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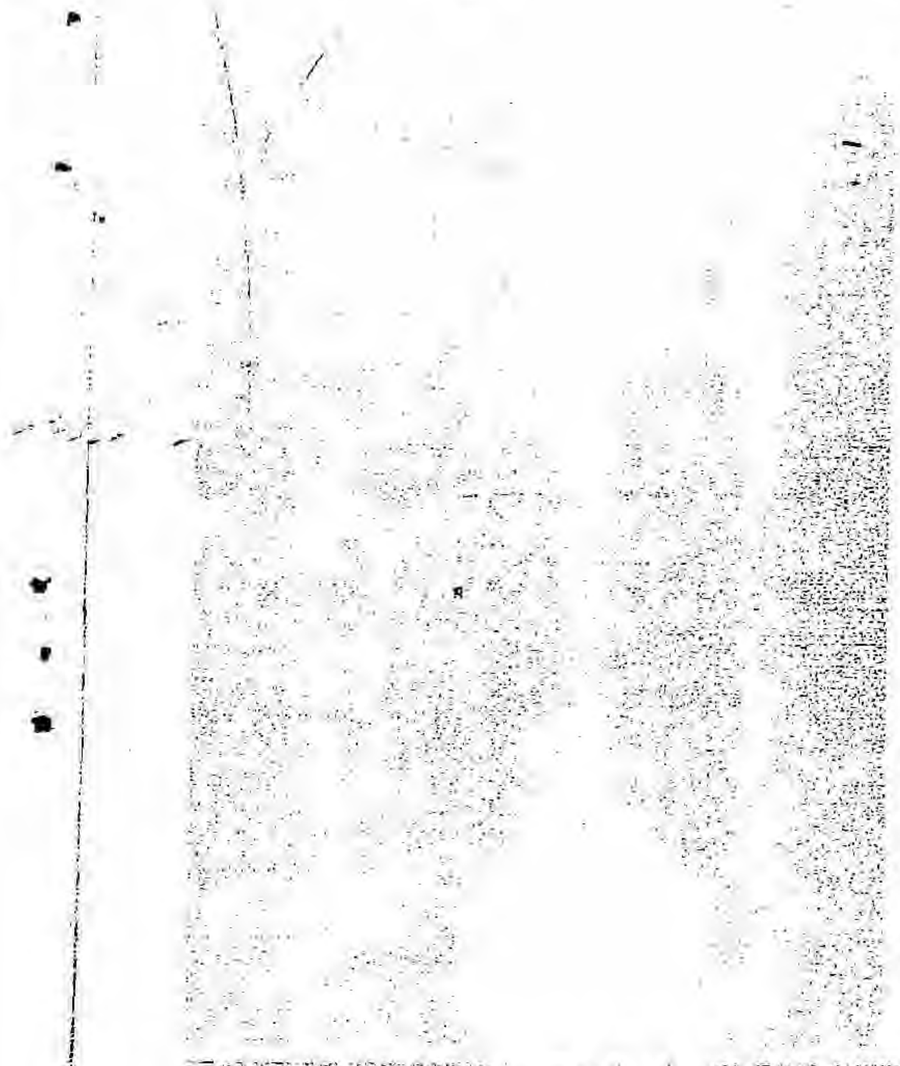
Chapter 1

Cell : The Unit of Life

Chapter Contents



Introduction

You have learnt about the diversity of living world comprising organisms like microscopic bacteria to huge multicellular plants and animals. All living organisms possess life and are made up of basic unit structure called cell. An organism consists of one or more cells. Accordingly there are two types of organisms : (i) **Unicellular organisms** - *e.g.*, *Amoeba*, Diatoms etc. (ii) **Multicellular organisms** - *e.g.*, plants, animals etc. In this chapter, you will be acquainted with structure and functions carried out by the various parts of the cell.

WHAT IS A CELL?

Unicellular organisms are capable of

(i) Independent existence

(ii) Performing the essential functions of life.

Anything less than a complete structure of a cell does not ensure independent living. Thus, cell is the **fundamental structural** and **functional unit** of all living organisms.

Robert Hooke studied and discovered the cell from a thin slice of cork but that was the 'dead cell'. **Anton Von Leeuwenhoek** was the first person who observed few **living cells** capable of moving, such as bacteria, protozoa, spermatozoa and red blood corpuscles under his own designed microscope. Later, **Robert Brown** discovered the nucleus of a cell. The invention of the microscope and its improvement leading to the electron microscope revealed all the structural details of the cell.

CELL THEORY

In 1838, **Matthias Schleiden**, a German botanist studied a large number of plants and observed that all plants are composed of different kinds of cells which form the tissues of the plant. At about the same time, another scientist **Theodore Schwann** (1839), a British zoologist, studied different types

of animal cells and reported that cells had a thin outer layer which is now known as the **'Plasma membrane'**. He also concluded, based on his studies on plant tissues, that the presence of cell wall is a unique character of the plant cells. On the basis of this, he proposed a hypothesis that the bodies of plants and animals are composed of cells and their products. **Schleiden** and **Schwann** together formulated the **cell theory**. This theory however, did not explain as to how new cells were formed. **Rudolf Virchow** (1855) first explained that cells divided and new cells are formed from pre-existing cells (***Omnis cellula-e cellula***). He modified the hypothesis of Schleiden and Schwann to give cell theory a final shape.

Cell theory is understood as

(i) All living organisms are composed of cells and products of cells.

(ii) All cells arise from pre-existing cells.

(iii) Activities of an organism are the outcome of sum total of activities and interactions of its constituent cells.

Knowledge Cloud

Viruses are an exception to cell theory as they are not made up of cells. They are composed of nucleoprotein particles. Therefore, they are not considered either living or non-living.

Example 1 : *Give two examples of unicellular organisms.*

Solution : *Amoeba* and Diatoms.

Example 2 : *Who gave the cell theory?*

Solution : Schleiden and Schwann.

Try Yourself

1. The first person who observed and described a living cell was
   (1) Anton Von Leeuwenhoek (2) Robert Brown
   (3) Robert Hooke (4) Rudolf Virchow
2. The nucleus of a cell was discovered by
   (1) Schleiden (2) Schwann
   (3) Robert Brown (4) Camillo Golgi
3. The cell theory was put forward by
   (1) Schleiden and Schwann
   (2) Anton Von Leeuwenhoek
   (3) Robert Brown
   (4) Robert Hooke

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Chapter 5

Morphology of Flowering Plants

Chapter Contents

Introduction

You know that flowering plants are multicellular organisms. They grow by cell division and their morphological features and traits are genetically determined. Even though the angiosperms show such a large diversity in external structure, they are all characterised by presence of roots, stems, leaves, flowers and fruits. Morphology deals with the study of forms and features of different plant organs like roots, stem, leaves, flowers, seeds, fruits etc. Morphology plays a key role in the classification of angiosperms. In this unit, you will learn about the important morphological features of the flowering plants. We shall learn how to describe a flowering plant, using examples from selected families. You will also learn how different parts of plants are modified to serve specific needs including defence from their enemies. You will get some idea of the economic importance of selected plant families.

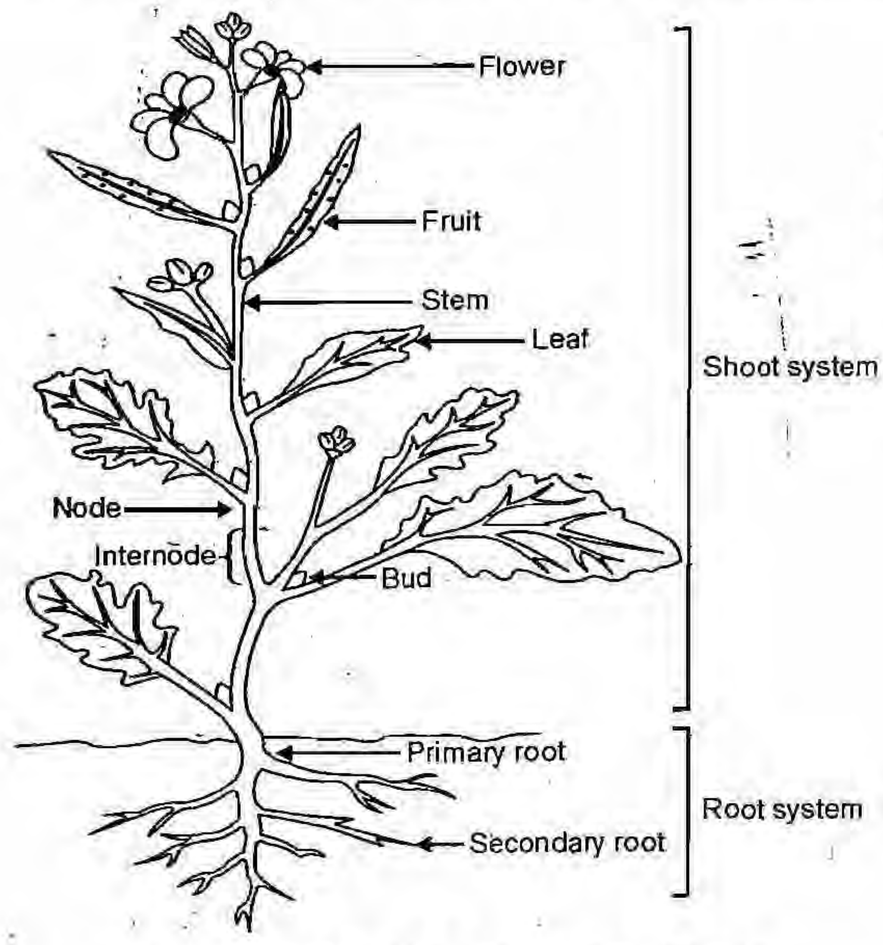


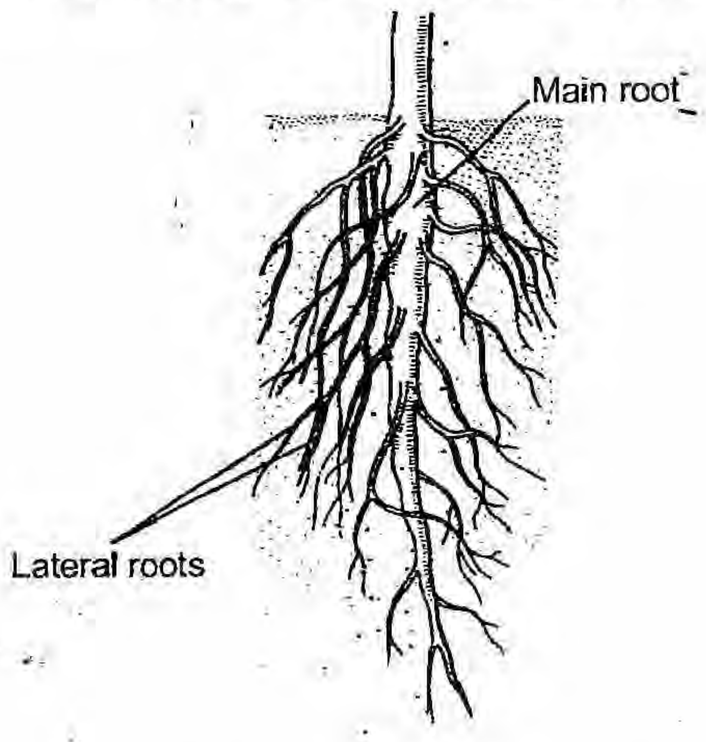
Fig. : Parts of a Flowering Plant

THE ROOT

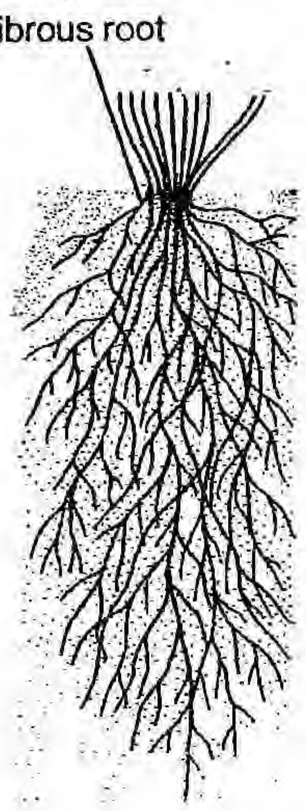
Roots are cylindrical, underground and non-green part of the plant. It is generally the descending portion of the plant axis *i.e.*, it grows downward into the soil. It lacks nodes, leaves, buds but gives rise to endogenous lateral branches. Roots move in the direction of gravity (geotropism) and against the direction of light (phototropism). Hence, the roots are said to be positively geotropic and negatively phototropic.

Plants have well developed root systems. The main root and its lateral branches form the **root system**. There are three types of root system.

(i) **Tap root system :** The **primary root** is directly elongated from the radicle and grows inside the soil (*e.g.* dicots). It bears lateral roots of several orders that are referred to as secondary, tertiary roots etc. The primary roots and its branches constitute the tap root system.



(ii) **Fibrous root system :** In monocotyledonous plants, the primary root is short-lived and is generally replaced by a number of fine fibrous roots. These roots originate from base of the stem and constitute the fibrous root system as seen in wheat plant.



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Chapter 17

Strategies for Enhancement in Food Production

Chapter Contents

Introduction

Humans derive their nutrition from plants and animals. Initially humans hunted wild animals and collected fruits from wild plants. Much later, they began to cultivate plant species and rear animals under their supervision. Human population is rising steadily. The requirement of food is rising proportionally. Therefore, a continued enhancement of food production has become a major necessity. Animal husbandry and plant breeding have to play major role to this purpose. New techniques like embryo transfer technology and tissue culture are of great importance to increase food production.

PLANT BREEDING

Traditional farming can only yield a limited food for humans and animals. Better management practices increased the crop yield but only to a limited extent which was insufficient to meet the requirement of rapidly growing human population. In India, **"Green Revolution"** was responsible for our country to not only meet the national requirement in food production but also helped us to export it. Green revolution was dependent mainly on plant breeding techniques for development of high-yielding and disease-resistant varieties in wheat, rice, maize, etc.

What is Plant Breeding?

Breeding is the process in which genotype of an organism is modified to make that organism more useful to humans. Therefore, **plant breeding** is the genetic improvement of the crop plants, in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant. Conventional plant breeding is in practice from 9,000–11,000 years ago. **Domestication** is the process of bringing a species under human management. A **variety** consists of a group of plants that have the similar genotype, and it differs in one or more characters from other varieties of the same crop. A **trait or character** is any morphological, biochemical or behavioural feature of an organism *e.g.*, yield of seed, size of fruit or seed, etc.

Many present-day crops are result of domestication in ancient times. Today, all our major food crops are derived from the domesticated varieties. **Classical plant breeding** involves **hybridisation** (crossing) of pure lines, followed by **artificial selection** to produce plants with desirable traits of higher yield, nutrition and resistance to diseases.

But, now due to advancements in genetics, molecular biology and tissue culture, plant breeding is being carried out by using molecular genetic tools. When the breeders wish to incorporate traits or characters into the crop plants, the first and prime objective would be **increased yield and improved food and nutrient quality**. Increased tolerance to environmental stresses like salinity, extreme temperatures, drought, resistance to pathogens (viruses, fungi, mycoplasma and bacteria) and increased tolerance to insect pests would be on our list too.

Did You Know?

(i) **Phenotype** is the observable feature of an organism.

(ii) **Genotype** is the genetic make up of an individual or a variety.

(iii) A **'line'** consists of a group of individuals related by descent, and often similar in genotype.

(iv) **Pure line** is a self-pollinated progeny of a homozygous plant.

Plant breeding for development of new varieties is carried out in a systematic way by government institutions and commercial companies.

The main steps required for developing new varieties of a crop are as follows :

(i) **Collection of variability (Germplasm) :** The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called **germplasm collection.**

Thus, the germplasm of any crop species would consist of the following types of materials :

(1) Cultivated improved varieties.

(2) Improved varieties that are no more in cultivation.

(3) Old local or 'desi' varieties.

(4) Lines produced by plant breeders.

(5) Wild species related to the crop species.

All these materials contain valuable alleles of genes that are important in breeding.

Germplasm is the building material out of which improved varieties are constructed. In other words, **genetic variability is the backbone or root of any breeding programme**. Collection and preservation of all the different wild varieties, species and relatives of the cultivated species (followed by their evaluation for their characteristics) is a **pre-requisite** for effective exploitation of natural genes available in the populations. The germplasm collections are usually maintained at a low temperature in the form of seeds.

(ii) **Evaluation and selection of parents:** The whole available germplasm is evaluated to identify plants with desirable combination of characters. Two or more types of plants are selected which possess all the required traits amongst them. These selected plants are called parents. Out of the two types of the parents, some plants are marked as female while others are marked as male. There is no such need in case of unisexual plants. The selected plants are multiplied and used in the process of hybridisation. Pure-lines are created wherever desirable and possible.

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Chapter 1

Some Basic Concepts of Chemistry

Chapter Contents

Introduction

When you start studying chemistry, different kinds of new questions come to your mind and these questions require some basic concepts and techniques of chemistry to be solved. In this chapter we will study only such concepts and techniques. We will discuss, what is chemistry, why shall we study chemistry and how useful is it to mankind? As you probably know, chemistry is about studies of matter, so we will study characteristics, classification and measurement of matter with international system of units and their conversions. Once units and their conversions are known we will study how to make precise and accurate scientific calculations. After this we will study how elements combine under the laws of chemical combinations and Dalton's atomic theory and how to deal with calculations involving atoms, molecules, moles and molar mass. Determination of empirical and molecular formula for a compound from the given experimental data.

IMPORTANCE OF CHEMISTRY

Man has always been curious about the changes taking place in his surroundings and this curiosity led him to study, observe and experiment with the changes taking place. When these observations and experiments or we can say knowledge is systematically arranged, it is called **science**, so we can define **science** as "a continuing human effort to systematize knowledge for describing and understanding nature".

Due to expansion and diversification in science, it has been subdivided into various disciplines like chemistry, physics, biology, geology etc. so that we can study each of them easily. We define **chemistry** as the branch of science that deals with the composition, properties and interaction of matter.

Chemistry has a very important role in our daily life.

Some important roles of chemistry are :

(1) Chemical principles are involved in everything from weather patterns to brain functioning to the operation of a computer.

Different chemical composition of atmosphere make different weather at different places on the earth as well as on different planets too. For example, higher concentration of oxides of sulphur and nitrogen in atmosphere causes acid rain, similarly green house gases lead to extreme weather events such as drought, flooding, high wind and storm. Here principles of geo-chemistry are involved.

In the brain, nitric oxide (NO) acts as a messenger compound in the transmission of brain waves and in immune system it slows down the growth of tumor cells. Here the principles of biochemical processes are important.

(2) Chemistry plays an important role in economic condition of a country by having its role in various industrial processes like manufacturing chemical fertilizers like urea, ammonium sulphate etc. which help in better production of crops.

Alkalis, acids, salts, dyes are important in synthesis of various chemical compounds and products of commercial value. Chemical industries involved in production of drugs, soaps, detergents, metals, alloys and various organic and inorganic compounds have a very big role in the economic growth of a nation.

(3) Chemistry has very important role in making human life comfortable and convenient by the following means :

Preservatives like sodium benzoate and sodium metabisulphite are used for better preservation of food and check its wastage.

Insecticides and pesticides like D.D.T., gammexane etc. are helpful for crop protection and storage of food grains.

Products of domestic consumptions like soaps, cosmetics, oils, perfumes etc. are outcomes of chemical synthesis.

Health-care products, skin cream and soaps contain chemical compound, similarly disinfectants and germicides also contain chemical compounds.

Materials for improving quality of life like air conditioner use chemical substances like liquid ammonia or liquid sulphur dioxide.

Life saving drugs such as **cisplatin** and **taxol** (used in cancer therapy) and **AZT** (azidothymidine is used for helping AIDS victims) are prepared by chemical processes.

(4) With advancement in chemistry now it is possible to make new materials with specific magnetic, electric and optical properties *e.g.*, superconducting ceramics (the ceramic materials used to make superconductors are a class of materials called perovskites), conducting polymers (are organic polymers that conduct electricity), optical fibres (an optical fibre is a flexible, transparent fibre made of a pure glass (silica) not much wider than human hair.

With increasing understanding in chemistry now it is possible to apply principles of chemistry to stop environmental degradation *e.g.*, CFCs (chlorofluorocarbons), a refrigerant responsible for ozone depletion in the stratosphere has been replaced with newly synthesised blends of various compounds *e.g.*, R-410A and also Natural refrigerants such as ammonia, carbon dioxide, sulphur dioxide and non-halogenated hydrocarbons, they preserve the ozone layer and have no (*e.g.*, ammonia) or only a low (carbon dioxide, hydrocarbons) global warming potential are in use once again.

Still there are some challenges to chemists like management of the green house gases like methane, carbon dioxide etc., understanding various chemical reactions in living organisms (= biochemical processes) and use of enzymes for large scale production of chemicals.

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Chapter 5

States of Matter

Chapter Contents

Introduction

Everything around us is made up of matter. Matter is something that occupies space and has mass. Matter consists of small particles (atoms and molecules). There are three states of matter namely gaseous state, liquid state and solid state. The state of a substance depends upon the intermolecular forces operating between the molecules and the thermal energy of the molecules. Till now, the chapters we studied dealt with the properties of individual atoms or molecules like in chemical bonding, we studied the structure and geometry of individual molecules. But in this chapter we will deal with the bulk properties like boiling, as in boiling of water no single water molecule boils, but the bulk of water molecules boils as a whole. The chemical properties depend upon the state of the substance, moreover the rate of the chemical reaction depends upon the state of the substance. Therefore, along with the individual properties of atoms and molecules, we must be familiar with the behaviour of matter in different states.

In this chapter we will deal with the two states of matter namely gaseous state and liquid state, the laws governing the behaviour of gases, and certain properties associated with liquids.

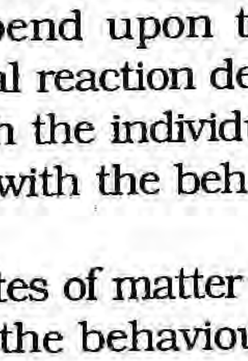
INTERMOLECULAR FORCES

There are certain forces that condense matter. These forces can be both bonding forces and non-bonding forces which are called Intramolecular forces and Intermolecular forces respectively.

(i) **Intramolecular forces** (Bonds that exist within molecules): Intramolecular forces are the chemical forces that operate by the formation of bonds between the atoms to form molecules. Example **Ionic bond**, **Covalent bond** which we have studied in the previous chapter.

Covalent bond formation in H_2 molecule

Ionic bond formation in NaCl molecule



(ii) **Intermolecular forces (Forces that exist between molecules) :** Intermolecular forces are the physical forces or just the interactions which act between the neighbouring bonded molecules. The intermolecular forces are weaker than the intramolecular forces.

In this chapter we will focus on intermolecular forces.

The forces of attraction and repulsion between the interacting particles (atoms and molecules) are called intermolecular forces. These forces hold the molecules together which are covalently bonded. Intermolecular forces are not encountered in systems that employ ionic bonding.

van der Waals (1837 - 1923), a Dutch scientist explained that the **attractive forces present between the molecules** lead to the deviation of real gases from the ideal gas behaviour which we will study later in this chapter. So, to honor the scientist, intermolecular forces are also known as **van der Waals forces**. These forces of attraction exist between polar as well as non-polar molecules. These are the **electrostatic forces of attraction that exist between an area of negative charge on one molecule and an area of positive on a second molecule.** There are three types of van der Waals forces or interactions.

(i) Dispersion forces or London forces

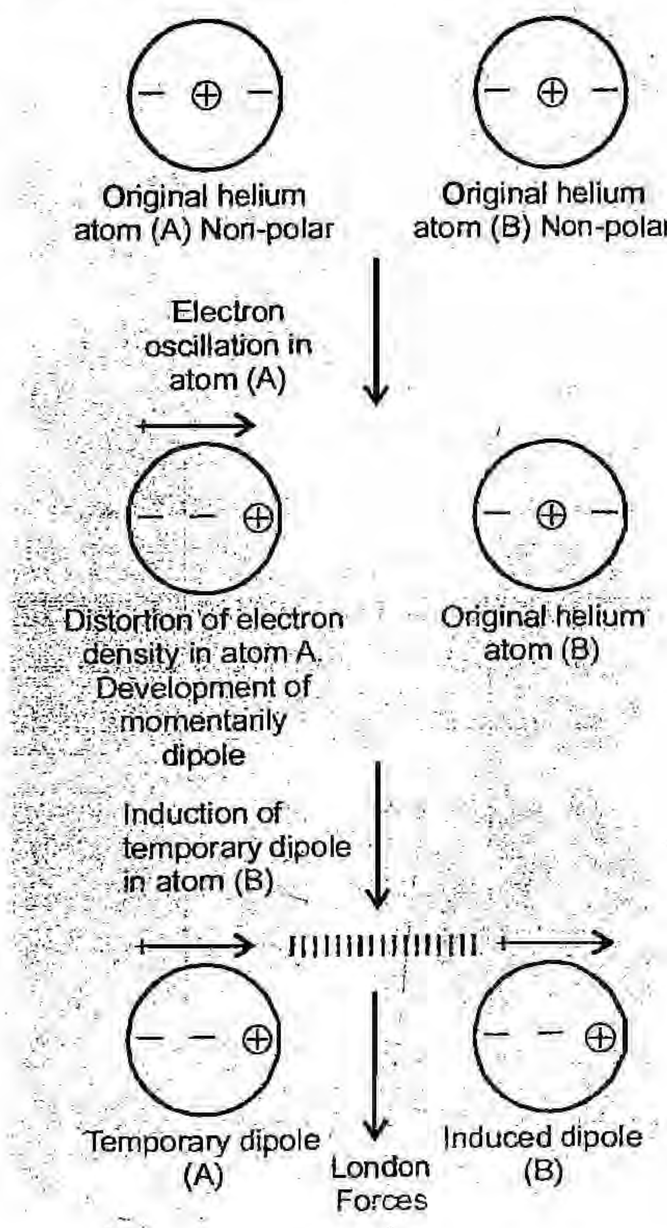
(ii) Dipole-Dipole forces

(iii) Dipole-Induced Dipole forces

Fourth type is a particularly strong type of dipole-dipole interactions called hydrogen bonding.

(i) Dispersion Forces or London Forces : (Associated with NON POLAR structures) These forces are present in **non-polar molecules like** H_2, O_2 and N_2 and also in nonpolar monoatomic molecules such as **noble gases** like He, Ne, Ar etc., which exist with intermolecular forces and no bonding at all.

These non-polar molecules are electrically symmetrical, so there is no dipole moment. But sometimes the temporary dipoles can be formed. The electrons of a neutral molecule keep on oscillating with respect to the nuclei of the atoms. As a result of this, at a given instant, positive charge may be concentrated in one region and the negative charge in another region of the molecule. **Thus the non-polar molecule develops momentarily dipole due to unsymmetrical electronic charge distribution.** Now, this polarised molecule distorts the electron density of the neighbouring molecule and dipoles are developed in the neighbouring molecule. These interactions are therefore also known as **induced dipole induced dipole interactions.** Now, the attraction between the two oppositely charged ends of the two neighbouring molecules attract each other and this type of force of attraction is called **London Force** after the name of the German Physicist **Fritz London** who proposed this type of force of interaction. This force is also known as **dispersion force.**



London forces are attractive in nature and the interaction energy is inversely proportional to the sixth power of the distance between the two interacting particles.

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Haloalkanes and Haloarenes

Chapter Contents

Introduction

Alkyl halides or haloalkanes and aryl halides or haloarenes are organic compounds obtained by replacement of one or more H-atoms of aliphatic and aromatic hydrocarbons respectively by halogen atom(s). Haloalkanes have each of the halogen atom attached to sp^3 hybridised C-atom of the alkyl group. Haloarenes have each of halogen atom attached to sp^2 hybridized C-atom of aryl group.

CLASSIFICATION

These compounds may be classified as :

Based on the Number of Halogen Atoms

(a) Monohaloalkanes and monohaloarenes are compounds containing one halogen atom only, *e.g.*, chloroethane, chlorobenzene etc.

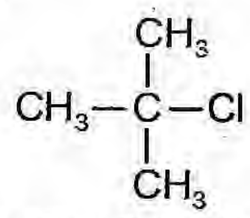
CH_3-CH_2-Cl
(Chloroethane)

C_6H_5Cl
(Chlorobenzene)

Monohaloalkanes may be further classified as primary (1°), secondary (2°) or tertiary (3°) depending on whether halogen atom is bonded to 1°, 2° or 3° C-atom, *e.g.*,

$CH_3-CH_2-CH_2-Cl$
1-Chloropropane (1°)

$CH_3-CHCl-CH_3$
2-Chloropropane (2°)
or Isopropylchloride

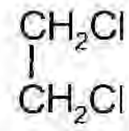


2-Chloro-2-methylpropane (3°)
or Tert. butyl chloride

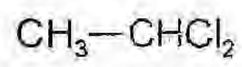
(b) Dihaloalkanes and dihaloarenes are compounds containing two halogen atoms. Dihaloalkanes may be further classified as

(i) Gem-dihalides containing two halogen atoms attached to the same C-atom and

(ii) Vicinal dihalides containing two halogen atoms attached to the adjacent C-atoms. Gem-dihalides are also known as alkylidene halides and vicinal dihalides are also known as alkylene halides. *e.g.*,



1, 2-Dichloroethane
or Ethylene chloride
(vic-dihalide)



1, 1-Dichloroethane
or Ethylidene chloride
(gem-dihalide)

1, 2-Dichlorobenzene
or o-Dichlorobenzene

(c) Polyhaloalkanes and polyhaloarenes are compounds containing three or more halogen atoms. They may be attached to the same or different C-atoms, *e.g.*,

1, 2, 3-Trichlorobenzene

Chloroform

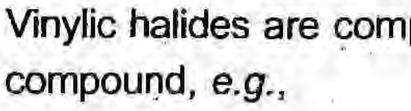
Bromoform

Iodoform

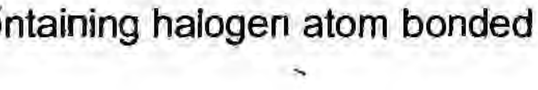
Carbon tetrachloride

Based on the type of sp^3 Hybridised C-atom containing Halogen Atom(s)

(a) Allylic halides are compounds containing halogen atom bonded to sp^3 hybridised C-atom next to carbon, carbon double bond, *e.g.*,



3-Chloropropene (1°)



1-Chlorobut-2-ene (1°)

(b) Benzylic halides are compounds containing halogen atom bonded to sp^3 hybridised C-atom next to an aromatic ring. For example

Benzyl chloride (1°)

1-Chloro-1-phenylethane (2°)

Based on sp^2 hybridised C-atom containing Halogen Atom(s)

(a) Vinylic halides are compounds containing halogen atom bonded to sp^2 hybridised C-atom of an aliphatic compound, *e.g.*,

Chloroethene

1-Chlorocyclopentene

(b) Aryl halides are compounds containing halogen atom bonded to sp^2 hybridised C-atom of an aromatic ring. For example

1-Chloronaphthalene

(m-Chlorotoluene)
1-Chloro-3-methylbenzene

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Chapter 1

Physical World

Chapter Contents

Introduction

"What has all of this to do with my life? Why should I study Physics?" If you think on these lines, the reply is, "Physics has got enough to do with the real life. Do you want to be the first person to invent a spaceship which travels faster than light or a car that runs on water...? All of you have the potential and realizing this starts right here, right now. You can reason from basic physics concepts all the way to valid conclusions about the world around you and the fun is in this understanding. Physics is the foundation of all engineering and technology. Could any engineer design a spaceship, a LED TV or a mobile phone which all of you use without first understanding the basic laws of physics. When we look around us at this fascinating, magnificent and immense cosmos - look at the awesome, vast cosmos - planets moving around the sun in an orderly manner, phases of moon or movement of machinery parts - all of them are following certain laws. The inquiring and imaginative human mind responds to this in many ways. One such response is to observe carefully, look for meaningful patterns, predict events, control environment. Don't you want to be the incharge of your environment with this powerful tool - Physics? This study is also an adventure. You will find it challenging, richly rewarding and satisfying. It will appeal to your sense, of beauty. Lets take a step forward by understanding 'Physical World'. In this chapter, you will study what is physics; its scope and excitement; physics, technology and society; fundamental forces in nature and nature of physical laws.

WHAT IS PHYSICS?

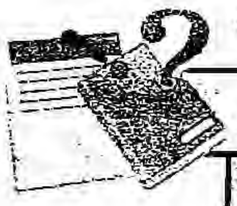
Origin of the word, 'Science', is from Latin word, 'Scientia' which means, 'to know'. The Sanskrit word, 'Vigyan' also has similar meaning, *i.e.*, knowledge. The early civilisations also made important contribution to its progress.

Science is a systematic (step by step) knowledge acquired through observation and experience, aimed at understanding natural phenomena in as much detail as possible. This knowledge is used to predict and control our environment.

The first step towards the discovery of science is a child's curiosity to learn about the world and disclose the secrets of nature. Let this child in you be alive.

Scientific method involves

1. **Systematic observation** : It is setting up our study so that we eliminate or reduce bias.
2. **Controlled experiment** : It generally compares the results obtained from an experimental sample against a control sample, which is practically identical to experimental sample except for the one aspect whose effect is being tested (the independent variable), *e.g.*, you want to know whether light or dark clothing would be more comfortable on a hot, sunny day. A controlled experiment involves setting up two experimental conditions that are exactly same except for a single factor that the scientist manipulates. Here, the factor is colour. You will apply a heat source, represented by a 60 W light bulb to different coloured jackets and compare the temperature change for each other.
3. **Qualitative and quantitative reasoning :** Qualitative measurement is at the heart of growth of science as laws of nature expressible in precise mathematical equations.
4. **Mathematical modelling** : It is the process of developing a mathematical model (Description of a system using mathematical concepts and language), *e.g.*, predicting the position of a vehicle from its initial position, direction and speed of travel, using the equation that distance travelled is the product of speed (constant) and time. It is common to use idealized models in physics to simplify things. Massless ropes, point particles, ideal gases are among the many simplified models used in Physics. The laws of physics are represented by simple equations such as Newton's laws, Maxwell's equations. Many real life situations are very complex and thus modeled approximate.
5. **Prediction** : It is a scientific statement about a future event. It is based on a scientific theory. It means in particular it is reproducible, consistent and the theory it is based on, is not in conflict with already available data. It is scientifically falsifiable.
6. **Verification or falsification of theories : Falsifiability** or reputability of an assertion, hypothesis or a theory is the logical possibility that it can be contradicted by an observation or the outcome of a physical experiment that something is 'falsifiable' does not mean it is false, rather if then some observation or experiment will produce a reproducible result, that is in conflict with it, *e.g.*, the assertion that 'all swans are white' is falsifiable because it is logically possible that a swan can be found which is not white. If one finds one single black swan, logic admits the conclusion that the statement that all swans are white is false. Falsification thus strives for questioning for falsification of hypothesis, instead of proving them. The statement 'all swans are white' is falsifiable because it can come in conflict with the observation that 'this swan is black'. In contrast, the statement that 'white swans do exist' is not falsifiable as no counter example is logically possible.



Did You Know?

Not everything can be proved in physics and mathematics, *e.g.*, the universal law of gravitation is an assumption or a **hypothesis**. Newton explained several observations, experiments and data of the planetary motion, bodies falling towards earth by making an assumption that any two bodies in the universe attract each other with a force proportional to the product of their masses and inversely proportional to the square of the distance between them. With this, he was able to explain all the observations. Not only that, it allows us to predict the results of future experiments. A hypothesis is a supposition without assuming that it is true.

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Chapter 5

Laws of Motion

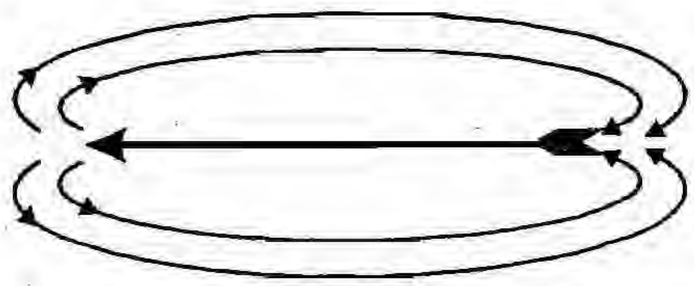
Chapter Contents

Introduction

When we look around us, we find the planets moving around the sun in orderly manner, movement of machinery parts in a factory, phases of the moon - all of them are following certain laws. They all are acted upon by certain forces. In the preceding two chapters, we described motion in terms of displacement, velocity and acceleration, *i.e.*, we used kinematic quantities for describing motion without considering what might cause that motion. In order to understand this beauty, let us take a step forward by understanding "Force and laws of motion". In this chapter, we shall study about force and its effects on the objects and various laws related to motion of the objects.

ARISTOTLE'S FALLACY

Aristotle, a Greek philosopher posed a view that for a body to be in its motion and keep moving, something external is required. He said that motion had to be caused by a force. To explain why an arrow kept flying after the bow string was no longer pushing on it, he said that the air rushed around behind the arrow and pushed it forward.



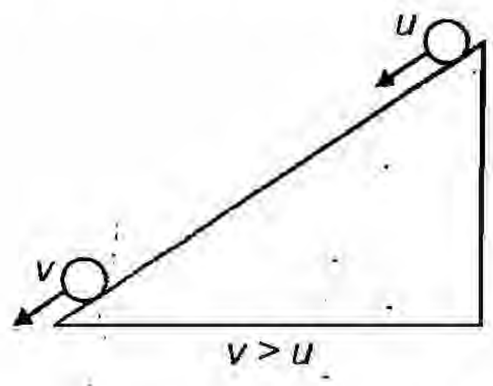
Aristotle gave his law of motion which may be phrased as **"An external force is required to keep a body in motion."** But this is wrong, because an arrow shot in a vacuum chamber does not instantly drop to the floor as soon as it leaves the bow. Most of the Aristotlion ideas on motion are now known to be wrong and need not concern as the flaw in Aristotle's argument can be understood by taking an example that a ball rolling on a floor comes to rest after a while due to the external force of friction on the ball by the

floor, which opposes its motion. Now, to keep that ball moving on the floor, we require to give some external force on it to move. But when the ball is moving in uniform motion, there is no net external force acting in its direction of motion. This is due to the fact that the force given by us to move a ball cancels with the force of friction by the floor. In simple language, we may say that to keep a ball in uniform motion, we would not be required to apply any external force in the absence of friction. This is the reason that why we need external sources to overcome opposing forces like friction (solids) and viscous drag (for fluids) which are always present in natural world.

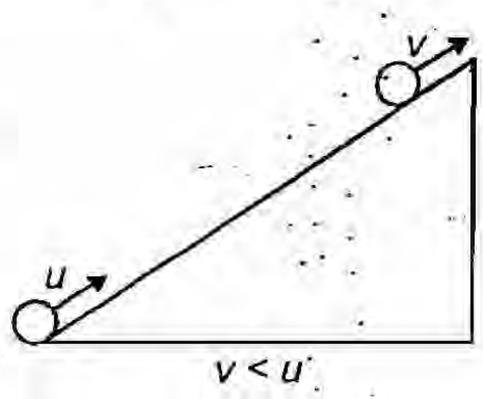
Now, we understand where the ideas and laws of Aristotle went wrong. Galileo and Newton realised that a force would only be needed to change the motion of a body, not to make it move continuously and uniformly.

THE LAW OF INERTIA

As we have seen that, before Galileo, it was thought that a force is required to keep a body moving with uniform velocity. Galileo observed that speed of a ball increases, as it rolls down an inclined plane.



Speed of that ball decreases, as it is rolled up that inclined plane.



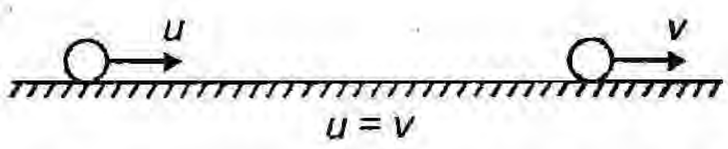
So, what should happen if it is rolled on a horizontal plane? As this case is just in between the situations discussed, the result must also be in between, *i.e.*, speed of ball should remain constant.

Explanation :

When you move down speed increases.

When you move up speed decreases.

Moving horizontally (*i.e.*, neither up nor down) speed should remain constant (neither increase nor decrease.



Galileo was also able to arrive at this conclusion in another way. He considered a simple pendulum. Take the bob to a side and release it. It starts swinging. It is a common observation that on releasing the bob from a height, it stops momentarily on other side, only after reaching the same height [Fig. (a)]. He argued that the same result would be there if the ball (bob in case of pendulum) is released on the inside surface of a smooth hemisphere [Fig.(b)]. The ball moves to the other side and attains the same height before coming to rest momentarily.

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Chapter 24

Ray Optics and Optical Instruments

Chapter Contents

Introduction

Electromagnetic radiations belonging to the wavelength range about 400 nm to 750 nm is called light. Human eye (ratina) has the sensitivity to detect electromagnetic wave of this range.

Speed of light in vacuum is $c = 2.99792458 \times 10^8\ ms^{-1} \approx 3 \times 10^8\ ms^{-1}$ which is highest speed attainable in nature.

Sir Isaac Newton, held the theory that light was made up of tiny particles. In 1678, Dutch Physicist, Christian Huygens, believed that light was made up of waves vibrating up and down perpendicular to the direction of propagation of the light, and therefore formulated a way of visualising wave propagation. This became known as "Huygens' Principle". Huygens theory was the successful theory of light wave motion in three dimensions. In a vacuum, or other uniform media, the light waves are spherical, and these wave surfaces advance or spread out as they travel at the speed of light. Newton's theory came first, but the theory of Huygens, better described early experiments.

At the time, some of the experiments conducted on light theory, both the Wave theory and Particle theory, had some unexplained phenomena. Newton could not explain the phenomenon of light interference, this forced Newton's particle theory in favour of the Wave theory.

In 1803, Thomas Young studied the interference of light waves by shining light through a screen with two slits equally separated, the light emerging from the two slits, spread out according to Huygen's principle.

Later in 1815, Augustin Fresnel supported Young's experiments with mathematical calculations.

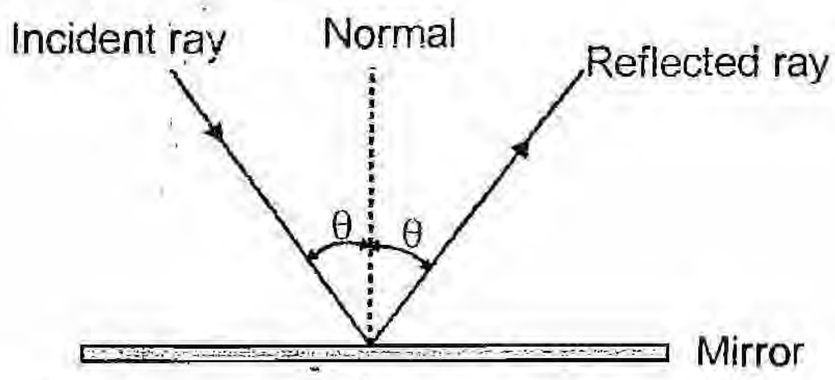
In 1900 Max Planck proposed the existence of a light quantum, a finite packet of energy which depends on the frequency.

In 1905, Albert Einstein had proposed a solution to the problem of observations made on the behaviour of light having characteristics of both Wave and Particle theory. From work of Planck on emission of light from hot bodies, Einstein suggested that light is composed of tiny particles called photons, and each photon has energy.

The wavelength of light is very small comapred to the size of ordinary objects so a light wave can be considered to travel from one point to other along a straight line joining them. The path is called ray of light. A bundle of such rays constitute a beam of light. In this chapter we deal with phenomena of reflection, refraction, dispersion, using ray picture of light. Using the simple law of reflection and refraction, we shall study the image formation by spherical reflecting surfaces, spherical refracting surfaces, plane surfaces, optical instruments, including human eye.

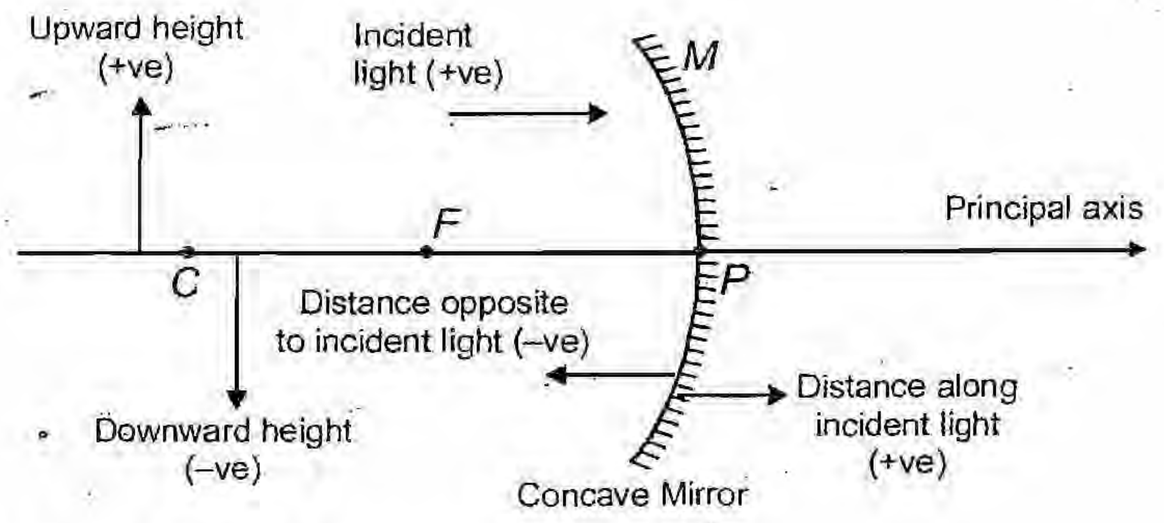
REFLECTION OF LIGHT BY SPHERICAL MIRRORS

The laws of reflection state that the angle of reflection (angle between reflected ray and the normal to the reflecting surface) equals the angle of incidence (Angle between incident ray and the normal). Also that the incident ray, reflected ray lie in the same plane with normal to the reflecting surface. These laws are valid at each point on any reflecting surface whether plane or curved.



Geometric centre of a spherical mirror is called its pole while that of a spherical lens is called its optical centre. The line joining the pole and centre of curvature of spherical mirror is known as principal axis.

Sign Convention : To derive any formulae for reflection at spherical surfaces we must first adopt a sign convention for measuring distances. According to Cartesian sign convention all distances are measured from pole of the mirror.



P – Pole ; *F* – Focus ; *C* – Centre of Curvature

PF = *f* = Focal length of mirror.

CP = *R* = Radius of curvature of mirror.

The distances measured in the same direction as the incident light are taken as positive and those measured in the direction opposite to the direction of incident light are taken as negative. Heights measured above principal axis are taken as positive and the heights below the principal axis are taken as negative.

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Chapter 1

Structural Organisation in Animals (Animal Tissues)

Chapter Contents

Introduction

Life evolved on this earth in the form of single-celled (unicellular) organisms. They were able to perform all the functions necessary for life such as digestion, respiration and reproduction. Even today, millions of such unicellular organisms are present, *e.g.*, *Amoeba*, *Paramecium*, *Euglena*, etc. They can perform all the activities of life, but without much efficiency. Moreover, such organisms cannot perform different activities simultaneously.

To attain more efficiency and perform such activities, multicellular organisms came into existence. They consist of several types of cells, each type specialised to perform different functions. Even the body of simple organisms like *Hydra* or *Sponges* is made of different types of cells and the number of cells in each type can be in thousands. The human body is composed of billions of cells organised into about 200 types to perform different functions. Group of similar cells along with intercellular substances, which are specialized to perform a specific function is called **tissue**. This cell grouping has resulted in developing different structures for different functions like protective structures, reproductive cells, information conducting cells, etc. This has increased the efficiency of multicellular animals.

Animals have four basic types of tissues. Each tissue performs one or more functions of the body. These tissues are organised in specific proportion and pattern to form an organ like stomach, lung, heart and kidney. When two or more organs perform a common function by their physical and/or chemical interaction, they together form organ system, *e.g.*, digestive system, respiratory system, etc. Thus, the body of a multicellular organism exhibits **division of labour** and contribute to the survival of the body as a whole.

ANIMAL TISSUES

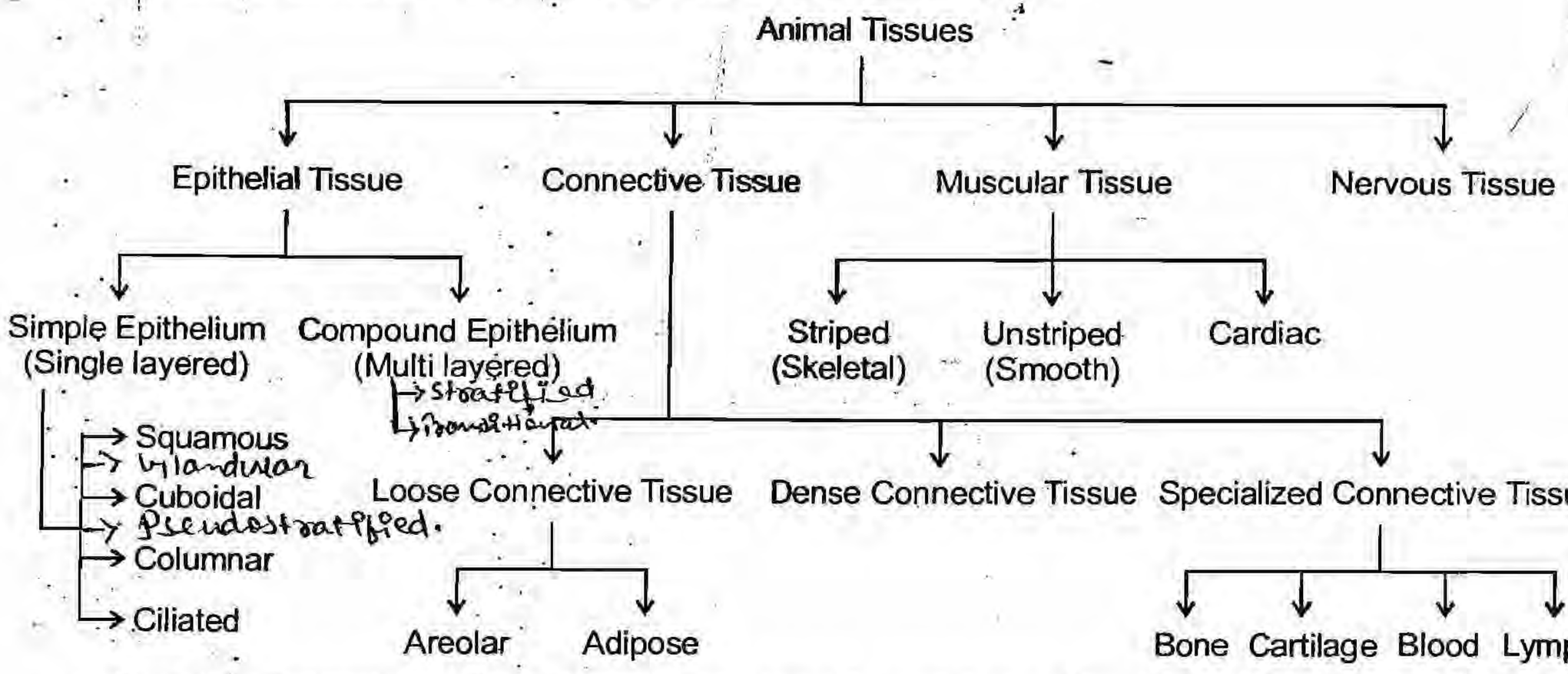
Tissue is a group of similar cells, having same origin and performing a specific function. The term tissue was given by **Bichat**. The term tissue had already been coined by N. Grew in connection with plant anatomy. The study of tissue is known as **histology**, a term introduced by **Mayer**. The tissue first evolved in **Coelenterates**.

Types of Animal Tissues

The structure of a cell varies according to its function. Therefore, different types of tissues are found in the body of animal at different locations. Depending on their location, structure and function; the animal tissues have been broadly classified into four types. These are :

1. Epithelial Tissue
2. Connective Tissue
3. Muscular Tissue
4. Neural/Nervous Tissue

These tissues are further differentiated as shown in the following chart:



All these tissues occur in the vertebrates and also in most invertebrates. Now let us study these tissues in detail.

EPITHELIAL TISSUE

Epithelial tissue is commonly referred to as epithelium (pl. : epithelia). The term 'epithelium' was introduced by **Ruysch**. An epithelium is made up of one or more layers of cells that covers or lines the external and internal surfaces of various body parts. Glands are also composed of epithelial tissue.

Structure : Epithelial tissue consists of variously shaped cells closely arranged in one or more layers. There is little intercellular material between the cells.

The epithelial tissue consists of a basal surface and a free surface. The basal surface lies in contact with a delicate **non-cellular layer** called **basement membrane**. The basement membrane provides elastic support and also anchors the epithelial tissue to the underlying connective tissue for obtaining nutrients. The free surface of epithelial tissue faces either a body fluid or the outside environment and thus, provides a protective covering to the external and internal exposed surfaces of the body parts.

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Chapter 7

Excretory Products and their Elimination

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Introduction

Animals accumulate ammonia, urea, uric acid, carbon dioxide, water and ions like Na^+, K^+, Cl^-, phosphate, sulphate etc., either by metabolic activities or by other means like excess ingestion. These substances have to be removed totally or partially. In this chapter, you will learn the mechanisms of elimination of these substances with special emphasis on common nitrogenous wastes. Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by the animals. Ammonia is the most toxic form and requires large amount of water for its elimination, whereas uric acid, being the least toxic, can be removed with a minimum loss of water.

The process of removal of metabolic wastes from the body is called **excretion**. The regulation of its solute and water movements by osmosis is done by two ways:

1. **Osmoconformers** are the animals that do not actively control the osmotic concentration of their body fluids. They rather change the osmolarity of body fluids according to the osmolarity of the surrounding medium. All marine invertebrates and some freshwater invertebrates are strictly osmoconformers. Hagfish is a vertebrate osmoconformer. Osmoconformers show an excellent ability to tolerate a wide range of cellular osmotic environments.
2. **Osmoregulators,** on the other hand, are the animals that maintain an internal osmolarity, different from the surrounding medium in which they inhabit. Many aquatic invertebrates are strict or limited osmoregulators. Most vertebrates are strict osmoregulators, *i.e*, they maintain the composition of the body fluids within a narrow osmotic range. **The notable exception, however, are the hagfish (*Myxine*, a marine cyclostome fish) and elasmobranch fish(sharks and rays).**

   Osmoregulators must either eliminate excess water if they are in a hypotonic medium or continuously take in water to compensate for water loss if they are in hypertonic solution. Therefore, osmoregulators have to spend energy to move water in or out and maintain osmotic gradients by manipulating solute concentrations in their body fluids.

Water and Solute Regulation in Fresh Water Environment

Osmolarity of fresh water is generally much less than 50 mOsm L^{-1} while the fresh water vertebrates have blood osmolarities in the range of 200 to 300 mOsm L^{-1}. The body fluids of fresh water animals are generally hypertonic to their surrounding environment. The problem faced by the animals will be :

(i) Loss of body salt to the outside.

(ii) Entry of excess of water.

Protozoa (*Amoeba, Paramoecium*) have contractile vacuoles that pump out excess water.

Adaptation shown by other animals include

(i) To minimise the gain of water and loss of salts by specialised body cover in the form scales or adipose cover.

(ii) Do not drink water to reduce the need to expel excess of water.

(iii) Passing out very dilute urine.

(iv) Presence of ionocytes or chloride cells which can actively uptake the salts (Na^+ and Cl^-) from the surrounding water (Surrounding water has less than 1 mM NaCl and plasma concentration has more than 100 mM, therefore uptaken actively).

Water and Solute Regulation in Marine Environment

Sea water usually have an osmolarity of about 1000 mOsm L^{-1}. Osmolarity of human blood is about 300 mOsm L^{-1}. The osmoregulatory problems in marine situation are opposite to those in freshwater environment. Marine bony fishes have the body fluids hypotonic to seawater, and thereby, they tend to lose water from the body through permeable surfaces (gill membranes, oral and anal membranes). .To compensate for the water loss, marine bony fish drink seawater. However, drinking seawater results in a gain of excess salts. The ionocytes or chloride cells of the gill membrane of marine bony fish help to eliminate excess monovalent ions from the body fluid to the seawater. Divalent cations are generally eliminated through faecal matter.

In general, the body fluids of marine invertebrates, ascidians and the hagfish are isosmotic to seawater. Osmolarity of the body fluids is raised by accumulating certain organic substances (osmolytes). Retention of osmolytes in body fluids reduces the osmoregulatory challenges. The best known examples of such organic osmolytes are urea and trimethylamine oxide (TMAO).

Did You Know?

Body fluids of sharks and coelacanths are slightly hyperosmotic to seawater due to retention of urea and TMAO while hypotonic to seawater as they maintain far lower concentration of inorganic ions in the body fluids.

Water and Solute Regulation in Terrestrial Environment

1. Humans for example, die if they lose around 12 percent of the body water. Therefore, water loss must be compensated by drinking and eating moist food.
2. Desert mammals are well adapted to minimise water loss. Kangaroo rats, for example lose so little water that they can recover 90 percent of the loss by using metabolic water (water derived from different cellular metabolic processes). The nasal countercurrent mechanism for conserving respiratory moisture is also important.
3. **Camels.** When water is not available, the camels do not produce urine but store urea in tissues and solely depend on metabolic water. When water is available, they rehydrate themselves by drinking up to 80 litres of water in 10 minutes.

Excretion is removal of metabolic wastes from the body. Removal of undigested food is called defaecation or egestion. Carbon dioxide and water are metabolic wastes of carbohydrate and fat metabolism. Their removal is therefore excretion.

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Chapter 17

Human Health and Disease

Chapter Contents

Introduction

Health, for a long time was considered as a state of body and mind where there was a balance of certain 'humors'. This was emphasised by early Greeks like *Hippocratès* (father of medicine) and Indian Ayurveda system. It was considered that persons with "blackbile" belonged to hot personality and would have fevers. The discovery of blood circulation by William Harvey using experimental method and the demonstration of normal body temperature in persons with blackbile using thermometer disproved the "good humor" hypothesis of health. In later years, biology stated that mind influences our immune system through neural systems and endocrine system and this immune system maintains our health. Hence, mind and mental state can affect our health. The normal structure of the body performing its various functions constitute physical health. Mental state constitute the mental health. Mental state and social environment cannot be isolated from health.

Health

The term health is very frequently used by every body. Health does not simply mean '**absence of disease**' or '**physical fitness**'.

It could be defined as a state of complete **physical, mental** and **social well being**. Of course, health is affected by

(i) **Genetic disorders :** Deficiencies with which a child is born and deficiencies/defects which the child inherits from parents from birth.

(ii) **Infections** and

(iii) **Life style** including food and water we take, rest and exercise we give to our bodies, habits that we have or lack etc.

Balanced diet, personal hygiene and regular exercise are very important to maintain good health. Yoga is being practised to achieve physical and mental health. When people are healthy, they are more efficient at work, increasing productivity and thus bringing economic prosperity. Health also increases longevity of people and reduces infant and maternal mortality.

Disease

When the functioning of one or more organs or systems of the body is adversely affected, characterised by various signs and symptoms, we say, that we are not healthy, *i.e.*, we have a **disease**. Disease can be broadly classified into two categories:

(A) **Congenital Diseases :** These diseases occur since birth and may result from metabolic disorder or defect in development.

(B) **Acquired diseases :** These diseases develop after birth and can be divided into two main categories :

(i) Infectious diseases/Communicable diseases : Diseases which are easily transmitted from one person to another are called as infectious diseases. Infectious diseases are very common and some of the infectious diseases like AIDS are fatal.

(ii) Non-infectious diseases/Non-communicable diseases : These diseases are not spread to other persons. Among non-infectious diseases, cancer is the major cause of death.

Pathogen

A wide range of organisms could cause diseases in man. Such disease causing organisms are called **pathogens** *e.g.*, bacteria, viruses, fungi, protozoans, helminths etc.

Most parasites are therefore pathogens as they cause harm to the host body by living in or on them. The pathogens can enter our body by various means, multiply and interfere with normal vital activities, resulting in morphological and functional damage. Pathogens have to adapt to life within the environment of the host. For example, the pathogens that enter the gut must know a way of surviving in the stomach at low pH and resisting the various digestive enzymes.

COMMON DISEASES IN HUMANS

A Bacterial Diseases

(i) Typhoid: (Enteric fever)

Pathogen: *Salmonella typhi* (A Gram negative bacterium)

Mode of transmission: These pathogens generally enter the small intestine through contaminated food & water and migrate to other organs through blood.

Symptoms: Sustained high fever (39° to 40°C), weakness, stomach pain, constipation, headache, and loss of appetite are some of the common symptoms of this disease. Intestinal perforation and death may occur in severe cases.

Test: Typhoid fever could be confirmed by **Widal test**.

Knowledge Cloud

A classic case in medicine, that of Mary Mallon nicknamed Typhoid Mary. She was a cook by profession and was a typhoid carrier who continued to spread typhoid for several years through the food she prepared.

(ii) Pneumonia:

Pathogen: Bacteria like *Streptococcus pneumoniae* and *Haemophilus influenzae*.

Mode of transmission: A healthy person acquires the infection by inhaling the droplets / aerosols released by an infected person or even by sharing glasses and utensils with an infected person.

Symptoms: In pneumonia, infection occurs in alveoli of the lungs. As a result of the infection, the alveoli get filled with fluid leading to severe problems in respiration. The symptoms of pneumonia are fever, chills, cough and headache. In severe cases, the lips and finger nails may turn gray to bluish in colour.