2 CELL : THE UNIT OF LIFE

Syllabus : The cell, a unit of life, protoplasm, basic difference between prokaryotic and eukaryotic cell; differences between an animal cell and a plant cell.

A basic understanding of the cell theory, structure of plant and animal cell with functions of various cell organelles. (Protoplasm, Cytoplasm, Cell Wall, Cell Membrane, Nucleus, Nucleolus, Mitochondria, Endoplasmic Reticulum, Ribosome, Golgi bodies, Plastids, Lysosomes, Centrosome and Vacuole). Major differences between a prokaryotic and eukaryotic cell. Difference between a plant cell and an animal cell should be mainly discussed with respect to cell wall, centrosome, vacuoles and plastids.

2.1 WHAT IS A CELL ?

The cell is the fundamental **structural** and **functional unit** of all living beings. It is the smallest part of the body of an organism which is capable of independent existence and of performing the essential functions of life.

Every organ in our body—the skin, the brain, the muscle or even the bone—is composed of hundreds of thousands of such cells. Similarly, every part of a plant—the leaf, the flower, the root and even the wood—is composed of an exceedingly large number of cells.

Every cell has its *own life*. Old and weak cells in the body continually die and are replaced by new cells. ***All organisms including ourselves, start life as a single cell called the egg.***

Cells are so small (microscopic) that they cannot be seen with the naked eye. It was, therefore, natural that their existence could not be detected by man until he invented magnifying aids in the form of microscopes.

2.2 THE INVENTION OF THE MICROSCOPE AND THE DISCOVERY OF CELL

The first microscope was constructed by Dutch scientist **Antony van Leeuwenhoek** (1632-1723). He was an ordinary public official who ground lenses and made microscopic observations as a hobby. He is said to have constructed 400 microscopes. Basically, all his microscopes consisted of a *single biconvex lens* and were called **simple microscopes.** Some of these microscopes had a considerable magnifying power up to 200 times. One of Leeuwenhoek's microscopes is shown in Fig. 2.1. In this microscope the eye was applied close to the lens on one side and the object was mounted on the needle-like screw point on the opposite side of the lens.

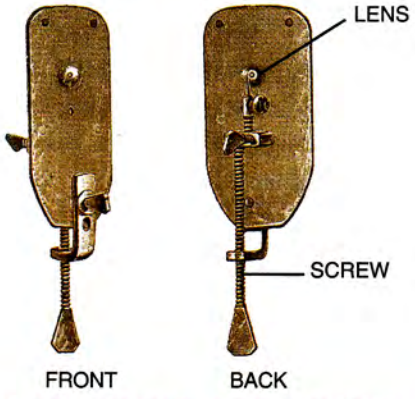


Fig. 2.1 Leeuwenhoek's simple microscope

Robert Hooke (1635-1703), an English scientist, developed a microscope by using two lenses for achieving greater magnification. Such microscopes were later known as *compound microscopes.* In Hooke's microscope (Fig. 2.2 A) the object to be seen was placed on the stage below and light from an oil flame was thrown on it by means of a concave mirror.

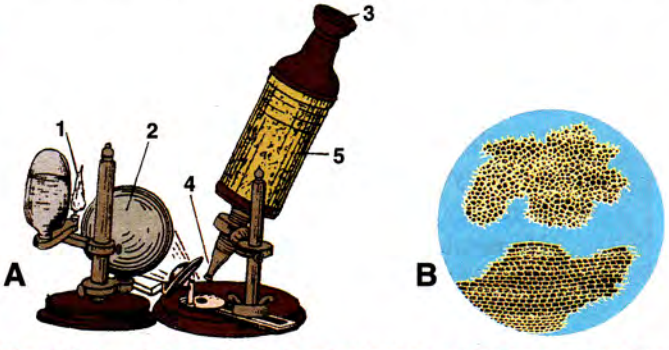


Fig. 2.2 *A* — Robert Hooke's microscope which was worked by the light from an oil lamp (1) focussed on the object below the microscope by a flask (2) filled with water. 3, 4 and 5 – Eyepiece, objective lens and tube respectively. *B* — Hooke's drawings of cork's cellular structure.

Hooke examined a thin slice of cork under his microscope (Fig. 2.2 B) and observed that it was made of tiny "boxlike" compartments piled up together. This reminded him of the rooms, or cells, of monks in a monastery and so he said that the cork was made up of cells. The cells which Hooke saw were all dead cells and they had only the empty "boxes" or the walls.

The ordinary compound microscope (Fig. 2.3) of today is a greatly improved design of the original Hooke's microscope.

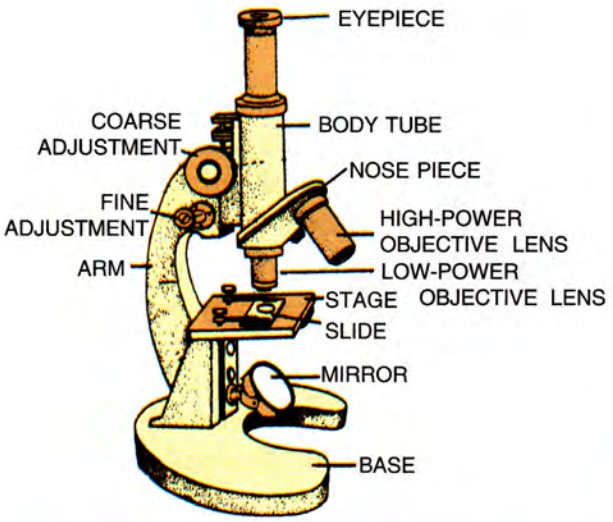


Fig. 2.3 An ordinary compound microscope

The invention of the electron microscope (Fig. 2.4) added further to the unknown facts about cells. It can give a magnification to over 200,000 times as against the ordinary compound microscope which magnifies an object up to a maximum of about 2,000 times. The ordinary compound microscope uses light which is bent by **glass lenses** to magnify the image while the electron microscope uses **beams of electrons** which are **bent by magnets.**

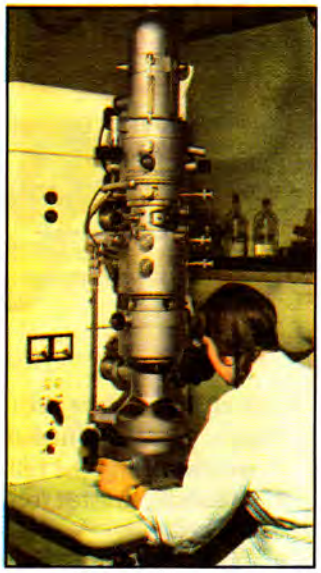


Fig. 2.4 An electron microscope

PROGRESS CHECK

1. Name the following :
   (i) The kind of microscope that consists of a single biconvex lens.
   (ii) The kind of mirror used for throwing light on the object in Hooke's microscope.
2. What is the maximum magnification that can usually be achieved by
   (i) a compound microscope, (ii) an electron microscope ?

2.3 CELL THEORY

In 1838, **Matthias Schleiden**, a German Botanist, announced that every plant is made up of a large number of cells. He added that each of these cells performed various life processes. A year later, **Theodor Schwann**, a German zoologist, made similar discoveries in animals. He declared that *all animals and plants are composed of cells, which serve as the units of structure and function.* This, in short, is called the **Cell Theory**, having been proposed by Schwann and Schleiden in the year 1839. **Rudolf Virchow** in 1858 made an addition to the cell theory by saying that all cells arise from pre-existing cells.

The **Cell Theory** states three major points.

1. The cell is the smallest unit of structure of all living things.
2. The cell is the unit of function of all living things.
3. All cells arise from pre-existing cells.

What does the cell theory mean ? Take two examples, a plant such as *mango* and an animal such as a *frog*.

- **Structural Unit.** If we take any part of the body of a frog or any part of a mango plant and examine it under a microscope, it will show a cellular structure.
- **Functional Unit.** Any function in the body of the frog or in the mango plant is due to the activity in its cells. *For example*, movement of the frog is due to the contractions of muscle cells, food is digested by the enzymes which the cells of the gut secrete, digested food is absorbed by the cells and absorbed food is used up in cells for various metabolic activities. In a mango plant, photosynthesis occurs in the cells of leaves, the root cells absorb water from the soil, and so on.

- **Cells die and are replaced.** The body of the frog, or of the mango tree, is composed of millions and millions of cells. Many of these cells continuously die and **are** replaced by new ones which are formed by the division of younger cells. Formation of cells from pre-existing cells is a never-ending chain.
- **All life starts as a single cell.** The life of the frog and the life of the mango tree started as an egg and as a seed respectively. The egg was a single cell produced by the cells of the ovary of the mother frog. The mango seed had an embryo which also started as a single cell in the ovary of the flowers of the parent mango tree.

2.4 CELLS – HOW NUMEROUS?

Larger an organism, greater the number of cells in its body.

Single-celled : Many small plants and animals are made up of just one single cell.

Examples : Bacteria, yeast, amoeba.

Few-celled : Some very small plants and animals are made up of relatively few cells—just a few hundred or a few thousand cells.

Examples : Spirogyra, Volvox

Multi-celled : Most plants and animals we see around us including ourselves, are made up of millions and billions of cells.

Examples : Human beings, Mango.

An average-sized adult human constitutes approximately :

- **1000 million million cells in the whole body.**
- **10,000 million nerve cells in the brain cortex.**
- **5-6 million red blood cells and 7 thousand white blood cells per cubic millimetre of blood.**

2.5 CELLS – HOW SMALL?

Cells are very small and are seen only with a microscope.

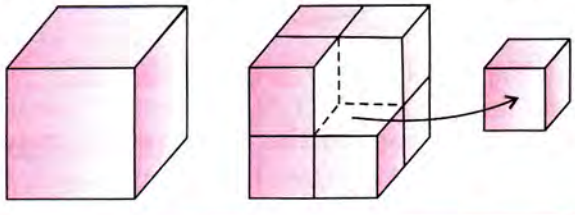
- **Smallest** cells are the bacteria (0.3-5.0 micrometre), red blood cells (about 7 micrometre) in the human body, etc.
- **Longest** cells are the nerve cells. Imagine a nerve cell extending from your finger tip up to the spinal cord inside your backbone.
- **Largest** cells are the birds' eggs (actually the central yellow sphere). Ostrich egg (before development begins in it) is the largest single cell of the living world today. The white (albumen) of the egg and the egg-shell are extra parts added on to the actual egg as it passes down the reproductive tract.

SMALLNESS OF CELLS : A GREATER EFFICIENCY

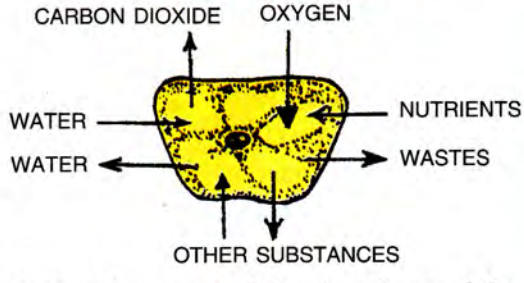
- **Cells** generally remain small in size and this is so for *two* main reasons.
  - (i) Different regions of a cell can communicate with each other rapidly for the cell to function effectively.
  - (ii) Cells have a large surface area / volume ratio for greater diffusion of substances in and out of the cell.

To understand this second advantage about surface area/volume ratio imagine a cube with each of its sides measuring 2 mm. The total surface area of this cube will be 2 mm × 2 mm × 6 (surfaces) = **24 sq. mm.**

Suppose we cut this cube into 8 equal smaller cubes by reducing each side by half its length, then the **total surface area** of these 8 smaller cubes will be 1 mm × 1 mm × 6 (surfaces) × 8 pieces = **48 sq. mm**, which is double that of the original larger cube. The total volume in both cases still remains the same.



Small size of cell presents a larger surface area / volume ratio.



The larger surface area relative to volume of the cell ensures greater diffusion of

- **nutrients into the cell,**
- **metabolic wastes from the interior to the outside of the cell,**
- **respiratory gases i.e. oxygen into the cell and carbon dioxide out of the cell**
- **Any damage to the cell, can be easily repaired.**

2.6 CELL SHAPES – TO SUIT FUNCTIONAL REQUIREMENT

Cells vary greatly in shape (Fig. 2.5). These may be disc-like, polygonal, rectangular, cuboid, thread-like, branched or even irregular. These shapes of cells are often related to the different functions they perform.

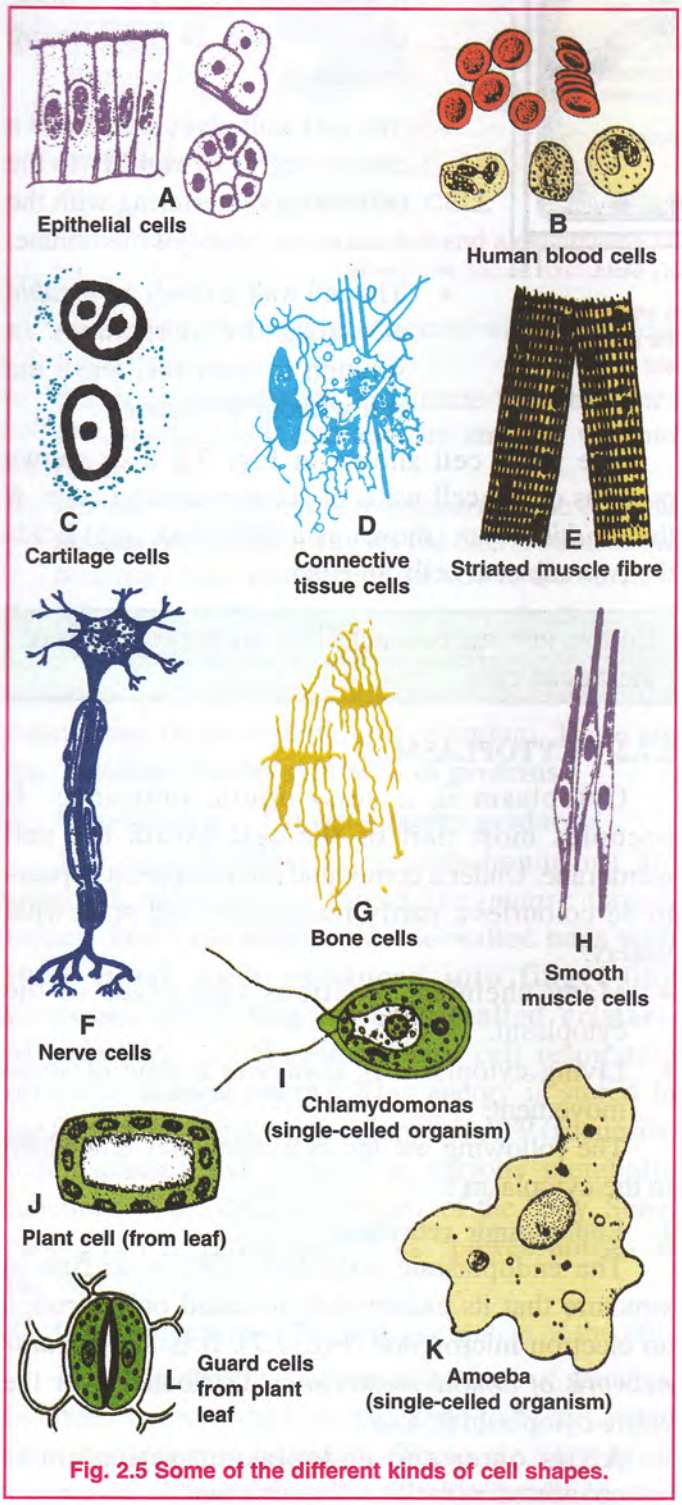


Fig. 2.5 Some of the different kinds of cell shapes.

- Human red blood cells are **circular** and **biconcave**, to pass through narrow capillaries and transport oxygen.
- White blood cells are **amoeboid** (amoeba-like movement, with pseudopodia) that can squeeze out through capillary walls.
- Nerve cells are **long** to conduct "impulse" from distant parts of the body to the brain and vice-versa.
- Muscle cells are **long** and **contractile** to pull or squeeze the parts.
- Guard cells of stomatal pore in the leaves are **bean-shaped** to open and close the pore.

PROGRESS CHECK

1. Name the following :
   - (i) Any two one-celled organisms.
   - (ii) The longest cells in animals.
   - (iii) Amoeboid cells in humans.
   - (iv) Outermost layer in plant cells.
   - (v) A cell component which is visible only in cell division stages.
2. List three categories of substances which are ensured greater diffusion due to large surface/volume ratio of the cells

2.7 STRUCTURE OF A CELL

Various kinds of cells show special differences, yet they all show some basic structural plan which may be expressed in the term "generalised cell". A generalised cell consists of three essential parts : **(1) cell membrane** (plasma membrane), **(2) nucleus** and **(3) cytoplasm**. Fig. 2.6 shows the structure of a generalised animal cell and of a generalised plant cell as seen under a compound microscope.

Cell organelles (the **"little organs").** Most parts of a cell have a definite shape, a definite structure and a definite function. Such parts are called **organelles** The organelles have the same status in a cell as the organs have in the entire body of an animal or a plant performing specific functions. *Cell organelles are living parts.*

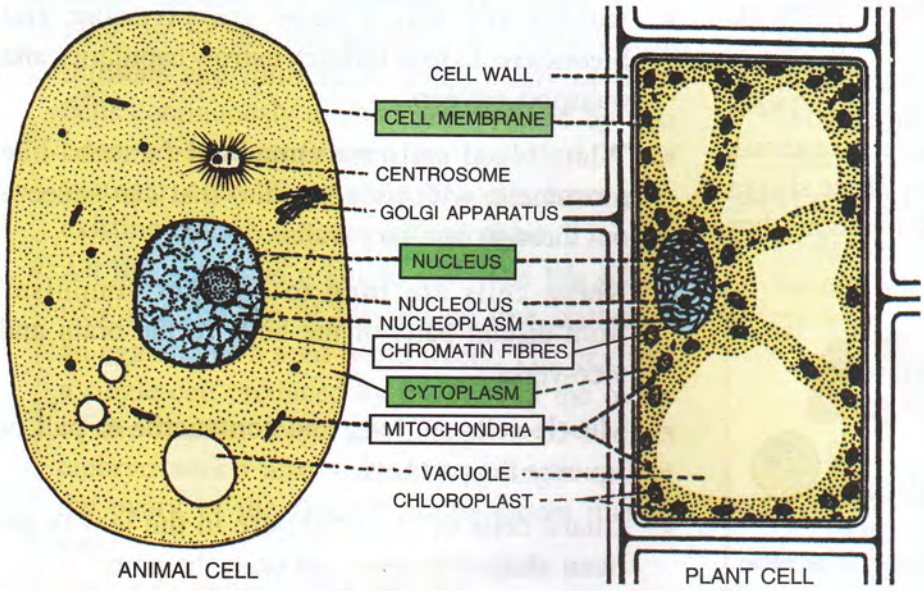


Fig. 2.6 A generalised animal cell and a generalised plant cell as seen under ordinary microscope. (Note the parts common to both cells and the parts which are found exclusively in an animal cell or in a plant cell)

Let us now describe the different parts of the animal and plant cells in some detail.

PARTS OF A CELL

Living Parts	Non-living Parts
Cell membrane	*Cell wall* (only in plant cell)
In the Cytoplasm	
1. Endoplasmic reticulum	1. Granules
2. Mitochondria	2. Vacuoles
3. Golgi apparatus	3. Fat droplets
4. Ribosomes	
5. Lysosomes	
6. Centrosome (only in animal cell)	
7. Plastids (only in plant cell)	
In the Nucleus	
1. Nuclear membrane	1. Nucleoplasm
2. Nucleoli	
3. Chromatin fibres	

2.7.1 CELL MEMBRANE and CELL WALL

Each cell is surrounded by a **cell membrane** or **plasma membrane.**

- The cell membrane has fine pores through which substances may enter or leave the cell.
- The permeability of the cell membrane is selective, *i.e.* it allows only certain substances to pass through while it prevents others.

Plant cells have a **cell wall** surrounding the cell membrane (Fig. 2.6). The cell wall is made of cellulose, a non-living substance.

- The cell wall gives **shape** and a certain degree of **rigidity** to the cell without interfering with the functions of the cell membrane.
- The cell wall is *freely permeable* allowing the substances in solution to enter and leave the cell without hindrance.

The plant cell shown in Fig. 2.6 also shows portions of the cell walls of six surrounding cells. A thin *middle layer* (shown as a thick dark line) holds the two adjacent cells together.

Cotton, jute and coconut fibres are the cell walls of their dead cells.

2.7.2 CYTOPLASM

Cytoplasm is a semi-liquid substance. It occupies most part of the cell within the cell membrane. Under a compound microscope, it appears to be colourless, partly transparent and somewhat watery.

- Many chemical reactions take place in the cytoplasm.
- Living cytoplasm is always in a state of some movement.

The following are the cell organelles embedded in the cytoplasm :

1. Endoplasmic reticulum

The endoplasmic reticulum (ER) is so fine in structure that its existence is revealed only through an electron microscope (Fig. 2.7). It is an *irregular* ***network*** *of double membranes* distributed over the entire cytoplasm in a cell.

- At its outer end endoplasmic reticulum is connected with the cell membrane.

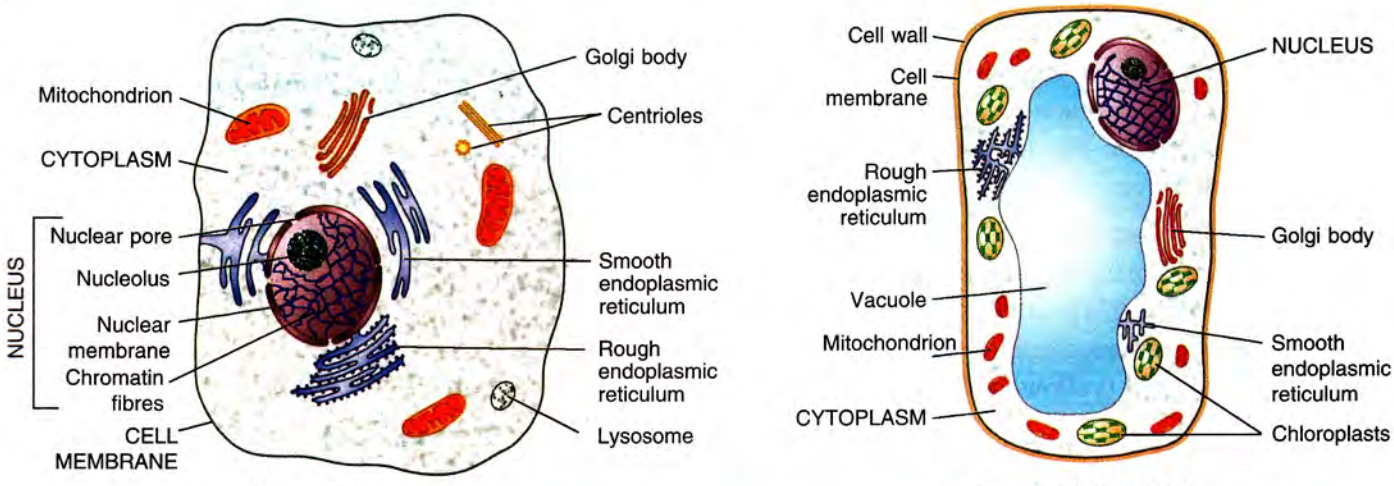


Fig. 2.7 A generalised animal cell and a generalised plant cell. (Note the parts common to both cells and the parts which are found exclusively in an animal cell or in a plant cell)

- At the its inner end it is connected with the nuclear membrane.
- It appears **rough** when the particle-like ribosomes are attached to it and appears **smooth** without them.
- It forms the *supporting framework* of the cell and also serves as a pathway for the distribution of the materials from one part of the cell to the other.

2. Ribosomes – The sites of protein synthesis

The ribosomes are numerous small granules *either* scattered freely in the cytoplasm *or* attached to the membranes of the endoplasmic reticulum. These are the 'factories' for the **synthesis of proteins.**

3. Mitochondria – The cell's energy producers

The mitochondria (*sing.*mitochondrion) are spherical, rod-shaped or thread-like (*mitos* : thread) bodies. These are **minute double-walled bags with their inner walls produced into finger-like processes projecting inwards (called cristae).** Mitochondria are the sites where cell respiration occurs to **release energy.** This energy is stored in the form of an energy-rich compound ATP (adenosine triphosphate) and is used in various metabolic functions of the cell, and in turn, of the body. Some people call the mitochondria as **"power houses of the cell".**

4. Golgi apparatus – The delivery system of the cell

The golgi apparatus occurs in the form of granules, filaments or rods which are supposed to be originated from endoplasmic reticulum. These are very small vesicles of different shapes, and are generally located near the nucleus. The golgi complex consists of many small groups of hollow tubular structures with membranous walls and is associated with some minute vesicles and vacuoles. It is concerned with the **secretions of the cell** including enzymes, hormones, etc.

5. Lysosomes – The intracellular digestive centres

Lysosomes are small vesicles of different shapes containing some digestive enzymes.

- Their enzymes **destroy** and **digest** foreign substances around them.
- They digest the stored food during starvation of the cell.
- Many damaged cells are rapidly destroyed or dissolved by their own lysosomes and hence these are also called the "suicide bags".

6. Centrosome and centrioles

A centrosome is found **only in an animal cell.** It is a clear area of cytoplasm close to nucleus, (from which spindle fibres develop during cell division both in mitosis and meiosis).

The centrosome contains two centrioles which are short bundles of microfilaments arranged at right angles to each other (that is why they always appear in this shape ⚬) in the microscopic view of cell. [*There are no centrosome and centrioles in plant cells*].

7. Plastids

Plastids are found **only in plant cells.** These are special organelles in different shapes—oval, spherical and disc-shaped. Depending upon the colour they

impart plastids are classified as leucoplasts, chromoplasts and chloroplasts.

(a) Leucoplasts (*leuco* : white) are colourless plastids. They have no pigment. They store starch. Cells of a potato have lots of leucoplasts in them.

(b) Chromoplasts (*chromo* : colour) These are variously coloured plastids—yellow, orange and red. They are mostly present in petals of flowers and in fruits, and the colouring substances (pigments) associated with them are **xanthophyll** (yellow) and **carotene** (orange-red).

Some colouring pigments such as blue, violet and purple are not associated with plastids; instead, they remain dissolved in the cell-sap and give that colour to the plant structure. Such pigments are called **anthocyanins.**

(c) Chloroplasts (*chloro* : green). These are green coloured plastids. They have green coloured pigment called **chlorophyll.** Chloroplasts are abundant in parts exposed to light, e.g. leaves. They also have other pigments such as orange and yellow, but these pigments are masked by large quantities of chlorophyll. Their function is to trap solar energy and absorb carbon dioxide for the manufacture of starch and sugar during photosynthesis. Chloroplasts contain DNA and have the capacity to divide.

Some people describe the chloroplasts as "kitchen" of the cell. It is a **wrong** analogy.
In kitchen we cook the **food** to make it suitable for eating and do not produce it whereas the chloroplasts produce the food.

Green turns into Red !

Raw tomatoes and unripe chillies are green (due to chlorophyll). During ripening the chlorophyll degenerates and the masked red (carotene) takes over.

Non-living substances or Cell inclusions

1. **Granules.** There are many small particles in the cytoplasm, these particles are believed to contain food materials, such as starch, glycogen and fats.

2. **Vacuoles.** These are certain clear spaces in the cytoplasm. They are filled with water and various substances in solution. In **plant cells** the vacuoles are usually quite large and the liquid which they contain is called **cell-sap.** An animal cell does not have such prominent vacuoles, and the vacuoles are fewer in number.

2.7.3 NUCLEUS

Nucleus is the most important part of the cell.
— It *regulates and coordinates various life processes of the cell.*
— It plays an important part in *cell division.*
— It contains factors (genes) which determine *heredity.*

Nucleus is a small spherical mass located somewhat in the centre of the cytoplasm. It has a delicate **nuclear membrane** which is filled with a relatively dense **nucleoplasm.** In the nucleoplasm there are certain threadlike structures called **chromatin fibres.** During cell division the chromatin fibres become thick and ribbon-like. These fibres are then called **chromosomes** (Fig. 2.8). Cells in which nuclear membrane is absent are called *Prokaryotic cells* (*pro*-primitive; *karyon*-nucleus). They have nuclear material called chromatin fibres which occur freely in the cytoplasm e.g. bacteria. Cells in which double nuclear membrane is present are called *Eukaryotic cells* (*eu*: true; *karyon* : nucleus), e.g. all organism other than bacteria.

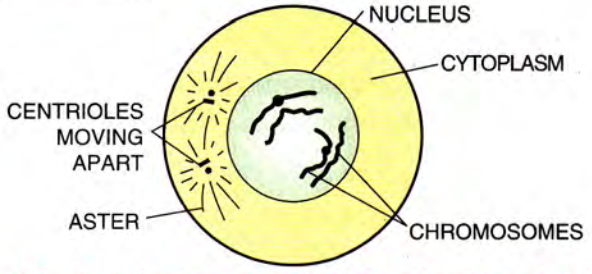


Fig. 2.8 An early stage of cell division showing two pairs of chromosomes that have condensed from the chromatin network, inside the nucleus. (Diagrammatic). Chromosome number varies from one organism to another.

Each nucleus also has, at least, one **nucleolus** in it. Some cells may have more than one nucleolus. The number of nucleoli in a cell is fixed. The nucleolus participates in **protein synthesis.**

The **number of chromosomes** is definite in each species. Every human body cell has 46 (23 pairs) chromosomes. Chromosome numbers of some other common animals and plants are as follows :

Ascaris (round worm)	2
Garden pea	14
Onion	16
Maize	20

Honey-bee	32
Lion	38
Mouse	40
Wheat	42
Potato	48
Chimpanzee	48
Monkey	54
Chicken	78
Dog	78
Sugarcane	80
Crayfish	200
Some insects	more than 1000

The chromosomes carry the genetic characters from the parents to the offspring through the union of the egg of the female and the sperm of the male.

Chromosomes are made of chromatin, which is composed of hereditary units called **genes.** Genes are made of a complex chemical substance DNA (deoxyribonucleic acid).

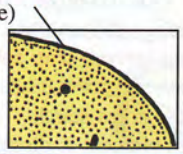
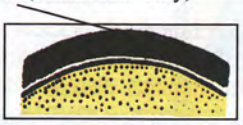
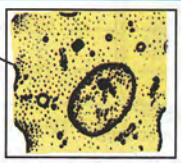
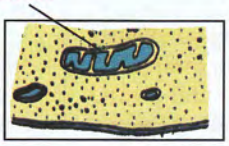
DNA - Fingerprinting

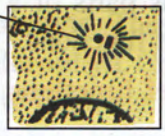
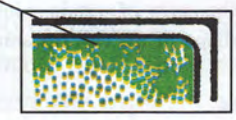
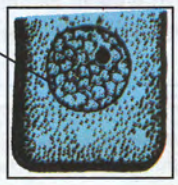
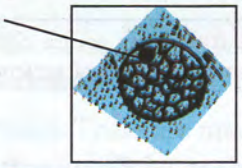
Like the fingerprints, the DNA pattern helps in ascertaining the identity of a person and hence the term DNA fingerprinting. This technique can even testify the parentage of an individual. In a woman's murder case of Delhi in July 1995 the DNA from her unidentifiable charred dead body was matched with the DNA from the body cells of her parents to confirm that they really were the father and mother of the murdered woman. That was one of the earliest cases. Now, DNA-fingerprinting has become very common.

Genes and not the number of chromosomes determine the characteristics of a species. Lion, tiger and the house cat all have 38 chromosomes but they look different due to their different genes located on these chromosomes.

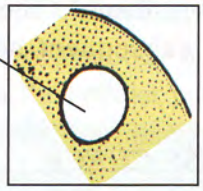
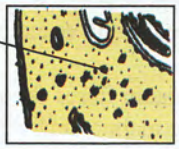
You can revise your understanding about the various cell parts by going through Table 3.1 which summarizes the various parts of a cell, their main characteristics and chief functions.

Table 2.1 Parts of cell, their main characteristics and chief functions

Part of cell	Main characteristics	Chief function(s)
1. **Plasma membrane** (also called cell membrane) 	1. Outermost in animal cells. 2. Lies next to cell wall in plant cells. 3. Very thin, flexible, **living membrane**. 4. Possesses **fine pores**. 5. **Semi-permeable.** 6. Made up of lipoproteins.	1. Separates contents of cell from its surroundings 2. **Regulates the entry** of certain solutes and ions. 3. Maintains shape of the cell (in animal cells).
2. **Cell wall** (Plant cells only) 	1. **Non-living** rigid layer surrounding plasma membrane 2. Mainly composed of **cellulose**. 3. **Freely permeable**.	1. **Gives rigidity and shape** to the plant cell. 2. Allows substances in solution to enter and leave the cell without hindrance. 3. Provides protection.
3. **Cytoplasm** 	1. All the parts together inside the plasma membrane excluding nucleus. 2. Contains a mixture of water and soluble inorganic and organic compounds, and various organelles.	1. Different organelles contained in it perform different functions. 2. All metabolic activities occur in it. 3. Seat of earlier steps of respiration (production of pyruvic acid) (anaerobic respiration).
4. **Endoplasmic reticulum** (ER) 	1. Irregular network of tubular double membrane. 2. It is continuous with the plasma membrane on the outside and the nuclear membrane on the inside. 3. May be smooth or rough (attached ribosomes).	1. **Supportive framework** for the cell. 2. **Synthesis and transport** of proteins and fat.
5. **Mitochondria** 	1. Various shapes but usually sausage-like. 2. Double walled; inner wall thrown into folds **(cristae)**. 3. Have their own DNA containing several genes 4. Also contain their own ribosomes	1. **Release of energy** from pyruvic acid produced in cytoplasm, in the form of ATP. (Seat **of cellular (aerobic)** respiration & stores energy). 2. Synthesis of respiratory enzymes.

6. **Golgi apparatus** (In animal cells) (called dictyosomes in plant cells) 	1. Stacks of **flattened membrane** sacs. 2. Consists of tubules, vesicles and vacuoles.	1. **Synthesis and secretion of enzymes, hormones,** etc. 2. Formation of acrosome of sperm.
7. **Ribosomes** 	1. **Small granules** either scattered in the cytoplasm or attached to the outside of endoplasmic reticulum. 2. **Single walled** dense, spherical bodies composed mainly of RNA.	1. **Protein synthesis.**
8. **Lysosomes** 	1. **Membranous sacs** budded off from Golgi bodies. 2. Contain 40 different types of enzymes.	1. **Intracellular digestion.** 2. **Destroy foreign substances.** 3. When cell is old or injured, these rapidly **destroy organelles** (hence called "suicide bags"). 4. Formation of bones by digesting cartilages.
9. **Centrosome** (Animal cells only) 	1. A region surrounding the centrioles, located near nucleus. 2. Contains **one or two centrioles** 3. Centrioles are surrounded by radiating microtubules to form a "star" (aster) during cell division	1. **Initiates and regulates cell division.** 2. Forms spindle fibres, with the help of asters.
10. **Plastids** (Plant cells only) 	1. Several kinds, most common ones are **chloroplasts** containing the green pigment chlorophyll. 2. **Double membrane**, proteinaceous matrix, **contain DNA.** 3. Disc-like structures called thylakoids contain **chlorophyll.**	1. **Chromoplasts** impart colour to flowers and fruits – (Xantho-phyll : yellow, carotene : orange, red). 2. **Chloroplasts (green) trap solar energy** for photosynthesis. 3. **Leucoplast** – stores starch. 4. Anthocyanin pigment is dissolved in cell sap and responsible for blue-violet colour in plants.
11. **Nucleus** 	1. Largest cell organelle. 2. Mostly spherical and dense. 3. Nuclear membrane with pores to allow substances to enter and leave. 4. Contains network of thread-like structures called chromatin fibres which contain DNA.	1. **Regulates cell functions.** 2. If removed, the cell dies. 3. **Contains chromosomes** (bearers of genes that control hereditary characters).
12. **Nucleolus** 	1. One or more round-shaped nucleoli inside the nucleus.	1. Produces ribosomes 2. **Participates in protein synthesis by forming and storing RNA.** 3. Dictates ribosomes to synthesise proteins.
13. **Chromatin fibres** 	1. The network in resting stage of the nucleus condenses into chromosomes during cell division. 2. Made up of **DNA threads.**	1. Chromosomes carry **hereditary information** or the genes.

The next two parts, i.e. vacuoles and granules are non-living, these are important in their own way.

14. **Vacuoles** 	1. Clear spaces with water or other substances in solution. 2. Plant cells have larger vacuoles, while the animal cells have fewer and smaller ones. 3. Covered by a covering called tonoplast.	1. **Storage of water** and other substances, food, pigments, and waste products. 2. Give **turgidity** to the cells.
15. **Granules** 	1. Small particles, crystals or droplets.	1. Starch (in plant cells), glycogen (in animal cells) and fat-containing granules serve as **food for the cell**.

2.8 THE PLANT AND ANIMAL CELLS

The basic structure is similar in all plant and animal cells. Both contain the cell membrane, cytoplasm, nucleus, endoplasmic reticulum, golgi bodies, mitochondria and ribosomes. However, there are some important **differences** between the two. These **differences** are shown in Fig. 2.6 as well as in Fig. 2.9, and are also summarized in Table 2.2.

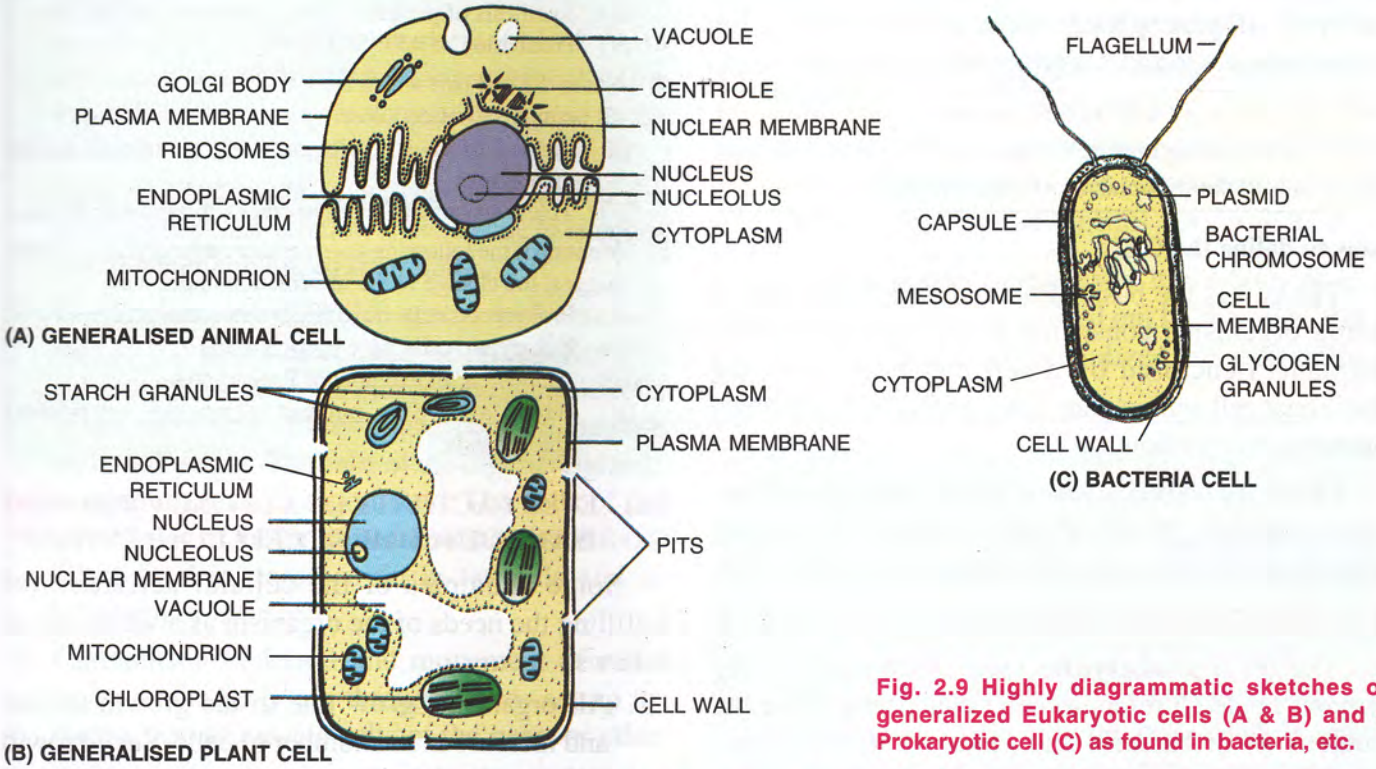


Fig. 2.9 Highly diagrammatic sketches of generalized Eukaryotic cells (A & B) and a Prokaryotic cell (C) as found in bacteria, etc.

Table 2.2 Differences between plant and animal cells

FEATURE	PLANT CELLS	ANIMAL CELLS
	Structural differences	
1. Cell wall	A definite *cell wall*, made up of cellulose.	1. No cell wall.
2. Centrosome	*Centrosome* is not present.	2. Centrosome is present.
3. Vacuoles	Vacuoles prominent, one or more. concerned with excretion or secretion.	3. Vacuoles, if any, are small and temporary;
4. Plastids	Usually contain plastids.	4. Do not contain plastids.
	Quantitative differences	
5. Size	Usually larger, with distinct outlines.	5. Usually smaller, with less distinct boundaries.
6. Cytoplasm	Cytoplasm not so dense.	6. Cytoplasm denser and more granular.
7. Arrangment of cytoplasm	Only a thin lining of cytoplasm, mostly pushed to the periphery.	7. Cytoplasm fills almost the entire cell.

2.9 PROTOPLASM

Biologists have been using the term "**protoplasm**" for a long time. By this they mean the **living substances in an organism.** This living substance or the protoplasm is contained in the cells. The protoplasm has been described as a translucent fluid somewhat colourless, greyish or brownish.

The chemical composition of protoplasm is very complex. It varies a little from one cell to another, although the common elements included in the composition of protoplasm, such as carbon, hydrogen, oxygen, nitrogen, sulphur, iron and phosphorus, are the same in all cells. These elements are in the form of specific compounds such as **water, proteins, carbohydrates, fats and mineral salts.** It is also true to say that it is impossible to make an accurate chemical analysis of protoplasm because it ceases to be protoplasm as soon as it is removed from the organism.

PROTOPLASM

It is the living matter, the total substance of a living cell, that is, the cytoplasm and the nucleus.

Now to define the CELL —

The cell is the basic structural building block of living organisms consisting of protoplasm (living substance) enclosed by a cell membrane with an additional cell wall in plant cells, and having a nuclear membrane or without it.

Check the above differences in the highly diagrammatic sketches of Eukaryotic cells (in plants and animals and Prokaryotic cells (bacteria, *etc.*) (Fig. 2.9).

2.10 PROKARYOTIC AND EUKARYOTIC CELLS

The term ***prokaryotic*** (*pro* : early/primitive, *karyon*: nucleus) refers to cells containing primitive nucleus as in bacteria and ***eukaryotic*** (*eu* : true/complete, *karyon* : nucleus) meaning cells with perfectly formed nucleus as in plants and animals.

[This type of nuclear difference is the first basis of classification of organisms : The earliest type Prokaryotes and the subsequent advanced type Eukaryotes.]

PROGRESS CHECK

1. Name the part of a cell in which
   (i) many chemical reactions occur with the help of enzymes.
   (ii) a network of chromatin fibres occurs.
   (iii) cellulose forms the main component.
2. Differentiate between
   (i) an organ and an organelle
   (ii) a plant cell and an animal cell pertaining to the presence of plastids
3. Name the cell organelles concerned with
   (i) Secretion of enzymes (ii) Trapping of solar energy
   (iii) Synthesis of proteins (iv) Intracellular digestion
   (v) Production of ATP
4. Name the cell part which is
   (i) composed of cellulose
   (ii) formed of an irregular network of tubular double membranes
   (iii) a clear space with water or other substances in solution
5. Mention if the following statements are ***true*** or ***false.*** If false, suggest the change in the information underlined.
   (i) Prokaryotic cells have larger ribosomes.
   (ii) Eukaryotic cells have mitochondria.
   (iii) Amoeba is an example of Prokaryotes.
   (iv) Bacteria have no nuclear membrane but possess chloroplasts.

2.11 EVERY ACTIVITY OF A LIVING ORGANISM IS THE OUTCOME OF CELLULAR ACTIVITY

Some examples of the cellular activities for fulfilling the needs of the organism as a whole are as follows :

1. All organisms **grow** due to the growth in size and increase in the number of cells. Such growth is the production of more body substance and cell substance.

Table 2.3 Differences between Prokaryotic and Eukaryotic cells

PROKARYOTIC CELL	EUKARYTOIC CELL
1. **No** well defined **nucleus**	1. **Well defined nucleus** with a nuclear membrane
2. A **single length** of only deoxyribonucleic acid (DNA)	2. Several lengths of genetic material (*chromosomes*) containing DNA wound around certain proteins
3. Small ribosomes	3. Larger ribosomes
4. No other cell organelles	4. Several organelles like mitochondria, endoplasmic reticulum, chloroplasts, etc.
Examples : Bacteria, Blue green algae (Cyanobacteria)	***Examples :*** Euglena, Amoeba and all plants and animals

2. **Repair** of an injury or regeneration of a lost part (as the tail of a lizard) is due to cell divisions.
3. **Movement** of the body is due to contractility of the cells or the cellular parts. *For example*:
   - Animals walk, run, jump, swim or fly with the help of muscles (contractile cells) which move the bones (formed of cells and cell secretions). Even the flow of blood in blood vessels and the passage of food in the gut are the result of muscle cell contractions.
   - Feathers which help the birds to fly are also the products of cells.
   - The drooping of leaves of the sensitive plant on touching and their subsequent recovery to stand out is due to the activity of the cells at the base of the leaves.
   - In plants, the bending movements of roots towards water or gravity, or movements of stems towards light or away from gravity are due to the activities of cells (unequal growth in the cells).
   - Closing of stomata of leaves at night and the opening of petals in a flower are all due to changes in the water content of their cells.
4. **Feeding** and **nutrition** has many steps and each step is the result of cellular activities. Sensory cells on the tongue taste the food and muscle cells of the jaws and of the tongue help in chewing and swallowing. The cells of the digestive glands secrete enzymes to digest food. The cells of the inner lining of the intestines absorb digested food. Extra food is stored as fat in fat cells and as glycogen in liver cells.
5. **Circulation of blood** and movement of other fluids in the body are through forces set up by contraction of muscle cells of the heart or other parts.
6. **Respiratory gases are transported** from the lungs to other parts of the body by blood cells.
7. **The body protects** itself from disease germs through certain cells (W.B.C.) which devour the germs or which give out antibodies and antitoxins to kill them or to neutralise their effects.
8. We see, hear, smell, taste or feel the sensation of touch, pain, heat, cold, etc. through sensory cells. The brain orders muscles to contract or a gland to secrete through its cells **(response)** The memory and the capacity to solve problems are also due to the activity of the cells.
9. We maintain our body heat **(thermo-regulation)** by cellular activity and we cool it when hot by sweating from gland cells in the skin.
10. All organisms **produce their young ones** (eggs or babies in animals, or the seeds in plants) through the activity of cells (eggs and sperms).
11. In plants, the **absorption of water** and nutrients is through root cells. The stem cells conduct the food and water to different parts of the plant.
12. **Light is trapped** by the leaf cells containing chloroplasts to produce food.
13. Flowers attract insects by their **colour** contained in the petal cells, or by nectar secreted by the cells.
14. The mango seed produces a mango plant, and a hen's egg produces a hen and similarly, the transmission of parental features to their young ones **(inheritance)** is also dependent on what the germ cells (egg and sperm) carry with them.

There is not a single activity in the body of an organism which is not carried out by the cells. But cells, of course, are specialized for particular functions.

PROGRESS CHECK

1. Column I lists a few activities of living organisms and column II the activity of cells related to them. Match the items in the two columns.

Column I (Activity of organism)	Column II (Activity of cells)
(i) Repair	(a) Contractility of cells
(ii) Cooling of body	(b) Cells devour germs
(iii) Movement	(c) Cell division
(iv) Protection from diseases	(d) Gland cells give out sweat for evaporation

2. Which cell organelle is the key to the life of the cell ?
3. How do you say that a cell also has a life span and death like an organism ? Give one example.
4. All organisms excrete. Does an individual cell also do it ? Give one example.
5. Every organism needs food. Does a cell also need it? Explain very briefly.

EXTRA INFORMATION

Stem cells — A popular modern term "stem cells" is becoming very familiar in medical sciences. What does it actually mean? Stem cell is an *undifferentiated* cell in the embryo or adult, which can undergo unlimited divisions and can give rise to one or several different cell types. The stem cells are broadly classified into *two* categories :

(a) **Embryonic stem cells —** Up to a certain stage every embryonic cell can develop into any tissue (pluripotent), e.g. they may restore damaged heart.

(b) **Tissue specific stem cells —** The embryonic cells reach a stage when they become destined to form a particular tissue such as nerve or the blood tissue, although not yet differentiated. *For example*, bone marrow in the long bones contains haematopoietic stem cells which can give rise to only the blood cells.

(c) **Induced pluripotent stem cells (iPS cells) —** According to some new researches, ordinary human skin cells can be transformed into pluripotent stem cells by using certain chemicals. Type 1 diabetes by birth can be corrected by regenerating pancreatic beta cells of islets of Langerhans by iPS technique.

[The word "stem" has numerous meanings, one of which is "*a line of ancestry*" or "*to make headway*". It is this aspect that is highlighted in the term "*stem cell*"]

A 9-year old girl Thamira from Chennai was cured of a serious genetic blood disease thallasemia, through the **stem cells** taken from the umbilical cord during the birth of her 9-year **younger** brother. Patients sufferring from thallasemia have to regularly take blood transfusions.

POINTS TO REMEMBER

- ***All plants and animals are made up of cells.***
- ***Every organism starts as a single cell.***
- ***The cell theory states three points.***
  1. ***The cell is the unit of structure of all living things***
  2. ***All cells develop from pre-existing cells***
  3. ***The cell is the unit of function of all living things***
- ***A cell consists of cell membrane, cytoplasm and nucleus.***
- ***Plant cells have an extra rigid cell wall made of cellulose and one or two large vacuoles.***
- ***Cells are often specialised in their shapes to carry out different functions.***
- ***The cell membrane is selectively permeable whereas the cell wall is freely permeable.***
- ***Ribosomes are the sites of protein synthesis, mitochondria produce chemical energy (ATP), golgi apparatus produces secretions, and lysosomes destroy foreign substances around them.***
- ***Plant cells have a variety of plastids.***
- ***Nucleus contains genes, and it controls the activities of the cell.***
- ***Prokaryotic cells have neither a distinct nucleus, nor the organelles like mitochondria and chloroplasts. They only have ribosomes.***
- ***Prokaryotes were the first form of life to appear on the earth.***

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. **Which one** of the following cell organelles is ***correctly*** matched with its function ?
   (a) Ribosomes — Synthesis of proteins
   (b) Mitochondria — Secretion of enzymes
   (c) Plasma membrane — Freely permeable
   (d) Centrosome — Carries genes

2. All life starts as
   (a) an egg (b) a single cell
   (c) a gene (d) a chromosome

3. **Which one** of the following is found both in the cells of a mango plant and a monkey ?
   (a) chloroplasts (b) centrioles
   (c) cell wall (d) cell membrane

4. A plant cell can be identified from an animal cell by the :
   (a) absence of centrosome.
   (b) presence of cell membrane.
   (c) presence of vacuoles
   (d) none of the above

5. Plant cell has a cell wall made of :
   (a) Protein (b) Fructose
   (c) Cellulose (d) Fatty acids

6. The cell organelle that helps in respiration of the cell is :
   (a) Mitochondria (b) Lysosome
   (c) Ribosome (d) Centrosome

B. VERY SHORT ANSWER TYPE

1. **Name** the part of the cell concerned with the following ?
   (a) Liberation of energy
   (b) Synthesis of proteins
   (c) Transmission of hereditary characters from parents to offspring
   (d) Initiation of cell division
   (e) Hydrolytic in function
   (f) Entry of only certain substances into and out of the cell.
2. State whether the following statements are **true** (T) or **false** (F) :
   (a) All animal cells contain a cell wall. T/F
   (b) The cell wall is made of protein. T/F
   (c) Centrosome occurs in animal cells. T/F
   (d) Plant cells contain large vacuoles. T/F
   (e) Protoplasm is the part of the cell which surrounds the nucleus. T/F
   (f) Genes are located in chromosomes. T/F
   (g) Anthocyanins are the pigments of flowers, which are dissolved in cell-sap. T/F
3. **How many** chromosome pairs are found in human cells ?
4. **What is the name** of the chemical substance which constitutes the genes ?
5. **Match the items** in column 'A' with those in column 'B'

Column A	Column B
(a) Vacuoles	(i) Intracellular digestion
(b) Nucleolus	(ii) Respiratory enzymes
(c) Lysosomes	(iii) Covered by tonoplast
(d) Anthocyanin	(iv) Dissolved in the cytoplasm
(e) Cristae	(v) Forms RNA

6. **Fill in** the blanks :
   (a) ..... consists of membranous sacs and secretes 40 types of digestive enzymes.
   (b) ..... is surrounded by microtubules, located near the nucleus.
   (c) Very thin flexible, living membrane which is differentially permeable, is called .....
   (d) More than 1000 chromosomes are found in the nucleus of certain .....
   (e) ..... are hereditary units.
   (f) ..... is a plastid which stores starch.

C. SHORT ANSWER TYPE

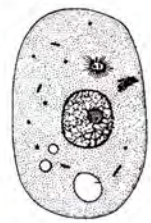
1. It is said that the protoplasm cannot be analysed chemically. **Why** ?
2. **What** is the difference between an organ and an organelle ?
3. **Do you think** the cells of an elephant would be larger than the cells of a rat ? Explain briefly.
4. **Differentiate** between the following pairs of terms :
   (a) Protoplasm and cytoplasm
   (b) Nucleolus and nucleus
   (c) Centrosome and chromosome
   (d) Cell wall and cell membrane
   (e) Plant cell and animal cell
   (f) Prokaryotes and eukaryotes.
5. **Mention** *three* features found only in plant cells and *one* found only in animal cells.
6. **Why** are the cells generally of a small size ?

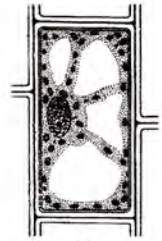
D. LONG ANSWER TYPE

1. **What** is the cell theory ? Who propounded it and when ?
2. **Mention** any three differences between a living cell and a brick in a wall.
3. Name the plastid and pigment likely to be found in the cells of :
   (a) petals of sunflower (b) ripe tomato
   (c) skin of green mango (d) cells of potato.
4. State the **major functions** of the following :
   (a) Plasma membrane (b) Ribosome
   (c) Lysosome (d) Mitochondria
   (e) Golgi apparatus (f) Cytoplasm
   (g) Asters of centrosome (h) Chromosomes
   (i) Glycogen granule (j) Vacuoles
5. **List** any *six* features found both in plant and animal cells.

E. STRUCTURED/APPLICATION/SKILL TYPE

1. Given below are the sketches of two types of cells A and B


A


B

   (a) **Which one** of these is a plant cell? **Give reason** in support of your answer.
   (b) **List** the cell structures which are common to both the types.
   (c) Name the structures found **only in plant cells** and those found **only in animal cells**.