

CHAPTER – 12



The fundamental unit of life : Cell

Cell is a Latin word that means a little room. It was first discovered by ROBERT HOOKE in 1665, while examining a thin section of cork, which is a substance obtained from the bark of a tree called cork oak (*Quercus suber*). He observed in the section of cork many small compartments that resembled the structure of a honeycomb. This observation was made through his own microscope (Fig.12.1). Robert Hooke called these small compartments as **cells**. It may be considered as an insignificant or small incident but it has occupied a very significant place in the history of science.

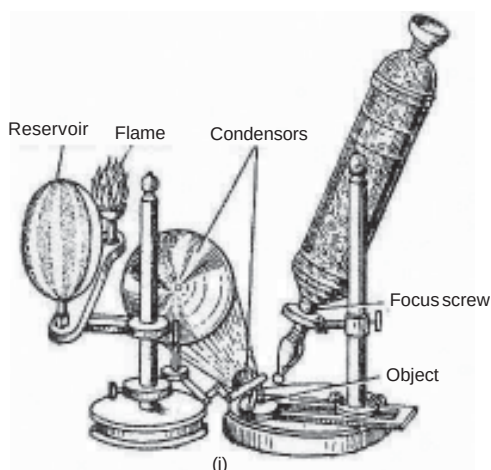
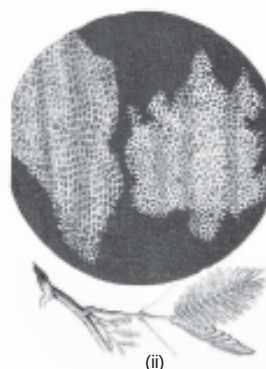


Fig.12.1: (i) Robert Hooke's microscope



(ii) Cork cell as seen under microscope and a twig of cork oak

12.1 What are living organisms made up of ?

Activity 12.1

Let us take a fleshy leaf from inside an onion bulb. With the help of a pair of forceps, we can peel off the skin (called epidermis) from the concave side (inner layer) of the onion and put immediately in a watch-glass containing water to prevent the peel from getting folded or dry. What do we do with this onion peel?

Let us take a glass slide, put a drop of clean water on it and transfer a small piece of the peel from the watch-glass to the slide. Make sure that the peel is perfectly flat on the slide. A thin camel hair paint brush to help you to transfer the peel. Now, put a drop of iodine solution on this piece followed by a cover slip. It is necessary to take care to avoid air bubbles while putting the cover slip with the help of a mounting needle. Even you ask teacher for help. In this way, we have prepared a temporary mount of onion peel. We can observe this slide under low and high powers of compound microscope (Fig.12.2)

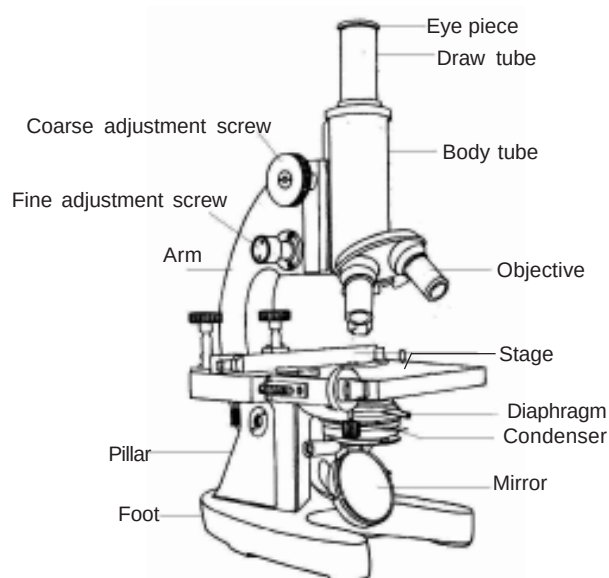


Fig.12.2: A compound microscope

What do we observe as we look through the lens? Can we draw the structures that we are able to see through the microscope, on an observation sheet? Does it look like as seen in Fig.12.3 ?

We can try preparing temporary mounts of peel of onions of different sizes and we can observe whether they have similar structures or different structures. These structures look similar to each other and together form a big structure like an onion bulb. We have found here from this activity that onion bulbs of different sizes have similar small structures visible under a microscope. The cells of the onion peel will look identical, regardless of the size of the onion they are taken from.

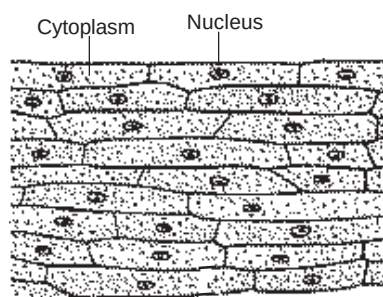


Fig.12.3: Onion cells

These small structures that we notice are the basic building units of the onion bulb. These structures are called **cells**. Not only onions, but all organisms that we observe around us are also made up of cells. Yet, there are many organisms made up of single cells living on their own. The discovery of microscopic world is possible with the inventions of magnifying lenses of various powers.

More to know

Robert Hooke first discovered CELLS in 1665. With the help of a primitive microscope, he observed the cells in a cork slice. With the improved microscope, **Anton von Leeuwenhoek** in 1674 discovered the free living cells in pond water for the first time. **Robert Brown** in 1831 discovered the nucleus in the cell. It was **Purkinje** in 1839 who coined the term '**protoplasm**' for the fluid substance of the cell. **Jacob Matthias Schleiden** in 1838 and **Theodor Schwann** in 1839 independently asserted that all the plants and animals are composed of cells and that the cell is the basic unit of life. This joint finding forms the basis of the **cell theory**. The cell theory was further refined by **Virchow** in 1855 by presenting that all cells arise from pre-existing cells. With the invention of the electron microscope by **Knoll** and **Ruska** in 1932, it was possible to observe and understand the complex structure of the cell and its various organelles.

In some organisms, a single cell may constitute the whole body as in *Amoeba*, *Chlamydomonas*, *Paramecium*, *Bacteria* etc. These are called **unicellular** organisms (*uni* = single). On the other hand, in many organisms such as some fungi, plants and animals, many cells are grouped together in a single body and assume different functions of it to form various body parts. These are called **multicellular** organisms (*multi* = many). Can you find out the names of some more unicellular organisms?

Activity 12.2

You can try preparing temporary mounts of leaf peels, roots tips of onion or even peels of onions of different sizes. Find out what answers to the following questions would be :

- Do all cells look alike in terms of shape and size?
- Do all cells look alike in structures?

After having performed the activities mentioned above, you will be able to know that all the cells of multicellular organisms are not look alike in terms of shape, size and structures. There are some basic similarities among all cells of higher organisms in having plasma membrane, a cytoplasm with organelles and a nucleus.

Some organisms can also have cells of different kinds. Look at the Fig.12.4 showing various types of cells.

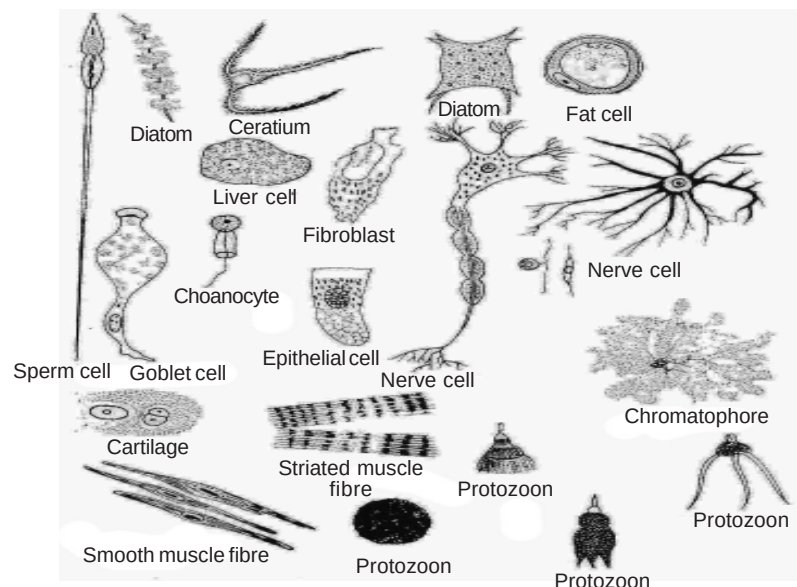


Fig.12.4.: Different kinds of cells

Cells are different in shape and size not only in different organisms but also in different parts of the same organism. They may be oval, spherical, discoid, columnar, polygonal, spindle shape etc. The shape of the cell is usually related with its specific function. Some cells like *Amoeba* have changing shapes. In some cases the cell shape could be more or less peculiar for a particular type of cell; for example, nerve cells have a typical shape. Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. Each cell has certain specific components within it known as **cell organelles** performing specific functions, such as forming new material in the cell, getting rid of the waste materials from the cell and so on. Because of these organelles a cell is able to live and perform all its functions. These organelles together constitute the basic unit called the cell. It is interesting that all cells are found to have the same organelles, no matter what their function is or what organism they are found in.

The size of the cells varies from very small cells of bacteria (0.2 to $5.0\ \mu$) to the very large egg of the ostrich ($170\ \text{mm}$).

Try to Answer the questions

1. Who discovered cell and how?
2. Give examples of two multicellular organisms?
3. What is the size of the egg of Ostrich?

12.2 The Structural organisation of a Cell

It is learnt that each cell has special components called **organelles**. These organelles perform various functions. You will come across in almost every cell, the three features: **plasma membrane**, **nucleus** and **cytoplasm** that are responsible for all activities performed inside the cell and interactions of the cell with its environment. (Fig.12.5).

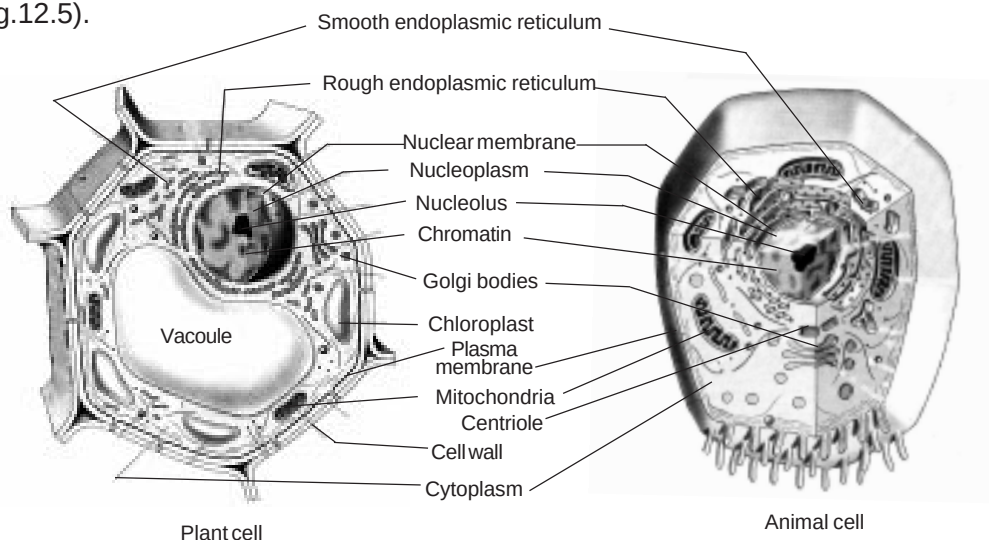


Fig.12.5: Structures of Plant and animal cells

12.2.1 Plasma membrane

Plasma membrane is the outermost covering of the cell. This separates the contents of the cell from its external environment. It is present in cells of plants, animals and microorganisms. The plasma membrane controls the movement of some materials in and out of the cell. It also prevents movement of some other materials. The cell membrane, therefore, is called a **selectively permeable membrane**.

The plasma membrane is flexible, living, thin, delicate, elastic, selectively permeable membrane. This is made up of organic molecules called lipids and proteins. But, it can not be observed under the light microscope. We can only observe the structure of the plasma membrane only through an electron microscope. The cell engulfs in food and other material from its external environment because of the flexibility of the cell membrane. Such processes are known as **endocytosis**. *Amoeba* acquires its food through such processes. Transportation of substances across the plasma membrane will be discussed in chapter 16.

Activity 12.3

Find out about electron microscopes from resources in the school library or through the internet. Discuss it with your teacher.

12.2.2 Cell Wall

In Plant cells, there is another rigid outer covering called **cell wall** which lies outside the **plasma membrane**. The cell wall is mainly composed of **cellulose** which is a complex substance and provides structural strength to plants.

When a living plant cell loses water through osmosis there is shrinkage or contraction of the contents of the cell away from the cell wall. This phenomenon is known as **plasmolysis**. We can observe this phenomenon by performing the following activity:

Activity 12.4

Mount the peel of a *Rheo* leaf in water on a slide and examine the cells of leaf under the high power of a microscope. Note the small green granules, called **chloroplasts**. They contain a green substance called **chlorophyll**. Put a strong solution of sugar or salt on the mounted leaf on the slide. Wait for a minute and observe under a microscope.

Now place some *Rheo* leaves in boiling water for a few minutes. This kills the cells. Then mount one leaf on a slide and observe it under a microscope. Put a strong solution of sugar or salt on the mounted leaf on the slide. Wait for a minute and observe it again. We can see that only living cells, and not dead cells, are able to absorb water by osmosis.

Cell walls allow the cells of plants, fungi and bacteria to survive in a very dilute (hypotonic) external media without bursting. In such media the cells tend to take up water by osmosis and it swells, building up pressure against the cell wall which in turn exerts an equal pressure against the swollen cell. Because of their walls, such cells can withstand much greater changes in the surrounding medium than animal cells.

12.2.3 Nucleus

The nucleus is an important, centrally located spherical cellular component. The nucleus consists of two layers covering called **nuclear membrane**. The nuclear membrane separates nucleus from cytoplasm. The nuclear membrane has many pores (the **nuclear pores**) and encloses the liquid ground substance, the **nucleoplasm**. Nuclear pores allow the transfer of materials between nucleoplasm and the cytoplasm.

The nucleus contains **chromosomes**. Chromosome is visible clearly during the cell division, as rod-shaped structures. Chromosomes are mainly composed of DNA (Deoxyribo Nucleic Acid), RNA (Ribo Nucleic Acid) and protein. DNA molecules contain information necessary for constructing and organising cells. Functional segments of DNA are called **genes**, which are hereditary units. In a cell which is not dividing, this DNA is present as part of **chromatin material**. Chromatin material is visible as entangled mass of thread like structure. Whenever the cell is about to divide, the chromatin material gets organised into chromosomes. Attaching to the chromatin materials, there is another spherical structure known as **Nucleolus**. (Fig.12.5). Nucleolus disappears and reappears during cell division stages. It is involved in synthesis of ribosomal RNA and ribosome.

Activity 12.7

Let us take a glass slide with a drop of water on it. Using an ice-cream spoon or toothpick, you can gently scrape the inside surface of the cheek. With the help of a needle we can transfer this material and spread it evenly on the glass slide kept ready for this. To colour the material we can put a drop of methylene blue solution on it. Now the material is ready for observation under microscope. Do not forget to put a cover-slip on it without allowing forming air bubbles. Then observe it under a high power of microscope. You will observe a spherical or oval dot-like structure, called nucleus near the centre of the cheek cell. These similar structures are found in onion peel cells too.

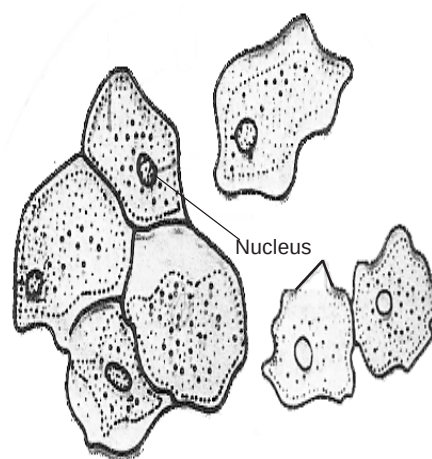


Fig. 12.6: Cheek cells showing nucleus

Nucleus is functionally known as brain of the cell or controlling chamber of the cell because it controls all the activities of the cell.

The nucleus plays a central role in cellular reproduction. Cellular reproduction is the process of dividing a single cell to form two new cells. It also plays a crucial part, along with the environment, in determining the way the cell exhibit at maturity, by directing the chemical activities of the cell.

The nuclear region of the cell is undefined in some organisms like *bacteria*. Such an undefined nuclear region lacking nuclear membrane and containing only nucleic acids is called a **nucleoid**. Such organisms are called **prokaryotes** (*pro* = primitive or primary; *karyote* = *karyon* = nucleus). Organisms with cells having a nuclear membrane are called **eukaryotes** (*eu* = true).

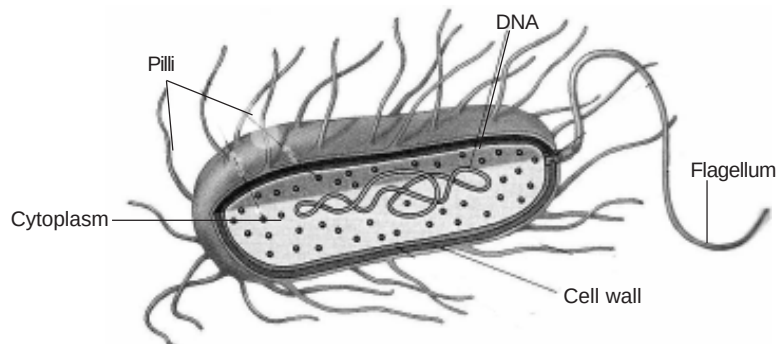


Fig. 12.7: A bacterium cell

Poorly organised parts of the cytoplasm in prokaryotes perform many of the functions like the chlorophyll in photosynthetic prokaryotic bacteria is associated with bag like membranous structures, **vesicles** but not with plastids as in eukaryotic cells.

12.2.4 Cytoplasm

We can see a large region of each cell enclosed by the membrane when we observe the temporary mounts of onion peel as well as human cheek cells. This region, between the plasma membrane and nuclear membrane, is called **cytoplasm**. The cytoplasm is the fluid content inside the plasma membrane. It also contains many specialized cell organelles that perform various specific functions for the cell. Cell organelles are enclosed by membranes.

In prokaryotic cell, there is no well defined nuclear region and membrane-bound cell organelles. On the other hand, in the eukaryotic cells there is nuclear membrane as well as membrane-enclosed organelles.

The importance of membranes can be understood with the example of viruses. Viruses do not show characteristics of life due to lack of membranes. They show the characteristics of life when they enter a living body and use its cell machinery to multiply.

Differences between prokaryotic and eukaryotic cells.

Prokaryotic Cell	Eukaryotic Cell
1. Size : generally small (1–10 μ m) 1 μ m = 10 ⁻⁶ m 2. Nuclear region is not well defined . 3. It has single chromosome 4. Membrane – bound cell organelles absent	1. Size: generally large (5 – 100 μ m) 2. Nuclear region is well defined and surrounded by a nuclear membrane. 3. It has more than one chromosome. 4. Membrane – bound cell organelles like mitochondria, chloroplasts, Golgi bodies etc. present

Try to answer the questions

1. Why is plasma membrane called a selectively permeable membrane?
2. What is the main chemical component part of plant cell wall?
3. How does *Amoeba* acquire its food?

12.2.5 Cell organelles

Cell has to perform various functions with the help of its different membrane-bound organelles. **Cell organelles** are the living part of the cell and each of them has a definite shape, structure and function. Examples are nucleus, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, plastids etc. We have already discussed about the nucleus in a previous section. In this section, we will talk about the rest of the cell organelles one after another. Some of these organelles are visible only with an electron microscope.

12.2.5 (i) Endoplasmic reticulum (ER)

The endoplasmic reticulum (ER) consists of an interconnected system of membrane bound flattened sacs in the cytoplasm. These are known as **cisternae** (Singular : Cisterna). It may assume the form of **tubules** or round or oblong bags known as **vesicles**. The ER membrane is similar in structure to that of the plasma membrane. ER is connected to the outer membrane of the nucleus on the one end and to the plasma membrane on the other end. ER is of two types – Rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER). RER looks rough under a microscope because it has **ribosomes** attached to its surface. The ribosome, present in both prokaryotic and eukaryotic cells, are the sites of protein synthesis. ER transports the synthesised proteins to various places in the cell according to their need. The SER is without ribosomes and helps in the manufacture of fat molecules or lipids. Some of these proteins and lipids help in membrane biogenesis, which is a process of building cell membrane. Some other proteins and lipids function as enzymes and hormones. ER always forms an interconnected system though it varies greatly in appearance in different cells.

Thus, one important function of the ER is to transport proteins between various regions of the cytoplasm or between the cytoplasm and the nucleus. It also functions as a cytoplasmic framework providing a surface for some of the biochemical activities of the cell. It also provides the pathway for the distribution of nuclear material from one cell to the other. SER is involved in the process of detoxification of many poisons and drugs in the liver cells of the group of animals called vertebrates.

12.2.5. (ii) Golgi Apparatus

The Golgi apparatus was first described by **Camillo Golgi**. It consists of a system of membrane-bound fluid-filled vesicles, vacuoles and flattened cisternae (closed sac). Cisternae are arranged approximately parallel to each other in stacks (placed one above the other). These membranes of Golgi apparatus connect with that of ER and therefore, form another portion of a complex cellular membrane system.

Golgi apparatus pack and dispatch the materials synthesised near the ER to various targets inside and outside the cell. The functions of Golgi apparatus include the storage, modification and packaging of products in vesicles. In some cases, complex sugars may be made from simple sugars in the Golgi apparatus. The Golgi apparatus is also involved in the synthesis of plasma membrane, lysosomes and cell wall.



Fig.12.8 : Golgi apparatus

12.2.5(iii) Lysosomes

Lysosomes are simple, tiny, single membrane-bound sac like structures. They are evenly distributed in the cytoplasm. They are filled with digestive enzymes that are made by RER. Lysosomes destroy any foreign materials which enter the cell such as bacteria and virus. They also remove the worn-out organelles to keep the cells clean. For this reason this organelle is considered to be a kind of waste disposal system of the cell. Lysosomes are able to carry out all this functions because they contain powerful digestive enzymes capable of breaking down all organic materials. During the disturbance in cellular metabolism, for example, when the cell gets damaged, lysosomes may burst and the enzymes digest their own cell. Therefore lysosomes are also known as the **suicide bags** of a cell.

12.2.5(iv) Mitochondria

The name **mitochondrion** comes from two Greek words, "*mito*" meaning "filament" and "*chondros*" meaning "grain". The number of mitochondria per cell may depend on the cell type. Each mitochondrion has two membranes-outer and inner. The outer membrane is porous while the inner membrane is deeply folded to increase a large surface area for **ATP** (Adenosine triphosphate). These folded finger like structures are called **cristae**, the inner surface of which are attached with many tennis racket like structures known as **oxysomes** or **F₁ particles**. The inner cavity of mitochondrion is filled with proteinous semi-solid substance called **matrix**. Inside matrix DNA, ribosomes and phosphate granules are found present (Fig.12.9).

Mitochondria can synthesize their own proteins with the help of their own DNA and ribosomes. So they are regarded as semi-autonomous organelles of the cell. They are self-replicating organelles ie, they have the power to divide.

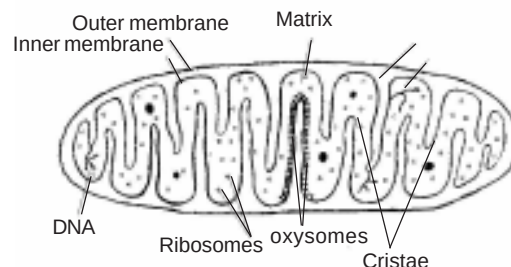


Fig.12.9: Structure of a mitochondrion

Functionally mitochondria are regarded as the sites for cellular respiration. They use molecular oxygen from the air to oxidise food substances like carbohydrate etc. to release energy in the form of ATP, Carbon dioxide and water molecules. ATP is known as energy currency of the cell. It is used by the body to perform various activities. As the organelle provides the required energy of the cell, mitochondria are also known as "Power House " of the cell.

12.2.5 (v) Plastids

Plastids are found in almost all plant cells. Plastids are similar to mitochondria in their external structures and also have their own DNA and ribosomes, and they are self-replicating organelle. There are three types of plastids – (i) leucoplasts (ii) chloroplasts and (iii) chromoplasts.

Leucoplasts are colourless or white plastids. They store starch, oils and protein granules and hence, are found in many storage parts of the plant.

Chloroplasts are green coloured plastids. They are found in all the green parts of the plants like leaves, young stems etc. A chloroplast has two membranes – an outer and an inner membrane with an intermediate space between them. Inside the inner membrane there is a semi-liquid substance known as **Stroma**. Spreading in stroma, there are many membrane bound discoid shape structures, **thylakoids**, piling one above another in the form of stack of coins known as **Grana** (Singular : **granum**). Grana are interconnected by intergrana or stroma lamellae, an unstacked membranous structure. Chlorophyll and carotenoid pigments are located in these membrane system (Fig.12.10). Functionally chloroplasts are regarded as sites for photosynthesis.

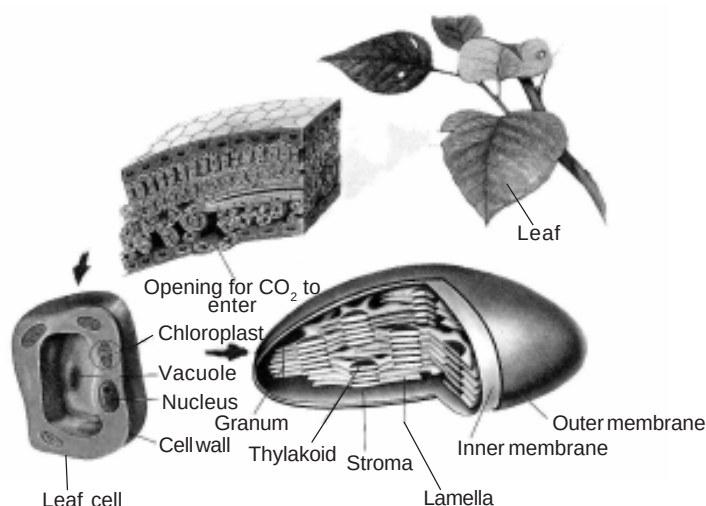


Fig. 12.10: Chloroplast from a leaf cell

Chromoplasts are coloured other than green plastids. They are found in the coloured flowers and other coloured parts of the plant. They help the plant to attract insects and birds for their pollination and dispersal of fruits and seeds.

12.2.5 (vi) Cytoskeleton

A wide variety of cells (both prokaryotes and eukaryotes) possess cytoskeleton system. It plays important role in maintaining their structure, function and behaviour. It is mainly consists of (i) **microtubules** which are elongated, cylindrical and unbranched, non-membranous structures present in all actively dividing and elongating cells (Fig.12.11). (ii) **microfilaments** which are long rod-like structures of variable length. And (iii) **Intermediate filaments** which are intermediate between micro-tubules and microfilaments in size.

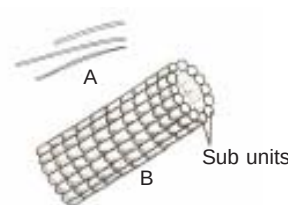


Fig. 12.11 : (A) Microtubules (B) A part

12.2.5 (vii) Vacuoles

Vacuoles are fluid- or solid-filled and membrane bounded spaces. The vacuolar membrane is called **tonoplast**. They are a kind of storage sacs for solid or liquid contents. In animal cells, vacuoles, if present, are small in size and temporary. They store water; glycogen and proteins. In plant cells vacuoles are very large and distinct. The central vacuole of some plant cells may occupy 50 – 90% of the cell volume. In plant cell, vacuoles are full of **cell sap** and provide turgidity and rigidity of the cell. Many important substances of life of the plant cell are stored in vacuoles. These include amino acids, sugars, various organic acids and some proteins. In single celled organisms like Amoeba, the food vacuole contains the food items that Amoeba has consumed. In some unicellular organisms, specialised vacuoles also play important roles in expelling excess water and some wastes from the cell.

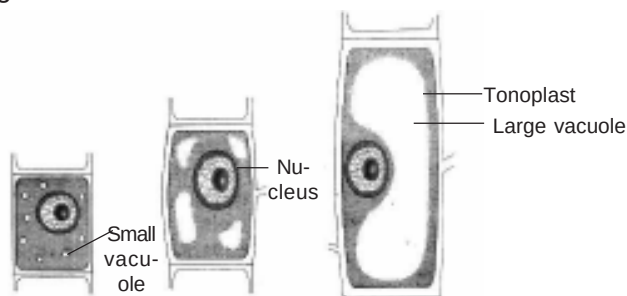


Fig.12.12 : Diagram showing formation of a central vacuole in plant cell

The cell has a basic structural organisation as each cell acquires its structure and ability to function because of the organisation of its membrane and organelles in specific ways. This helps the cells to perform functions like respiration, obtaining nutrition, and clearing of waste material, or forming new proteins.

Thus, the cell is the fundamental structural unit of living organisms. It is also the basic functional unit of life.

Try to answer to questions

1. Can you name two organelles that contain their own DNA and ribosomes?
2. Why are lysosomes known as suicide bags of the cell?
3. Name the organelle which is regarded as "power house" of the cell?
4. What ATP stands for?
5. Where do the ribosome get synthesis?

12.3 Cell Division

A cell never appears spontaneously but is always formed from some pre-existing cells. This was stated by **Rudolph Virchow** in 1855. In his words "*Omnis cellula – e – cellula*" meaning cells arise from cells. Cell gradually increases in bulk till it reaches a certain limit in size and divides into two similar daughter cells. By cell division we mean division of the nucleus i.e. nucleus is first divided into two and then division of the cytoplasm follows. Division of the nucleus is known as **Karyokinesis** (*Karyo* – nucleus; *kinesis* – division) and division of the cytoplasm is called **cytokinesis** (*cyto* – cytoplasm; *kinesis* – division). Cell division is important because growth is characteristics of living organisms and growth is initiated by cell division. The nucleus may divide in three ways: (i) amitosis (ii) mitosis and (iii) meiosis.

12.3.1 Amitosis

It is also known as Direct nuclear division. It is a simple process. Here, the nucleus constricts in the middle into a dumb – bell form and the two nuclei of approximately equal sizes are formed. Division of the cytoplasm soon takes place by constrictions, so that two new daughter cells are formed. It is found in lower forms of plants and animals such as protozoa.

12.3.2 Mitosis/Karyokinesis/Equational Division

This takes places in the somatic cells (*soma* – body) of all higher plants and animals. Here, the contents of nucleus and cytoplasm of the cell are equally divided into two, hence called **Equational division**. Mitosis involves karyokinesis and cytokinesis as mentioned above.

Karyokinesis is completed into four successive stages :

- (i) **Prophase** (the early phase) : This is the first stage of mitosis, where the chromatin condenses to form **chromosomes**. Chromosomes are duplicated to form two chromatids attached to a single **centromere**. Nucleolus and nuclear membrane dissolve and spindle fibres begin to form.
- (ii) **Metaphase** : It is a short phase when the nuclear membrane and nucleolus completely disappear. The chromosome arrange themselves at the equator. Each of the chromosomes has spindle-fibre attachment region, called centromere, to which a fibre remains attached. Other fibres of the spindle (supporting fibres) extend from pole to pole.
- (iii) **Anaphase** : Centromeres of the chromosomes are duplicated longitudinally to form two daughter chromosomes. Groups of daughter chromosomes separate and move to opposite poles.
- (iv) **Telophase** : It is also known as reconstruction phase. This is the last phase when chromosomes have reached the poles. Nuclear membrane and nucleolus reappear, and two daughter nuclei are formed.

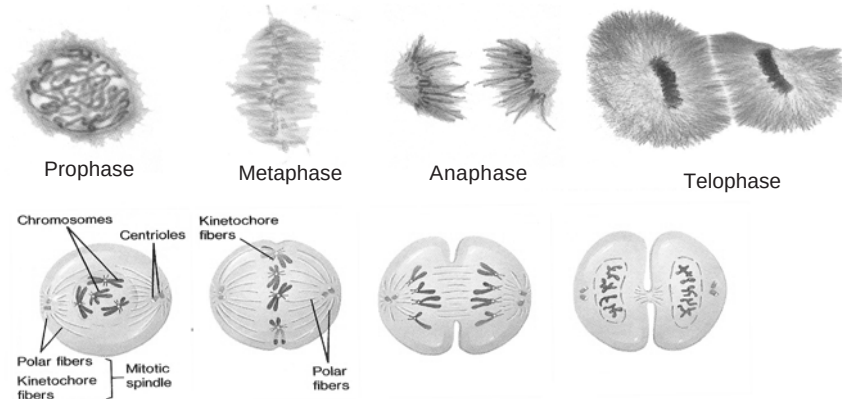


Fig.12.13 : Different stages of Mitosis in Animal cell

Cytokinesis (Division of cytoplasm) : It usually follows the telophase. In animal cells, a furrow appears at the beginning of telophase. This furrow constriction deepens and ultimately divides the cytoplasm into two daughter cells. In plant cells, there is a formation of cell plate between the two groups of chromosomes. The cell plate grows from middle towards periphery and finally develop into cell wall. Thus, two daughter cells are formed.

Significance of Mitosis

1. Mitosis maintains uniformity among the daughter cells. All the cells in the multicellular organisms possess the same number of chromosomes.
2. Mitosis helps in repairing old and damaged cells by producing new cells.
3. Mitosis helps in the growth of the multicellular organisms.
4. Mitosis helps in increase of individuals in unicellular organisms.

12.3.3 Meiosis : (Gr.meioun = to less; osis = state)

Meiosis is a special type of cell division in which the chromosome number of a diploid parent cell is reduced to half. It is restricted to only reproductive cells. It is also known as **reduction division** as it forms four daughter cells, each having half the number of chromosomes of the parent cell. This method involves two divisions, of which the first division is **reductional** and second one is **mitotic** or **equational**. Both divisions are completed under four successive stages each, as in mitosis. They are listed as follows:

1. Meiosis I (Reduction Division):

- (i) **Prophase I** : It is of very long duration and completed under five successive sub stages i.e. leptotene, zygotene, pachytene, diplotene and diakinesis. Leptotene (G. *leptos* = fine; *tene* = thread): Here nucleus enlarges in size and chromatin condenses to form long and coiled filamentous individualised chromosome.

Zygotene (G. *zygon* = yoke; *tene* = thread): Here shortening and thickening of chromosomes start. Pairing of homologous chromosome takes place due to force of attraction. This process is called **synapsis**. The synapsed chromosome is known as **bivalent**.

Pachytene (G. *pachus* = thick; *tene* = thread): Shortening and thickening of chromosomes still continue. Each chromosome in the bivalent is duplicated forming a tetrad. **Crossing over** or exchange of segments of homologous chromatids at the fixed points, takes place.

Diplotene (G. *diplos* = double; *tene* = thread): Shortening and thickening of chromosomes continue. Force of repulsion takes place in between homologous chromosomes. This leads to separating of chromatids at the centromere and proceeds towards the ends. However, the paired chromosomes remain attached at one or more points. Such point of attachment is called **chiasmata** (singular, chiasma).

Diakinesis (G. *di* = two; *kinesis* = movement): Shortening and thickening of chromosomes will continue and chiasmata will move to the terminal region of bivalent.

- (ii) **Metaphase I** : Nuclear membrane and nucleolus completely disappear. Bivalents move to the equatorial plane. Of the bivalents centromeres are away from the equatorial region, which is occupied by chromosome arms. Spindle fibres are formed and they get attached to the centromere of the bivalents.
- (iii) **Anaphase I** : The two chromosomes of bivalent start moving to poles and thereby complete the reduction in number of chromosome.
- (iv) **Telophase I** : Groups of chromosome arrive at the respective poles and chromosomes starts uncoiling and elongate. Nuclear membrane and nucleolus reappear and thus two daughter **haploid** nuclei are formed.

Meiosis I is followed by meiosis II or equational division. It is completed in four successive stages as in mitosis. Those stages are known as Prophase II, Metaphase II, Anaphase II and Telophase II. In Anaphase II, duplication of chromosome is completed. And in Telophase II, four daughter nuclei are formed (Fig.12.14).

Cytokinesis : The division of nucleus is followed by the division of cytoplasm. In plant cells, cell walls are laid down resulting in the formation of four haploid cells. In animal cells, cytokinesis is completed by furrowing method in the formation of four haploid cells.

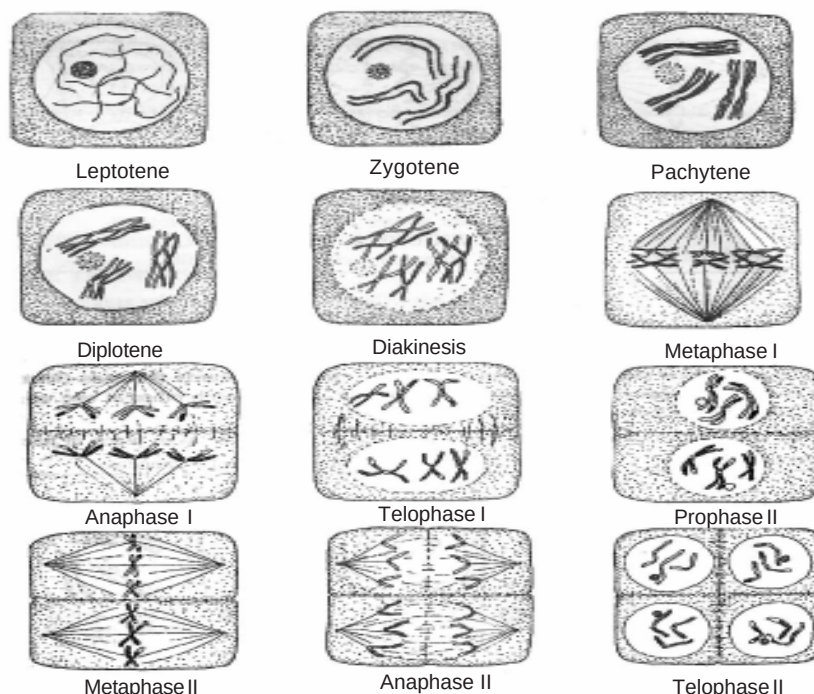


Fig. 12.14 : Different stages of Meiotic division in plant cell

Significance of Meiosis:

Meiosis is a must for all sexually reproducing organisms. It keeps chromosome number constant of an individual from generation to generation. Meiosis also plays an important role in specific character of individual species. It also results in the occurrence of variance in nature.

Comparison of Mitosis and Meiosis

Mitosis	Meiosis
1. Mitosis occurs in somatic cells of all plants and animals.	1. Meiosis occurs in germ cells all sexually reproducing organisms.
2. It includes only one division which is equational.	2. It includes two divisions in which the first one is reductional and the second one is equational.
3. It gives rise to two daughter cells which are identical to each other and to the parent cell.	3. It results in the formation of four daughter cells which differ from parent cell.
4. Prophase is comparatively short	4. Prophase of meiosis I is comparatively longer and divided into five sub stages.
5. Synapsis and tetrad chromosome do not occur.	5. Synapsis and bivalent formation occur.
6. No exchange of chromosome materials	6. Exchange of chromosome material takes place during crossing over.
7. It has no variance in nature.	7. It has variance in nature.

12.4 Chromosome (*Chroma* = Colour; *Soma* = body)

The term chromosome was first given by Waldeyer in 1888 for the coloured thread like structures seen during cell division stages. Metaphase chromosome consists of two chromatids attached to a single centromere whereas anaphase chromosome consists of a single chromatid with its own centromere. Chromosomes are the most important component of the cell carrying hereditary materials. Chromosome's shapes or types are determined by the position of the centromere which is an unstained part of the chromosome. Accordingly, chromosomes are (i) metacentric (ii) sub metacentric (iii) acro-centric and (iv) telocentric chromosome as shown in the Fig.12.15.

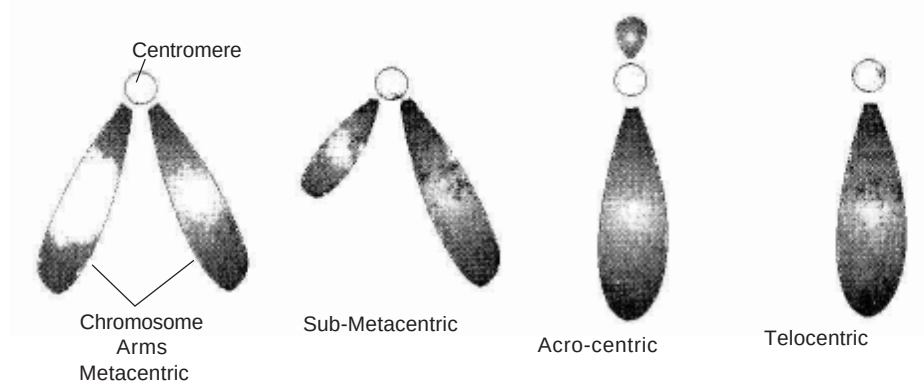


Fig.12.15 : Different types of chromosome

- (i) Metacentric chromosome : Here both the arms are more or less equal in length and it takes the shape of letter 'V'.
- (ii) Sub-metacentric chromosome : Here one arm is shorter than the other and it takes the shape of letter 'J' or 'L'.
- (iii) Acrocentric chromosome : Here the smaller arm is very short and it cannot bend and it takes the shape of letter 'I'.
- (iv) Telocentric chromosome : Centromere occupies one terminal end of the chromosome and it takes the shape of letter 'I'.

There is definite number of chromosome of each species in its cells. Thus the cells of potato has 48, rice has 24, onion has 14, mouse cell has 40, dog has 64, and we human beings have 46 chromosomes. These chromosome exist in pairs or two copies. The members of each pair is called **homologous chromosomes** and total number of chromosome in its cell is the **diploid number**. Thus, you have 46 homologous diploid chromosomes in your body cells.

Try to answer the questions

1. Who stated, *omnis cellula-e-cellula*?
2. Why do you called mitosis as equational division?
3. Meiosis is known as reductional division. Why?
4. In which stage of meiosis, crossing over takes place?

POINTS TO REMEMBER

- * The cell is the fundamental unit of life.
- * Cells are enclosed by a plasma membrane composed of lipids and proteins.
- * The cell membrane is an active part of the cell. It regulates the movement of materials between the interior of the cell and outer environment.
- * In plant cells, a cell wall composed mainly of cellulose is located outside the cell membrane. It is absent in animal cell.
- * The presence of the cell wall enables the cells of plants, fungi and bacteria to exist in hypotonic media without bursting.
- * The nucleus in eukaryotes is separated from the cytoplasm by double-layered membrane and it directs the life processes of the cell.
- * The ER functions both as a passageway for intracellular transport and as a manufacturing surface.
- * The Golgi apparatus consists of stacks of membrane-bound vesicles that function in the storage, modification and packaging of substances manufactured in the cell.
- * Most plant cells have large membranous organelles called plastids, which are of three types – leucoplasts, chloroplasts, and chromoplast. Chloroplast is responsible for photosynthesis.
- * Cytoskeleton consists of microtubules, microfilaments and intermediate filaments.
- * Presence of vacuoles is characteristic feature of plant cells.
- * Cell division is of three types – amitosis, mitosis and meiosis.
- * Amitosis is found in lower organisms, where cell is directly divided into two.
- * Mitosis occurs in the somatic cells to increase the number of individual in unicellular organisms or to increase to number of cells in multi cellular organisms.
- * Mitosis consists of four successive stages – Prophase, Metaphase, Anaphase Telophase, and followed by the division of the cytoplasm or cytokinesis, forming two daughter cells.
- * Meiosis occurs in all the sexually reproducing organisms at the time of formation of eggs and sperms.
- * Occurrence of variance in organisms is due to meiosis.
- * Chromosomes are carriers of hereditary characters.
- * Chromosome is of four types based on the position of centromere.
- * Number of chromosome is definite in an individual.

EXERCISES

1. *Why is the cell called the structural and functional unit of life ?*
2. *Make a comparison and write down the ways in which plant cells are different from animal cells.*
3. *How is a prokaryotic cell different from a eukaryotic cell ?*
4. *Why is the plasma membrane called a selectively permeable membrane ?*
5. *What would happen if the plasma membrane ruptures or breaks down ?*
6. *What would happen to the life of a cell if there was no Golgi apparatus ?*
7. *Which organelle is known as the power house of the cell ? Why?*
8. *Where do the lipids and proteins constituting the cell membrane get synthesised?*
9. *Can you name two organelles that contain their own genetic materials ?*
10. *If the organisation of a cell is destroyed due to some physical or chemical influence, what will happen ?*
11. *Where are proteins synthesised inside the cell ?*
12. *Differentiate between mitosis and meiosis.*
13. *Draw a metaphase chromosome.*
14. *Diagrammatically differentiate a metaphase chromosome from an anaphase chromosome.*
15. *Draw and label different stages of mitosis.*
16. *Draw a neat labelled sketch of ultrastructure of a plant cell or an animal cell.*
17. *Describe the stages of prophase 1st of meiosis.*