. Leaves have stomata which close in extreme heat and wind to prevent transpiration.

6.3 Adaptations of animals to Habitat, Temperature and Light

Animals can adapt themselves according to their habitat. Temperature and light are forms of energy which influence various stages of life activities such as growth, metabolism, reproduction, movement, distribution and behaviour. Animals develop special features or behaviour patterns to escape from extreme conditions of temperature and light. In this context, let us study the adaptive features of bat and earthworm.

GCQTDV

6.3.1 Adaptations of Bat

Bats are the only mammals that can fly. Mostly, bats live in caves. Caves provide them protection during the day from most predators and the temperature here is very stable. Apart from caves, bats also live in trees, hollowed logs and rock crevices. They are extremely important to humans as they reduce insect population and help to pollinate plants. Here, we will see the adaptations of bat in relation to their habitat.

Nocturnality

Bats are active at night. This is a useful adaptation for them, as flight requires a lot of energy during day. Their thin, black wing membrane (Patagium) may cause excessive heat absorption during the day. This may lead to dehydration.

Flight adaptation

Bat wings are entirely different from those of birds or insects. Modified forelimbs serve as wings. The bones in the wings of bats are elongated fingers and are connected by the flaps of skin on either side of the body known as Patagia. Tail supports and controls movements during flight. Muscles are well developed and highly powerful and achieve in beating of wings. Tendons of hind limbs provide a tight grasp when the animals are suspended upside down at rest.

Hibernation

Hibernation is a state of inactivity in which the body temperature drops with a lowered metabolic rate during winter. Bats are warm blooded animals but unlike other mammals, they let their internal temperature reduce when they are resting. They go to a state of decreased activity to conserve energy.

Echolocation

Bats are not blind. But to fly around and hunt for insects in the dark, they use a remarkable high-frequency system called echolocation. Bats give out high-frequency sounds (ultrasonic sounds). These sounds are reflected back from its prey and perceived by the ear. Bats use these echoes to locate and identify the prey.

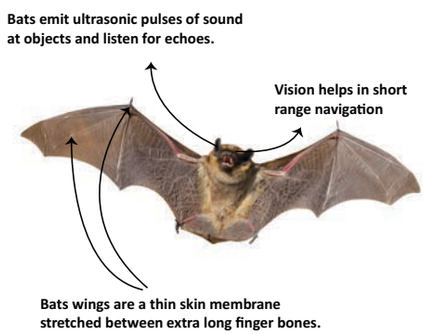

Figure 6.6 Bats

6.3.2 Adaptations of Earthworm

An earthworm is a segmented worm which belongs to Phylum Annelida. It is commonly found living in soil, feeding on live and dead organic matter. The faecal wastes are called worm castings (Vermicasts) which are rich in nitrogenous content adding fertility to the soil. Earthworm plays a large role in keeping soil health facilitating aeration, water infiltration and producing organic matter to increase crop growth. Some of the adaptations of earthworm are explained below.

Stream-lined body

The earthworm has a cylindrical, elongated and segmented body. This helps them to live in narrow burrows underground and for easy penetration into the soil.

Skin

Mucus covers the skin which does not allow soil particles to stick to it. The slippery skin is kept moist as it respires through the skin. Moist skin helps in oxygenation of blood.

Burrowing

Its body is flexible having circular and longitudinal muscles which help in movement and subsoil burrowing. Each segment on the lower surface of the body has number of bristles called setae. They help the earthworm to move through the soil and provide anchor in the burrows.

Aestivation

When the soil becomes too hot or dry, earthworms become inactive and undergo a process called aestivation. Earthworm moves deeper into the soil. It secretes mucus and lowers their metabolic rate in order to reduce water loss. They remain dormant until conditions become favourable. They come out of their burrow during rainy season. The ideal temperature range is 60-80°F. The ability to tolerate temperature depends on the surrounding moisture in the environment.

Nocturnality

Earthworms are sensitive to light. It has no eyes but can sense light through light sensitive cells (Photo-receptors) present in their skin. They give the skin the capacity to detect light and changes in light intensity. They react negatively to bright light (Photophobic). It remains in its burrow during the day to avoid light.

Figure 6.7 Earthworms

DO YOU KNOW?

Earthworms are referred as '***Farmer's friend'.*** After digesting organic matter, earthworms excrete a nutrient- rich waste product called castings.

Vermicompost is a manure prepared by using earthworms to speed up the process of decomposition of plant and animal waste. Vermicomposting is a fundamental practice of organic gardening. Vermicompost helps better plant growth and crop yield, improves physical structure of soil, increases the water holding capacity of soil and is helpful in elimination of biowastes.

6.4 Water conservation

Water is one of the precious natural resources. Clean and fresh water is essential for almost every human activity. Pollution has decreased our own water supply. We are polluting and decreasing the water for all creatures on earth.

Water conservation is the preservation, control and management of water resources. It also includes activities to protect the hydrosphere and to meet the current and future human demand.

6.4.1 Importance of water conservation

- It creates more efficient use of the water resources.
- It ensures that we have enough usable water.
- It helps in decreasing water pollution.
- It helps in increasing energy saving.

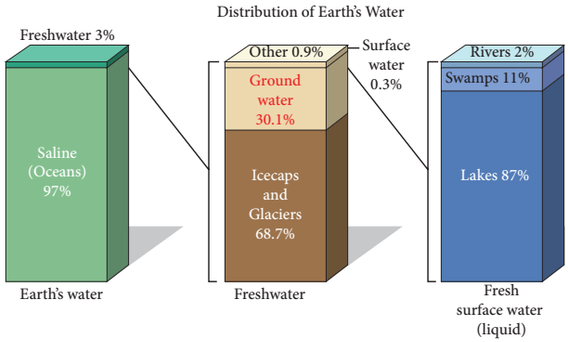

Figure 6.8 Distribution of Earth's water

Activity 2

Write slogans to support conservation of water.

1. ----------

2. ----------

3. ----------

6.4.2 Ways of water conservation

Industrial conservation

Water conservation measures that can be taken by industries are:

- using dry cooling systems.
- if water is used as cooling agent, reusing the water for irrigation or other purposes.

Agricultural conservation

Agricultural water is often lost due to leaks in canals, run off and evaporation. Some of the water conserving methods are:

- using lined or covered canals that reduce loss of water and evaporation.
- using improved techniques such as sprinklers and drip irrigation.
- encouraging the development of crops that require less water and are drought resistant.
- mulching of soil in vegetable cultivation and in horticulture.

DO YOU KNOW?

World Water Day on 22nd March every year, is about focusing attention on the importance of water.

The theme for World Water Day 2018 is 'Nature for Water'- exploring nature-based solutions to the water challenges we face in the 21st century.

Domestic conservation

All of us have the responsibility to conserve water. We can conserve water by the following activities:

- Using a bucket of water to take bath than taking a shower.
- Using low flow taps.
- Using recycled water for lawns.
- Repairing the leaks in the taps.
- Recycling or reusing water where ever it is possible.

6.4.3 Some of the strategies to support water conservation

(i) Rain water harvesting.
(ii) Improved irrigation techniques.
(iii) Active use of traditional water harvesting structures.
(iv) Minimising domestic water consumption.
(v) Awareness on water conservation.
(vi) Construction of farm ponds.
(vii) Recycling of water.

6.5 Farm ponds

Farm ponds are used as one of the strategies to support water conservation. Much of the rainfall runs off the ground. The run off not only causes loss of water but also washes away precious top soil. Farm ponds help the farmers to store water and to use it for irrigation.

6.5.1 Layout of a farm pond

Farm pond is a dugout structure with definite shape and size. They have proper inlet and outlet structures for collecting the surface runoff flowing from the farm area. The size and depth of the pond depend upon the amount of land available, the type of soil, water requirement of farmers and the cost of excavation. The stored water is used for irrigation.

Figure 6.9 Farm pond

6.5.2 Advantages of farm ponds

The advantages of farm ponds are:

- They provide water to growing crops, without waiting for rainfall.
- They provide water for irrigation, even when there is no rain.
- They reduce soil erosion.
- They recharge ground water.
- They improve drainage.
- The excavated soil can be used to enrich soil in fields and levelling lands.
- They promote fish rearing.
- They provide water for domestic purposes and livestock.

6.5.3 Limitations of farm ponds

- Farm ponds reduce water flow to other tanks and ponds situated in lower-lying areas.
- They occupy a large portion of farmer's lands.

6.6 Water recycling

Water recycling, apart from rain water harvesting, is also one of the key strategies to conserve water. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, flushing in toilets and ground water recharge.

DO YOU KNOW?

Grey water is reusable waste water from residential, commercial and industrial bathroom sinks, bath tub, shower drains and washing of clothes. Use of non-toxic and low sodium soap and personal care products is required to protect vegetation when reusing grey water for irrigation.

6.6.1 Water recycling stages

Conventional waste water treatment consists of a combination of physical, chemical and biological processes which remove solids, organic matter and nutrients from waste water. The waste water treatment involves the following stages:

Primary treatment

Primary treatment involves temporary holding of the waste water in a tank. The heavy solids get settled at the bottom while oil, grease and lighter solids float over the surface. The settled and floating materials are removed. The remaining liquid may be sent for secondary treatment.

Activity 3

Make a poster depicting the ways and importance of conserving water and recycling of water.

Secondary treatment

Secondary treatment is used to remove the biodegradable dissolved organic matter. This is performed in the presence of oxygen by aerobic microorganisms (Biological oxidation). The microorganisms must be separated from treated waste water by sedimentation. After separating the sediments of biological solids, the remaining liquid is discharged for tertiary treatment.

Tertiary treatment

Tertiary or advanced treatment is the final step of sewage treatment. It involves removal of inorganic constituents such as nitrogen, phosphorus and microorganisms. The fine colloidal particles in the sewage water are precipitated by adding chemical coagulants like alum or ferric sulphate.

Inlet - sewage water

↓

Primary treatment(physical)

- Sedimentation (heavy solids)
- Floatation (oil, grease, lighter solids)
- Filtration

↓

Secondary treatment(biological)

- Biological oxidation (biodegradable dissolved organic matter)
- Sedimentation (biological solids)
- Filtration

↓

Tertiary treatment (physio-chemical)

- (nitrogen, phosphorus, suspended solids, heavy metals)
- Disinfection (chlorination 5-15mg/l)

↓

Outlet- recycled water

6.6.2 Uses for recycled water

- Agriculture
- Landscape
- Public parks
- Golf course irrigation
- Cooling water for power plants and oil refineries
- Toilet flushing
- Dust control
- Construction activities

6.7 IUCN (International Union for Conservation of Nature and Natural Resources)

IUCN is an international organization working in the field of nature conservation and sustainable use of natural resources. It provides public, private and non- governmental organizations with the knowledge to enable human progress, economic development and nature conservation to take place together. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

Vision of IUCN

The vision of IUCN is 'A just world that values and conserves nature'.

Mission of IUCN

The mission of IUCN is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. IUCN has widened its focus beyond conservation of ecology and now incorporates issues related to sustainable development in its projects. It tries to influence the actions of governments, business and other stakeholders by providing information and advice.

The organization is best known to the wider public for compiling and publishing the IUCN red list of threatened species, which assesses the conservation status of species worldwide.

India, a mega diverse country with only 2.4 % of world's land area, accounts for 7-8% of all recorded species. It includes over 45,000 species of plants and 91,000 species of animals. The country's diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, wetlands, grasslands, desert, coastal and marine ecosystems. Four of 34 globally identified biodiversity hotspots are found in India. They are:

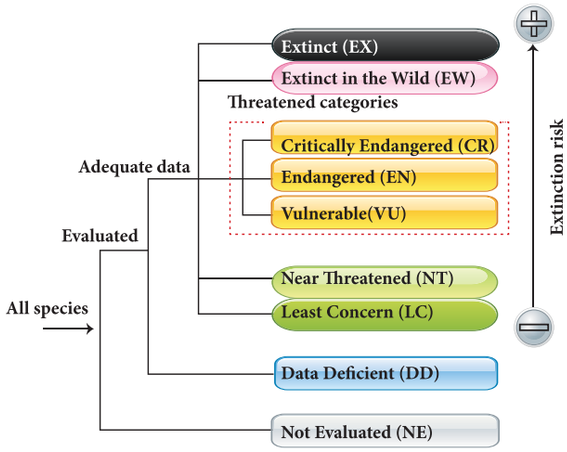

Figure 6.10 Red list categories of IUCN

- The Himalayas
- The Western ghats
- The North-East
- The Nicobar islands

India became state member of IUCN in 1969, through the Ministry of Environment, Forest and Climate change(MoEFCC). The following data for plants and animals in India is given in Table 6.2 available on the IUCN Red List Version 2017-3 (Table 6 A & B). It has been last updated on 5th December 2017.

IUCN was founded on 5th October 1948 at Gland, Switzerland.

Table 6.2 IUCN Red List Categories

Category	EX	EW	CR	EN	VU	NT	LR/cd	DD	LC
Plants	6	2	72	175	143	45	1	77	932
Animals	0	0	77	207	391	330	2	784	3774

CR: Himalayan brown/red bear

EN: Red Panda

Figure 6.11 Animals in Red List

Points to Remember

- Environmental science is the study of patterns, processes in the natural world and their modification by human activities.
- Biotic or living factors include plants, animals and all other living organisms.
- Abiotic or non-living factors include all factors which affect ability of organisms to survive and reproduce like water, soil, air and sunlight.
- Cyclic flow of nutrients between non-living environment and living organisms are termed as biogeochemical cycles.
- *Nitrogen fixation* is the conversion of atmospheric nitrogen into reactive compounds available to living organisms.
- The process of decomposition of nitrogenous waste by putrefying bacteria and fungi into ammonium compounds is called *ammonification.*
- The ammonium compounds formed by ammonification process is oxidised to soluble nitrates. The process of nitrate formation is known as *nitrificatio*n.
- Hydrophytes may be free floating or submerged plants living in lakes, ponds, shallow water, marshy lands and marine habitat.
- Plants that grow in dry habitat are called xerophytes.
- Mesophytes are common land plants which grow in situations that are neither too wet nor too dry.
- Animals develop special features or behaviour patterns to escape from the extreme conditions of temperature and light.
- When the soil becomes too hot or dry, earthworms become inactive and undergo a process called Aestivation.
- Hibernation is a state of inactivity in which the body temperature of earthworms drops with a lowered metabolic rate during winter.
- Water conservation is the preservation, control and management of water resources.
- Farm pond is a dugout structure with definite shape and size. They have proper inlet and outlet structures for collecting the surface runoff flowing from the farm area.
- Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing and ground water recharge.
- IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

GLOSSARY

Aestivation	A state of inactivity and a lowered metabolic rate in animals, during summer.
Assimilation	The conversion of nutrients into usable form that is incorporated into the tissues and organs.
Biogeochemical cycle	The cyclic flow of nutrients between non-living environment and living organisms.
Buoyancy	The capacity to remain afloat in liquid or gas.
Echo location	The use of sound waves and their echoes to determine the location of objects.
Hibernation	A state of inactivity and a lowered metabolic rate in animals, during winter.
Infiltration	The process by which water on the ground surface enters the soil.
Precipitation	Any product of condensation of atmospheric water vapour that falls on earth.
Setae	The hair-like locomotory structure, present in each segment of an earthworm.
Stomata	Minute pores in the epidermis of leaves which facilitate gaseous exchange and transpiration.
Sublimation	The conversion of solid state into vapour state without going through a liquid state.

TEXTBOOK EVALUATION

GCZPFI

I. Choose the correct answer.

1. All the factors of biosphere which affect the ability of organisms to survive and reproduce are called as _____.
   a. biological factors
   b. abiotic factors
   c. biotic factors
   d. physical factors

2. The ice sheets from the north and south poles and the icecaps on the mountains, get converted into water vapour through the process of_____.
   a. evaporation b. condensation
   c. sublimation d. infiltration

3. Free living soil bacteria such as Pseudomonas sp. are responsible for the _____ process in the nitrogen cycle.
   a. ammonification
   b. nitrogen fixation
   c. nitrification
   d. denitrification

4. The atmospheric carbon dioxide enters into the plants through the process of _____.
   a. photosynthesis
   b. assimilation
   c. respiration
   d. decomposition

5. Increased amount of _____ in the atmosphere, results in greenhouse effect and global warming
   a. carbon monoxide
   b. sulphur dioxide
   c. nitrogen dioxide
   d. carbon dioxide

6. Which of the following is not an adaptation of hydrophytes?
   a. poorly developed root system
   b. reduced plant body
   c. water storing parenchymatous tissues
   d. finely divided submerged leaves

7. In some xerophytes, leaves are modified into spines as an adaptation _____.
   a. to reduce transpiration rate
   b. to store water
   c. to reduce consumption of water
   d. all of the above

8. Identify the incorrect statement with respect to adaptations of earthworm.
   a. Earthworm has a stream lined body with no antennae or fins.
   b. Each segment of earthworm has setae.
   c. Many earthworms become inactive in a process called hibernation, during winter season.
   d. Earthworms remain in its burrow during day time, to avoid sunlight.

9. Which of the following is one of the strategies to conserve water?
   a. Water recycling
   c. Increasing the number of bore wells
   b. Using large overhead water tanks
   d. Watering the plants using hose

10. Specific constituents such as nitrogen, phosphorus, suspended solids and heavy metals found in the wastewater are removed during _____ treatment of water recycling process.
   a. primary
   c. tertiary
   b. secondary
   d. none of the above

II. Match the following.

Microorganism	Role Played
Nitrogen fixation	Nitrosomonas
Ammonification	Azotobacter
Nitrification	Pseudomonas species
Denitrification	Putrefying bacteria

III. State whether the statements are true or false. Correct the false statements.

1. Nitrogen is a greenhouse gas.
2. Poorly developed root is an adaptation of mesophytes.
3. Bats are the only mammals that can fly.
4. Earthworms use the remarkable high frequency system called echoes.
5. Aestivation is an adaptation to overcome cold condition.

IV. Answer in brief.

1. What are the two factors of biosphere?
2. According to you, which process of water cycle is adversely affected by human activities?
3. How do human activities affect nitrogen cycle?
4. What is adaptation?
5. What are the challenges faced by hydrophytes in their habitat?

6. Identify the given plant. How does it adapt itself to its habitat?

7. Why is it important to conserve water?
8. List some of the ways in which you could save water in your home and school?
9. What is grey water?
10. What are the uses of recycled water?
11. What is IUCN? What is the vision of IUCN?

V. Answer in detail.

1. Describe the processes involved in the cyclic flow of water between biotic and abiotic factors of biosphere?
2. Explain carbon cycle with the help of a flow chart? How can you reduce your contribution of carbon dioxide to the atmosphere?
3. What are the conditions in a dry habitat to which plants develop adaptations? List out the adaptations of xerophytes?
4. How does a bat adapt itself to its habitat and also in response to temperature and light?
5. What is water recycling? Explain the conventional wastewater recycling treatment?

VI. Give reason.

1. Roots grow very deep and reach the layers where water is available. Which type of plants develops the above adaptation? Why?
2. Why streamlined bodies and presence of setae is considered as adaptations of earthworm?
3. Echo location serves as an adaptation in bats. Justify the given statement.
4. Farm ponds serve as an excellent water conservation strategy. Why is it impossible for all farmers to construct it in their fields?

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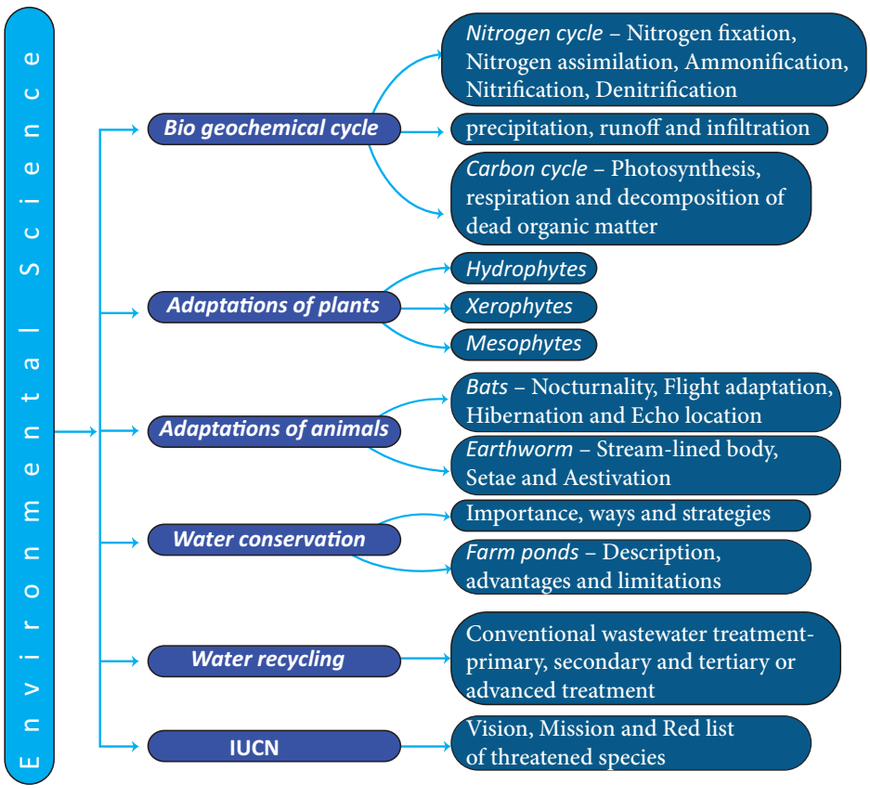
INTERNET RESOURCES

1. www.freedringkingwater.com
2. www.freesciencefairproject.com
3. www.gissnasa.gov
4. www.nature.com
5. www.sciencefocus.com
6. www.sciencelearn.org
7. www.batsorg.com
8. www.fao.org
9. www.worldwaterday.org
10. www.IUCN.org

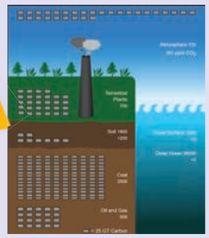
Concept Map



ICT CORNER

Environmental Science

Experiment with *Carbon cycle* using virtual simulator.



Steps

- Type the given URL to reach "The Carbon Cycle" simulation page.
- Press "Run Decade" button to observe the carbon cycle accumulating every 10 years.
- Select "Curb Emission" from "lesson" tab and adjust the simulation parameters to watch the effect of cycle.
- Select "Feedback Effects" from "lesson" tab and run the cycle and analyze the carbon accumulation result.


Step1


Step2


Step3


Step4

Carbon cycle

URL: https://www.learner.org/courses/envsci/interactives/carbon/carbon.html
or Scan the QR Code.

*Pictures are indicative only

B567_9_SCI_EM_T3

UNIT

7

Economic Biology

GD9KH6

Learning Objectives

At the end of this lesson, students will be able to

- know about horticulture and floriculture.
- classify bio manures and know their importance.
- know the steps involved in mushroom cultivation.
- differentiate between hydroponics, aquaponics and aeroponics.
- know the importance of dairy farming and cattle breeds.
- gain knowledge on the aspects of aquaculture and pisciculture.
- understand the culture practices of economically important fishes and crustaceans.
- gain awareness on vermicomposting methods and the benefits of vermicompost.
- identify the commercial products obtained from apiculture.

Introduction

The gift of nature is almost unlimited and thus a variety of useful products are obtained from plants. Economic plants are numerous and have a variety of uses. Many of them occur in nature, particularly in hills and forests while a number of them are cultivated for food and industry. Economic uses of plants are varied and therefore the scope for improvement and their cultivation is immense to meet our ever growing demands with the advancement of civilization. Floriculture and Horticulture have created considerable public awareness. Several drug yielding plants are known and utilised as medicinal herbs in crude form (indigenous way) from ancient days. Edible mushrooms are valuable source of supplementary protein, hence their cultivation is gaining importance.

In recent scenario more emphasis is given to the progress of economic aspects of zoology like aquaculture (culture of fish, prawn, crabs, pearl and edible oysters), vermiculture, apiculture and dairy farming which are gaining more importance as animal-based farming due to their economic and commercial values. Attention is now given to find out ways and means to get more food to meet the demand of the growing population without depleting the environment and natural resources. Animal farming has now become an agro based entrepreneurship and is beneficial to rural farmers. The yield of animal food products has increased to satisfy the increasing demand of food for the

growing population. Bee keeping (Apiculture) and vermiculture are also progressing and in future they may be considered as important commercial trade.

7.1 Horticulture

Horticulture is a branch of agriculture that deals with cultivation of fruits, vegetables, and ornamental plants. The word horticulture is derived from the latin words 'hortus' meaning garden and 'colere' meaning to cultivate. Horticulture is both a science and an art of growing plants with improved growth, quality, yield, and with resistance to diseases, insects, stress etc. There are four main classes of horticulture: (i) Pomology (fruit farming), (ii) Olericulture (vegetable farming), (iii) Floriculture (flowers farming), (iv) Landscape gardening.

7.1.1 Pomology or Fruit farming

The term pomology is derived from the latin word 'pomum' means fruit and 'logy' means study. It deals with development, enhancement of fruit quality, cultivation techniques, regulation of production periods and reduction of production cost of fruits.

More to Know

- More than 10 million tonnes of Bananas are produced worldwide.
- India is the largest producer of guava, litchi and mango, and the second largest producer of sapota.

7.1.2 Olericulture or Vegetable farming

Olericulture is the science of growing vegetables. Vegetable farming can be classified into: i) Kitchen or Nutrition gardening ii) Commercial gardening iii) Vegetable forcing.

Kitchen gardening

Kitchen gardening is growing of vegetables in small scale at household. e.g. Beans, Cabbage, Lady's finger, Tomato, Brinjal, Carrot, Spinach etc.

Figure 7.1 Kitchen gardening

Commercial gardening

It is the production of vegetables in large scale to be sold in markets.

Figure 7.2 Commercial gardening

INFO BIT

UZHAVAN APP

Government of Tamil Nadu has launched Uzhavan (farmer) mobile application. It can be used by farmers to gather information on farm subsidies, farm equipments, crop insurance and weather conditions. It also provides information on available stock of seeds and fertilizers in local government and private stores.

Activity 1

Discuss in your class room about the importance of crop insurance to farmers.

Vegetable forcing

It is the method of growing vegetables in buildings, green houses, cold farms or under other artificial growing conditions. It is the most intensive type of vegetable growing. e.g. Cabbage, Tomato, Brinjal etc.

Figure 7.3 Vegetable forcing

- India is the second largest producer of vegetables next to China.
- India stands first in the world in the production of potato and lady's finger, second in the production of brinjal, cabbage, peas, onion, cauliflower and tomato.

Green House or Poly House

It is a framed structure covered with transparent material to grow crops under partialiy or fully controlled environmental conditions to get optimum growth and productivity. It is the fastest growing sector in the agriculture worldwide.

Advantages of Green House

1. Disease-free plants can be produced continuously.
2. Water requirement of crops is very low.
3. Yield is very high compared to outdoor cultivation.
4. Limited pesticide is needed.
5. It protects plants from uncertain weather.

Figure 7.4 Green House

INFO BIT

Pradhan Mantri Fasal BimaYojana (PMFBY)

It is an agricultural crops insurance scheme of Indian government. Under this scheme the central government provides insurance cover and financial assistance to farmers. It was launched on 18th February 2016.

7.1.3 Floriculture or Flower farming

Floriculture is the art of cultivation of flowering and ornamental plants in garden for beauty or floristry. It is concerned with growing traditional flowers, cut flowers, bedding plants, foliage potted plants, arboriculture trees, turf grass for beautification and value added products like essential oils, pharmaceutical and nutraceutical compounds. Examples: Geraniums (*Pelargonium*), Busy lizzies (*Impatiens*), *Chrysanthemum* and *Petunia*.

Figure 7.5 Flower Farming

More to Know

Floriculture Zones of Tamil Nadu

Zones	Flowers
Hosur Zone	Jasmine, Marigold, *Chrysanthemum*, Rose
Chennai Zone	Jasmine, *Crossandra*, Marigold
Madurai Zone	Jasmine, Marigold, Scented rose, *Nerium*, *Crossandra*
Trichy Zone	Jasmine, Rose, Scented rose
Coimbatore Zone	Jasmine, Tuber rose, *Celosia*, Scented rose
Kanyakumari Zone	Jasmine, Scented rose
Hill area Zone	*Chrysanthemum*, Marigold.

Uses of flowers

1. Flowers are used for decoration purpose.
2. They are also used for personal needs and, religious and ceremonial offerings.
3. They impart colour and beauty to the garden.
4. They increase country's economy.

Cultivation and growing of loose flowers mostly for worship, garland making and decoration is the domestic industry of India with an annual growth rate of about 30%. It is a business of approximately 10,000 crore rupees.

7.1.4 Landscape gardening

Landscape horticulture is the study of designing and constructing landscapes in homes, business firms and public areas.

Figure 7.6 Landscape gardening

7.2 Manuring (Biomanuring)

Organic manures are predominantly derived from plant debris, animal faeces and microbes. They make the soil fertile by adding nutrients like nitrogen. Few of them are listed below.

7.2.1 Animal manure

It consists of faeces and urine from livestocks like cattle, horses, pigs, sheep, chickens, turkeys, rabbits, etc. Manures from different animals have different qualities and different applications.

a. Farmyard manure

It is a mixture of cattle dung, urine, litter material and other dairy wastes. On an average well decomposed farm yard manure contains 0.5% Nitrogen, 0.2% available phosphate and 0.5% available potash.

b. Sheep and Goat manure

It contains higher nutrients than farm yard manure. It contains 3% Nitrogen, 1% phosphorus pentoxide and 2% potassium oxide.

7.2.2 Compost

Compost is a soil conditioner as well as a fertilizer, which is rich in nutrients. It is produced by natural decomposition of organic matter such as crop residues, animal wastes, food wastes, industrial and municipal wastes by microorganisms under controlled conditions.

Vermicompost is the method of making compost with the use of earthworms, which generally live in soil. They eat biomass and excrete it in digested form. This compost is generally called vermicompost.

Figure 7.7 Earthworms

7.2.3 Green manure

Green manure is obtained by collection and decomposition of green leaves, twigs of trees, shrubs and herbs growing in wastelands, field bunds etc. Green manure improves soil structure, increases water holding capacity and decreases soil loss by erosion. It also helps in reclamation of alkaline soils and reduces weed proliferation. It is a manure obtained from undecomposed green material derived from leguminous plants e.g. Sunhemp (*Crotolaria juncea*), Dhaincha (*Sesbania aculeata*), Sesbania (*Sesbania speciosa*).

7.3 Biofertilizers

Biofertilizers are substances that contain living microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant.

7.3.1 Types of Biofertilizers

Rhizobium

Rhizobium is a soil bacterium that colonize the roots of leguminous plants to form root nodules. The bacteria fix atmospheric nitrogen and convert them to ammonia.

Figure 7.8 *Rhizobium* biofertilizer

Azospirillum

Azospirillum has the ability to use atmospheric nitrogen and transport this nutrient to the crop plants. It is inoculated on maize, barley, oats and sorghum crops. It increases productivity of cereals by 5 - 20%, of millets by 30% and fodder by over 50%.

Figure 7.9 *Azospirillum* biofertilizer

Azotobacter

Application of *Azotobacter* has been found to increase yield of wheat, rice, maize and sorghum. Apart from nitrogen fixation, these organisms are capable of producing antifungal and antibacterial compounds.

Figure 7.10 *Azotobacter* biofertilizer

Mycorrhizae

These fungi have symbiotic association with the roots of vascular plants. They increase the uptake of phosphorus. e.g. Citrus, Papaya.

Figure 7.11 *Mycorrhizae* biofertilizer

Azolla

Azolla is a free floating, aquatic fern found on water surfaces having a cyanobacterial symbiotic association with *Anabaena.* It is a live floating nitrogen factory using energy from photosynthesis to fix atmospheric nitrogen.

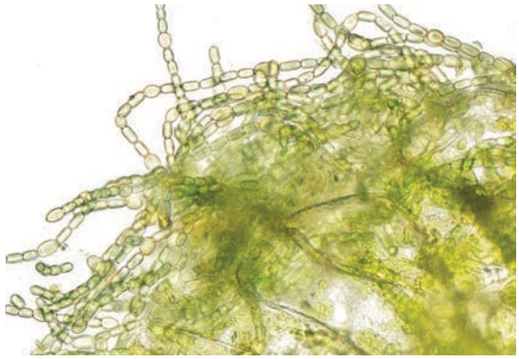


Figure 7.12 *Azolla* biofertilizers

Info bits

Biofertilizer Scheme

Tamil Nadu Government has recently launched '**Biofertiliser Scheme**'. It is aimed at better management of natural farming and helps to boost and maintain soil fertility.

7.4 Medicinal Plants

The history of the medicinal plants is as old as the history of human beings. Most medicines are obtained either directly or indirectly from plants. All the major system of medicines such as Ayurveda, Yoga, Unani, Siddha, Homeopathy (AYUSH) use drugs obtained from plants and animals. These drugs from medicinal plants are called secondary metabolites. Plants produce primary metabolites for their own living e.g. carbohydrates, amino acids etc., and secondary metabolites for protection, competition and species interaction. e.g. alkaloids, terpenoids, flavonoids etc. Phytochemistry is the study of phytochemicals which are chemical substances derived from various parts of the plant. Few plant derived drugs are described in (Table 7.1).

Activity 2

Collect at least five medicinal plants from your locality. Identify the plant and try to find out its medicinal value.

Table 7.1 Drugs derived from Medicinal plants

S. No.	Tamil Name	Botanical Name	Drug	Parts used	Disease cured
1	Katralai	*Aloe vera*	Anthraquinones	Leaves	Heal wounds, Skin disease, Cancer.
2	Tulsi	*Ocimum sanctum*	Essential oil	Leaves	Cold, Fever, Skin disease
3	Nannari	*Hemidesmus indicus*	Terpene	Roots	Bacterial infections, Diarrhoea
4	Nilavembu	*Andrograhis paniculata*	Terpenoids	All parts	Dengue fever, Diabetes, Chikungunya
5	Vepalai	*Wrightia tinctoria*	Flavonoids	Latex, Leaves	Psoriasis, Diarrhoea, Swellings
6	Cinjona maram	*Cinchona officinalis*	Quinine	Bark	Malaria, Pneumonia
7	Chivan Amalpodi (Sarpagandha)	*Rauwolfia serpentina*	Reserpine	Root	Blood pressure, Antidote for Snake bite
8	Thaila maram	*Eucalyptus globulus*	Essential oil	Leaves	Fever, Headache
9	Pappali	*Carica papaya*	Papain	Leaf, Seed	Dengue
10	Nithya kalyani	*Cathyranthus roseus*	Alkaloids	All parts	Leukemia, Cancer

More to Know

Father of Indian Medicines

Ayurveda	**Charaka Samhita**
Yoga	**Patanjali**
Unani	**Hippocrates (BUKRATH)**
Siddha	**Agasthya**
Homeopathy	**Samuel Hahnemann**

Info bits

The Council of Scientific and Industrial Research (CSIR) and National Botanical Research Institute (NBRI) and Central Institute for Medicinal and Aromatic Plants (CIMAP) have jointly launched India's first anti diabetic ayurvedic drug **BGR -34** (BGR-Blood Glucose Regulator). It contains 34 identified active phytoconstituents from herbal resources. It works by controlling blood sugar levels.

7.5 Mushroom Cultivation

Mushroom cultivation is a technology of growing mushrooms using plant, animal and industrial waste. In short it is wealth out of waste technology. This technology has gained importance worldwide because of its dietary fibres and proteins value. Mushroom is a fungi belonging to basidiomycetes. It is rich in proteins, fibres, vitamins and minerals. There are more than 3000 types of mushrooms. e.g. Button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus sps.*), Paddy straw mushroom (*Volvariella volvacea*). The cultivation takes one to three months. Major stages of mushroom cultivation are explained below.

Composting

Compost is prepared by mixing paddy straw with number of organic materials like cow dung and inorganic fertilizers. It is kept at about 50°C for one week.

DO YOU KNOW?

Ganoderma lucidum, is commonly known as lingzhi mushroom which produces triterpenes, similar to steroids. It has the following benefits for human:

- Oxygenates the body and boosts stamina.
- Provides more energy and vigour.
- Increases brain power.
- Improves quality of sleep and blood circulation.
- Reduces blood pressure.

Spawning

Spawn is the mushroom seed. It is prepared by growing fungal mycelium in grains under sterile conditions. Spawn is sown on compost.

Casing

Compost is covered with a thin layer of soil. It gives support to the growing mushroom, provides humidity and helps regulate the temperature.

Pinning

Mycelium starts to form little bud, which will develop into mushroom. Those little white buds are called pins.

Harvesting

Mushroom grow better in 15°C - 23°C. They grow 3 cm in a week which is the normal size for harvesting. In the third week the first flush mushroom can be harvested.

Fig 7.13 Mushrooms

Preservation

Discolouration, weight, and flavour loss are the main problems of harvesting stage of mushrooms.

The following methods are used to increase their life.

(i) Freezing (ii) Drying
(iii) Canning (iv) Vacuum Cooling
(v) Gamma radiation and storing at 15°C.

7.6 Hydroponics

Hydroponics is the method of growing plants without soil, using mineral nutrient solutions in water. The containers are made of glass, metal or plastic. They range in size from small pots for individual plants to huge tank for large scale growing. It was demonstrated by a German Botanist Julius Von Sachs in 1980. Hydroponics is successfully employed for the commercial production of seedless cucumber and tomato. Plants are suspended with their roots submerged in water that contain plant nutrients. The roots absorb water and nutrients, but do not perform the anchoring function. Therefore, the plants must be mechanically supported from above.

Importance of hydroponics

(i) Conservation of water and nutrients.
(ii) Controlled plant growth.
(iii) In deserts and Arctic regions hydroponics can be an effective alternative method.

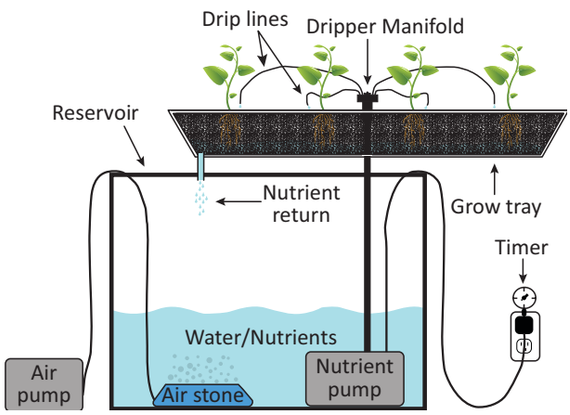


Figure 7.14 Hydroponics

7.7 Aeroponics

The aeroponic system is the high-tech type of hydroponic gardening. The growth medium in this type is primarily air. The roots hang in the air and are misted with nutrient solution. The misting is usually done for every few minutes, as roots will dry out rapidly if the misting cycles are interrupted. A timer controls the nutrient pump much like other types of hydroponic systems, except the aeroponic system needs a short cycle timer that runs the pump for a few seconds every couple of minutes.

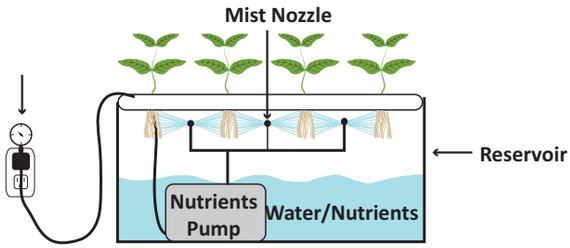


Figure 7.15 Aeroponics

7.8 Aquaponics

Aquaponics is a system of a combination of conventional aquaculture with hydroponics in a symbiotic environment, in which plants are fed with the aquatic animals' excreta or wastes. These wastes are broken down by nitrifying bacteria initially into nitrites and later into nitrates that are utilized by the plants as their nutrients. Thus the wastes are utilized and water is recirculated back to the aquaculture system.

Aquaponics consists of two main parts, aquaculture- for raising aquatic animals like fish and hydroponics-for raising plants. Green leafy vegetables like chinese cabbage, lettuce, basil, coriander, parsley, spinach and vegetables like tomatoes, capsicum, chillies, bell peppers, sweet potato, cauliflower, broccoli and egg plant can be grown in aquaponics.

Figure 7.16 Aquaponics

7.9 Dairy Farming

Dairy farming involves rising of cattle for milk production. It involves the proper maintenance of cattle along with, collection and processing of milk and milk products which are useful to man. Dairying is the production and marketing of milk and its products.

7.9.1 Cattle breeds

The Indian cattle include cows and buffaloes. They are domesticated for milk, meat, leather and transportation. They belong to two different species, *Bos indicus* (Indian cows and bulls) and *Bos bubalis* (buffaloes). These cattle animals are reared for milk and farm labour.

They are classified into three types:

(i) Dairy breeds

(ii) Draught (or) Draft breeds

(iii) Dual purpose breeds.

Dairy breeds

Dairy animals are domesticated for obtaining milk. The cows (milk producing females) are high milk yielders (**milch animals**). The dairy breeds may be indigenous breeds (or) exotic breeds.

Indigenous breeds are native of India. They include **Sahiwal, Red Sindhi, Deoni** and **Gir**. These cattle are well built with strong limbs, prominent hump and loose skin. Milk production depends on the duration of the lactation period (the period of milk production after the birth of a calf). These local breed animals show excellent resistant to diseases.

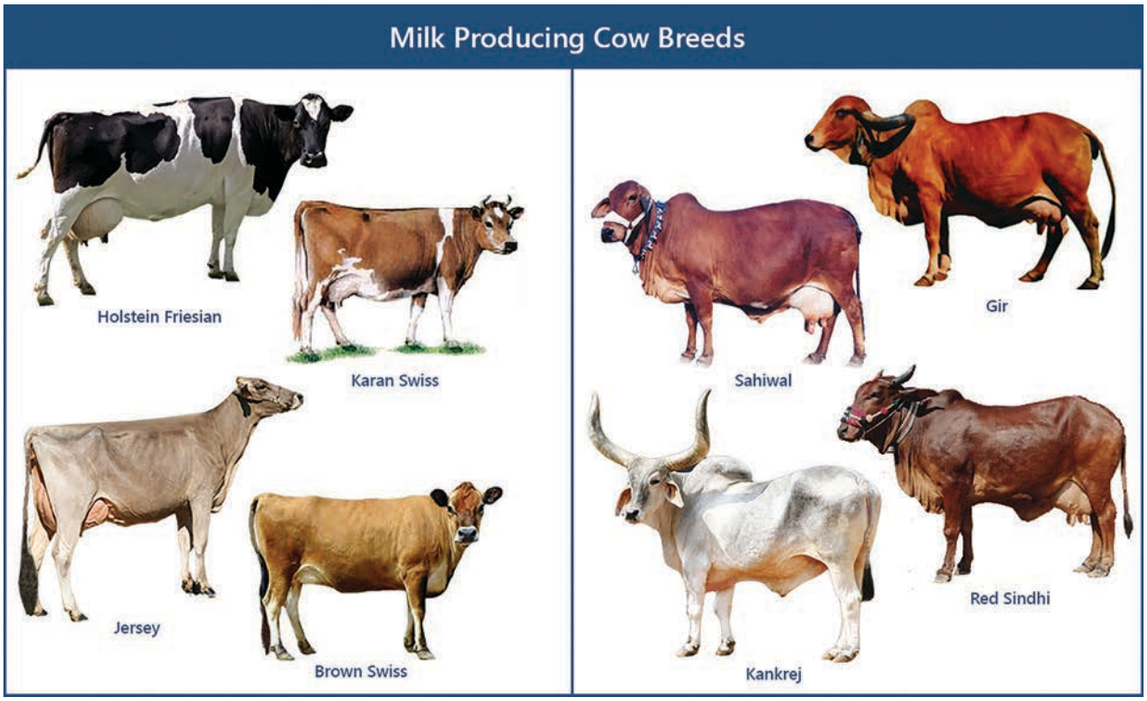


Figure 7.17 Cattle breeds

The **exotic breeds** (*Bos taurus*) are imported from foreign countries. They include **Jersey, Brown Swiss** and **Holstein-Friesian** etc. These foreign breeds are selected for long lactation periods.

The Indian (local) breeds and foreign breeds can be cross bred to produce animals with both desired qualities.

Info bits

Indigenous Draught breeds - Native to Tamil Nadu

Kangayam It is also known as kongu and konganad. It originated in Kangayam and is observed in Dharapuram, Perundurai, Erode, Bhavani and part of Gobichettipalayam taluk of Erode and Coimbatore district. The Kangayam breed was developed by the efforts of the late Pattogar of Palayamkottai, Sri N. Nallathambi Sarkari Manradia.

Bargur It is found around Bargur hills in Bhavani taluk of Erode district. It is developed for work in uneven hilly terrains.

Umblachery It is otherwise called as Jathi madu, Mottai madu, Molai madu, Therkathi madu. It originated in Thanjavur, Thiruvarur and Nagappattinam districts of Tamil Nadu and is suitable for wet ploughing and known for their strength and sturdiness.

Pulikulam This breed is commonly seen in Cumbum valley of Madurai district in Tamil Nadu. It is also known as Jallikattu madu, Kidai madu, Sentharai. They are mainly used for penning in the field and useful for ploughing. They have the typical backward curving horns of Mysore type cattle.

Draught (or) Draft breeds

They are used for agricultural work, such as tilling, irrigation and carting. These include **Amritmahal, Kangayam, Umblachery, Malvi, Siri** and **Hallikar** breeds. Bullocks are good draft animals while the cows are poor milk yielders.

Dual purpose breeds

These breeds provide milk and they are useful for farm work. In India these breeds are favoured by farmers as the cows are fairly good milk yielders and bullocks are good for draught work. They includes **Haryana, Ongole, Kankrej** and **Tharparkar**.

Buffalo breeds

In India buffaloes are domesticated in great number. They are the main milk producers. The milk production of buffaloes is more than that of cows. **Murrah**, **Mehsana** and **Surti** are indigenous buffalo breeds which are good milk yielders.

More to Know

- Young female calf is called a Heifer (Until she has her first calf). Young male is called bull calf.
- Two months before giving birth, a dairy cow takes rest from giving milk in order to grow her calf.
- Holstein cow produces maximum quantity of milk than other breeds
- Cow spends upto 6 hours a day in eating, over 8 hours a day in chewing their cud which is regurgitated (partially digested food).

Activity 3

Can you identify the indigenous cattle breeds which belong to Tamil Nadu. Name them and write any two distinguishing characters for each.

7.9.2 Composition of cattle feed and its requirements

The food requirement for cattle should support healthy life of the animal and milk producing requirement. The feed for dairy cattle is broadly classified into two:

a) Roughages
b) Concentrates

Roughage is a coarse and fibrous fodder. It consists of succulent feed (cultivated grass, fodder and root crops) and dry fodder (hay, straw and chaff).

Concentrates are low in fibre and contain high level of carbohydrates, protein and other nutrients. A variety of raw materials such as cholam (jowar), kambu (pearl millet), ragi (finger millet), rice bran, wheat bran, cotton seed cake, mustard cake, linseed cake, groundnut cake, mango seed, neem cake and yellu (sesame) cake can be used to make concentrate feed. They should also be fed on green fodder (maize, lucerne, berseem, millet, and elephant grass).

When green fodder is not available, cattle can be fed with silage. Silage can be defined as fermented high moisture stored food which can be fed to cows. It is prepared from green grass, sorghum, cereals and weeds by using the entire green plant.

7.9.3 Feed Management

Dairy cattle need balanced rations containing all nutrients in proportional amounts and food additives which contain minerals, vitamins, antibiotics and hormones to promote the growth of animals, good yield of milk and to protect from diseases. The daily average feed ratio of a milking cow is:

(i) 15-25 kg of roughage (dry grass and green fodder)
(ii) 4-5 kg of grain mixture
(iii) 100-150 litres of water

DO YOU KNOW?

The concentrates are fed at the time of milking. This helps in 'let down' of milk. For a cow that gives above 2.5 kg milk yield per day, 1 kg of concentrate feed should be given for every additional milk yield.

Table 7.2 Nutritional Information of Cow's Milk

Composition of Milk	Average Quantity per 100ml
Energy	266 kJ
Total Protein	3.4g
Casein	0.7g
Total Fat	0.4g
Saturated Fat	3.4g
Total Carbohydrate	2.3g
Sodium	44mg
Calcium	128mg

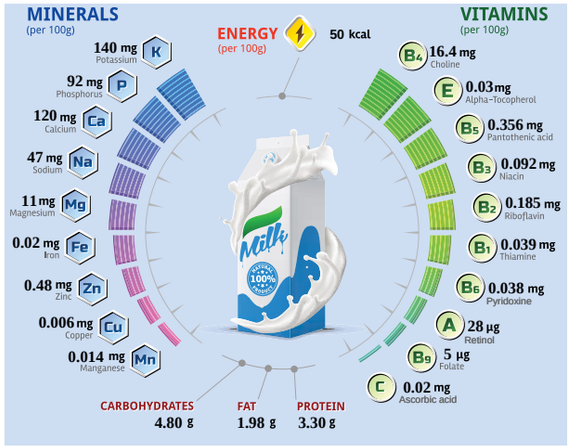


Figure 7.18 Nutrient contents of milk

7.9.4 Improvement of Livestock development in India

Several policies have been adopted by the Government to increase the livestock development in India. Improved breeding techniques in cattle have tremendously increased the production of new breeds with high capacities.

Intensive Cattle Development Programme

It is based on cross breeding of indigenous cows with exotic European breeds to increase milk production. New methods and modern equipments are made available for machine – milking of cows.

Operation Flood Programme

It is based on dairy commodity aid to increase milk supply in urban areas.

DO YOU KNOW?

Dr. Verghese Kurein, was the founder of National Dairy Development Board (NDDB) and was called the **Architect of India's Modern Dairy Industry** and the **Father of White Revolution.** NDDB designed and implemented the world's largest dairy development programme called **OPERATION FLOOD.**

More to Know

Panchagavya is an organic liquid fertilizer. This product has the potential to play the role of promoting growth and providing immunity to plant system. Panchagavya consists of various products viz. Cow dung (25%), Cow urine (25%), Fresh milk (15%), Curd (10%), Ghee (5%), Banana (5%), Tender coconut water (5%) and jaggery (10%).

Activity 4

Visit a nearby livestock farm. Make a chart of different breeds of cattle in the farm and collect the information about the following.

Number of cattle, number of different breeds, amount of daily intake of fodder and water, amount of daily milk production.

7.10 Aquaculture

Aquaculture is the rearing of economically important aquatic organisms like fishes, prawns, shrimps, crabs, lobsters, edible oysters, pearl oysters and sea weeds under controlled and confined environmental conditions using advanced technologies.

Figure 7.19 Aquatic organisms used for rearing

Info bits

Tamil Nadu is a leading state endowed with rich fishery resources from Marine, Inland and Coastal Aquaculture. The marine fisheries potential of the state is estimated at 0.719 million tonnes. The inland fishery resources have a potential to yield 4.5 lakh metric tonnes of fishes. Tamilnadu ranks sixth among the maritime states in coastal farming.

7.10.1 Types of Aquaculture

Aquaculture is classified into:

1. Freshwater aquaculture
2. Brackish water aquaculture
3. Marine water aquaculture (Mariculture)

The classification is made based on the salinity of the respective culture system.

Freshwater aquaculture

The rearing of aquatic organisms in freshwater is called freshwater aquaculture. The salinity of this water is less than 0.5 ppt (parts per thousand). Culture of organisms is carried out in pond, river, dam, lake and cold water. These freshwater resources remain within the land. Tilapia, carps (Catla, Rohu, Mrigal), catfishes, and air breathing fishes are cultured in freshwater.

Figure 7.20 Freshwater aquaculture

Marine water aquaculture

The cultivation of aquatic organisms is in sea water. This is also referred as Mariculture or Sea farming. The salinity of water ranges from 30 to 35 ppt. Culture of organisms is carried out along the sea coast (inshore area) and in deep sea. Organisms like shrimps (marine prawns), pearl oysters, edible oysters, mussels and fin fishes like salmons, trouts, sea bass, murrels, milk fishes and mullets are cultured in marine water.

Figure 7.21 Marine water aquaculture

Brackish water aquaculture

Brackish water is where sea water and freshwater mix together such as estuaries, lagoons and backwaters. The organisms are cultured in water where the salinity is more than 1 and less than 32 ppt. The important organisms cultured are Tilapia, spiny lobsters, crabs, marine prawns and milk fishes.

Info bits

The Central Marine Fisheries Research Institute (CMFRI) was established by the Government of India in 1947 at Cochin, Kerala State. Its main focus is on marine fisheries landings, research on taxonomy and bioeconomic characteristics of marine organisms.

The Central Institute of Brackish Water Aquaculture (CIBA) was established in 1987 with its headquarters at Chennai. The objective of CIBA is management of sustainable culture system for fin fish and shell fish in brackish water. CIBA assists small aquafarmers in fin fish and shrimp farming by providing sustainable modern technologies.

7.10.2 Prospects of Aquaculture

Aquaculture has become the fastest growing food producing sector to meet the demand of food and nutrition to the growing population through increased production from aquatic food resources. It aims at blue revolution. It is a major source of export and foreign exchange earnings for the country. It generates employment through fish farming in rural and under developed area.

It increases food supply and enhances nutritional status of people who rely on freshwater and marine water edible food resources. These cultured organisms are a valuable source of animal protein and also rich in vitamins and minerals.

FISH PRODUCTION IN INDIA

Aquaculture production – 2nd in South East Asian countries.

Total fish production- 7th position in the world.

Marine fish production – 10th position in the world.

7.11 Pisciculture

Pisciculture or Fish culture is the process of breeding and rearing of fishes in ponds, reservoirs (dams), lakes, rivers and paddy fields. It is the farming of economically important fishes under controlled conditions. Pisciculture helps in integrated rural development by generating employment and income to fishing community and fish farmers.

7.11.1 Types of fish culture practices

a) **Extensive fish culture**: Culture of fishes in large areas with low stocking density and natural feeding.

b) **Intensive fish culture**: Culture of fishes in small areas with high stocking density and providing artificial feed to increase production.

c) **Pond culture**: Rearing of fishes in pond water.

d) **Riverine fish culture**: Rearing of fishes in lotic water.

e) **Dam culture (Culture in Reservoir)**: Culture of fishes in artificial man made constructed reservoirs.

f) **Lake culture (Culture in Lake)**: Rearing of fishes in lakes which are natural standing water bodies.

g) **Monoculture**: Culture of single type of fish in a water body. It is also called mono species culture.

h) **Polyculture**: Culture of more than one type of fish in a water body. It is also called composite fish culture.

i) **Integrated fish farming**: It is the culture of fishes along with agricultural crops or animal husbandry farming. Rearing of fish along with paddy, poultry, cattle, pig and ducks.

7.11.2 Types of ponds for fish culture

Fish farm requires different types of pond for the various developmental stages of fish growth. They are:

a) **Breeding pond**: Healthy and sexually mature male and female fishes are collected and introduced in this pond for breeding. The eggs released by the female are fertilized by the sperm and fertilized eggs float in water as frothy mass.

b) **Hatchling pits:** The fertilized eggs are transferred to hatching pits for hatching. Two types of hatching pits are hatcheries and hatching hapas.

Figure 7.22 Spawn production (Fish Seed) and Stocking of fingerlings in hapas

c) **Nursery ponds**: The hatchlings are transferred from hatching pits after 2 to 7 days. The hatchlings grow into fry and are cultured in these ponds for about 60 days with proper feeding till they reach 2 - 2.5 cm in length.

d) **Rearing ponds**: Rearing ponds are used to culture the fry. The fish fry are transferred from nursery pond to rearing ponds and are maintained for about three months till they reach 10 to 15 cm in length. In these rearing ponds the fry develops into fingerlings.

e) **Stocking pond**: The stocking pond is also called as culture pond or production pond. These ponds are used to rear fingerlings upto the marketable size. Before releasing the fingerlings, the pond is manured with organic manure and inorganic fertilizers.

Figure 7.23 Stocking pond

7.11.3 Cultivable food fishes in India

Freshwater cultivable fishes: Indian major carps (Kendai) – Catla, Rohu, Mrigal, catfishes (Keluthi), Murrels (Veral) and Tilapia (Jilebi kendai) are cultured in freshwater.

Marine water cultivable fishes: Sea bass (Koduva), Grey mullet (Madavai) and *Chanos chanos* (Milk fish) are the fishes cultured in marine water.

Freshwater fishes

Catla - *Catla catla*

Rohu - *Labeo rohita*

Mrigal - *Cirrhinus mrigala*

Marine water fishes

Sea Bass

Grey Mullet

Milk Fish

Figure 7.24 Freshwater and Marine water fishes

7.11.4 Nutritional value of fishes

Cultivable freshwater and marine food fishes are highly nutritious, rich source of animal proteins and are easily digestible. They are rich in essential amino acids such as lysine and methionine, minerals like calcium, phosphorus, iron, sodium, potassium and magnesium. Fat soluble vitamins A, D and water soluble B-complex vitamins like pyridoxine, cyanocobalamine and niacin are found in fishes. Polyunsaturated fatty acid (PUFA) which are helpful in regulation of cholesterol are present in plenty in fishes and thus promote cardiac health.

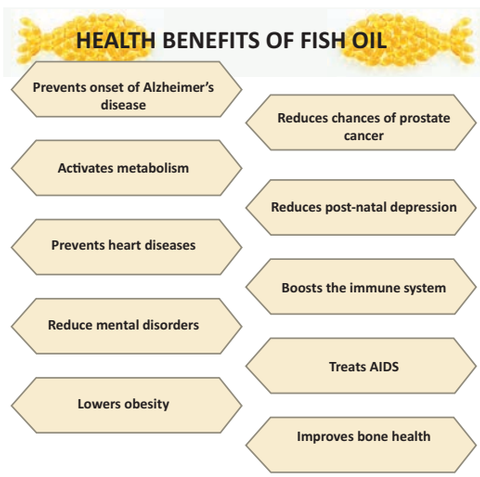
7.11.5 Fishery by-products

In addition to providing food, most of the fishing industries yield a number of by-products of commercial importance. These processed byproducts are used for human consumption and also for other purposes. These include:

a. Fish oil: It comprises of liver oil and body oil.

Liver oil of Cod, Tuna, Halibut and Shark are of great medicinal value and are rich in vitamin A, D and E.

Body oil is extracted from Sardines, Herrings, Salmons, Mackerels and Anchovies. They are used in industries for the preparation of lubricants, paints, varnishes and cosmetics.



b. Fish Meal

It is prepared from the wastes of fish oil or from whole fish and contains nutritents like protein, fat, minerals and vitamins. It is used as feed for cattle and poultry farming animals.

Other by-products obtained from fishing industry are fish flour, fish manure, fish silage, fish guano, fish sausage, fish glue, fish leather and isinglass.

Activity 5

Visit a fish farm during the breeding season near your locality and collect information about the following:

a) Different types of pond you see.
b) Different varieties of fishes in the pond.
c) Type of feed and their ingredients used to prepare feed.
d) The sources from where the fish seeds are procured.
e) The annual production of the pond.

7.12 Prawn Culture

One of the most economically important shell fish resources of India are prawns. They are crustaceans which inhabit freshwater, marine water, estuaries, backwaters and shallow waters of temperate and tropical countries. They are of great demand both in the local and international market. Due to their great taste, they are a cherished delicacy to be served as food.

In view of their popularity and marketing avenues in foreign countries there is a need for developing advanced technology and intensify prawn culture in India. The export earning from prawn and prawn products has increased tremendously during the last 25 years.

7.12.1 Commercially important prawns of India

Marine prawns

They occur in coastal waters. *Penaeus indicus* (Indian prawn) and *Penaeus monodon* (Giant tiger prawn) are the important species of Indian coast. The marine penaeid prawns are also called as shrimps. The mature shrimp breeds in deep sea. Most of the developmental stages are spent in estuaries and backwaters.

Figure 7.25 Marine water prawn

Freshwater prawns

They inhabit rivers and lakes. They migrate to brackish water for breeding. *Macrobrachium rosenbergii* (Giant river prawn) and *Macrobrachium malcomsonii* (small prawns) are the common freshwater prawns.

Figure 7.26 Freshwater prawn

Info bits

Penaeid prawns are called shrimps (e.g. *Penaeus indicus*)

Non - penaeid prawns are called prawns (e.g. *Palaemon* sps, *Macrobrachium* sps)

7.12.2 Types of Prawn culture

A number of species of prawns of different sizes are found distributed in water resources. Only those prawns which are good in size, weight, available in plenty and easily cultivable are commonly selected for prawn culture on commercial basis.

Marine water prawn culture

The rearing of marine penaied prawn is called marine prawn culture or shrimp culture. *Penaeus indicus* can attain a maximum length of upto 20 cms and *Penaeus monodon* upto 30 cms when fully grown.

Freshwater prawn culture

The rearing of freshwater prawn is called fresh water prawn culture. *Macrobrachium rosenbergii* and *Macrobrachium malcomsonii* can attain a maximum length of 20 and 15 cms respectively when fully grown.

7.12.3 Methods of prawn culture

In our country different localized methods of prawn culture are being followed. The methods employed for prawn culture are given below.

a. Seed collection and hatchery method
b. Paddy cum prawn culture method

Seed collection and hatchery method

The larvae and juveniles obtained by collection from natural resources (estuaries, lagoons and backwaters) or by hatchery methods (controlled breeding) are reared and grown into adults with supplementary feeding.

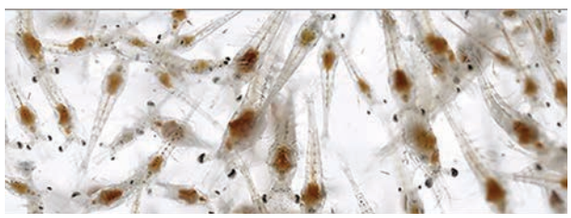


Figure 7.27 Post larvae (Prawn seed)

Paddy cum prawn culture

It is also called Pokkali culture. It is the oldest and traditional method of prawn culture practiced in Kerala. The low lying paddy fields along the coastal areas serve as suitable grounds for prawn culture. It is the practice of rearing prawns as 'secondary crop' in paddy fields. Prawns are cultured in these fields after the harvest of paddy. Both freshwater and marine prawns are cultured by this method based on their required salinity conditions.

Figure 7.28 Paddy cum prawn/fish culture

7.12.4 Nutritional value of prawns

Apart from being a delicacy, prawns are a rich nutritive source of protein, vitamin A and D, glycogen and amino acids. They contain less amount of fat. Cultured prawns also provide polyunsaturated fatty acid (PUFA) which plays an important role in health and weight maintenance.

7.13 Vermitechnology

The awareness of organic matter and concept of sustainable agriculture is gaining importance among our farmers in the recent years to produce good quality crops. Maintenance of soil organic matter is very important for sustainable productivity. Biowaste, especially the organic fraction of solid waste, can be reused for soil conditioning after composting. Recycling of available biowastes from different sources is helpful and can reduce environmental pollution.

DO YOU KNOW?

The Egyptian Pharaoh, Cleopatra said, "Earthworms are sacred." She recognized the important role the worms played in fertilizing the Nile Valley croplands after annual floods. Charles Darwin was intrigued by the worms and studied them for 39 years. Referring to an earthworm, Darwin said, "It may be doubted whether there are any other animals in the world which have played so important a part in the history of the world." The earthworm is a natural resource of fertility and life.

7.13.1 Vermiculture

Vermiculture involves the artificial rearing or cultivation of earthworms and using them for the production of compost from natural organic wastes. These wastes are degraded into nutrient rich manure that can be used as vermicompost.

INFO BIT

NUTRITION FACTS AND HEALTH BENEFITS OF SHRIMP

- Shrimp is merely water
- Shrimp lack carbohydrates
- Shrimp is low in calories and excellent source of protein
- An abundant source of minerals such as iron, sodium, zinc and phosphorus
- Rich source of vitamins such as thiamin and niacin

- Helps to prevent hair loss
- Helps maintain healthy bones
- Helps improve memory performance
- Beneficial in eliminatiing bad cholesterol
- Reduces risk of lung and prostate cancer

DO YOU KNOW?

Earthworm is one of the nature's pinnacle. It turns common soil into superior quality compost. In one acre land there can be more than one million earthworm. Slime, a secretion of earthworm contains nitrogen, which is an important nutrient for plants.

7.13.2 Earthworm species used for vermiculture

Different types of earthworm are living in our soil. Among the vast community of earthworms only very few species can be used for vermicompost production. They are *Perionyx excavatus* (Indian blueworm), *Eisenia fetida* (Red worms), *Eudrilus eugeniae* (African night crawler).

Perionyx excavatus

Eisenia fetida

Eudrilus eugeniae

Figure 7.29 Earthworm species for vermicomposting

Info bits

Vermiwash : During earthworm culture, water is sprinkled over the feed and the excess water and the excretory content of earthworm is slowly drained out which is known as Vermiwash. It is a liquid plant growth regulator which contains high amount of enzymes along with macro and micronutrients.

7.13.3 Vermicomposting

It is an important component of organic farming which can convert bio-wastes into nutrient rich organic manure by using earthworms. The burrowing and soil feeding habits of earthworms make the soil porous which permits both aeration and quick absorption of water. It feeds on the organic wastes and excrete it in digested form known as castings. The compost is generally called vermicompost.

GDNPHJ

7.13.4 Vermicompost

Vermicompost is the excreta (worm castings) which is a fine, granular organic matter formed by the decomposition of organic materials by the earthworm. It improves physical, chemical and biological properties of the soil and makes it an ideal fertilizer for the soil.

7.13.5 Materials required for vermicomposting

Biologically degradable organic wastes are used as potential organic resources for vermicomposting. They are:

- Agricultural wastes (crop residue, vegetables waste, sugarcane trash)
- Crop residues (rice straw, tea wastes, cereal and pulse residues, rice husk, tobacco wastes, coir wastes)
- Leaf litter
- Fruit and vegetable wastes
- Animal wastes (cattle dung, poultry droppings, pig slurry, goat and sheep droppings)
- Biogas slurry

7.13.6 Methods of vermicomposting

Vermicomposting methods can range from a wormbin in the kitchen for household scraps to large mechanized systems, which can be able to accommodate tons of organic material. In general these methods are of the following types:

- Bin (or) Container method
- Vermicomposting of organic wastes in field pits
- Vermicomposting of organic wastes on ground heaps

Let us now study how vermicompost is obtained by bin method.

Vermicomposting by bin method

It is the rearing of earthworms in a container or bin. The container is half filled with bedding materials such as shredded cardboard, leaves, paddy husk, chopped straw, saw dust and manure. Small quantity of soil and sand is added to provide necessary grit for the worms. The bedding material should be moistened by adding water that enables free movements of the worms. The worms are gently placed and spread evenly on the bedding.

Organic wastes (kitchen wastes, vegetable and fruit wastes) are added which are fed by the earthworms. The bin is covered with coconut leaves or gunny bags to conserve moisture, provide darkness and keep out of pests. After a period of 60 days the wastes are completely transformed into nutrient rich materials that are excreted by earthworms known as **worm castings.** These castings are harvested and used as organic manure.

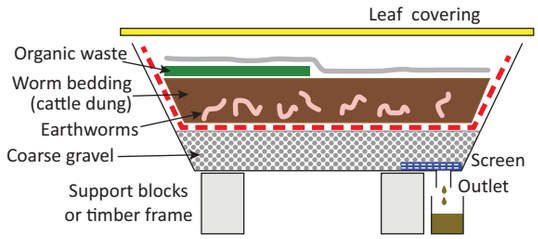


Figure 7.30 Vermicomposting bin

7.13.7 Advantages of Vermicompost

Vermicompost is dark brown in colour and similar to farmyard manure in colour and appearance.

- It is a rich source of nutrients essential for plant growth. It makes the soil fertile.
- It improves soil structure, texture, aeration and water holding capacity and helps to prevent soil erosion.
- It contains valuable vitamins, enzymes and growth regulator substances for increasing growth, vigour and yield of plants.
- It enhances decomposition of organic matter in soil.
- Vermicompost is free from pathogens and toxic elements.
- Vermicompost is rich in beneficial microflora.

Figure 7.31 Vermicompost

Activity 6

Prepare vermicompost from organic waste materials present in your school surroundings and garden. The above activity can be done in a circular container/ bin and kept in shady place with optimal temperature and light.

7.14 Apiculture

Apiculture is the rearing of honey bee for honey. It is also called Bee keeping. It is a profitable rural based industry and it is developed as an agro-based cottage industry. Apiculture provides employment to rural people and honey bee is domesticated by farmers to produce honey.

Honey bees are social insects. The nest of honey bee is known as the bee hive. They live in colonies and show division of labour.

7.14.1 Types Honey Bee

There are three types of individuals in a colony namely the Queen bee, the drones and the worker bees.

a. **Queen Bee**: The queen is the largest member and the fertile female of the colony. They are formed from fertile eggs. The queen is responsible for laying eggs in a colony. The life span of the queen bee is 3-4 years.

b. **Drones**: They are the fertile males. They develop from unfertilized eggs. They are larger than the workers and smaller than the queens. Their main function is to fertilize the eggs produced by the queen.

c. **Worker Bees:** They are sterile female bees and are the smallest members of the colony. Their function is to collect honey, look after the young ones, clean the comb, defend the hive and maintain the temperature of the bee hive.

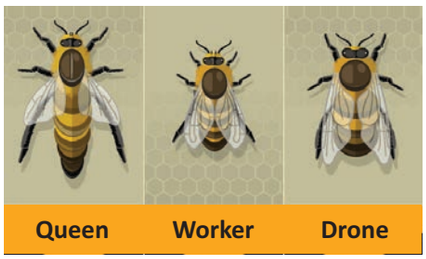


Figure 7.32 Types of Honey bee

7.14.2 Indigenous and Exotic varieties of Honey Bee

a) Indigenous varieties

i) Apis dorsata (Rock bee or Wild bee)

ii) Apis florea (Little bee)

iii) *Apis indica* (Indian bee)

b) Exotic varieties

iv) Apis mellifera (Italian bee)

v) Apis adamsoni (African bee)

7.14.3 Structure of Bee Comb

The comb of the bees is formed mainly by the secretion of the wax glands present in the abdomen of the worker bee. A comb is a vertical sheet of wax with double layer of hexagonal cells. The cells of the comb are of various types.

The **storage cells** contain honey and pollen. They are built in the margin and at the top of the comb.

The **brood cells** contain the young stages of the honey bees and they are built in the centre and the lower part of the comb. The **brood chamber** is divided into three types **Worker chamber**, **Drone chamber** and **Queen chamber** where the larvae developing into worker, drone and queen are reared.

Formation of Honey: The honey bees suck the nectar from various flowers. The nectar passes to the honey sac. In the honey sac,

Figure 7.33 Bee Comb

sucrose present in the nectar mixes with acidic secretion and by enzymatic action it is converted into honey which is stored in the special chambers of the hive.

7.14.4 Useful products from Honey Bee

Honey bees are used in the production of honey and bee wax. Honey is the aromatic sweet material and its quality depends upon the flowers available to the bees for nectar and pollen collection.

DO YOU KNOW?

- Honey bee visits 50 to 100 flowers during a collection trip.
- Average bee will make only $1/12^{th}$ of a teaspoon of honey in its lifetime.
- One kilogram of honey contains 3200 calories and is an energy rich food.

a. Honey

Honey is a sweet, viscous, edible natural food product. Dextrose and sucrose gives sweet taste to the honey. It also contains protein, free amino acids, vitamins like ascorbic acid, niacin, riboflavin and thiamine. Minerals like calcium, iron, phosphorus and manganese are present. Acids such as citric acid, gluconic acid and formic acid are found in honey. Formic acid is a preservative in honey. Invertase is an enzyme present in honey.

Uses of Honey

- Honey has an antiseptic and antibacterial property. It is a blood purifier.
- It helps in building up of haemoglobin content in the blood.
- It is used in Ayurvedic and Unani system of medicines.
- It prevents cough, cold, fever and relieves sore throat.
- It is a remedy for ulcers of tongue, stomach and intestine.
- It enhances digestion and appetite.

b. Bee wax

Bee wax is the natural by product secreted by the wax glands of worker bee to construct the combs of bee hive. It is widely used in cosmetic and pharmaceutical industries.

Other useful products obtained from honey bees are bee pollen, royal jelly, propolis and bee venom.

More to Know

Bee-keeping industry is one of the important activities of Khadi and Village Industries Commission (KVIC). Honey manufactured by the Khadi Board has good patronage from the public. The Board's honey processing unit at Amsi in Kanyakumari district is producing "A" Grade honey. The raw honey is procured mostly from Jamunamaruthur in Thiruvannamalai district and Marthandam in Kanyakumari district. This raw honey is 100% tested before packing for sales.

Points to Remember

- ❖ Horticulture, is a branch of agriculture that deals with cultivation of fruits, vegetables, and ornamental plants.
- ❖ The four main classes of horticulture are pomology (fruit farming), olericulture (vegetable farming), floriculture (flowers farming) and landscape gardening.

- Floriculture is the art of cultivation of flowering and ornamental plants for gardens and floristry.
- The organic manures are predominantly derived from plant debris, animal faeces, microbes. They make the soil fertile by adding nutrients like nitrogen.
- A biofertilizer is a substance which contains living microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.
- All the major system of medicines such as Ayurvedic, Yoga, Unani, siddha, Homeopathy (AYUSH) use drugs obtained from plants.
- Mushroom cultivation is a technology of growing mushrooms using plant, animal and industrial waste.
- Hydroponics is the method of growing plants without soil, using mineral nutrient solutions in water.
- The aeroponic system is high-tech type of hydroponic gardening and the growth medium is primarily air.
- Aquaponics is a system of a combination of conventional aquaculture with hydroponics in a symbiotic environment in which plants are fed with the aquatic animals' excreta or wastes.
- Dairy farming involves raising of cattle for milk production.
- Aquaculture is the rearing of economically important aquatic organisms like fishes, prawns, shrimps, crabs, lobsters, edible oysters, pearl oysters and sea weeds under controlled and confined environmental conditions using advanced technologies.
- Pisciculture or fish culture is the process of breeding and rearing of fishes in ponds, reservoirs (dams), lakes, rivers and paddy fields.
- The most economically important shell fish resources of India are prawns.
- Vermiculture involves the artificial rearing or cultivation of earthworms and using them for the production of compost from natural organic wastes.
- Apiculture is the rearing of honey bee for honey.

A-Z GLOSSARY

Aquaculture	Culture of fishes, prawns, shrimp, oysters and crabs in either sea water or freshwater.
Aquaponics	Combination of conventional aquaculture with hydroponics in a symbiotic environment in which plants are fed with the aquatic animals' excreta or wastes.
Compost	Soil conditioner, fertilizer, natural pesticide, a decomposed organic matter which is rich in nutrients.
Floriculture	Production of ornamental plants.
Green manure	Undecomposed green material derived mostly from leguminous plants.
Hydroponics	Soil less growing system in which plants grow in water.

Mariculture	Culture of fishes and other aquatic organism in marine water near the sea coast.
Nectar	It is a sweet viscous secretion secreted by the flower of plants.
Olericulture	Production of vegetables.
Pasturage	The availability of flowers to bees for nectar and pollen collection.
Pisciculture	It is the culture and rearing of fishes under controlled conditions.
Polyculture	Culture of more than one species of fish in a pond.
Pomology	Production of fruits.
Silage	Fermented high moisture stored food which can be fed to cows.
Vermicompost	Vermicompost is the excreta of earthworm which is a natural rich organic soil formed by the decomposition of organic material by the earthworm.
Vermicomposting	Earthworms degrade organic waste materials into useful product which can be used as a nutrient rich fertilizer.
Vermiculture	The artificial rearing or cultivation of earthworms for the production of vermicompost.

TEXTBOOK EVALUATION

GDSCKG

I . Choose the correct answer.

1. The production and management of fish is called
   a. Pisciculture b. Sericulture
   c. Aquaculture d. Monoculture

2. Which one of the following is not an exotic breed of cow?
   a. Jersey b. Holstein-Friesan
   c. Sahiwal d. Brown Swiss

3. Which one of the following is an Italian species of honey bee?
   a. *Apis mellifera* b. *Apis dorsata*
   c. *Apis florae* d. *Apis cerana*

4. Which of the following are Indian cattle?
   i. *Bos indicus* ii. *Bos domesticus*
   iii. *Bos bubalis* iv. *Bos vulgaris*
   a. i and ii b. i and iii
   c.ii and iii d. iii and iv

5. Which one of the following is not an Indian major carp?
   a. Rohu b. Catla
   c. Mrigal d. Singhara

6. Drones in the honey bee colony are formed from
   a. unfertilized egg b. fertilized egg
   c. parthenogenesis d. both b and c

7. Which of the following is an high milk yielding variety of cow?

a. Holstein- Friesan b. Dorset
c. Sahiwal d. Red Sindhi

8. Which one of the following is refered as red worms?

a. *Eudrilus fetida*
b. *Eudrilus eugieniae*
c. *Perionyx excavatus*
d. *Lampito mauritii*.

9. Which Indian variety of honey bee is commonly used for apiculture?

a. *Apis dorsata* b. *Apis florea*
c. *Apis mellifera* d. *Apis indica*

10. Mehsana is a breed of

a. Cow b. Buffalo c. Goat d. Sheep

11. Binomial name of Nilavembu is

a. *Leucas aspera*
b. *Andrographis paniculata*
c. *Crotolaria juncea*
d. *Cassia fistula*

12. _____ is the method of growing plants without soil.

a) Horticulture b) Hydroponics
c) Pomology d) None of these.

13. The symbiotic association of fungi and vascular plants is

a) Lichen b) *Rhizobium*
c) Mycorhizae d) *Azotobacter*

14. The plant body of mushroom is

a) Spawn b) Mycelium
c) Leaf d) All of these

II. Fill in the blanks.

1. _____ is a nodulating type of micro organism associating symbiotically with the root of legume plants.
2. Quinine drug is obtained from _____.
3. *Carica papaya* leaf can cure _____ disease.
4. *Ganoderma lucidum*, is commonly known as _____ mushroom.
5. _____ is the maintenance of bee colonies in modern hives.
6. Vermicompost is a type of soil made by _____ and microorganisms.
7. _____ refers to the culture of prawns, pearl and edible oysters.
8. The fertile female in a honey bee hive is _____.
9. _____ is a preservative in honey.
10. _____ is the method of culturing different variety of fish in a water body.
11. Pasturage is related to _____.

III. State whether true or false, If false, correct the given statement.

1. Medicinal plants contain compounds that can be used for therapeutic purposes.
2. Anthraquinones is obtained from *Ocimum sanctum*.
3. Mycorrhiza is an algae.
4. Aquaponics is a technique of growing plants with their root supplied with moisture present in the air.
5. Milch animals are used in agriculture and transport.
6. *Apis florea* is a rock bee.
7. Ongole is an exotic breed of cattle.
8. Sheep manure contains high nutrients than farm yard manure.

IV. Match the following.

Column A	Column B
Lobsters	Marine fish
Catla	Pearl
Sea bass	Shell fish
Oysters	Paddy
Pokkali	Fin fish
Pleurotus sps	Psoriosis
Sarpagandha	Oyster mushroom
Olericulture	Reserpine
Wrighta tinctoria	Vegetable farming

V. Define the following.

a. Pisiculture
b. Apiculture
c. Vermiculture
d. Mariculture
e. Floriculture
f. Compost
g. Pomiculture
h. Pinning

VI. Differentiate the following.

a. Exotic breed and Indigenous breed
b. Pollen and Nectar
c. Shrimp and Prawn
d. Fin fish and Shell fish
e. Farmyard manure and Sheep manure

VII. Answer in brief.

1. What are secondary metabolites?
2. What do you know about AYUSH?
3. What are the types of vegetable garden?
4. Mention any two mushroom preservation methods.
5. Why do we call Haryana and Kankrej breed of cattle as dual purpose breeds?
6. How is division of labour observed in honey bees?
7. What is the nutritional importance of fish liver oils? Name any two marine fishes which yield these oils.
8. Enumerate the advantages of vermicompost over chemical fertiliser.
9. What are the species of earthworm used for vermiculture?
10. List the medicinal importance of honey.

VIII. Answer in detail.

1. Enumerate the advantage of hydroponics.
2. Give an account on medicinal plants.
3. What are biofertilisers? Give examples. Why are biofertilisers better than other fertilizers.
4. Define Mushroom culture. Explain the mushroom cultivation methods.
5. Write short notes on;
   a) Importance of green houses
   b) Uzahavan mobile Application
   c) Major floriculture zones
   d) Azospirillum
5. What are the sources of organic resources for vermicomposting?
6. Give an account of different types of fish ponds used for rearing fishes.
7. Explain the feeding management of dairy cattle.
8. Classify the different breeds of the cattle with suitable examples.

IX. Assertion and Reason.

Direction: In each of the following questions, a statement of Assertion is given and a corresponding statement of Reason is given just below it. Of the statements given below, mark the correct answer as

a. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

b. If both Assertion and Reason are true and Reason is not the correct explanation of Asssertion.

c. If Assertion is true but Reason is false.

d. If both Assertion and Reason are false.

1. Assertion: Hydroponics can be defined as a soilless growing system in which plants grow in water.

Reason: If a plant is provided with water, minerals and required nutrients, it will grow well and yield more even in the absence of soil.

2. Assertion: Fish and other varieties of aquatic animals are used as food.

Reason: Fish and other varieties of sea food constitute good source of nutrition.

3. Assertion: The production of food from animal sources has increased greatly in the last few decades.

Reason: Operation flood and blue revolution production has increased in the recent years.

X. Thinking Skills

1. Biomanuring plays an important role in agriculture. Justify
2. Arun and Akash were given fertilisers and earthworm compost both to be used in the fields. Akash preferred to use earthworm compost. Why he did not select the fertilizers?
3. What is pasturage and how is it related to honey production?
4. Each bee hive consists of hexagonal cells. Name the material in which the cell is formed and mention the significance of the hexagonal cells.

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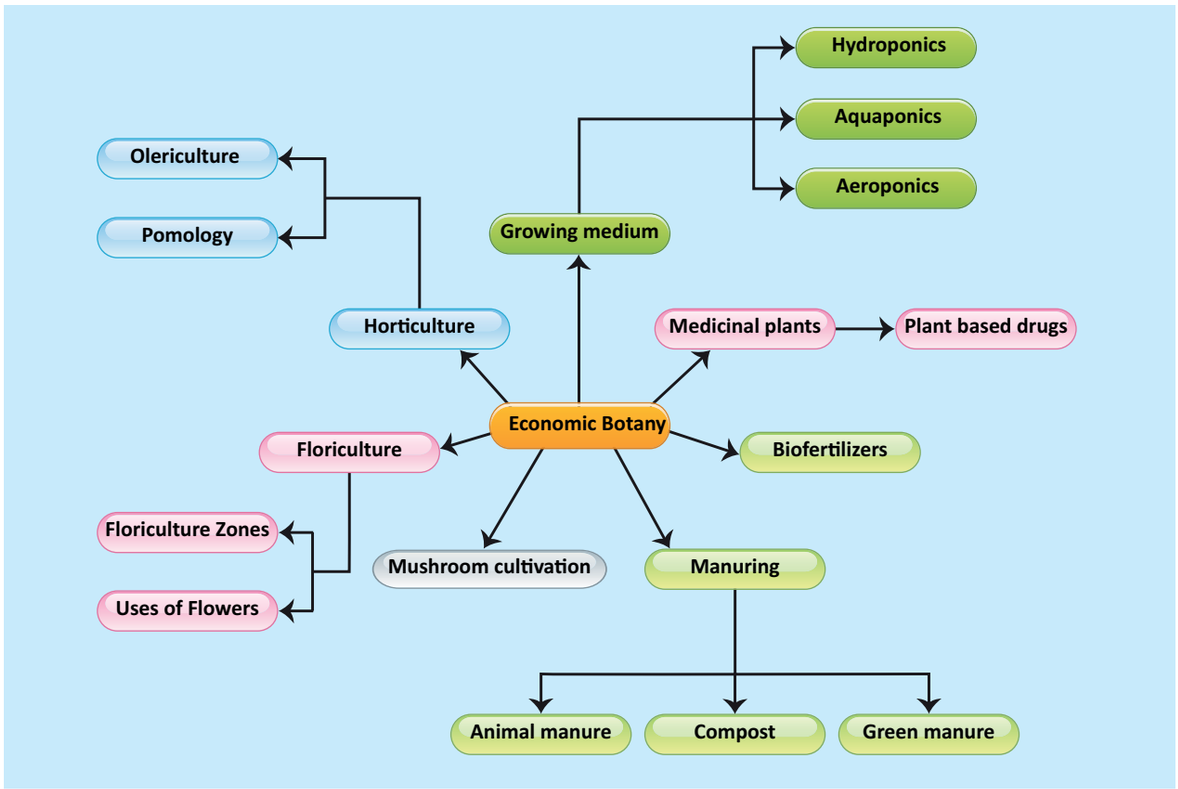
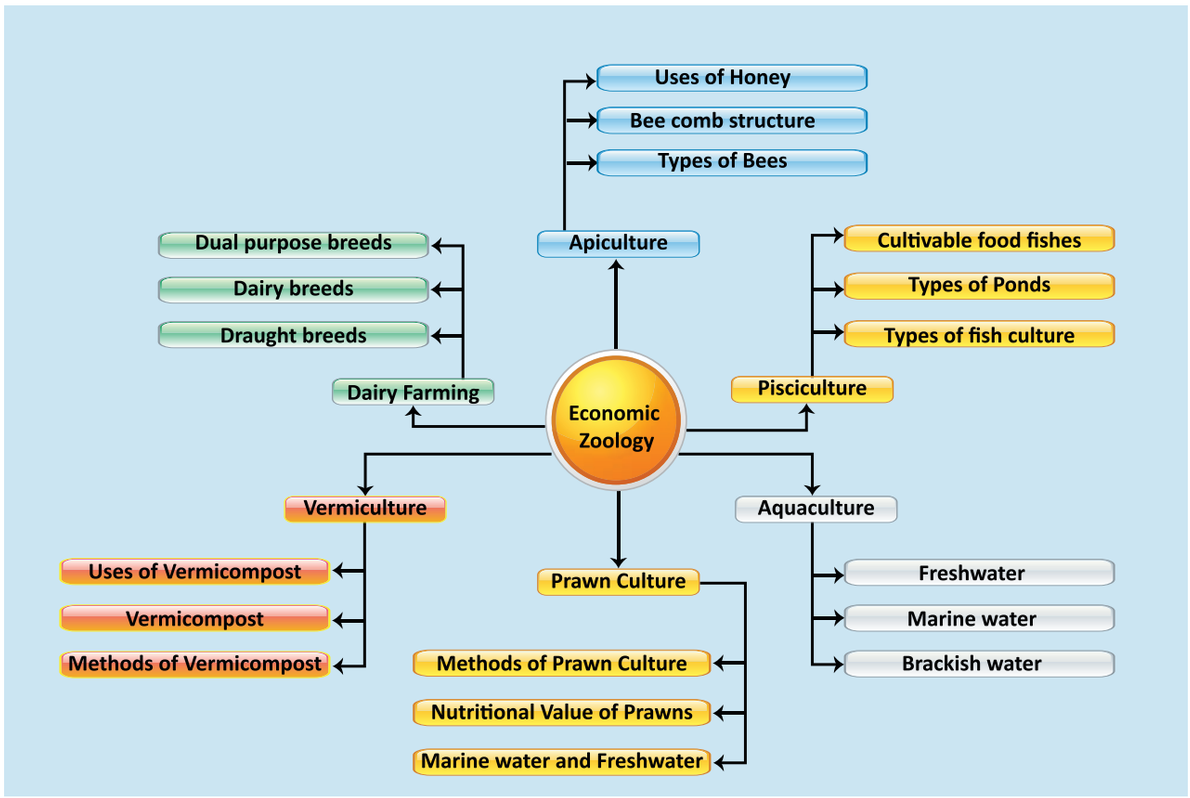
Concept Map

Economic Botany



Economic Zoology



UNIT 8

World of Microbes

Learning Objectives

GDXKY7

After completing this lesson, students will be able to

- identify different groups of bacteria based on their shape and structure.
- categorize types of viruses.
- recognize the structural differences between unicellular and multicellular fungi.
- know the role of microbes in agriculture, food industries and medicine.
- gain knowledge on causative organism, modes of infection and disease transmission.
- describe the spectrum of diseases on the basis of the causative agents.
- understand microbe - host interaction, symptoms of the diseases caused by the microbes.
- know disease control and preventive measures.

Introduction

Microbiology (greek words: mikros -small, bios- life bearing, logy- study), is a branch of biology that deals with living organisms of microscopic size, which include bacteria, fungi, algae, protozoa and viruses. Microbes are found in habitats like terrestrial, aquatic, atmospheric or in living hosts. Some of them survive in extreme environments like hot springs, ice sheets, water bodies with high salt content and low oxygen, and in arid places with limited water availability.

Some of the microorganisms are beneficial to us and they are used in the preparation of curd, bread, cheese, alcohol, vaccines and vitamins, while some others are harmful causing diseases to plants and animals including human being. We at one time or the other in our life, have suffered from bodyache, fever, cold, vomiting, diarrhoea and many other conditions which may give an individual discomfort or uneasiness. All these symptoms are associated with diseases which affect our health and make us feel uncomfortable. This topic will explore the beneficial and harmful effects of microbes in relation to welfare of human kind.

8.1 Microbes and their Types

Microorganisms differ from each other in size, morphology, habitat, metabolism and several other features. Microbes may be unicellular (Bacteria), multicellular (Fungi), acellular (not composed of cells-Virus). Types of microbes include bacteria, viruses, fungi, microscopic algae and protists.

8.1.1 Bacteria

Bacteria are microscopic, single celled prokaryotic organisms without nucleus and other cell organelles. Although majority of bacterial species exist as single celled forms, some appear to be filaments of loosely joined cells. The size varies from less than 1 to 10 µm in length and 0.2 to 1 µm micrometer in width. Bacteria may be motile or non-motile. For motility they have special structures called flagella which are found on the cell surfaces. Location of flagella varies with bacterial species.

Based on the arrangement of flagella, there are four types of bacteria:

(i) **Monotrichous:** A single polar flagella. e.g. *Pseudomonas aeruginosa*.

(ii) **Lophotrichous:** A cluster of polar flagella. e.g. *Pseudomonas fluorescens*.

(iii) **Amphitrichous:** Either a single or cluster of flagella at both the cell poles. e.g. *Aquaspirillum serpens*.

(iv) **Peritrichous:** Flagella arranged along the sides of the bacteria. e.g. *Salmonella typhi*.

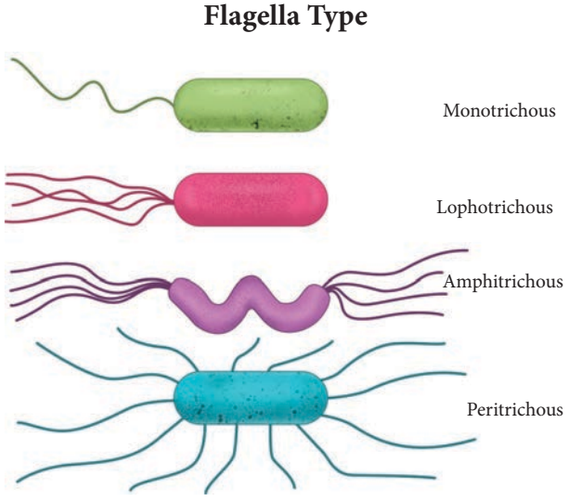


Figure 8.1 Arrangement of flagella in bacteria

A. Shapes of bacteria

Based on the shapes, bacteria are grouped as:

1. Spherical shaped bacteria called as cocci (or coccus for a single cell).
2. Rod shaped bacteria called as bacilli (or bacillus for a single cell).
3. Spiral shaped bacteria called as spirilla (or spirillum for single cell)

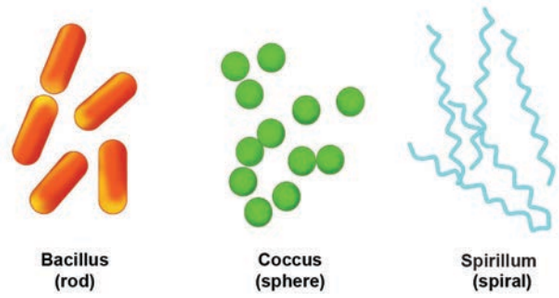


Figure 8.2 Shapes of bacteria

B. Structure of a bacterial cell

Bacterial cell has cell membrane, covered by strong rigid cell wall made up of **peptidoglycan**. In some bacteria, outside the cell wall there is an additional slimy protective layer called **capsule** made up of **polysaccharides**. The plasma membrane encloses the cytoplasm, **incipient nucleus** (nucleoid), ribosomes and DNA which serve as genetic material. Ribosomes are the site of protein synthesis. They lack membrane bound organelles. In addition to this, a small extra chromosomal circular DNA called plasmid is found in the cytoplasm.

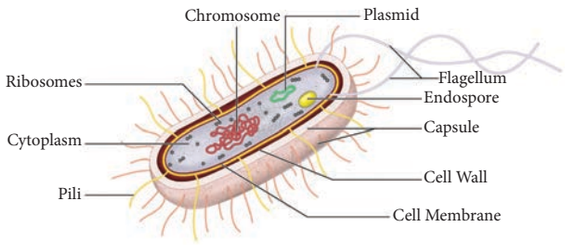


Figure 8.3 Structure of a bacterial cell

C. Nutrition in bacteria

All living organisms require a source of energy. Bacteria have diversified energy requirements. Based on this they are categorized into autotrophic bacteria and heterotrophic bacteria.

a. Autotrophic bacteria (Autotrophs)

They synthesize their own food from inorganic sources (CO_2 and hydrogen donor). e.g. *Nitrosomonas sp*. Autotrophic bacteria are classified into two types based on their source of energy.

- **Phototrophs** that use light as source of energy.
- **Chemotrophs** that rely on chemical compounds for their energy.

b. Heterotrophic bacteria (Heterotrophs)

They are most abundant in nature. They do not synthesize their own food but depend on other organisms or dead organic matter for food. They may be classified as:

- **Parasitic bacteria** that live on live hosts like plants, animals and human. They can cause diseases to the living host.
- **Saprophytic bacteria** that live on dead organic matter.
- **Symbiotic bacteria** may live inside a live host, where they obtain nutrition and benefit the host in digestion and nitrogen fixing (*Rhizobium*).

Antonie Van Leeuwenhoek, the first microbiologist designed his own microscope. In 1674, he took plaque from his own teeth and observed it under the microscope. He was astonished to see many tiny organisms moving around, which was otherwise invisible to naked eyes.

More to Know

Different shapes of Bacteria

	Arrangement of Cocci	Examples
Diplococci	cocci are arranged in pairs	*Streptococcus pneumoniae*
Streptococci	cocci are arranged in chains	*Streptococcus pyogenes*
Tetracocci	cocci are arranged in packets of four cells	*Aerococcus sp*
Staphylococci	cocci are arranged in grape-like clusters	*Staphylococcus aureus*
	Arrangement of Bacilli	**Examples**
Diplobacilli	diplobacilli appear in pairs	*Klebsiella sp*
Streptobacilli	bacilli are arranged in chains	*Streptobacillus sp*
Coccobacilli	short and stumpy and appear ovoid	*Haemophilus sp*
	Arrangement of Spirilla	**Examples**
Vibrio	comma-shaped bacteria	*Vibrio cholerae*
Spirilla	rigid spiral structure	*Helicobacter pylori*
Spirochetes	helical shape and flexible bodies	*Treponema pallidum*

8.1.2 Viruses

The term 'virus' in Latin means 'venom' or 'poisonous fluid'. Viruses are non-cellular, **self-replicating parasites**. They are made up of a **protein** that covers a central **nucleic** acid molecule, either RNA or DNA. The amount of protein varies from 60% to 95% and the rest is nucleic acid. Nucleic acid is either DNA (T4 bacteriophage) or RNA (Tobacco mosaic virus, TMV).

A simple virus particle is often called a **virion**. They grow and multiply only in living cells. They are the smallest among the infective agents varying over a wide range from 18-400 nm (nanometre). They can live on plants, animals, human being and even bacteria. They can be easily transmitted from one host to another.

A. Living and Non-living characters

Viruses exhibit both living and non-living characters.

Living characters of viruses

(a) They have the nucleic acid (DNA or RNA) i.e., the genetic material that can replicate.
(b) They can multiply in the living cells of the host.
(c) They can attack specific hosts.

Non-living characters of viruses

(a) Viruses remain as inert material outside their hosts.
(b) They are devoid of cell membrane and cell wall. Viruses are devoid of cellular organelles like ribosomes, mitochondria, etc.
(c) They can be crystallised.

More to Know

The protein free pathogenic RNA of virus is Viroids. They are found in plant cells and cause disease in plants.

B. Types of Viruses

Viruses are categorised as:

i. Plant virus: Virus that infect plants. e.g. Tobacco mosaic virus, Cauliflower mosaic virus, Potato virus.

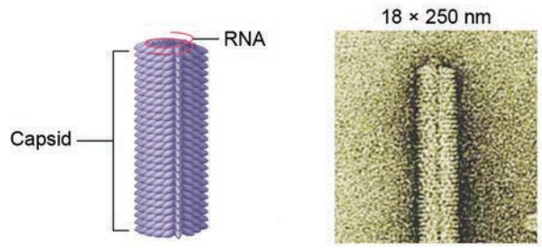
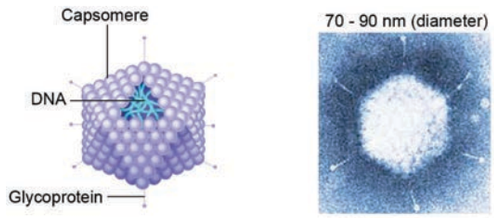
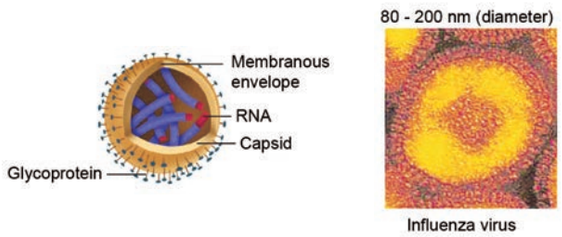


Figure 8.4 Tobacco mosaic virus

ii. Animal virus: Virus that infect animals. e.g. Adenovirus, Retrovirus(HIV), Influenza virus, Polio virus.



Aenovirus



Influenza virus

Figure 8.5 Animal virus

iii. Bacteriophages: Virus that infect bacterial cells. e.g. T4 bacteriophage.

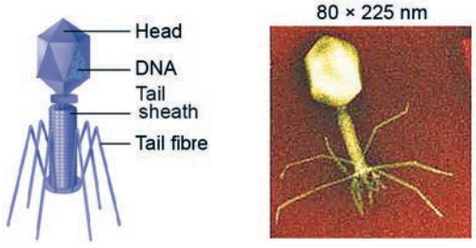


Figure 8.6 T4 bacteriophage

8.1.3 Fungi

They lack chlorophyll, hence depend on living or dead host for their nutritional needs. Fungi living on living hosts are called parasites, and those living on dead organic matter are called saprophytes. The body of the fungus is called **thallus**.

In general, fungi are larger than bacteria. Single celled yeast ranges from 1-5 µm in width. They are spherical in shape. Flagella are absent and hence they are non-motile. In the case of multicellular forms, thallus is called mycelium. **Mycelium** is a complex of several thin filaments called **hyphae** (singular: Hypha).

Each hypha is 5 to 10 µm wide. They are tube like structures filled with protoplasm and cellular organelles. Hyphae may or may not be intersected with plasmalemma (cell wall). Cell wall is made up of cellulose and hemicellulose.

Yeast cell

Penicillium

Figure 8.7 Structure of fungi

Activity 1

Observation of yeast cell

- Prepare a suspension of commercially available yeast powder with water.
- Take a drop of this suspension and a make a thin smear on a clean glass slide.
- Stain the smear using eosin or methylene blue.
- Observe the stained slide under compound microscope.
- Draw the structure of the cell you observe and label it.

Cytoplasm contains small vacuoles filled with cell sap, nucleus, mitochondria, golgi body, ribosomes, and endoplasmic reticulum. Food material is stored in the form of glycogen or oil globules.

They reproduce vegetatively (binary fission, budding and fragmentation), asexually (spore formation-conidia) and sexually (male and female gamatengium are called antheridium and oogonium).

8.1.4 Prions

'Prion' means **proteinaceous infective particle** ('Protein gone bad'). The term 'prion' was coined by Stanley B. Prusiner in 1982. Prions are **viral particles** which contain only proteins. They do not contain nucleic acid. They are infectious and smaller than viruses. Prions are found in neurons and are rod shaped. Prions induce changes in normal folded proteins. Misfolded proteins aggregate and accumulate as plaques. This results in the degeneration of nervous tissue.

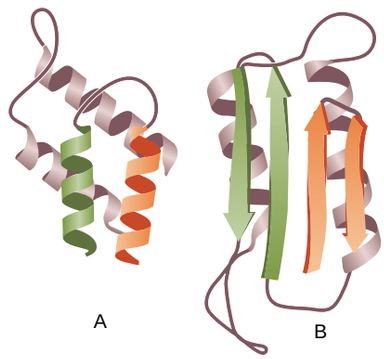


Figure 8.8 Normal (A) and Abnormal (B) prion protein

DO YOU KNOW?

Creutzfeldt-Jakob disease (CJD) is a **neurodegenerative disease**. As a result of this disease cerebral cortex is affected and it is characterised by progressive dementia, memory loss, behavioral changes, poor coordination and visual disturbances.

8.2 Applications of Microbes

Microorganisms contribute to human welfare in many ways. In this section we will study about the diversified usefulness of microbes.

8.2.1 Microbes in Agriculture

Microbes play an important role in agriculture as biocontrol agents and biofertilizers. Microbes play a vital role in the cycling of elements like carbon, nitrogen, oxygen, sulphur and phosphorus.

(i) Microbes as biocontrol agents

Microorganisms used for controlling harmful or pathogenic organisms and pests of plants are called as biocontrol agents (Biopesticides). *Bacillus thuringiensis* (Bt) is a species of bacteria that produces a protein called as 'cry' protein. This protein is toxic to the insect larva and kills them. Spores of *B.thuringiensis* are available in sachets, which are dissolved in water and sprayed on plants infected with insect larva.

(ii) Microbes as biofertilizers

Microorganisms which enrich the soil with nutrients are called as biofertilizers. Bacteria, cyanobacteria and fungi are the main sources of biofertilizers. Nitrogen is one of the main source of plant nutrients. Atmospheric nitrogen has to be converted to available form of nitrogen. This is done by microbes either in free living conditions or by having symbiotic relationship with the plants. e.g. *Nitrosomonas*, *Nostoc* (free living), symbiotic microbes like *Rhizobium*, *Frankia*, mycorrhizae.

Figure 8.9 Rhizobium biofertilizer

Activity 2

Observation of symbiotic microbes

- Take the root nodules of any pulse or leguminous plant available in your locality.
- Wash it throughly with water. Crush the nodules on a clean glass slide.
- Add a drop of distilled water to the crushed material on the glass slide.
- Observe the preparation under compound microscope.

8.2.2 Microbes in Industries

Microorganisms play an important role in the production of wide variety of valuable products for the welfare of human beings.

(a) **Production of fermented beverages**: Beverages like wine are produced by fermentation of malted cereals and fruits by *Saccharomyces cerevisiae*.

(b) **Curing of coffee beans, tea leaves and tobacco leaves**: Beans of coffee and cocoa, leaves of tea and tobacco are fermented by the bacteria *Bacillus megaterium*. This gives the special aroma.

(c) **Production of curd**: *Lactobacillus sp.* converts milk to curd.

(d) **Production of organic acids, enzymes and vitamins**: Oxalic acid, acetic acid and citric acid are produced by fungus *Aspergillus niger*. Enzymes like lipases, invertase, proteases, and glucose oxidase are derived from microbes. Yeasts are rich source of vitamin-B complex.

8.2.3 Microbes in Medicine

Antibiotics are metabolic products of microorganisms, which in very low concentration are inhibitory or detrimental to other microbes. In 1929, Alexander Fleming produced the first antibiotic pencillin. In human beings antibiotics are used to control infectious diseases like cholera, diptheria, pneumonia, typhoid, etc.

Table 8.1 Antibiotics produced by micro organisms

Class of Microorganisms	Type of Microorganism	Antibiotic produced
Bacteria	*Streptomyces griseus*	Streptomycin
	Streptomyces erythreus	Erythromycin
	Bacillus subtilis	Bacitracin
Fungi	*Penicillium notatum*	Penicillin
	Cephalosporium acremonium	Cephalosporin

Vaccines are prepared by killing or making the microbes inactive (attenuated). These inactive microbes are unable to cause the disease, but stimulate the body to produce antibodies against the antigen in the microbes.

Table 8.2 Vaccines produced against diseases

Type of Vaccine	Name of the vaccine	Disease
Live attenuated	MMR	Measles, Mumps and Rubella
	BCG (Bacillus Calmette Guerin)	Tuberculosis
Inactivated (Killed antigen)	Inactivated polio virus (IPV)	Polio
Subunit vaccines (Purified antigens)	Hepatitis B vaccine	Hepatitis B
Toxoid (Inactivated antigen)	Tetanus toxoid (TT)	Tetanus
	Ditpheria toxoid	Diptheria

8.3 Microbes and Diseases

Disease (dis = against; ease = comfort) can be defined as an impairment or malfunctioning of the normal state of the living organism that disturbs or modifies the performance of vital functions of the body. Disease can be categorized based on:

i. The extent of occurrence (endemic, epidemic, pandemic or sporadic).
ii. Whether infectious or non-infectious.
iii. Types of pathogen – whether caused by bacterial, viral, fungal or protozoan infections.
iv. Transmitting agent – whether air borne, water borne or vector borne.

Activity 3

Can you frame the definition of health from the picture below?

8.3.1 Classification of disease based on occurence

Endemic: When the disease is found in a certain geographical area affecting a fewer number of people (low incidence). e.g. Occurrence of goitre in Sub-Himalayan regions.

Epidemic : When the disease breaks out and affects large number of people in a particular geographical region and spreads at the same time. e.g. Influenza.

Pandemic: When the disease is widely distributed on a global scale. e.g. Acquired Immunodeficiency Syndrome (AIDS).

Sporadic: When there is an occasional occurrence of a disease. e.g. Malaria and Cholera.

DO YOU KNOW?

World Health Day – 7th April
World Malaria Day – 25th April
World AIDS Day – 1st December
World Anti -Tuberculosis Day – 24th March

8.3.2 Manifestation of Disease

Communicability of diseases

Infectious diseases are communicable diseases. They are caused by external factors like pathogenic organisms (bacteria, virus, vectors, parasites) invading the body and causing diseases. e.g. Influenza, Tuberculosis, Chickenpox, Cholera, Pneumonia, Malaria, etc

Non-infectious disease are non-communicable diseases. They are caused by internal factors like malfunctioning of organs, genetic causes, hormonal imbalance and immune system defect. e.g. Diabetes, Coronary heart diseases, Obesity, Cancer, Goitre, etc

Point of entry and place of infection

The disease causing microbes enter the body through different means. An infection develops when these pathogens enter the human body through contaminated air, water, food, soil, physical contact, sexual contact and through infected animals. They may be organ specific or tissue specific within our body where microbes reside.

Reservoir of infection

Reservoir of infection refers to the specific environment in which the pathogens can thrive well and multiply without causing diseases. In other words, they are the breeding ground for pathogens. eg. Water, soil and animal population.

Incubation period

The interval between infection and first appearance of the diseases is called incubation period. It may vary from few hours to several days.

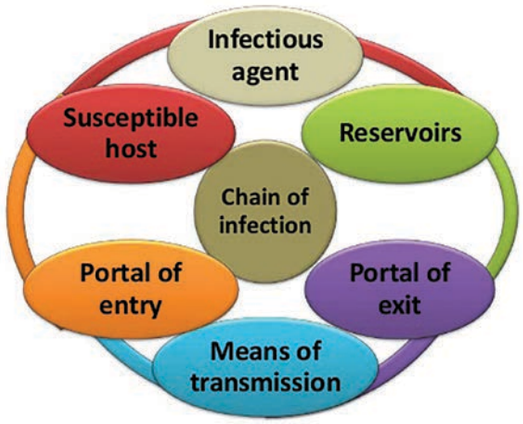


Figure 8.10 Chain of transmission of infection

Infection and Illness

Infection is the entry, development or multiplication of an infectious agent in the human body or animals. An illness is due to a specific infectious agent, capable of being directly or indirectly transmitted from person to person, animal to animal or from the environment (through air, water and food) and insects (vectors).

8.3.3 Harmful effects of microbes

Pathogens cause disease in two ways. They are tissue damage and toxin secretion.

Tissue Damage: Many pathogens destroy the tissues or organs of the body causing morphological and functional damage. For example, bacterium of pulmonary tuberculosis damages the cells of the lungs, and virus causing hepatitis destroys liver tissue.

DO YOU KNOW?

Robert Koch (Father of Bacteriology) is the first German physician to study how pathogens cause diseases. In 1876, he showed that the disease called anthrax of sheep was due to *Bacillus anthracis* which exist in pastures in the form of protective spores. He found the rod shaped bacteria in the blood vessels of infected sheep and came to a conclusion that sheep and cattle came in contact with bacteria while grazing in the pastures.

Toxin Secretion: Many pathogens secrete poisonous substances called toxins which cause diseases. **Exotoxins** are directly secreted by the pathogens. **Endotoxins** are released by the disintegration of pathogens.

Let us now study the causative organism, mode of infection, occurrence, symptoms and preventive measures of a few airborne, waterborne, vectorborne and sexually transmitted diseases.

8.4 Airborne Diseases

Human beings inhale atmospheric air. Due to continuous inhalation of contaminated air the chances for airborne microorganisms to find a host and cause infection are higher. Most of the respiratory tract infections are acquired by inhaling air containing the pathogen that are transmitted through droplets caused by cough or sneeze, dust and spores. Airborne diseases are caused by bacteria and viruses. A few air borne diseases and their modes of transmission are explained below.

8.4.1 Diseases caused by bacteria

Tuberculosis (TB)

It is one of the widely occurring communicable diseases. It is caused by the bacteria *Mycobacterium tuberculosis*. It mostly affects the lungs. Infected person has to be treated with anti-tuberculosis drugs for a period of 6 months to one year.

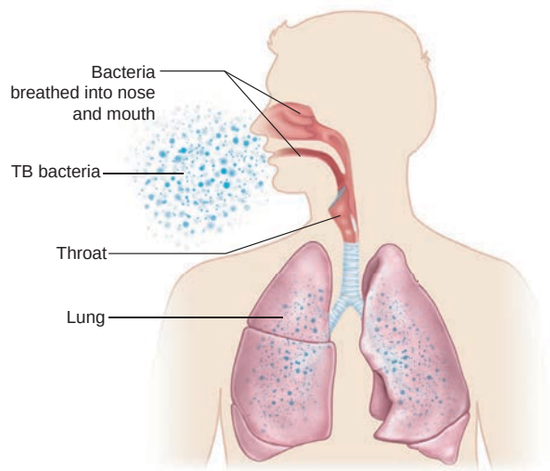


Figure 8.11 Tuberculosis

Diphtheria

It is caused by *Cornybacterium diphtheriae*. It generally affects the upper respiratory tract (nose and throat) and causes fever, sore throat and choking of air passage.

Whooping Cough

Whooping cough is caused by *Bordetalla pertussis*. It also affects the respiratory tract and causes mild fever, severe cough ending in whoop.

More information about airborne diseases caused by bacteria are given in Table 8.3.

More to Know

- Tuberculosis causing bacteria *Mycobacterium tuberculosis* was discovered by Robert Koch.
- Mantoux test: A highly specific tuberculin skin test for detection of tuberculosis.
- National Tuberculosis (TB) control programme was started in 1962.

Table 8.3 Airborne diseases caused by bacteria

Disease	Causative Organism	Mode of Transmission	Tissue/ Organ Affected	Symptoms
Tuberculosis	*Mycobacterium tuberculosis*	Droplet infection from sputum of infected persons	Lungs	Persistent cough, chest pain, loss of weight and appetite
Diptheria	*Cornyebacterium diphtheriae*	Droplet infection, droplet nuclei	Upper Respiratory tract (nose, throat)	Fever, sore throat, choking of air passage
Whooping Cough	*Bordetalla pertussis*	Droplet infection, direct contact with infected person	Respiratory tract	Mild fever, severe cough ending in whoop (loud crowing inspiration)

8.4.2 Diseases caused by viruses

Common cold

Common cold is an infectious disease which affects the upper respiratory system and it is easily spread. Symptoms of common cold include cough, painful throat, running nose and sometimes fever. Though many viruses can cause this, it is generally caused by the **Rhinovirus**.

Influenza

Better known as flu, influenza commonly occurs during childhood. It is caused by **Myxovirus** resulting in inflammation of nasal mucosa and pharynx.

Measles

Measles is caused by **Rubeola virus** and it is easily transfered from infected people. Symptoms of measles include eruption of small rashes in skin, cough, sneezing, redness of eye, pneumonia and bronchitis. Affected individuals can recover from this by proper rest and diet.

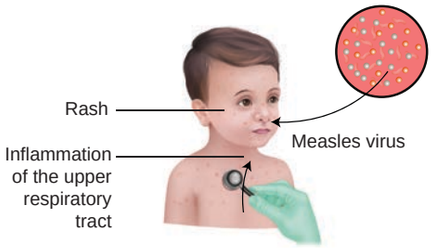


Figure 8.12 **Measles**

Mumps

It is caused by *Myxovirus parotidis* and affects the upper respiratory tract. Some of the more common symptoms of mumps include fever, headache, sore throat and swelling of parotid glands which makes the jaw movement difficult.

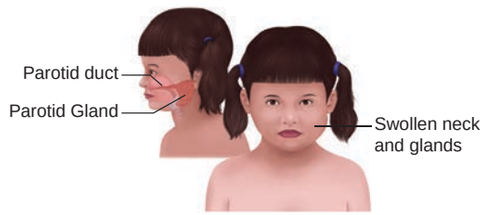


Figure 8.13 **Mumps**

Chickenpox

It is common among children and adults. It is a communicable disease caused by *Varicella virus*. It is characterized by eruptions of the skin in the form of blisters or spots in the body and face. The infected persons are isolated for a week until blisters are crusted.

Figure 8.14 **Chicken pox**

Table 8.4 Airborne diseases caused by virus

Disease	Causative Organism	Mode of Transmission	Tissue/ Organ Affected	Symptoms
Common Cold	*Rhino virus*	Droplet infection	Upper respiratory tract (Inflammation of nasal chamber)	Fever, cough, running nose, sneezing and headache
Influenza	*Myxovirus*	Droplet Infection	Respiratory tract, (Inflammation of nasal mucosa, pharynx)	Fever, body pain, cough, sore throat, nasal discharge, respiratory congestion
Measles	*Rubeola Virus*	Droplet infection, droplet nuclei and direct contact with infected person	Respiratory tract	Eruption of small red spots or rashes in skin, cough, sneezing, redness of eye (conjunctiva), pneumonia, bronchitis
Mumps	*Myxovirus parotidis*	Droplet infection, droplet nuclei and direct contact with infected person	Upper respiratory tract	Enlargement of parotid gland, movement of jaw becomes difficult
Chicken Pox	*Varicella Zoster virus*	Droplet infection, droplet nuclei and direct contact with infected person	Respiratory tract	Eruptions of the skin, fever and uneasiness

8.5 Waterborne Diseases

Microbes present in the contaminated water cause various infectious diseases. Some of the water borne diseases are cholera, typhoid, infectious hepatitis, poliomyelitis, diarrhoea, etc. The most common waterborne diseases and their causative microbial agents are given below.

8.5.1 Diseases caused by bacteria

Cholera

Cholera is an epidemic disease and in the earlier days many people died due to this. It is caused by *Vibrio cholerae* mostly due to contaminated food and water. Acute diarrhoea with watery stool, vomiting, nausea and dehydration are the symptoms of this disease.

Figure 8.15 *Vibrio cholerae*

Typhoid

This disease is common in children of age group 1-15 years. Nearly 2.5 million people suffer from typhoid disease every year. This is caused by the bacteria *Salmonella typhi*. Food and water contaminated by the faeces of infected person causes this disease. Infected persons show symptoms of fever, weakness and vomiting.

Table 8.5 gives more information about water borne diseases caused by bacteria.

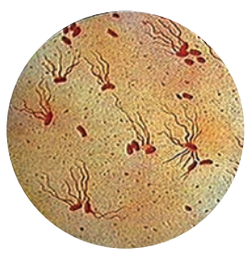


Figure 8.16 *Salmonella typhi*

Table 8.5 Waterborne diseases caused by bacteria

Disease	Causative Organism	Mode of Transmission	Tissue/ Organ Affected	Symptoms	Preventive and Control Measures
Cholera (Acute diarrhoeal disease)	*Vibrio cholerae*	Contaminated food, water, oral route and through houseflies	Intestinal tract	Acute diarrhoea with rice watery stools, vomiting, muscular cramps, nausea and dehydration	Hygienic sanitary condition, intake of Oral Rehydration Solution (ORS)
Typhoid (Enteric fever)	*Salmonella typhi*	Food and water contaminated with faeces of infected person and through houseflies	Small intestine	High fever, weakness, abdominal pain, headache, loss of appetite, rashes on chest and upper abdomen	Preventing contamination of food by flies and dust, improvement of basic sanitation, treatment with antibiotic drugs

More to Know

- Cholera caused by *Vibrio cholerae* was first published by Robert Koch.
- Chloragen is a toxin produced by *Vibrio cholerae* causing harmful effects.

8.5.2 Diseases caused by virus

Poliomyelitis

It is caused by *polio virus* and spreads from person to person. This virus gets into the blood and enters into the brain or spinal cord and affects the central nervous system. Muscles get paralysed and result in difficulty in walking.

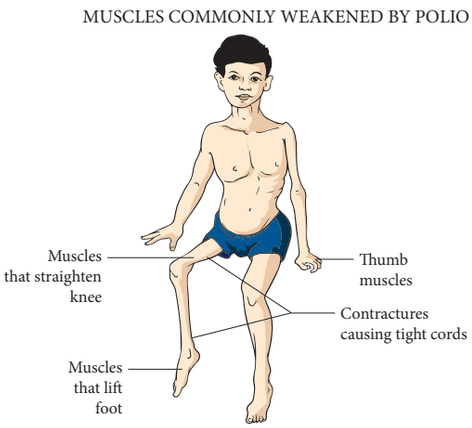


Figure 8.17 Poliomyelitis

More to Know

Polio virus is also called enterovirus. It is primarily an infection of the alimentary tract. The most vulnerable age is between 3-6 years of age. Pulse-polio programme was started in December 1995 in India. India has taken up a massive programme for the eradication of Polio under Pulse Polio Immunisation Programme in which young children are given polio vaccine drops orally.

DO YOU KNOW?

No cases of polio reported in India since 13th January 2011. Without reporting any case of polio for three years, WHO declared India as 'Polio-free country' on 13th January 2014.

Activity 4

Collect data on the success of pulse polio programme in your city/town/village.

Hepatitis A or Infectious Hepatitis

It is caused by Hepatitis A virus (HAV). It is transmitted through contaminated water and food and through oral route. It causes inflammation of liver resulting in jaundice (Yellow fever).

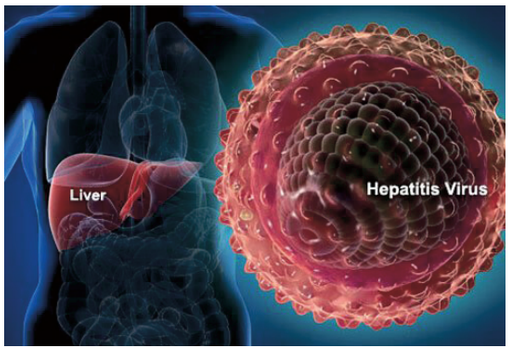


Figure 8.18 Hepatitis B virus

Acute Diarrhoea

Acute diarrhoea is commonly caused by infection of intestine. It is caused by **Rotavirus** and results in sudden onset of frequent stools, three or more in a day. It is transmitted through contaminated water and food. Increased fluidity and the volume of bowel movements result in excessive loss of fluid and electrolytes from the intestine.

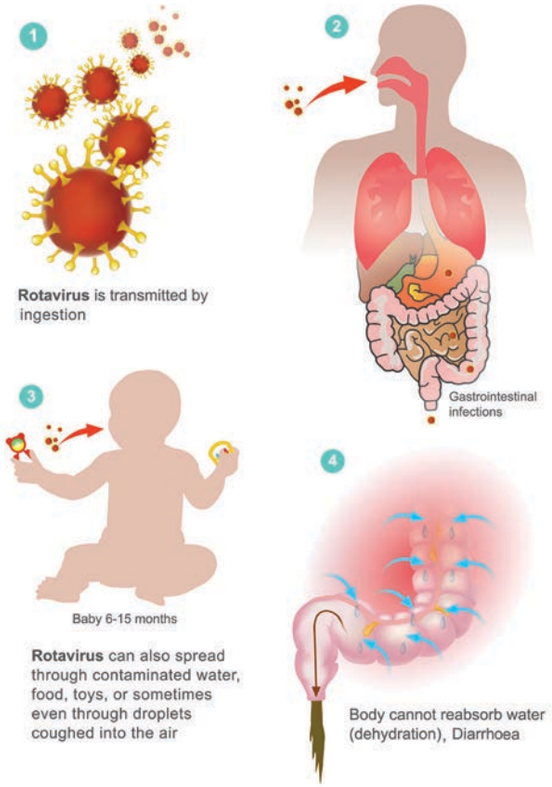


Figure 8.19 Rotavirus infection

Symptoms of these diseases and preventive measure are given in Table 8.6.

Table 8.6 Waterborne diseases caused by virus

Disease	Causative Organism	Mode of Transmission	Tissue/Organ Affected	Symptoms	Preventive and Control Measures
Poliomyelitis	*Polio virus*	Droplet infection, sputum discharge, secretion from nose, throat, contaminated water, food and milk	Central nervous system	Paralysis of limbs	Salk's vaccine or Oral Polio Vaccine (OPV) is administered
Hepatitis A or Infectious Hepatitis	*Hepatitis A virus (HAV)*	Contaminated water, food and oral route	Inflammation of liver	Nausea, anorexia, acute fever and jaundice	Prevention of food contamination, drinking chlorinated boiled water, personal hygiene
Acute Diarrhoea	*Rotavirus*	Contaminated water, food and oral route	Intestine	Vomiting, fever, watery stools with mucus	Proper sanitation and hygiene

8.6 Vector Borne Diseases

Vector is an agent that acts as an intermediate carrier of the pathogen. Many insects and animals acts as vectors. Diseases transmitted by vectors are called vector borne diseases. These vectors can transfer infecting agents from an infected person to another healthy person. Some of the insect vector borne diseases are Malaria, Filaria, Chikungunya, Dengue, and the diseases which are transmitted through animals are Bird flu and Swine flu.

8.6.1 Malaria

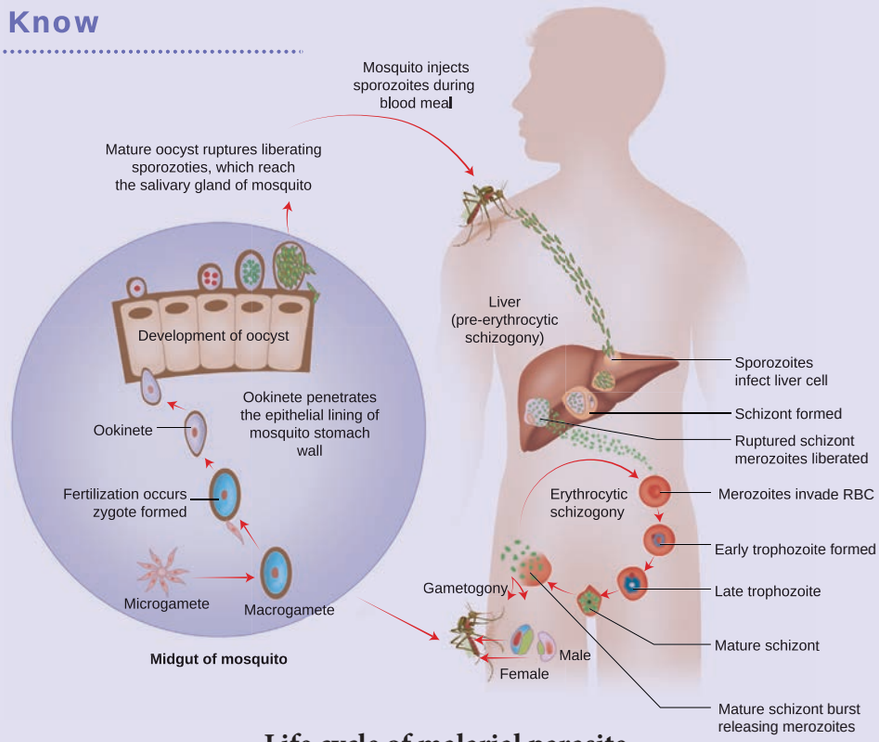
Malaria continues to be one of the major health problems of developing countries. Malaria is caused by **protozoan** parasite *Plasmodium*. Four different species of *Plasmodium* namely, *P.vivax, P.malariae, P.falciparum* and *P.ovale* cause malaria. Malaria caused by *Plasmodium falciparum* is malignant and fatal. Approximately 300 million people around the world get infected with Malaria every year. It may be fatal to human beings, but cure is available.

It spreads through the bite of an insect vector the female *Anopheles* mosquito which feeds on human blood and usually lasts less than 10 days. A person affected by malaria will show symptoms of headache, nausea, muscular pain, chillness and shivering, followed by rapid rise in temperature. The fever subsides with profuse sweating. Use of Quinine drugs kills the stages of malaria parasite.

Know your Scientist

Sir Ronald Ross was an Indian born British doctor who is famous for his work concerning malaria. He worked in the Indian Medical Service for 25 years. He identified the developing stages of malarial parasite in the gastrointestinal tract of mosquito and proved that malaria was transmitted by mosquito. In 1902, he received the Nobel Prize for Physiology or Medicine for his work on the transmission of malaria.

More to Know



Life cycle of malarial parasite

8.6.2 Chikungunya

Chikungunya, which is caused by single stranded RNA virus, is transmitted in humans by the bite of infected *Aedes aegypti* mosquito during the day time. It causes severe and persistent joint pain, body rashes, headache and fever. Joint pains can last for a very long time.

Incubation period of the virus is usually 2-12 days. Chillness, high fever, vomiting, nausea, headache, persistent joint pain and difficulty in walking are the common symptoms associated with this disease. The joints get inflamed and the person finds it difficult to walk. Paracetamol is given to relieve pain and reduce fever.

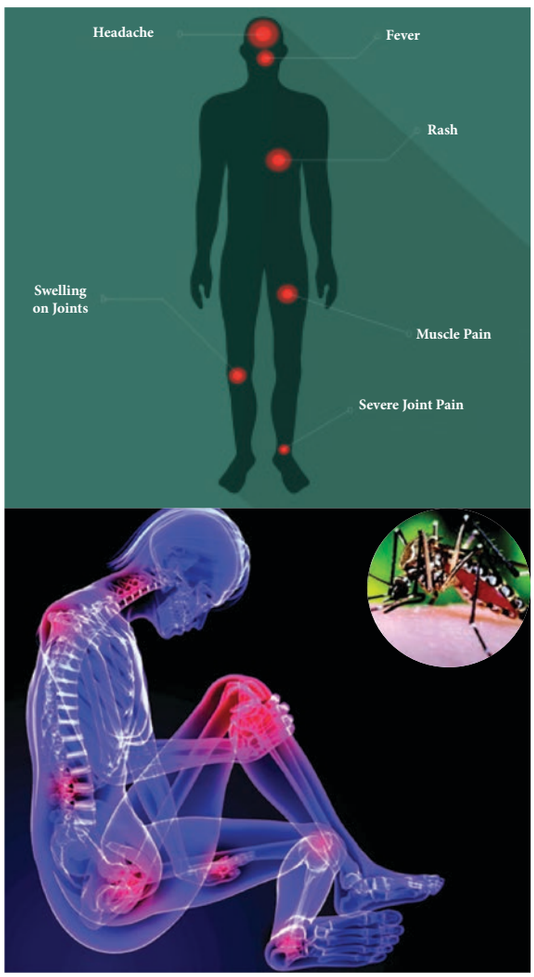


Figure 8.20 Chikungunya

8.6.3 Dengue

Dengue is known as **break bone** fever. The name break bone fever was given because of the contortions caused due to the intense joint and muscle pain. Dengue haemorrhagic fever is more severe form and can be life threatening or fatal.

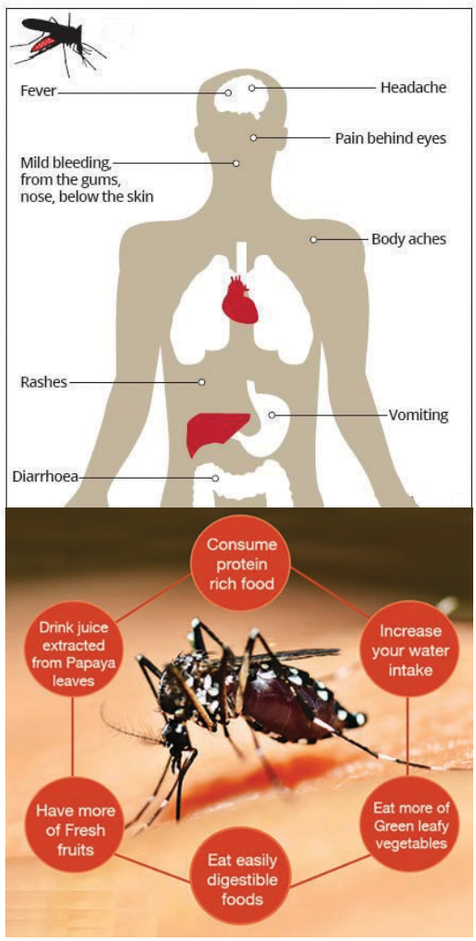


Figure 8.21 Dengue

Activity 5

Observe the mosquitoes that are active during the day time. Catch them using an insect net and observe their body and legs. What do you observe?. Why are cases of Dengue reported in large numbers during post-monsoon season?

Dengue fever and Dengue haemorrhagic fever are caused by virus. It is transmitted by *Aedes aegypti* mosquito that has previously bitten an infected person. Incubation period of the virus is usually 5-6 days. Onset of high fever, severe headache, muscle and joint pain (break bone fever), rash and other haemorrhagic manifestation, fall in blood platelet count are the symptoms associated with this disease. Vomiting and abdominal pain, difficulty in breathing, minute spots on the skin signifying bleeding within the skin are also associated with dengue fever. Paracetamol is given to reduce fever and body ache. Complete rest and increased intake of fluid is essential.

Herbal Facts on Dengue Treatment (Source: AYUSH)

An extraction of tender leaves of papaya and herbal drink Nilavembu Kudineer is given to dengue patients. It is known to increase the blood platelet count.

8.6.4 Filaria

Filariasis is a major health problem in India. This disease is caused by **nematode** worm *Wuchereria bancrofti*. The adult worms are usually found in the lymphatic system of man. It is transmitted by the bite of infected *Culex* mosquito.

Incubation period of filarial worm is 8-16 months and the symptoms include acute infection, fever and inflammation in lymph glands. In chronic infection the main feature is **elephantiasis** which affects the legs, scrotum and the arms.

The parasite is deposited at the site of mosquito bite. It passes through the punctured skin and finally reaches the lymphatic system. They appear in large number in the blood stream during night displaying **nocturnal periodicity.**

8.6.5 Control and prevention of vector borne diseases transmitted through mosquitoes

- Prevention of mosquito bites by using mosquito nets, mosquito screens, mosquito repellents and ointments.
- Elimination of breeding places by providing adequate sanitation, underground wastewater disposable system and drainage of stagnant water.
- Collection of water in any uncovered container such as water tank, pots, flower pots, discarded tyres should be avoided.
- Control of mosquito larvae by spraying oil on stagnated water bodies.
- Adult mosquitoes can be killed by spraying insecticides.
- Application of citronella oil or eucalyptus oil on the exposed skin.

8.7 Diseases Transmitted by Animals

8.7.1 Swine Flu

Swine Flu is so termed because the virus that first caused the disease had originated from pigs. People with weak immune system are at high risk of contracting swine flu. It is an acute respiratory virus which is contagious and spreads through air. Swine flu is caused by virus that affects pigs and has started infecting humans as well.

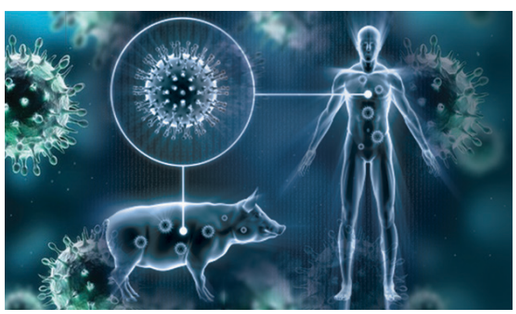


Figure 8.22 Swine flu

Influeuza virus H1N1 has been identified as the cause of this disease. It is transmitted from person to person by inhalation or ingestion of droplets containing virus from people sneezing or coughing. Fever, cough, nasal secretion, fatigue, headache, sore throat, rashes in the body, body ache or pain, chills, nausea, vomiting and diarrhoea, and shortness of breath are the symptoms associated with the disease.

Prevention and Control

- Administration of nasal spray vaccine.
- Avoiding close contact with a person suffering from flu.
- Intake of water and fruit juices will help prevent dehydration.
- Plenty of rest will help the body fight infection.
- Always wash hands and practice good hygiene.

More to Know

Swine flu first surfaced in April 2009. It affected millions of people and then in June 2009 it was declared a pandemic by the World Health Organization (WHO). In 2015, India reportedly had over 31,000 people infected and 1,900 resulting deaths. There was a small outbreak in the Maldives in early 2017. Swine flu has spread to more than twenty countries across the world. World Health Organisation had then assigned pandemic alert level 5 to swine flu. This level indicates that human to human outbreak of swine flu is high.

8.7.2 Avian Influenza

Avian influenza is a contagious bird disease caused by a number of viruses. Birds that can carry and spread an avian influenza virus include poultry (like chickens, turkeys or ducks), wild birds and even pet birds. The virus has infected people during outbreaks in Asia, Africa, Middle East and parts of Europe. It is caused by **Influenza Virus H5N1.** The incubation period of the virus is 2-7 days.

People who have close contact with infected birds or surfaces that have been contaminated by the bird's secretion from mouth, eyes, mucus, nasal secretion or droppings (bird faeces) transmit this disease.

Fever, cough, sore throat, running nose, muscle and body aches, fatigue, headache, redness of eyes (conjunctivitis) and difficulty in breathing are the symptoms of this disease.

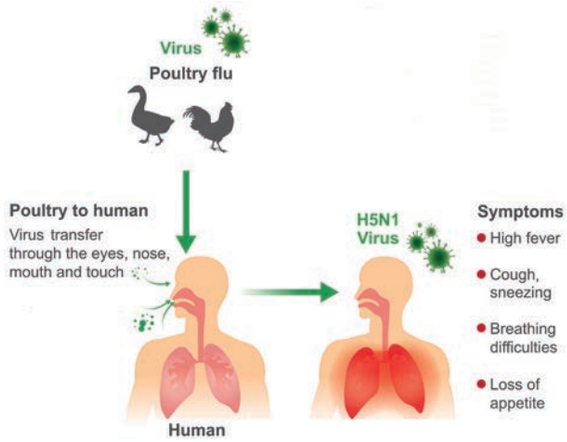


Figure 8.23 Transmission of Avian influenza virus

Prevention and Control

- Avoiding open air markets where infected birds are sold.
- Avoiding contact with infected birds or consumption of infected poultry.
- Proper cleaning and cooking of poultry.

DO YOU KNOW?

The avian influenza virus A (H5N1) emerged in 1996. It was first identified in Southern China and Hong Kong. The A(H5N1) virus kills a high proportion of the poultry that it infects and is therefore known as a highly pathogenic avian influenza virus. H5N1 was first discovered in humans in 1997 by World Health Organisation. First outbreak was in December 2003.

8.8 Sexually Transmitted Diseases

Some pathogens are transmitted by sexual contact from one partner to another and not by casual physical contact. A few sexually transmitted diseases are gonorrhea, genital warts, genital herpes, syphilis and AIDS

8.8.1 AIDS

Acquired Immunodeficiency Syndrome (AIDS) is caused by **retrovirus** (RNA virus) known as **Human Immunodeficiency Virus** (HIV). The virus attacks the white blood cells or **lymphocytes** (T-lymphocytes) and weakens the body's immunity or self defence mechanism. It is transmitted through sexual contact (from infected person to a healthy person), blood contact (transfusion of unscreened blood), by surgical equipments (infected needles and syringes), maternal – foetal transmission (from infected mother to the foetus).

Weight loss, prolonged fever, sweating at night, chronic diarrhoea are some of the important symptoms.

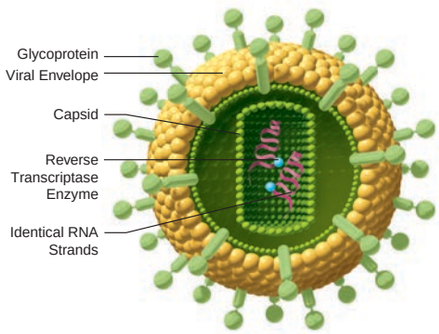


Figure 8.24 Structure of HIV

Prevention and Control

- Disposable syringes and needles should be used.
- Protected and safe sexual contact.
- Screening of blood before blood transfusion.
- Avoid sharing shaving blades/razors.
- People should be educated about AIDS transmission.

Robert Gallo at National Institute of Health, USA and Luc Montagnier at Pasteur Institute, Paris in 1983 isolated the Human Immunodeficiency Virus (HIV), which causes AIDS.

More to Know

Acquired Immunodeficiency Syndrome caused by HIV (Human Immunodeficiency Virus), a retrovirus was first recognised in Hatai (USA) in 1981. In India the first confirmed evidence of AIDS infection was reported in April 1986 from Tamil Nadu. The AIDS vaccine RV 144 trial was conducted in Thailand in 2003 and reports were presented in 2011.

8.8.2 Hepatitis -B or Serum Hepatitis

It occurs due to infection of **hepatitis-B virus** (HBV) which is an enterovirus. The infecting virus damages the liver cells, causing **acute inflammation** of **liver**.

It is transferred from infected mother to their babies or by sexual contact. It is also transmitted by contact with infected person's secretions such as saliva, sweat, tears, breast milk and blood.

Individual affected by this disease shows symptoms of fever, loss of appetite, nausea vomiting, yellowness of eyes and skin, light coloured stools, itching of skin, headache and joint pain. It also causes cirrhosis of liver.

Prevention and Control

- Screening of blood donors before blood donation can prevent the transmission.
- Injection of drugs to be prevented.
- Having safe and protected sex.
- Sharing of razors should be avoided.

- The hepatitis B vaccine offers excellent protection against HBV. The vaccine is safe and highly effective.

Some of the other sexually transmitted diseases caused by bacteria and virus are discussed in Table 8.7.

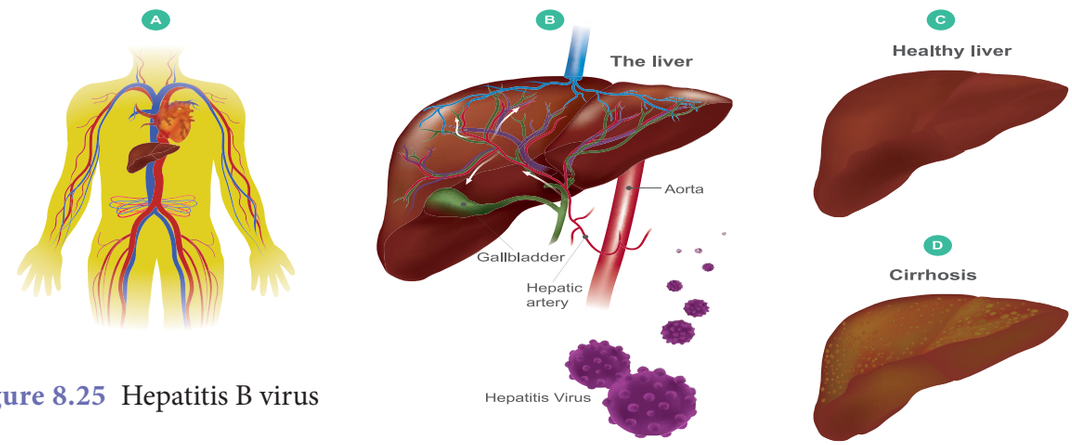


Figure 8.25 Hepatitis B virus

Table 8.7 Sexually transmitted diseases

Infectious agent	Disease	Causative Organism	Mode of Transmission	Tissue/ Organ Affected	Symptoms
Bacteria	Gonorrhoea	*Neisseria gonorrhoea*	Sexual contact	Urethra is affected	Discharge from genital openings, pain during urination
	Syphilis	*Treponema pallidum*	Sexual contact	Minute abrasion on the skin or mucosa, of genital area	Ulceration on genitals, skin eruption
Virus	Genital Herpes	*Herpes Simplex Virus*	Sexual contact, entry through mucous membrane of genital region	Genital organs of male and female individuals	Painful blisters in mouth, lips, face and genital region
	Genital Warts	*Human Papilloma virus*	Sexual contact (skin to skin)	Genital areas of male and female individuals	Vaginal discharge, itching, bleeding and burning

8.9 Immunization

Immunization is a process of developing resistance to infections by administration of antigens or antibodies. Inoculation of vaccines into the body to prevent diseases is called as vaccination.

One effective way of controlling the spread of infection is to strengthen the host defenses. This is accomplished by immunization, which is one of the cost effective weapon of modern medicine.

When a large proportion of a community is immunized against a disease, the rest of the

people in the community are benefited because the disease does not spread.

The process of vaccination was introduced by Edward Jenner and according to the World Health Organisation (WHO), Jennerian vaccination has eliminated small pox totally from the human population.

8.9.1 Vaccines and its types

Vaccines are preparation of living or killed microorganisms or their products used for prevention or treatment of diseases. Vaccines are of two types: Live vaccines and Killed vaccines

Live Vaccines

They are prepared from living organisms. The pathogen is weakened and administered. e.g. BCG vaccine, oral polio vaccine.

Killed Vaccines

Micro organisms (bacteria or virus) killed by heat or chemicals are called killed or inactivated vaccines. They require a primary dose followed by a subsequent booster dose. e.g. Typhoid vaccine, cholera vaccine, pertussis vaccine.

8.9.2 Immunization Schedule

The World Health Organization in the year 1970 has given a schedule of immunization for children. This schedule is carried out in almost all countries. The immunization schedule indicates the age at which the vaccine should be administered to protect the children from infectious diseases. Table 8.8 gives the schedule of vaccination procedures followed in India.

BCG (Bacillus Calmette Guerin): This was prepared by two French workers Calmette and Guerin (1908-1921). It was developed for over a period of thirteen years. The bacilli are weakened and used for immunization against tuberculosis.

DPT (Triple Vaccine): It is a combined vaccine for protection against Dipetheria, Pertussis (whooping cough) and Tetanus.

MMR: Mumps, Measles, Rubella vaccine gives protection against viral infections.

DT: It is a dual antigen or combined antigen. It gives protection from Diphtheria and Tetanus.

TT (Tetanus Toxoid): Toxin of Tetanus bacteria.

TAB: Combined vaccine for typhoid, paratyphi A and paratyphi B.

Table 8.8 Immunization Schedule for Children

Age	Vaccine	Dosage
New born	BCG	1st dose
15 days	Oral Polio	1st dose
6th week	DPT and Polio	1st dose
10th week	DPT and Polio	1st dose
14th week	DPT and Polio	1st dose
9 – 12 months	Measles	1st dose
18 – 24 months	DPT and Polio	1st dose
15 months – 2 years	MMR	1st dose
2 – 3 years	TAB	2 doses at 1 month gap
4 – 6 years	DT and Polio	2nd booster
10th year	TT and TAB	1st dose
16th year	TT and TAB	2nd booster

Know your Scientist

Louis Pasteur was an 18th century French chemist and microbiologist best known for vaccination and pasteurisation. He coined the term vaccine. Pasteur developed vaccine against chicken pox, cholera, anthrax, etc. In 1885 Pasteur administered his first vaccine to a young boy named Joseph Meister who had been repeatedly bitten by rabid dog. The boy was inoculated with less virulent or weakened rabies virus preparations and was saved. He discovered the basis for attenuation, the process of weakening the virulence of pathogenic organisms without losing the capacity to induce immunity.

- According to WHO, immunisation currently prevents 2-3 million deaths every year.
- A new vaccine against dengue has been licensed in several countries. In 2018, first vaccine to protect children against malaria will be piloted in three African countries.
- Globally, mortality rate due to measles is reduced by 7 %.

Activity 6

Recently in 2018, Nipah virus was in the headlines of the daily newspaper. Collect the following information.

(a) What is Nipah virus?

(b) How it gets transmitted?

(c) Mention the preventive measures taken by the government to check the disease.

Points to Remember

- ❖ Bacteria are single celled prokaryotic organisms, without a well defined nucleus (nucleoid) and other cell organelles. The genetic material is DNA.
- ❖ Viruses are small microscopic infectious agents that can multiply only inside the living cells.
- ❖ Fungi are group of eukaryotic heterotrophs which are either single celled (Yeast) or multicellular (*Penicillium*, *Agaricus*).
- ❖ Microbes play an important role in agriculture as biocontrol agent.
- ❖ Microorganisms which enrich the soil with nutrients are called as biofertilizers.
- ❖ Microbes play a vital role in the cycling of elements like carbon, nitrogen, oxygen, sulphur and phsopshorus.
- ❖ Microorganisms play an important role in the production of wide variety of valuable food products for the welfare of mankind.
- ❖ Certain bacteria and fungi are used to produce antibiotics.
- ❖ Vaccines are prepared from microbes that are dead or inactive.
- ❖ Microorganisms, insects and parasites (also called as pathogens) infect the human body and cause diseases.
- ❖ The time between infection and the first appearance of the diseases is called incubation period.
- ❖ Reservoir of infection refers to the specific environment in which the pathogens can thrive well and multiply without causing diseases.
- ❖ Most of the respiratory tract infections are acquired by inhaling air containing the pathogen that are transmitted through droplets caused by cough or sneeze, dust and spores.
- ❖ Some of the air borne diseases are tuberculosis, whooping cough, diphtheria, chicken pox, mumps, measles and influenza.

- ❖ Infectious diseases that can spread through water are diarrhoea, dysentery, cholera, typhoid, hepatitis and poliomyelitis.
- ❖ Diseases transmitted by vectors are called vector borne diseases. Some of them are malaria, filaria, chikungunya and dengue.
- ❖ Diseases transmitted by animal to man are swine flu and bird flu.
- ❖ Sexually transmitted diseases such as gonorrhea, genital warts, genital herpes, syphilis, AIDS are transmitted from one person to another by close physical contact.

A-Z GLOSSARY

Acute disease	It is a short duration disease which generally has a relatively severe effect.
Antibiotics	Substances that kill or prevent the growth of microorganisms.
Biofertilizer	Microorganisms which enrich the soil with nutrients are called as biofertilizers.
Biopesticides	The agents which control insect pests in natural way without causing harm to the environment. e.g. bioinsecticides.
Chronic disease	Disease which lasts for a long time, even throughout lifetime.
Flagella	It is a lash-like appendage protruding from the cell body of bacterial cell. It helps in locomotion.
Goitre	Swelling of the neck region due to the enlargement of thyroid gland.
Immunisation	It is the process by which the body produces antibodies against the specific vaccine when administered.
Killed vaccines	These vaccines are prepared by killing the pathogenic organisms by heat, UV rays, alcohol, formalin or phenol. (eg) Typhoid vaccine, Cholera vaccine.
Live vaccines	The pathogen is weakened to make it non-virulent (eg) Oral polio, BCG, MMR vaccine.
Microfilaria	Infective stage of filarial worm (*Wuchereria bancrofti*).
Pathogen	A pathogen is a biological agent that causes disease to its host. e.g. bacteria,virus etc.
Peptidoglycan	Peptidoglycan, is a combination of sugars and amino acids that forms the cell wall of most bacteria.
Prions	Viral particles which contain only protein. They do not contain nucleic acid.
Sporozoites	Infective stage of *Plasmodium* (Malarial parasite) which infect man and transmitted from salivary gland of mosquito.
Vaccination	It refers to the administration of vaccine.

Vaccines	Preparation of antigenic proteins of pathogens (weakened or killed) which on inoculation into a healthy person provides temporary / permanent immunity against a particular disease.
Vector	Pathogens of certain diseases reach the human body through intermediate agents which act as carrier or vector. (eg) Housefly, Mosquito.
Virion	It is a complete viral particle (functional virus) comprising of nucleic acid (DNA or RNA) surrounded by a protective protein coat.
Viroids	Smaller than viruses with self replicating RNA and do not bear protein coat and infect plant cells.

TEXTBOOK EVALUATION

GEB4NR

I. Choose the correct answer.

1. Mycology is the branch of biology that deals with the study of

   (a) algae (b) virus

   (c) bacteria (d) fungi

2. The major constituent of vinegar is

   (a) citric acid (b) acetic acid

   (c) oxalic acid (d) hydrochloric acid

3. Bacteria involved in curd formation is
   (a) *Lactobacillus acidophilus*
   (b) *Nitosomonas*
   (c) *Bacillus ramous*
   (d) none of the above

4. Which of the following is transmitted through air?
   a. Tuberculosis b. Meningitis
   c. Typhoid d. Cholera

5. The most fatal form of Malaria is caused by
   a. *Plasmodium ovale*
   b. *Plasmodium falciparum*
   c. *Plasmodium malariae*
   d. *Plasmodium vivax*

6. One of the means of indirect transmission of a disease is
   a. sneezing b. coughing
   c. vectors d. droplet infection

7. Syphilis is caused by
   a. *Treponema pallidum*
   b. Leptospira
   c. Pasteurella
   d. *Vibrio cholerae*

8. Mosquito borne viral diseases are
   a. malaria and yellow fever
   b. dengue and chikungunya
   c. filariasis and typhus
   d. kala azar and diptheria

9. Diptheria affects the
   a. Lungs b. Throat
   c. Blood d. Liver

10. Which one of the following is a pair of viral disease?
    a. Filariasis, AIDS
    b. Common cold, AIDS

c. Dysentry, Common cold
d. Typhoid, Tuberculosis

11. Which of the following disease is spread by animal bite?
    a. Pneumonia b. Tuberculosis
    c. Cholera d. Rabies

12. The primary organ infected during tuberculosis is
    a. bone marrow b. intestine
    c. spleen d. lungs

13. Microbes that generally enter the body through nose are likely to affect
    a. gut b. lungs
    c. liver d. lymph nodes

14. The organ affected by jaundice is
    a. liver b. lungs
    c. kidney d. brain

15. Severity of disease symptom depends upon
    a. number of microbes
    b. target organ
    c. both a and b
    d. none of these.

16. Poliomyelitis virus which causes infantile paralysis enters the body through
    a. skin b. mouth and nose
    c. ears d. eye

II. Fill in the blanks.

1. _____ break down organic matter and animal waste into ammonia.
2. The hyphae with branches form a complex network called _____.
3. First antibiotic _____ was developed by _____.
4. Baker's yeast is _____.
5. The two non symbiotic nitrogen fixing bacteria are _____ and _____.
6. Typhoid fever is caused by _____.
7. H1N1 virus causes _____.
8. _____ is a vector of viral disease dengue.
9. _____ vaccine gives considerable protection against tuberculosis.
10. Cholera is caused by _____ and malaria is caused by _____.

III. Expand the following.

1. ORS 2. HIV 3. DPT
4. WHO 5. BCG

IV. Pick out the odd one from the following.

i) AIDS, Retrovirus, Lymphocytes, BCG,
ii) Bacterial disease, Rabies, Cholera, Common cold and Influenza
iii) Sporozoites, Merozoites, Trophozoites, Gametocytes (Infective stages of plasmodium in human)

V. State whether True or False. If false write the correct statement.

1. Glycogen and oil globules are stored form of food in fungi.
2. One of the differences between virus and viroid is the presence of protein coat in viroid and its absence in virus.
3. *Rhizobium,* associated with root nodules of leguminous plants fixes atmospheric nitrogen.
4. Lophotrichous is a cluster of polar flagellae.
5. Non- infectious diseases remain confined to the person who develops the disease and do not spread to others.
6. The process of vaccination was developed by Jenner in the year 1796.
7. Hepatitis B is more dangerous than Hepatitis A.

VI. Match the following.

Swine flu	Human Papilloma virus
Genital warts	Human Immunodeficiency Virus
AIDS	*Mycobacterium*
Tuberculosis	Influeuza virus H1N1

VII. Analyze the table and select the option given below that correctly fills the blank.

Disease	Causative organism	Symptoms
Hepatitis	-	Inflammation of the liver
Elephantiasis	Filarial worm	-
Malaria	Protozoan	-
Diarrhoea	-	Nausea, Vomitting, Dehydration

(Swelling of legs, Virus, Rota virus, Fever, Chills and Sweating)

VIII. Answer the following in a word or a sentence.

1. Name the chronic diseases associated with respiratory system.
2. Name the scientist who first discovered penicillin antibiotic. Can you name any other known antibiotic?
3. Name the organism causing diarrhoeal diseases and give one precaution against it.
4. Name two common mosquitoes and the diseases they transmit.
5. Name one disease that is transmitted by houseflies. Mention their causative pathogen.

IX. Define the following.

1. Pathogen
2. Bacteriophages
3. Plasmid
4. Vaccines
5. Prions

X. Answer the following in brief.

1. Distinguish between Virion and Viroid.
2. A baby is suffering from diarrhoea, while other babies in the same locality do not. Mention the possible causes that you think. What would be the possible solutions for this?
3. Name the vector of the malarial parasite. Mention the species of malarial parasite which cause malignant and fatal malaria.
4. What is triple antigen? Mention the disease which can be prevented by using the antigen.
5. Sanjay had an attack of chicken pox and has just recovered. The health officer of his locality says that the disease would not occur again for him. What would be the reason for this?

XI. Answer in detail.

1. Give an account of classification of bacteria based on the shape.
2. Describe the role of microbes in agriculture and industries.
3. Explain the various types of viruses with examples.
4. Suggest the immunization schedule for a new born baby till 12 months of age. Why it is necessary to follow the schedule?
5. Name the causative agent of typhoid in human. How does the pathogen gain entry into the human body? Write the diagnostic symptoms and mention the organ that is affected in severe cases.

6. Some human diseases are transmitted only when the blood of a patient comes in close contact with the blood of a healthy person. In one such disease, there is a progressive decrease in WBC of the patient.
   a. Name the disease and its causative agent.
   b. Name the type of WBC affected during infection.
   c. How does the blood of a patient come in contact with blood of healthy patient?
   d. Suggest three methods that help in preventing such infection.

XII. Questions based on thinking skills.

1. We are advised to take bland and nutritious food when we are sick. What is the reason?
2. Suggest precautionary measures you can take in your school to reduce the incidence of infectious disease.
3. Tejas suffered from typhoid while, Sachin suffered from tuberculosis. Which disease could have caused more damage and why?
4. How will you differentiate Hepatitis A from Hepatitis B?

XIII. Assertion and Reason.

Direction: In each of the following questions a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Mark the correct statement as.

a) If both A and R are true and R is correct explanation of A

b) If both A and R are true but R is not the correct explanation of A

c) If A is true but R is false

d) If both A and R are false.

1. **Assertion :** A patient with cholera is given oral rehydration therapy for rapid replacement of fluid and electrolytes.

   Reason : Cholera can be diagnosed by the microscopic examination of the stool to identify the bacteria.

2. **Assertion:** Chicken pox is a disease indicated by scars and marks in the body.

   Reason: Chicken pox causes rashes on face and further spreads throughout the body.

3. **Assertion:** Dengue can be treated by intake of antibiotics.

   Reason: Antibiotics blocks the multiplication of viruses.

REFERENCE BOOKS

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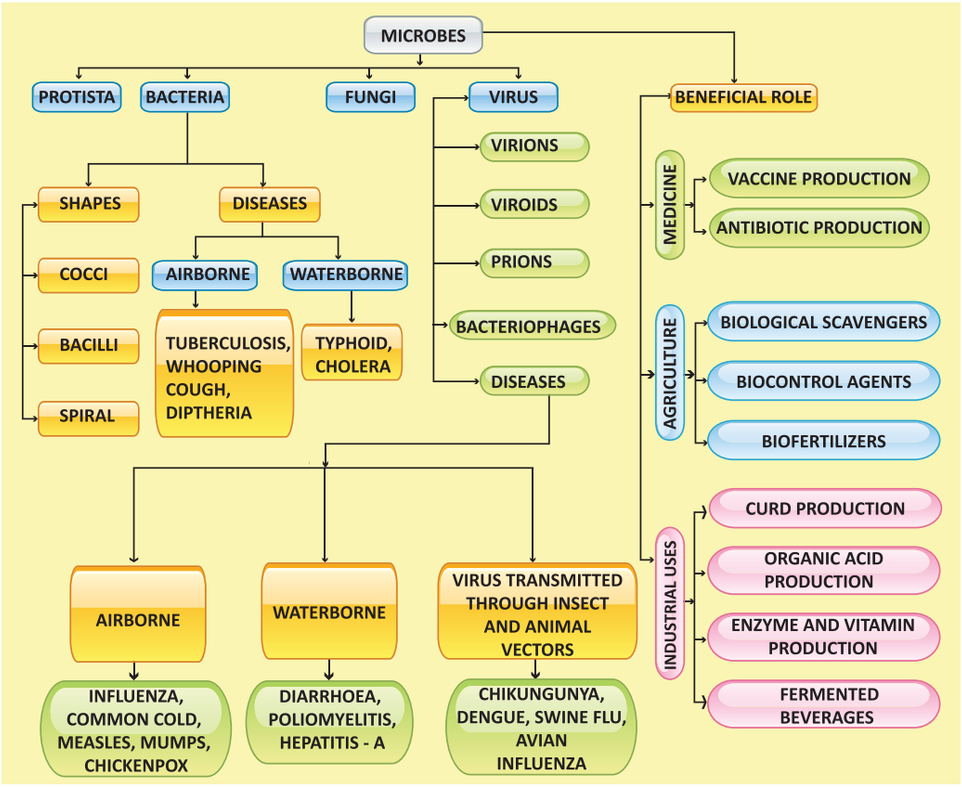
INTERNET RESOURCES

www.biology.online.org

www.biologydiscussion.com

www.nios.ac.in.textbook.com

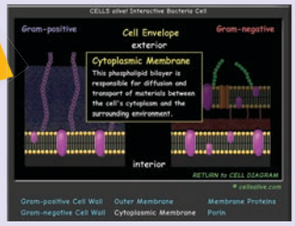
Concept Map



ICT CORNER

Explore the structure and parts of micro-organisms.

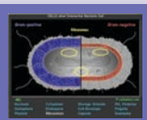
Microbes



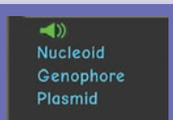
Steps

- Type the following URL to reach "Cells Alive" home page and select "Start the Animation".
- Place the pointer on the "Bacteria Cell Model" to view the parts of the cell, or click the parts given below the animation to highlight it on the diagram.
- Click the highlighted parts to get a brief description about it.
- Click the "Speaker Icon" on the bottom of the animation to read the description for you.


Step1


Step2


Step3



Step4

Cells alive

URL: https://www.cellsalive.com/cells/bactcell.htm or Scan the QR Code.

*Pictures are indicative only

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UNIT 9

Hardware and Software

GEGD2H

Learning Objectives

After completing this lesson, students will be able to:

- identify the software and hardware of a computer.
- distinguish the features of hardware and software.
- recognize different types of software.
- identify some Open source software and utilize them effectively.

Introduction

Computer is a device comprising both hardware and software. The functions of hardware and software combines together to make the Computer functional. A hardware device helps to enter input information. The software processes the input data and gives the output in the monitor, a hardware device. Thus a computer is like a human body, where human body is the hardware and soul is the software.

9.1 Hardware

Hardware is the parts of a computer which we can touch and feel. Hardware includes Input and Output devices, Cabinet, Hard Disk, Mother Board, SMPS, CPU, RAM, CD Drive and Graphics Card.

Figure 9.1 Hardware of a computer

DO YOU KNOW?

Email existed before the World Wide Web.

9.2 Software

Hardware is lifeless without software in a computer. Software are programmed and coded applications to process the input information. The software processes the data by converting the input information into coding or programmed language. Touching and feeling the software is not possible but we can see the functions of the software in the form of output.

9.3 Types of Software

The software is divided into two types based on the process. They are:

1. System software (Operating System)
2. Application software

9.3.1 System software

System software (Operating system) is a software that makes the hardware devices process the data fed by the user and to display the result on the output devices like Monitor. Without the operating system, computer cannot function on its own. Some of the popular operating system are Linux, Windows, Mac, Android etc.

9.3.2 Application Software

Application software is a program or a group of programs designed for the benefit of end user to work on computer. The application programs can be installed in the hard disk for the usage on a particular computer. This type of application program completes one or more than one works of the end user. The following are the examples of application program: Video player, Audio player, Word processing software, Drawing tools, Editing software, etc.

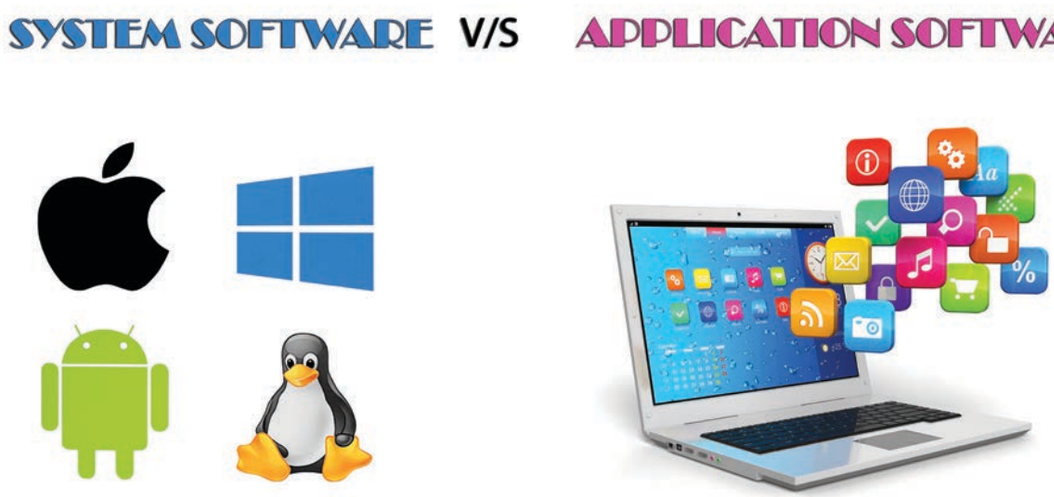


Figure 9.2 System and Application Software

9.4 System and Application Software types

The operating system and application software are available in two forms. They are:

1. Free and Open source
2. Paid and Proprietary Software

9.4.1 Free and Open source

Free and open software is available at free of cost and can be shared to many end users. Free software is editable and customizable by the user and this leads to updation or development of new software. Examples of Free and Open source software are: LINUX, Open office, Geogebra etc.

The Open Source Initiative (OSI) is an organization dedicated to promote Open Source Software.

9.4.2 Paid and Proprietary Software

There are softwares that need a license to use it. They have to be paid for using either permanently or temporarily. The license of the software would not be provided unless it is purchased. Similarly the end users are legally prohibited to steal the software program or to use the pirated version of the Paid and Proprietary Software. Some of the examples of Paid and Proprietary Software are: Windows, Microsoft office, Adobe Photoshop, etc.

TEXTBOOK EVALUATION

GEJZQE

I. Choose the correct answer.

1. Find out the part that is not found in CPU?
   a. Mother Board b. SMPS
   c. RAM d. Mouse
2. Which of the following is correct?
   a. Free and Open source
   b. Free and Traditional software
   c. Passive and Open source
   d. Passive and Traditional source
3. LINUX is a
   a. Paid Software
   b. Licensed Software
   c. Free and Proprietary software
   d. Free and Open source software
4. Find out the Paid and Proprietary software from the given list
   a. Windows b. MAC OS
   c. Adobe Photoshop d. All the above
5. _____ is an Operating System.
   a. Android b. Chrome
   c. Internet d. Pendrive

II. Match the following.

MAC OS	-	Free and Open source Software
Software	-	Paid and Proprietary Software
Hardware	-	Input Device
Keyboard	-	RAM
LINUX	-	Geogebra

III. Answer in brief.

1. What is Hardware and Software?
2. What do you mean by Operating System? How it Works?
3. What is Free and Open Source Software? Give any two examples?

PRACTICAL - TABLE OF CONTENTS

I. DENSITY OF THE MATERIAL OF THE BODY DENSER THAN WATER

Aim of the experiment:

To determine the density of the material of the body denser than water.

Apparatus required:

A metal bob, measuring cylinder and weighing balance.

Formula used:

Density of the material of the body denser than water, $\rho = M / V$ kg/ℓ.

Where, M = Mass of the body in water (kg) and V = volume of the body (ℓ)

Procedure:

- Take a metal bob. Weigh the bob in weigh balance. Let the mass of the bob be M.
- Take a measuring cylinder and fill about half of it with water. Note the reading of water level in the measuring cylinder. Let it be V_1.
- Suspend the bob in the measuring cylinder so that it is completely immersed in water. Note down the level of water in the measuring cylinder. Let it be V_2.
- The difference in the two readings of the measuring cylinder i.e., $V_1 - V_2$ is the volume of the metal bob.

- Find out the ratio of mass of the bob in air to the volume of the metal bob. This gives you the density of material of the bob. The ratio of mass of a body to its volume is equal to the density of the material of which the metal bob is made.

Observation:

S. No	Reading of water level in measuring cylinder before immersing the metal bob (V_1 mℓ)	Reading of water level in measuring cylinder after immersing the metal bob (V_2 mℓ)	Volume of the metal bob ($V_1 - V_2$) = V mℓ

Calculation:

Mass of the metal bob in air, M = _____ $\times 10^{-3}$ kg

Volume of the metal bob, V = _____ $\times 10^{-3}$ ℓ

Density of the material of the metal bob, ρ = M / V = _____ kg/ℓ.

Result:

The density of the material of the body denser than water is found to be _____ kg/ℓ.

II. SOUND

GETVS2

Aim:

To verify the laws of reflection of sound.

Apparatus required:

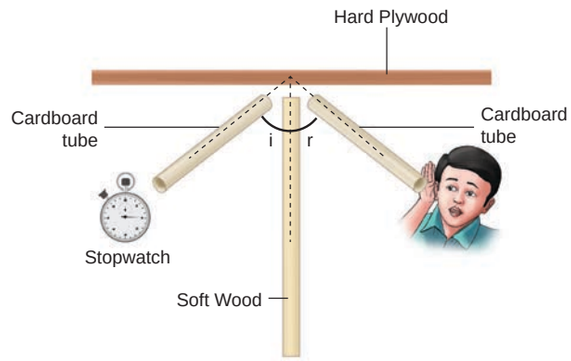
Stop clock, two identical pipes made of card board or chart paper, card board, etc.,

Procedure:

Arrange two identical cardboard pipes on a table near a wall. Keep an alarm clock near the open end of the pipes. Try to hear the sound of alarm clock through the other pipes as shown in figure.

Adjust the angle of pipes, so that you get maximum sound. Repeat the experiment with

different angle of incidences. Find out the angle of reflection and tabulate it. From the table you can realize that the angle of incidence is equal to angle of reflection.



S. No	Angle of incidence (i)	Angle of reflection (r)

Result:

From the above observation and table the laws of reflection of sound is verified.

III. ECONOMIC BIOLOGY

Aim:

To identify the plants and animals of economic importance.

GEZ55S

Observation:

To observe the following using specimen/photograph/picture/model.

a. **Biofertilizer** – *Rhizobium*

b. **Medicinal plants** – Nilavembu, *Aloe vera*

c. **Mushroom** - *Agaricus bisporus*

d. **Indigenous cattle breed** - Umblachery

e. **Indian major carp** - *Catla catla*

f. **Type of Honey bees** - Queen bee, Worker bee

Answer the following:

a. Draw a neat labelled sketch

b. Write its economic importance

IV. IDENTIFICATION OF MICROBES

GF3RTP

Aim:

To identify the different types of microbes (Bacteria and Virus).

Observation:

To observe the following with the help photograph/picture/permanent slide using a compound microscope/model/biovisual chart.

a. *Escherichia coli*

b. *Vibrio cholerae*

c. *Lactobacillus*

d. *Retrovirus (HIV)*

Answer the following:

a. Draw a neat labelled diagram.

b. Write the shape of the bacteria and virus observed.

c. Mention the structural details of the bacteria and virus.

d. Indicate its microbial importance/disease caused.

V. LIFE CYCLE OF MOSQUITO

GF917F

Aim:

To study the life cycle of mosquito.

Requirement:

A chart/formalin preserved bottle jar specimen/permanent slides showing the different stages of development in mosquito (*Anopheles*/*Culex*/*Aedes*)

Observation:

a. Observe the chart/specimen showing the different stages of development.

b. Permanent slides (each stage of development) under low power of compound microscope.

Answer the following questions as required from your observation

a. What is the sequence of development?

b. Draw the various stages of development and name them.

c. Identify the main characteristics of each stage.

d. Which of these stages require water for development?

e. What is the purpose of studying the life cycle of mosquito?

f. Point out two differences you observe between the male and female mosquito.

GLOSSARY

GFCMVC

Altitude	–	குத்துயரம்
Amplitude	–	வீச்சு
Asteroid	–	சிறுகோள்கள்
Allotropes	–	புறவேற்றுமை வடிவம்
Amorphous	–	படிக வடிவமற்ற
ABS	–	அக்ரிலோநைட்ரில் பியூட்டாடையின் ஸ்டைரின்
Anaesthetics	–	மயக்க மருந்து
Analgesics	–	வலி நிவாரணி
Antacids	–	அமில நீக்கி
Aestivation	–	கோடைகால உறக்கம்
Aquaculture	–	நீர் உயிர் வளர்பியல்
Apiculture	–	தேனி வளர்பியல்
Auto Trophs	–	சுய ஜீவிகள் / தன் ஜீவிகள் / சுய ஊட்ட உயிரி
Biogeochemical Cycle	–	உயிர் புவி வேதியியல் சுழற்சி
Bell jar	–	மணி ஜாடி
Biological Oxidation	–	உயிரியியல் ஆக்ஸிசனேற்றம்
Brackish water	–	உவர் / உப்பு நீர்
Bacteriophages	–	பாக்டீரியா அழிப்பு உயிரி / பாக்டீரியா கொல்லிகள்
Biofertilizers	–	உயிர் உரங்கள்
Compressions	–	இறுக்கங்கள்
Crest	–	முகடு
Comet	–	வால்நட்சத்திரம் (வால்மீன்)
Carbon Cycle	–	கார்பன் சுழற்சி
Catenation	–	சுய சகப்பிணைப்பு
chemotherapy	–	வேதிய சிகிச்சை முறை
Deformation	–	உருக்குலைவு
Dye Chemistry	–	சாய வேதியியல்
drug-	–	மருந்து
Electric bell	–	மின்சார மணி
Echo	–	எதிரொலி
Electrochemistry	–	மின் வேதியியல்
Electrochemical Cell	–	மின்வேதிக்கலம்
Echolocation	–	எதிரொளியிடம்
Endangered species	–	அழிவின் விளிம்பில் உள்ள சிற்றினங்கள்
Fossil water	–	புதைபடிவ நீர்
Frequency	–	அதிர்வெண்

GLOSSARY

Forensic Chemistry	–	தடய வேதியியல்
Floriculture	–	மலர்வளர்தல் கலை (மலரியல்)
Fermented beverages	–	நொதித்த பானங்கள்
Hydraulic System	–	நீர்மவியல் அமைப்பு
Harmfull	–	தீங்கு விளைவிக்க கூடிய
Hydrophytes	–	நீர்வாழ்த் தாவரங்கள்
Hibernation	–	குளிர்கால உறக்கம்
Horticulture	–	தோட்டக்கலையியல்
Hetero trophs	–	அயல் ஜீவிகள் / சார்ந்துண்ணும் உயிர் / அயலூட்டவுயிரி
Iceberg	–	பனிப்பாறை
Incompressible	–	அழுத்தமுறா
International	–	பன்னாட்டு
Isomerism	–	மாற்றியம்
Immunization	–	நோய்த்தடுப்பு
Levitate	–	மிதத்தல்
Longitudinal waves	–	நெட்டலைகள்
Lamp Black –	–	விளக்கு கரி
Meteorological	–	வானிலை ஆய்வு
Musical sound	–	இசையொலி
Milkyway Galaxy	–	பால்வழி விண்மீன் திரள்
Meteor	–	விண்கற்கள்
Multiple bonds	–	பலபிணைப்பு
Microbiology	–	நுண்ணுயிரியல்
Microorganisms	–	நுண்ணுயிர்கள்
nano	–	நூறு கோடியில் ஒன்று என்பதன் முன்னொட்டு (10^{-9})
Nocturnal	–	இரவில் இயங்கும்
Orbital Velocity	–	சுற்றியக்கத் திசைவேகம்
Olericulture	–	காய் கறி மற்றும் உணவுத்தாவரங்களை வளர்த்தல்
Piston	–	உந்து தண்டு
Propagation	–	பரவுதல்
Planet	–	கோள்
PVC	–	பாலிவினைல் குளோரைடு
PS	–	பாலிஸ்டைரின்
PC	–	பாலிகார்பனேட்
Pomology	–	கனியியல்
Pharmaceutical chemistry	–	மருந்தாக்க வேதியியல்

Pisciculture	–	செயற்கை மீன் வளர்பியல்
Rarefactions	–	தளர்ச்சிகள்
Reflection of sound	–	ஒலி எதிரொளித்தல்
Range of hearing	–	செவியுணர் நெடுக்கம்
Reverberation	–	எதிர்முழக்கம்
Resin code	–	ரெசின் (பிசின்) கோடு
Radiochemistry	–	கதிரியக்க வேதியியல்
Radioactive decay	–	கதிரியக்க சிதைவு
Radiocarbon dating	–	கதிரியக்க கார்பன் வயதுக்கணிப்பு
Roughage	–	தவிடு / சக்கை
Reservoir of Infeetism	–	தொற்றுகளின் தேக்கிடம்
seaweed	–	கடற்களை
Solar Family	–	சூரிய குடும்பம்
Satellite	–	துணைக்கோள்
Space Station	–	விண்வெளி நிலையம்
surface	–	மேற்பரப்பு
Symbiotic Microbes	–	கூட்டுயிர் நுண்ணுயிர்கள்
Therapy	–	சிகிச்சை
Transverse waves	–	குறுக்கலைகள்
Trough	–	அகடு
Time period	–	அலைவுக் காலம்
Tetravalency	–	நான்கு இணைதிறன்
Toxic	–	நஞ்சு
Transmitting	–	கடத்தி
Ultrasonics	–	மீயொலி
Universe	–	பிரபஞ்சம் / அண்டம்
vase	–	குவளை, திறந்த கொள்கலன்
velocity	–	திசைவேகம்
Vibrations	–	அதிர்வுகள்
Vulnerable species	–	பாதிப்புக்குள்ளான சிற்றினங்கள்
Vermiculture	–	மண்புழு வளர்பியல்
Vaccination	–	தடுப்பான்கள் / அம்மை குத்துதல்
Wave length	–	அலைநீளம்
WHO	–	உலக சுகாதார நிறுவனம்
Xerophytes	–	வறண்ட நிலத்தாவரங்கள்

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