Notes

# 4

# CELL – STRUCTURE AND FUNCTION

## INTRODUCTION

All organisms are composed of structural and functional units of life called 'cells'. The body of some organisms like bacteria, protozoans and some algae is made up of a single cell while the body of fungi, plants and animals are composed of many cells. Human body is built of about one trillion cells.

Cells vary in size and structure as they are specialized to perform different functions. But the basic components of the cell are common to all cells. This lesson deals with the structure common to all types of the cell. You will also learn about the kinds of cell division and the processes involved therein. in this lesson.

## OBJECTIVES

After completing this lesson, you will be able to :

- *justify that cell is the basic structural and functional unit of all organisms;*
- *list the components of the cell and state cell theory;*
- *differentiate between prokaryotic and eukaryotic cells;*
- *differentiate between plant and animal cells;*
- *illustrate the structure of plant and animal cells by drawing labelled diagrams;*
- *describe the structure and functions of plasma membrane, cell wall, endoplasmic reticulum (ER), cilia, flagella, nucleus, ribosomes, mitochondria, chloroplasts, golgi body, peroxisome, glyoxysome and lysosome;*
- *describe the general importance of the cell molecules-water, mineral ions, carbohydrates, lipids, amino acids, proteins, nucleotides, nucleic acids, enzymes, vitamins, hormones, steroids and alkaloids;*
- *justify the need for cell division;*
- *describe various phases of cell cycle;*
- *explain the term karyotype and mention the karyotype analysis and its significance.*

## 4.1 THE CELL AND CELL THEORY

### 4.1.1 Landmarks in cell study

Soon after Anton van Leewenhock invented the microscope, Robert Hooke in 1665 observed a piece of cork under the microscope and found it to be made of small compartments which he called "cells" (Latin cell = small room). In 1672, Leewenhock observed bacteria, sperm and red blood corpuscles, all of which were cells. In 1831, Robert Brown, an Englishman observed that all cells had a centrally positioned body which he termed the **nucleus**.

### 4.1.2 The cell theory

In 1838 M.J. Schleiden and Theodore Schwann formulated the "cell theory." The cell theory maintains that

- all organisms are composed of cells.
- cell is the structural and functional unit of life, and
- cells arise from pre-existing cells.

The cells vary considerably, in shape and size (Fig.4.1). Nerve cells of animals have long extensions. They can be several feet in length. Muscle cells are elongated in shape. Egg of the ostrich is the largest cell (75 mm). Some plant cells have thick walls. There is also wide variation in the number of cells in different organisms.

### 4.1.3 The Cell

A cell may be defined as a unit of **protoplasm** bounded by a plasma or cell membrane and possessing a nucleus. Protoplasm is the life giving substance and includes the cytoplasm and the nucleus. The cytoplasm has in it **organelles** such as ribosomes, mitochondria, golgi bodies plastids, lysosomes and endoplasmic reticulum. Plant cells have in their cytoplasm large vacuoles containing non-living inclusions like crystals, pigments etc. The bacteria have neither organelles nor a well formed nucleus. But every cell has three major components

- plasma membrane
- cytoplasm
- DNA (naked in bacteria and covered by a membrane in all other organisms

**Two basic types of cells**

Cytologists recognize two basic types of cells (Fig. 4.1). Their differences have been tabulated below in table 4.1. Organisms which do not possess a well formed nucleus are **prokaryotes** such as the bacteria. All others possess a well defined nucleus, covered by a nuclear membrane. They are **eukaryotes**.

**Table 4.1 Differences between Eukaryotic and Prokaryotic cells**

| **Eukaryotic cell** (eu = true, karyon = nucleus) | **Prokaryotic cell** (Pro = early/primitive) |
|---|---|
| 1. Nucleus distinct, with well formed nuclear membrane. | 1. Nucleus not distinct, it is in the form of nuclear zone 'nucleoid'. Nuclear membrane absent. |
| 2. Double-membraned cell organelles (Chloroplasts, mitochondria nucleus) and single membraned (Golgi apparatus, lysosomes vacuole endoplasm reticulum) are present | 2. Single-membraned cell bodies like mesosomes present. Endoplasmic reticulum and Golgi body absent. |
| 3. Ribosomes - 80 S | 3. Ribosomes - 70 S |
| 4. Distinct compartments in the cell i.e. the cytoplasm and the nucleus | 4. No compartments. |

**Fig. 4.1a** Eukaryotic Cell

**Fig. 4.1b** Prokaryotic Cell

(As seen in an electron micrograph.)

**Svedberg unit**

When the cell is fractionated or broken down into its components by rotating in an ultracentrifuge at different speeds the ribosomes of eukaryotic and prokaryotic sediment (settle down) at different speeds. The coefficient of sedimentation is represented in Svedberg unit and depicted as S.

The plant cell and the animal cell also differ in several respects as given in Table 4.2 and shown in Fig. 4.2.

**Table: 4.2 Difference between plant cell and animal cell**

| **Plant cell** | **Animal cell** |
|---|---|
| 1. Cellulose cell wall present around cell membrane. | 1. No cell wall. |
| 2. Vacuoles are usually large. | 2. Generally vacuoles are absent and if present, are usually small.. |
| 3. Plastids present. | 3. Plastids absent. |
| 4. Golgi body present in the form of units known as dictyosomes. | 4. Golgi body well developed. |
| 5. Centriole absent. | 5. Centriole present. |

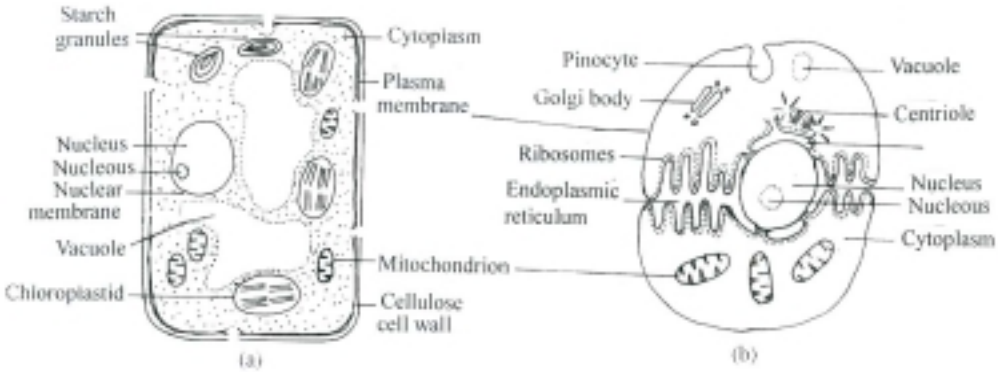



**Fig. 4.2a** Generalised plant cell

**Fig. 4.2b** Generalised animal cell

## INTEXT QUESTIONS 4.1

1. From where do new cells arise?

   .....

2. Name the scientists who proposed the cell theory.

   .....

3. Name an organelle which a plant cell has but an animal cell does not.

   .....

4. Give two points of difference between a prokaryotic cell and a eukaryotic cell

   .....

## 4.2 COMPONENTS OF THE CELL

The major components of the cell are (1) cell membrane, (2) cytoplasm, and (3) nucleus.

### 4.2.1 Cell membrane (Plasma membrane)

Each cell has a limiting boundary, the cell membrane, plasma membrane or plasmalemma. It is a living membrane, outermost in animal cells but next to cell wall in plant cells.

It is flexible and can fold in (as in food vacuoles of *Amoeba*) or fold out (as in the formation of pseudopodia of *Amoeba*)

The plasma membrane is made of proteins and lipids and several models were proposed regarding the arrangement of proteins and lipids. The **fluid mosaic model** proposed by Singer and Nicholson (1972) is widely accepted. It is represented in Fig 4.3.

According to the fluid mosaic model,

(i) The plasma membrane is composed of a lipid bilayer of phospholipid molecules into which a variety of globular proteins are embedded.

(ii) Each phospholipid molecule has two ends, an outer head hydrophilic i.e. water attracting, and the inner tail pointing centrally hydrophobic, i.e. water repelling

(iii) The protein molecules are arranged in two different ways:

(a) Peripheral proteins or extrinsic proteins: these proteins are present on the outer and inner surfaces of lipid bilayer.

(b) Integral proteins or intrinsic proteins: These proteins penetrate lipid bilayer partially or wholly.

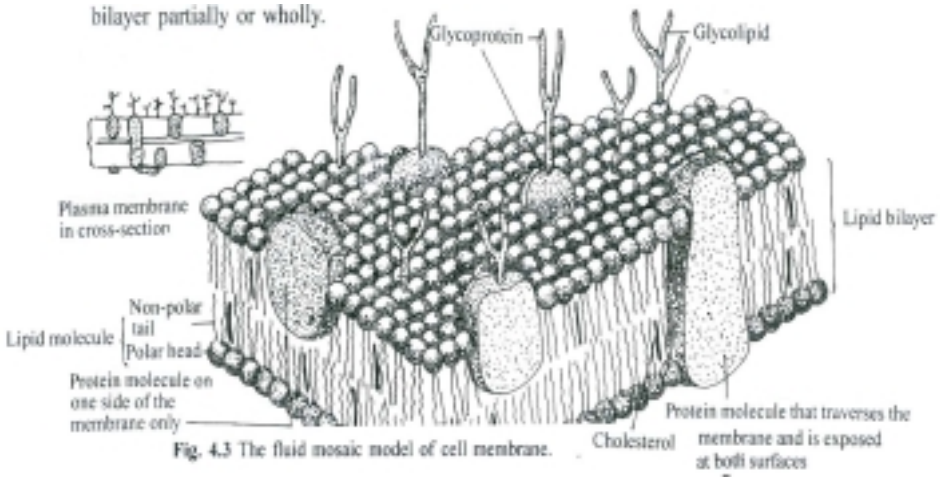



**Fig. 4.3** The fluid mosaic model of cell membrane.

## Functions

(i) The plasma membrane encloses the cell contents.

(ii) It provides cell shape (in animal cells) e.g. the characteristic shape of red blood cells, nerve cells, bone cells, etc

(iii) It allows transport of certain substances into and out of the cell but not all substance, so it is termed selectively permeable.

Transport of small molecules (such as glucose, amino acids, water, mineral ions etc).

Small molecules can be transported across the plasma membrane by any one of the following three methods:

(i) **Diffusion** : molecules of substances move from their region of higher concentration to their region of lower concentration. This does not require energy. Example : absorption of glucose in a cell.

(ii) **Osmosis** : movement of water molecules from the region of their higher concentration to the region of their lower concentration through a semipermeable membrane. There is no expenditure of energy in osmosis. This kind of movement is along concentration gradient.

(iii) **Active Transport** : When the direction of movement of a certain molecules is opposite that of diffusion i.e. from region of their lower concentration towards the region of their higher concentration, it would require an "active effort" by the cell for which energy is needed. This energy is provided by ATP (adenosine triphosphate). The active transport may also be through a carrier molecule.

**Transport of large molecules (bulk transport)**

During bulk transport the membrane changes its form and shape. It occurs in two ways:

(i) endocytosis (taking the substance in)

(ii) exocytosis (passing the substance out)

Endocytosis is of two types :

**Endocytosis**

| Phagocytosis | Pinocytosis |
|---|---|
| 1. intake of solid particles | 1. intake of fluid droplets |
| 2. membrane folds out going round the particle, forming a cavity and thus engulfing the particle (Fig. 4.4a) | 2. membrane folds in and forms a cup like structure sucks in the droplets (Fig. 4.4b) |

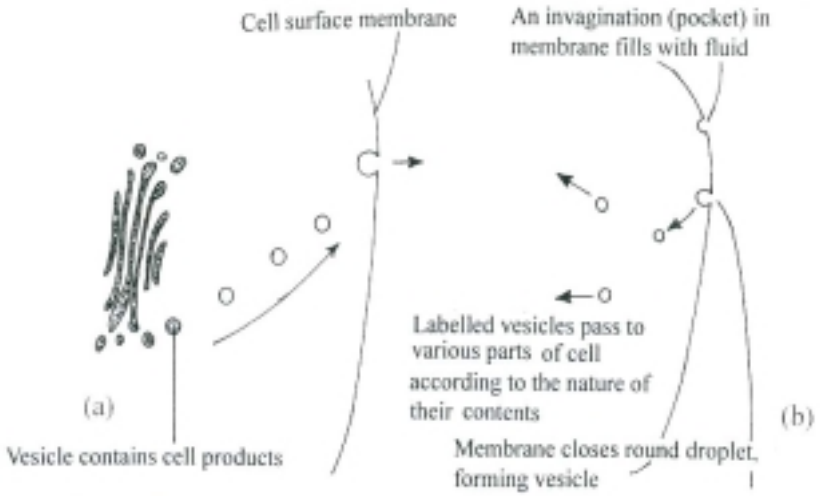



**Fig. 4.4** Diagrammatic representation of (a) phagocytosis; (b) pinocytosis

Cell membrane regulates movement of substance into and out of the cell. If the cell membrane fails to function normally the cell dies.

**Cell wall**

In bacteria and plant cells the outermost cell cover, present outside the plasma membrane is the **cell wall** about which we shall study now.

Bacterial cell wall is made of peptidoglycan. Given below is the structure and function of the plant cell wall.



**(a) Structure**

– Outermost non-living, layer present in all plant cells.

– Secreted by the cell itself.

– In plant, made of cellulose but may also contain other chemical substance such as pectin and lignin.

– The substance constituting the cell is not simply homogenous but it consists of fine threads or fibres called microfibrils.

– It may be thin (1 micron) and transparent as in the cells of onion peel. In some cases it is very thick as in the cells of wood.

**(b) Functions**

– The cell wall protects the delicate inner parts of the cell.

– Being rigid, it gives shape to the cell.

– Being rigid, it does not allow distension of the cell, thus leading to turgidity of the cell that is useful in many ways

– It freely allows the passage of water and other chemicals into and out of the cells

– There are breaks in the primary wall of the adjacent cells through which cytoplasm of one cell remains connected with the other. These cytoplasmic strands which connect one cell to the other one are known as **plasmodesmata**.

– Walls of two adjacent cells are firmly joined by a cementing material called **middle lamella** made of calcium pectate.

## INTEXT QUESTIONS 4.2

1. Define diffusion and osmosis.

   .....

2. What does active transport mean?

   .....

3. Give one point of difference between phagocytosis and pinocytosis.

   .....

4. Match the following :

| | | | |
|---|---|---|---|
| (i) | hydrophilic end | (a) | cell wall |
| (ii) | microfibrils | (b) | inner ends of lipids |
| (iii) | fluid-mosaic model | (c) | fluid droplets |
| (iv) | hydrophobic end | (d) | outer ends of lipids |
| (v) | pinocytosis | (e) | Nicolson and Singer |

5. Give two functions of the plant cell wall.

   (i) ..... (ii) .....

## 4.3 THE CYTOPLASM AND THE CELL ORGANELLES

The cytoplasm contains many cell organelles of which we shall learn about :

1. those that trap and release energy e.g. mitochondria and chloroplasts;
2. those that are secretory or involved in synthesis and transport e.g. Golgi, ribosomes and endoplasmic reticulum
3. the organelles for motilily - cilia and flagella
4. the suicidal bags i.e. lysosomes
5. the nucleus which controls all activities of the cell, and carries the hereditary material

### 4.3.1 Mitochondria and chloroplast - the energy transformers

Mitochondria (found in plant and animal cells) are the energy releasers and the chloroplasts (found only in green plant cells) are the energy trappers.

**Mitochondria (Singular = mitochondrion)**

Appear as tiny thread like structure under light microscope. Approximately 0.5 - 1.00 μm (micrometer)

Number usually a few hundred to a few thousand per cell (smallest number is just one as in an alga (**Micromonas**)).

**Structure:** The general plan of the internal structure of a mitochondria observed by means of electron microscope is shown in Fig. 4.5. Note the following parts.

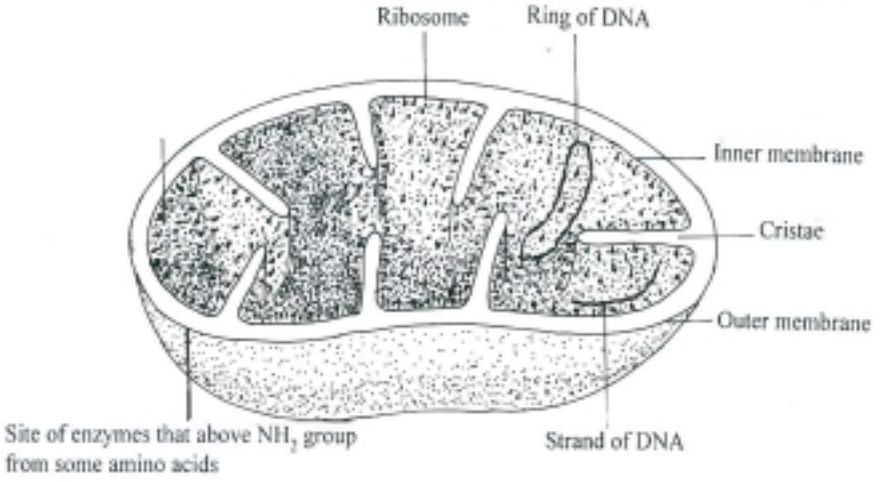



**Fig. 4.5** structure of a mitochondron

– Wall made of double membrane

– The inner membrane is folded inside to form projections called cristae which project into the inner compartment called matrix.

**Function :** Oxidises pyruvic acid (breakdown product of glucose) to release energy which gets stored in the from of ATP for ready use. This process is also called **cellular respiration**.

A highly simplified flow-chart of the fate of glucose to in the release energy is shown below :

| In cytoplasm. glucose enters cells (containing 6 atoms of carbon) | → | Broken into two Pyruvic acid molecules (containing 3 atoms of carbon) | → | In mitochondria Oxidised into $CO_2$, $H_2O$ and ATP |
|---|---|---|---|---|

**Plastids**

Plastids are found only in a plant cell. They may be colourless or with colour. Based on this fact, there are three types of plastids.

(i) Leucoplast-white or colourless

(ii) Chromoplast – blue, red, yellow etc.

(iii) Chloroplast – green

### 4.3.2 Chloroplast

- Found in all green plant cells in the cytoplasm.
- Number 1 to 1008
- Shape: Usually disc-shaped or spherical as in most plants around you. In some ribbon - shaped as in an alga *spirogyra* or cup - shaped as in another alga Chlamydomonas.
- Structure: the general plan of the structure of a single chloroplast is shown in Fig. 4.6.

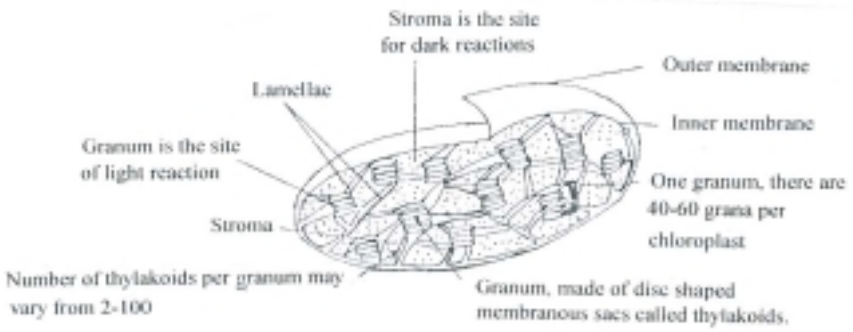



**Fig. 4.6** Structure of a single chloroplast

Note the following parts :

- Wall made of double membrane i.e. outer membrane and inner membrane numerous stack-like (piles) groups or *grana* (singular = granum) are interconnected by *lamellae.*
- Sac like structures called thylakoids Placed one above the other constitut granum.

- Inside of the chloroplast is filled with a fluid medium calleds stoma.
- Function: chloroplasts are the seat of photosynthesis (production of sugar, from carbondioxide and water in the presence of sunlight).

**Chloroplast versus mitochondria**

Can you now visualize how these two organelles are opposite to each other, one traps the solar energy locking it in a complex molecule (by photosynthesis), the other releases the energy by breaking the complex molecule (by respiration).

**Similarities between mitochondria and chloroplasts** : both contain their own DNA (the genetic material) as well as their own RNA (for protein synthesis). Thus, they can self duplicate to produce more of their own kind without the help of nucleus.

Since chloroplasts and mitochondria contain their own DNA the hereditary molecule and also their own ribosomes, they are termed semi-autonomous only because they are incapable of independent existence though they have ribosomes and DNA.

## INTEXT QUESTIONS 4.3

1. What is a cell organelle?

   .....

2. Name the chemical which provides energy trapped in its bonds to the cell.

   .....

3. Which part of the chloroplasts is the site of light reaction?

   .....

4. Name the sac like structure which form the grana?

   .....

5. Why is mitochondria called the “energy currency” of the cell?

   .....

6. Which organelle contains enzymes for cellular respiration?

   .....

7. State two similarities between mitochondria and chloroplast.

   .....

8. Which plastids impart colour to flower petals?

   .....

9. Which plastid is green in colour?

   .....

10. Why are mitochondria and Chloroplast called semi-autonomous?

    .....

### 4.3.3 Endoplasmic reticulum (ER), golgi body and ribosomes

Endoplasmic reticulum (ER) and Golgi body are single membrane bound structures. The membrane has the same structure (lipid-protein) as the plasma membrane but ribosomes do not have membranes Ribosomes are involved in synthesis of substances in the cell, Golgi bodies in secreting and the ER in transporting and storing the products. These three organelles operate together.

Fig. 4.7 and Fig. 4.8 show the diagram of ER and Golgi body under an electron microscope. Note the ribosomes present in ER.

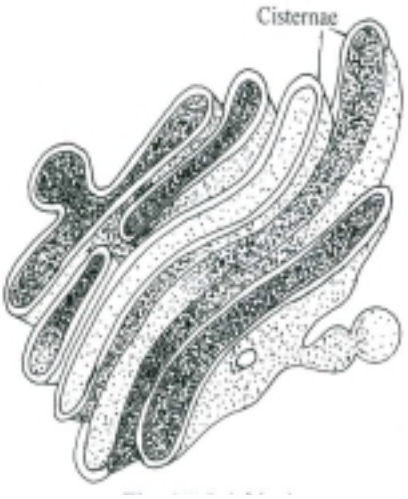



**Fig. 4.7** Golgi body

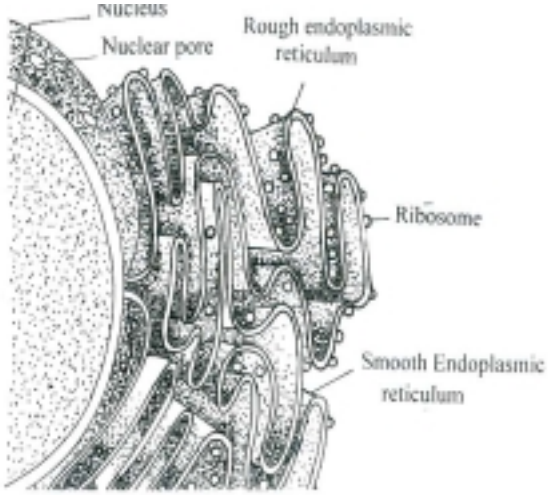



**Fig. 4.8** Endoplasmic reticulum

| Endoplasmic reticulum (ER) | Gogli body | Ribosomes |
|---|---|---|
| **Structure** | | |
| A network of membranes with thickness between 50 - 60A°. It is of two types– rough endoplasmic reticulum (RER) i.e. when ribosomes are attached to it and Smooth-endo-plasmic reticulum (SER) when no ribosomes are present. | Is a stack of membranous sacs of the same thickness as ER. Exhibit great diversity in size and shape. | Spherical about 150 - 250 Å in diameter, made up of large molecules of RNA and proteins (ribonucleo proteins) |
| Throughout the cytoplasm and is in contact with the cell membrane as well as the nuclear membrane. | In animal cells present around the nucleus, 3 to 7 in number. In plant cells, many and present scattered throughout the cell called dictyosomes. | Present either as free particles in cytoplasm or attached to ER. Also found stored in nucleolus inside the nucleus. 80S types found in eukaryotes and 70S in prokaryotes (S-svedberg unit of measuring ribosomes). |
| **Function** | | |
| Provides internal framework, compartment and reaction surfaces, transports enzymes and other materials through out the cell. RER is the site for protein synthesis and SER for steroid synthesis, stores carbohydrates. | Synthesis and secretion as enzymes, participates in transformation of membranes to give rise to other membrane structure such as lysosome, acrosome, and dictyosomes, synthesize wall element like pectin, mucilage. | Site for protein synthesis. |

## INTEXT QUESTIONS 4.4

1. Given below is a list of functions, relate them to their respective organelles:
   (a) synthesis of some enzymes .....
   (b) synthesis of steroids .....
   (c) storage of carbohydrates .....
   (d) Intracellular transport .....
   (e) Synthesis of proteins .....
2. Name the equivalent structure of Golgi body in plants. Mention two differences between their structures.
   (i) ……..…. (ii) …….....……
3. Mention any two advantages of the extensive network of endoplasmic reticulum?
   (i) …….. (ii) ……....……
4. What are the three places where ribosomes occur in a cell?
   .....
5. Name the membrane system that connects the nuclear membrane with the cell membrane?
   .....

### 4.3.4 The microbodies (tiny but important)

These are small sac-like structures bounded by their membranes. These are of different kinds of which we will take up three like lysosomes, peroxisomes and glyoxysomes.

**1. Lysosomes (lysis = breaking down; soma = body)**

Lysosomes are present in almost all animal cells and some non - green plant cells (Fig 4.9). They perform intracellular digestion.

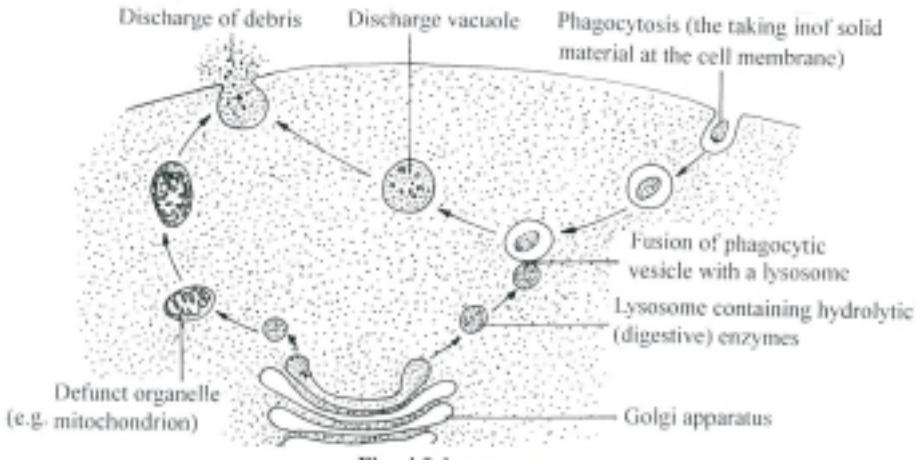



**Fig. 4.9** Lysosomes



Some main features of lysosomes are as follows :

(i) Membranous sacs budded off from golgi body.

(ii) May be in hundreds in single cell.

(iii) Contain several enzymes (about 40 in number)

(iv) Materials to be acted upon by enzymes enter the lysosomes.

(v) Lysosomes are called "suicidal bags" as enzymes contained in them can digest the cell's own material when damaged or dead.

**Importance of intracellular digestion by the lysosomes**

(i) help in nutrition of the cell by digesting food, as they are rich in various enzymes which enable them to digest almost all major chemical constituents of the living cell.

(ii) Help in defence by digesting germs, as in white blood cells.

(iii) Help in cleaning up the cell by digesting damaged material of the cell.

(iv) Provide energy during cell starvation by digestion of the cells own parts (autophagic, auto : self; phagos: eat up).

(v) Help sperm cells in entering the egg by breaking through (digesting) the egg membrane.

(vi) In plant cells, mature xylem cells lose all cellular contents by lysosome activity.

(vii) When cells are old, diseased or injured, lysosomes attack their cell organelles and digest them. In other words lysosomes are autophagic, i.e. self devouring.

**2. Peroxisomes**

Found both in plant and animal cells. Found in the green leaves of higher plants. They participate in oxidation of substrates resulting in the formation of hydrogen peroxide.

- Thet often contain a central core of crystalline material called nucleoid composed of urate oxidase crystals.
- These bodies are mostly spherical or ovoid and about the size of mitochondria and lysosomes.
- They are usually closely associated with E.R.
- They are involved in with photorespiration in plant cells.
- They bring about fat metabolism in cells.

**3. Glyoxysomes**

- The microbodies present in plant cells and morphologically similar to peroxisomes.
- Found in the cell of yeast and certain fungi and oil rich seeds in plants.
- Functionally they contain enzyme of fatty acid metabolism involved in the conversion of lipids to carbohydrates during germination.

## INTEXT QUESTIONS 4.5

1. Why are lysosomes called suicidal bags?

   .....

2. List the usefulness of intracellular digestion by lysosomes

   .....

3. What is the function of peroxisomes in plant cells

   .....

### 4.3.5 Cilia and flagella (the organelles for mobility)

(i) Some unicellular organisms like *Paramecium* and *Euglena* swim in water with the help of cilia and flagella respectively.

(ii) In multicellular organism some living tissues (epithelial tissues) have cilia. They beat and create a current in the fluid in order to move in a given direction e.g. in the wind pipe (trachea) to push out the mucus and dust particles.

(iii) Cilia beat like tiny oars or pedals (as in a boat) and flagella bring about whip – like lashing movement.

(iv) Both are made up of contractile protein tubulin in the form of microtubules.

(v) The arrangement of the microtubules in termed 9 + 2, that is, two central microtubules and nine set surrounding them.

| Cilia | Flagella |
|---|---|
| shorter (5 to 10 µm) | longer (15 µm) |
| several 100 per cell structure : protoplasmic projection and membrane bound | usually 1 or 2 in most cells |
| consist of 9 sets of peripheral microtubules and 1 set of tubules in the centre | same as in cilia |

**Centriole**

It is present in all animal cells (but not in *Amoeba*), located just outside the nucleus. It is cylindrical, 0.5 µm in length and without a membrane. It has 9 sets of peripheral tubules but none in the centre. Each set has three tubules arranged at definite angles (Fig. 4.10). It has its own DNA and RNA and therefore it is self duplicating.

**Function :** Centrioles are involved in cell division. They give orientation to the 'mitotic spindle' which forms during cell division

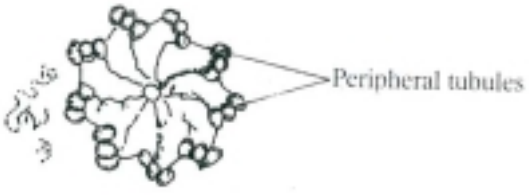



**Fig. 4.10** Centriole



### Basal bodies

These are structures similar to centrioles. They have the same nine sets of triplet organization, as in the centrioles. The cilia and flagella appear to arise from the basal bodies.

## 4.4 NUCLEUS (THE HEREDITARY ORGANELLE)

General structure of nucleus :

(i) It is the largest organelle seen clearly when the cell is not dividing.

(ii) It stains deeply, is mostly spherical, WBC have lobed nuclei.

(iii) It is mostly one in each cell (uninucleate, some cells have many nuclei; (multinucleate).

(v) Double layered nuclear membrane enclosing nucleoplasm which contains chromatin network and a nucleolus.

### Functions

- Maintains the cell in a working order.
- Co-ordinates the activities of organelles.
- Takes care of repair work.
- Participates directly in cell division to produce genetically identical daughter cells, this division is called mitosis.
- Participates in production of gametes through another type of cell division called meiosis.

The part of a nucleus are given here :

### 4.4.1 Nuclear membrane

- Double layered membrane is interrupted by large number of pores.
- Membrane is made up of lipids and proteins (like plasma membrane) and has ribosomes attached on the outer membrane which make the outer membrane rough.
- The pores allow the transport of large molecules in and out of nucleus, and the membranes keep the hereditary material in contact with the rest of the cell.

### 4.4.2 Chromatin

- Within the nuclear membrane there is jelly like substance (karyolymph or nucleoplasm) rich in proteins.
- In the karyolymph, fibrillar structures form a network called *chromatin fibrils*, which gets condensed to form distinct bodies called **chromosomes** during cell division. On staining the chromosomes, two regions can be identified in the chromatin material heterochromatin dark and autromaticn (light). Heterochromatin has less DNA and genetically less active than euchromatin which has more DNA and genetically more active.

- Number of chromosomes is fixed in an organism. During cell division chromosomes divide in a manner that the daughter cells receive identical amounts of hereditary matter.

### 4.4.3 nucleolus

- Membraneless, spheroidal bodies present in all eukaryotic cells except in sperms and in some algae.
- Their number varies from one to few, they stain uniformly and deeply.
- It has DNA, RNA and proteins.
- Store house for RNA and proteins; it disappears during cell division and reappears in daughter cells.
- Regulates the synthetic activity of the nucleus.
- Thus nucleus and cytoplasm are interdependent, and this process is equal to nucleo–cytopalsmic interaction.

**INTEXT QUESTIONS 4.6**

1. Why cannot the cell survive without the nucleus?

   .....

2. Explain the following terms:

   (a) chromatin network..... .....

   (b) chromosomes .....

3. What is the function of the nucleolus in the cell?

   .....

## 4.5 MOLECULES OF THE CELL

The cell and its organelles are made of organic chemicals such as proteins, carbohydrates, nucleic acid and fats. These are aptly termed biomolecules. Inorganic molecules such as water and minerals are also present in the cell.

### A. Water

- Water with unique physical and chemical properties has made life possible on earth.
- It is a major constituent of protoplasm.
- It is a medium in which many metabolic reactions occur.
- It is universal solvent in which most substances remain dissolved.
- It is responsible for turgidity of cells.



## B. Elements necessary for life

| Elements | Functions |
|---|---|
| Hydrogen, Carbon, Oxygen, Nitrogen, Calcium, Potassium, Sodium, Magnesium, Phosphorous, Sulphur, Chlorine, Iron, Boron, Silicon, Manganese, Copper, Zinc, Cobalt, Molybdenum, Silicon | 1. Required for organic compounds of the cell and present as major constituents. Ca in plant cell wall, C, H, O, N as organic compounds)<br>2. Act as major cations (Na, K) and anions (Cl) in most physiological process.<br>3. As cofactor of enzymes participate in most of the biochemical reaction of a cell (Fe, Cu, Mo, Zn, B)<br>4. Involved in energy transfer reactions (P in ATP).<br>5. Green pigment chlorophyll in plants have magnesium in the centre. |

## C. Biomolecules

### (i) Carbohydrate

| Structure | Functions |
|---|---|
| 1. Composed of C, H and O | 1. Most abundant organic substance present in nature in the form of cellulose in plant cell wall. |
| 2. Simple six carbon sugar (glucose) is called a monosaccharide. | 2. In both plants and animals it is used as a source of energy (sugar). |
| 3. Two molecules or units join together to form disaccharide (sucrose). | 3. An important storage form in plants is starch and in animals it is glycogen. |
| 4. More than ten units of monosaccharides join in a chain to form a polysaccharide e.g. starch and cellulose. | 4. Present in nucleic acids as five carbon surgar (Ribose). |

### (ii) Amino acid

| | |
|---|---|
| 1. Basic amino acid structure shows that the central carbon atom is attached with an amino group ($–NH_2$), a carboxylic acid group (–COOH), one hydrogen and one side group (R). | 1. Plants have the ability to utilize inorganic nitrogen and synthesize amino acid. |
| 2. There are 20 different side groups which give 20 different amino acids. | 2. In animals principal source of amino acid is the plant or animals that it consumes in its diet (pulses are rich in protein). |

### (iii) Proteins

| | |
|---|---|
| 1. Composed of C, H, O and N. | 1. Structurally proteins form integral part of the membranes |

| | |
|---|---|
| 2. Amino acids join together by "peptide" bonds to form protein moelcules. | 2. Functionally in the form of enzymes they play a vital role in metabolic reactions. |
| 3. Twenty different amino acids make numerous simple and complex proteins. | 3. Synthesis of DNA is regulated by protein. |
| 4. Based on the complexity of structure they can have primary, secondary, tertiary and quaternary structures. | 4. Proteins are so important that nucleic acids directly regulates protein synthesis |
| 5. When proteins exist with other molecules they are known as conjugated proteins e.g. glycoprotein, lipoprotein, chromoprotein etc. | |

### (iv) Nucleic Acids

| | |
|---|---|
| 1. They are of two types : Deoxyribose nucleic acid (DNA) and Ribosose nucleic acid (RNA) | 1. DNA is the main genetic material for almost all organisms except certain viruses. |
| 2. They are long chain polymers composed of units called **nucleotides**. | 2. RNA molecules are involved in information transfer and protein synthesis. |
| 3. Each nucleotide has pentose sugar, nitrogen base and phosphate group. | |
| 4. DNA has one oxygen less in its sugar molecule. | |

### (v) Lipids

| | |
|---|---|
| 1. Composed of C, H, O. Amount of oxygen is very less. | 1. Due to their low oxygen content, they store and release more energy during oxidation |
| 2. They are synthesized from fatty acids and glycerol. Simple lipids are called glycerides. | 2. A molecule of fat can yield twice as much energy as from carbohydrate. |
| 3. Fats can be saturated or unsaturated. | 3. Phospholipids are important component of cell membranes. |
| 4. Fats are solid at room temperature, those that remain liquid at room temperature are called oils. | |

### (vi) Vitamins

| | |
|---|---|
| 1. Vitamins are organic compounds required in the diet of animals for their healthy growth. | 1. Vitamins (from plant) are essential nutrients in animals diet as animals can not synthesise such compounds. |
| 2. Vitamins are classified according to their solubility into two groups : Water soluble vitamin B and ascorbic acid and fat soluble vitamins (viz. A, D, E, K) | 2. Their deficiency cause various diseases in animal, like deficiency of vitamin B causes "beri-beri" and that of vitamin C causes scurvy. |



| | |
|---|---|
| 3. Plants have the ability to synthesize vitamines from $CO_2$, $NH_3$ and $H_2S$. | 3. Vitamin A present in carotene pigment of carrot. Vitamin D can be produced by man with the help of sunlight. Vitamin K produced by bacteria in human intestine. |
| **(vii) Hormones** | |
| 1. Hormones are specific organic substances effective in low concentrations, synthesized by cells in one part of the organism and then transported to another part of the organism, where it produces characteristic physiological responses. | 1. In animals hormones are produced in glands called endocrine glands which control all the biochemical activities of the organism<br>2. In animals hormones may be proteins, peptides or steroids.<br>3. In plants hormones (growth regulators) are generally produced in metabolically active cells and control the vegetitive and reproductive growth of the entire plant. |
| **(viii) Alkaloids** | |
| 1. Alkaloids are complex organic compounds made of C, H, O and N. | 1. The active principles of drugs from medicinal plants are generally alkaloids e.g. Quinine from cinehona plant. Ephedrine from Ephedra Morphine from poppy plants |
| 2. Alkaloid in plants are produced from amino acids. | |
| **(ix) Steroids** | |
| 1. These are fat soluble lipid compounds synthesized from cholesterol. | |
| 2. They are produced by the reproductive organs like ovaries, testes and placenta and also by adrenal glands. | |
| 3. They include testosterone, estrogen, cortisol etc. | |

## INTEXT QUESTIONS 4.7

1. What is the importance of water in a living cell.

.....

2. What is the basic molecule in starch?

.....

3. What is a peptide bond and where do you find it?

.....

4. Which is the most energy containing biomolecule in living organisms?

.....

5. What are nucleotides?

.....

## 4.7 CELL DIVISION

A single cell divides many times and forms a multicelled organism. Unicellular bacteria and protozoa divide and increase in number. Injured tissues are replaced by new cells through cell division. Thus cell division is one of the most important activities in all organisms. In this lesson you will study about the two kinds of cell division and the processes involved in them.

Majority of cells in a multicellular organism grow and then can divide. But cells like the nerve and muscle cells of animals and guard cells of plants do not divide.

The process of cell division is almost same in all organisms. A cell passes through phases of growth after which are able to duplicate their chromosomes before they divide. These phases in the life of a cell constitute the **cell cycle.**

### 4.7.1 The cell cycle

You can use the term mother or parent cell for the cell that undergoes division and the daughter cells for the ones that are the result of this division. Before each daughter cell undergoes division, it must grow to the same size as its mother cell. We can distinguish two main phases in the life of a cell.

(i) Interphase - Non-dividing period (Growth phase)

(ii) Dividing phase - Also called M-phase (M for mitosis)

(i) **Interphase** - (**Inter = in between**)

The interval between two successive cell divisions is termed interphase (phase at which the cell is not dividing). It is the longest period in the cell cycle (Fig.4.11). The interphase is subdivided into three main periods - $G_1$, S and $G_2$.

**$G_1$ (Gap-1 ) Phase** i.e. **First phase of growth** – This is the longest phase. Lot of protein and RNA are synthesised during this phase.

**S or synthetic Phase** - It comes next. Lot of DNA is (synthesised). A chromosome contains a single double helical strand of DNA molecule. After S-phase each chromosomes has two molecules of DNA. Thus each chromatid

containing one molecule of DNA. The two chromatids are joined by the centromere to form a single chromosome.

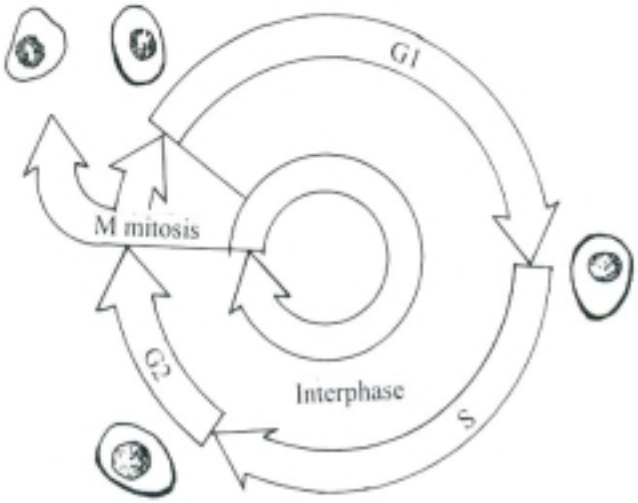



**Fig. 4.11** The cell cycle consists of various stages ($G_1$, S, $G_2$ and M)

**$G_2$ (GAP 2) phase** - More protein is synthesised in this phase. Cytoplasmic organelles such as mitochondria, golgi bodies get duplicated. Centriole also divides into two centrioles contained in a single centrosome.

(ii) **M-phase or dividing phase** - Represented by the symbol M (Mitosis or meiosis) (Fig. 4.l1). Mitosis occurs so that during this period the chromatids separate and form daughter chromosomes. The daughter chromosomes go to daughter nuclei and cytoplasm divides forming two identical daughter cells.

## INTEXT QUESTIONS 4.8

1. Explain in one sentence

   (i) Interphase .....

   (ii) Synthetic-phase .....

   (iii) Dividing-phase .....

2. What is the full form of the following in the cell cycle?

   (i) $G_l$ .....

   (ii) S .....

   (iii) $G_2$ .....

   (iv) M-Phase .....

### 4.7.2 Kinds of cell division

There are two kinds of cell division- mitosis and meiosis.

1. Mitosis : Cell division for growth and replacement wherein the two daugher cells are identical and similar to mother cell in all respects.

2. Meiosis : It occurs in the gonads for sexual reproduction to produce gametes. The resultant cells, egg (in female) and sperms (in male), possess half the chromosome number of the parent cell.

1. **Mitosis (mitos = thread)** Mitosis is divided into 4 phases or stages termed as

   (i) Prophase (ii) Metaphase

   (iii) Anaphase (iv) Telophase

   These phase refer to the changes taking place in the nucleus (Fig. 4.12).

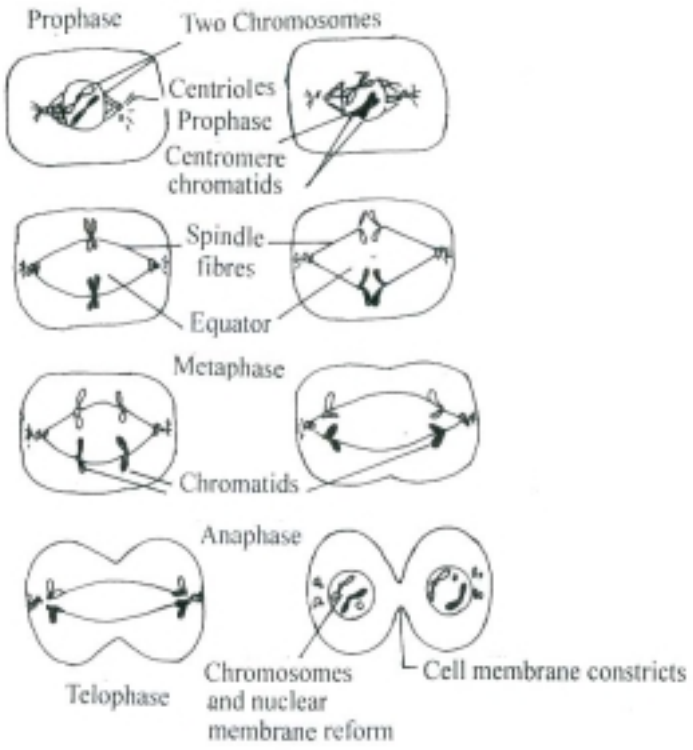



**Fig. 4.12** Stages of Mitosis in an animal cell (presuming there is just one pair of chromosome in groups).

The nucleus divides first and then the whole cell divides. Division of one nucleus to give two daughter nuclei (karyokinesis). Division of cytoplasm to give two daughter cells (**cytokinesis**).

**Prophase :** It shows three subphases :

(i) **Easly prophase**

(a) Centrioles start moving towards opposite poles of the Nucleolus cell.

(b) Chromosomes appear as long threads.

(c) nucleus become less distinct (Fig. 4.13a)

(ii) **Middle prophase**

(a) Chromosomes conden-sation is complete

(b) Each chromosome is made up of two chromatids held togeilier at their centromeres.

(c) Each chromatid contains newly replicated daughter DNA. molecule.

(iii) **Late Prophase**

(a) Centrioles reach the pole.

(b) Some spindle fibres extend from pole to the equator of die cell.

(c) Nuclear membrane disappear

(d) Nucleolus is not visible.


**Fig. 4.13a** Prophase

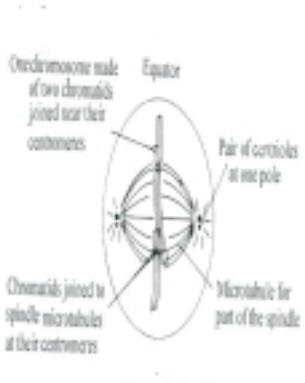



**Fig. 4.13b** Metaphase

**Metaphase**

(a) chromosomes move, towards the equator of the cell.

(b) Each chromosome becomes attached to the spindle fibre by centromere.

(c) The sister chromatids are not yet separated. (Fig. 4.13b)

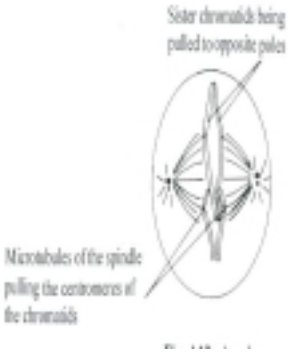



**Fig. 4.13c** Anaphase

**Anaphase**

(a) Centromeres divide

(b) Two daughter chromatids separate

(c) Each chromatid now contains a centromere and is now termed a chromosome.

(d) Half the number of now chromosomes (daugher chromatids) move toward one pole and the other half to the other pole.

(e) Cytokinesis begins as the cleavage furrow starts in animal cells.

**Telophase**

(a) Chromosomes begin to form a chromatin network as in a nucleus.

(b) New nuclear membrane is formed around each daughter nucleus

(c) Nucleolus becomes visible again.

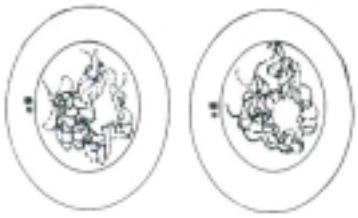


**Fig. 4.13d** Telophase

**Cytokinesis**

It is the process of the division of cytoplasm into two. It is initiated in the beginning of telophase and is completed by the end of telophase. The cytokinesis is different in plant cell and animal cell. In an animal cell, invagination of plasma membrane proceeds from the periphery of the cell towards the interior. In plant cell phragmoplast (cell plate) begins to form in the centre of cell and then expands towards the periphery (Fig. 4.13e).

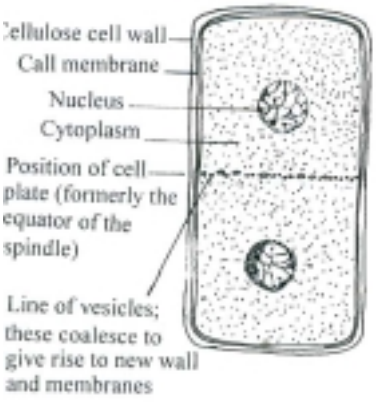



**Fig. 4.13e** Cytokinesis

**Siginificance of Mitosis**

It is an equational division, and the two daughter cells are identical in all respects. They receive the same number and kind of chromosomes as were in the mother cells.

- It is the only mode of reproduction in unicellular organisms.
- It is the process by which growth takes place in animals and plants by constantly adding more and more cells.
- It also plays a role in repair by growth, example in wound healing, regeneration of damaged parts (as in the tail of lizard), and replacement of cells lost during normal wear and tear (as the surface cells of the skin or the red blood cells).

**Mitosis (Limited or unlimited)**

Growth by mitosis occurs in a limited or controlled manner to the extent it is required in the body. But at times due to some special causes it may continue to unlimited situation which may cause **Cancer**.

In plant tissue culture, a cell from a plant can be grown in a nutrient medium, where it divides repeatedly by mitosis to give an undifferentiated cell mass called **callus** which differentiates into a plant. In animals, stem cell culture is also based on the ability of a cell to divide.



## INTEXT QUESTIONS 4.9

1. Name the stage of cell cycle during which chromatin material is duplicated.

   .....

2. Is the number of chromosomes reduced in the daughter cells during mitosis? yes/no?

   .....

3. Name the stage in nuclear division described by each of the following sentences:

   (i) disappearance of the nuclear membrane

   .....

   (ii) The nuclear membrane and nucleolus reappear

   .....

   (iii) The centromere divides and the chromatids move to opposite poles due to the shortening of spindle fibres

   .....

   (iv) The chromosomes arrange themselves at the equatorial plane of the spindle with the spindle fibres attached to the centromeres.

   .....

**2. Meiosis** (GK meioun = make smaller, sis = action)

This division is also known as '**reduction division**'. But why this name? This is because, in this kind of cell division the normal **chromosome number of the mother cell is reduced to half in daughter cells.** The normal chromosome number in human being is 46 (23 pairs), but as a result of meiosis this number is halved to 23 in daughter cells.

**Where does it occur?** It occurs in reproductive cells, e.g. in the testes of male and in the ovaries of female animals; in the pollen mother cell of the anthers (male organs) and in the megaspore mother cells of the ovary (female organ) of the flowers.

**Why does it occur?** In meiosis the chromosome number is reduced to half so that when doubled at fertilisation (zygote formation) during reproduction it once again becomes full or normal.

- The number of chromosomes remains constant in a species generation after generation.
- Cells divide mitotically in the organisms that reproduce vegetatively/ asexually. Thus, there is no change in the number of chromosomes, but sexually reproducing organisms form gametes such as sperms in males and ova in females. The male and female gametes fuse to form zygote which develops into a new individual. .
- If these gametes were, produced by mitosis, the offspring developing from zygote then would have double the number of chromosomes in the next generation.

- Every living organism has a definite number of chromosomes in its body cells. e.g. onion cell-16; potato-48; horse-64; man-46. Therefore to keep the chromosome number constant the reproductive cells of the parents (ovaries and testis in animals, and pollen mother cells and cells of ovary in plants) divide through meiosis.

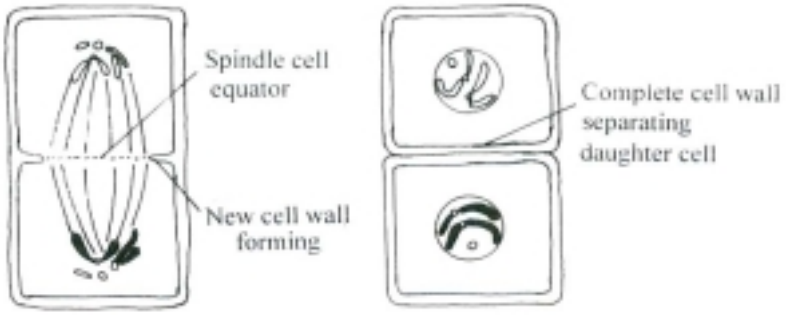
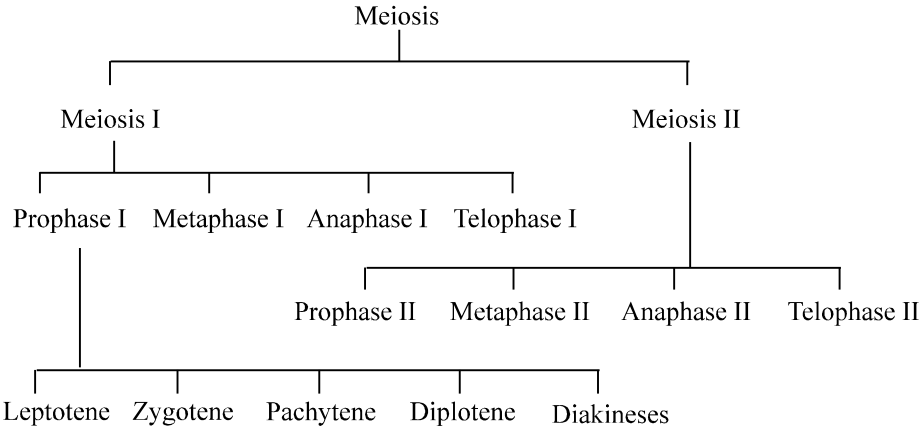



**Fig. 4.14 :** Cell wall formation after mitosis in a plant cell

**How does meiosis occur?**

Meiosis is characterized by two successive divisions of the nucleus (meiosis I and II) and cytoplasm, while the chromosomes divide only once. The phases of meiotic division are given in the flow chart drawn here.

– **The interphase** which precedes the onset of meiosis is similar to the interphase which precedes mitosis. At S-phase, the DNA molecule of each chromosome duplicates to give two DNA molecule and hence two chromatids are found in one chromosome.




– Meiosis-I and meiosis-II are continuous and have sub-stages.

**Meiosis-I**

Like mitosis, meiosis also consists of four stages; prophase, metaphase, anaphase and telophase.

**Prophase-I**

The prophase of meiosis-I is much longer as compared to the prophase of mitosis.

- It is further sub-dividied into the following five sub-stages :

(i) **Leptotene** (GK 'leptos' - thin; 'tene - thread) (Fig. 4.15a)

- The chromosomes become distinct and appear as long and thin threads due to condensation and thickening of chromosomes.
- Each chromosome consist of two chromatids held together by a centromere but these are not easily visible.

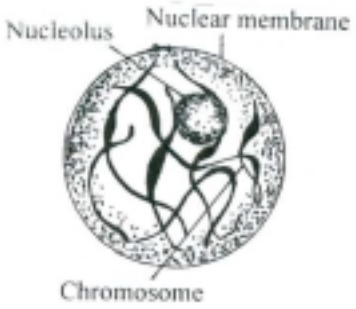



**Fig. 4.15a** Leptotene

(ii) **Zygotene** (GK. 'Zygos'-pairing) (Fig. 4.15b)

- Similar or homologus chromosomes start pairing from one end. This pairing is known as **synapsis**
- Each pair of homologous chromosomes is called a **bivalent**.


**Fig. 4.15b** Zygotene

(iii) **Pachytene** (GK. 'pachus' - thick) : (Fig. 4.15c)

- The chromosome become shorter and thicker due to contraction.
- Each paired unit called a bivalent consists of four chromatids (hence bivalents are also known as **tetrads**.
- Crossing-over occurs at the end of pachytene i.e. break and exchange of parts (genes) occurs between non-sister chromatid (chromatids of a homologous pair)

  The point of interchange and rejoining appears X-shaped and is known as chi or points of **crossing over**.

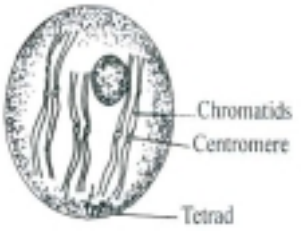



**Fig. 4.15c** Pachytene

(iv) **Diplotene** ('Diplous'-double) (Fig. 4.15d)

- The homologous chromosomes beg separate.
- The two non-sister chromatids of a homologous pair remain, attached at one or two points, the **chiasmata**.


**Fig. 4.15d** Diplotene

- It is at the chiasmata that exchange of segments of chromatids (genes) between homologous chromosomes has taken place. The proces of gene exchange is known as **genetic recombination**.

(v) **Diakinesis** (GK dia = through, in different directions, kinesis = motion) (Fig. 4.15e)

- The homologous chromosomes of a bivalent move apart from each other.
- Nuclear membrane and nucleolus disappear.
- Spindle formation is completed.

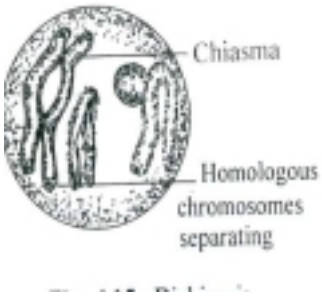



**Fig. 4.15e** Diakinesis

(vi) **Metaphase-I** (Fig. 4.15f)

- The bivalents arrange themselves at the equator.
- The spindle fibres are attached at the centromere of the chromosomes.


**Fig. 4.15f** Metaphase

(vii) **Anaphase-I** (Fig. 4.15g)

- The spindle fibres shorten.
- The centromeres of homologous chromosomes are pulled along by the spindle fibres towards the opposite poles (no division of centromere)
- Thus, half of the chromosome (each with two chromatids) of the parent cell go to one pole and the remaining half to the opposite pole.
- Each set of chromosomes that moves to one pole consists of a mixture of paternal and maternal chromosome parts (new gene combination).

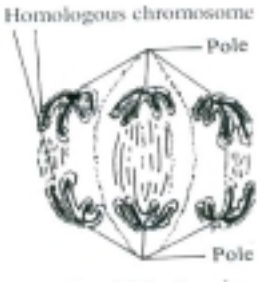



**Fig. 4.15g** Anaphase

(viii) **Telophase-I** (Fig. 4.15h)

- The separated chromosomes form nuclei.


**Fig. 4.15h** Telophase

- The daughter nuclei have half the number of the parent nucleus. The full set of chromosomes of a cell has paired chromosomes or a **diploid set** (2n).
- The daughter cells are now called haploid (n) or having 1 set of chromosomes
- The nucleous reappears and nuclear membrane forms
- The daughter nuclei begin the second meiotic division.,

**Second Meiotic Division** has the same four stages;

(i) Prophase II (ii) Metaphase II

(iii) Anaphase II (iv) Telophase II

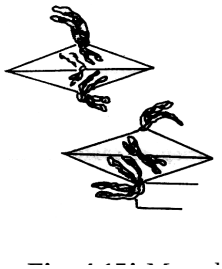
(i) **Prophase II** (Fig. 4.15i)

- The chromosomes shorten and reappear. The two chromatids are attached to the single centromere.
- Formation of spindle starts.
- Nucleolus and nuclear membrane begin to disappear.

**Fig. 4.15i** Prophase II

(ii) **Metaphase II** (Fig. 4.15j)

- The chromosomes arrange themselves along the equator.
- Formation of spindle apparatus is completed.
- The centromere of each chromosome is attached to the spindle fibre.



(iii) **Anaphase II** (Fig. 4.15k)

- The centromere in each chromosome divides.
- The chromatids get their centromore and become daughter chromosomes and begin to move towards the opposite poles.

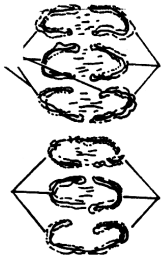


**Fig. 4.15k** Anaphase II

(iv) **Telophase II** (Fig. 4.15l)

- On reaching the poles the chromo-somes organize themselves into haploid daughter nuclei.
- The nucleolus and the nuclear membrane reappear.

**Fig. 4.15l** Telophase II

### Cytokinesis

- This may occur in two successive stages, once after meiosis I and then after meiosis II, or in some instances it occurs only after meiosis II.
- **Meiosis results in four haploid cells.**

### Significance of Meiosis

(i) It helps to maintain constant number of chromosomes in a species undergoing sexual reproduction.

(ii) Meiosis occurs during gamete formation (gemetogenesis) and reduces the number of chromosomes from diploid (2n) to haploid (n) in the gametes. These haploid gametes fuse to form diploid zygote during fertilization. The diploid zygote develops into a normal diploid individual.

(iii) Meiosis establishes new combination of characters due to (i) mixing of paternal and maternal chromosomes and (ii) crossing over during prophase I. As a result the progeny inherits the traits of both mother and the father in new gene combinations.

**Comparision of Mitosis and Meiosis**

| Mitosis | Meiosis |
|---|---|
| 1. Cell divides only once | There are two cell divisions. First mitotic division and the second meiotic division. |
| 2. Takes place in somatic cells | Takes place in germ cells. |
| 4. Duration of prophase is short (few hours) | Prophase compartively longer. (takes many days). |
| 5. Prophase simple. | Prophase complicated having five sub-stages namely leptotene, zygotene, pachytene, diplotene and diakinesis. |
| 7. Synapsis does not occur. | Synapsis of homologous chromosomes takes place during prophase. |
| 8. No exchange of segments during prophase between two chromatids of chromosomes. | Exchange of segments during crossing over between non sister chromatids of two homologous chromosomes. |
| 9. Each chromosome consists of two chromatids united by a centromere. | Each bivalent has four chromatids and two centromeres. |
| 10. Chromosomes are duplicated at the beginning of prophase. | In prophase I, chromosomes appear single although DNA replication has taken place in interphase I. |
| 11. In metaphase all the centromeres line up in the same plane. | In metaphase I, the centromeres are lined up in two planes which are parallel to one another. |
| 12. The metaphasic plate is made up of duplicated chromosome. | The metaphasic plate is made up of paired chromosome. |
| 13. Centromere division takes place during anaphase. | No centromere divisions during Anaphase I, centromeres divide only during Anaphase II. |



| | |
|---|---|
| 14. Spindle fibres disappear completely in telophase. | Spindle fibres do not disappear completely during telophase I. |
| 15. Reappearance of nucleoli at telophase. | Nucleoli do not appear in telophase I. |
| 16. The chromosome number does not change at the end of mitosis. | There is reduction in the chromosome number from diploid to haploid. |
| 17. The genetic constitution of daughter cells is absolutely identical to that of parent cells. | The genetic constitution of daughter cells is different as compared to the parent cells. The daughter cell chromosomes contain a mixture of maternal and paternal genes. |
| 18. Mitosis is of shorter duration. | Meiosis is of longer duration. |
| 19. It is the basis of growth and repair. | It is basis of maintaining chromosome number in sexual reproduction, as well as for providing variation in the progeny. |

**What is a karyotype**

Chromosomes can be seen only at metaphase. They are then photographed, cut and arranged in pairs according to size. Such an arrangement is termed karyotype (see human karyotype in lesson 21).

## INTEXT QUESTIONS 4.10

1. Name the sub-stage of meiosis-I in which the :
   (i) Homologous chromosomes pair
   .....
   (ii) Tetrads are formed.
   .....
   (iii) Homologous chromosomes begin to move away from each other.
   .....
2. Rearrange the following stages of meiosis I in their proper sequence :
   zygotene, pachytene, leptotene, metaphase-I diakinesis, anaphase-I, telophase-I.
   .....
3. Mention two major points in which meiosis I differs from meiosis II
   .....

## WHAT YOU HAVE LEARNT

- A living cell is a self-sufficient unit.
- Important cell organelles are mitochondria, Golgi complex ER, ribosomes, peroxisomes, chloroplast, glyoxisomes, nucleus.

- With the exception of centrioles, ribosomes and nucleolus, all other organelles are membrane-bound.
- Although a cell fails to lives, grow and reproduce in the absence of a nucleus, nucleus all by itself is also ineffective.
- Some organelles like mitochondria and chloroplast have the capacity to duplicate themselves to some extent without the help of the nucleus i.e. they are termed semi-autonomous.
- The living cells divide to produce new cells.
- Growth in body occurs due to increase in the number of cells.
- The continuity of the chromosomal set is maintained by cell division.
- The life cycle of a cell includes interphase ($G_1$, S & $G_2$) and M-phase (mitosis or meiosis)
- Mitosis occurs in somatic cells, results in the formation of the equal identical cells
- Meiosis occurs in germ cells only i.e. testis and ovary. This is a reduction division where chromosome number becomes half.
- The significance of mitosis is growth.
- The Significance of meiosis is in reproduction where ova and sperm both have half the number of chromosomes i.e. 23 each in human gametes (but normal number of chromosome of human is 46 or 23 pair) and on fertilization the chromosome number becomes normal.
- Meiosis also helps in mixing the paternal and maternal characters.

## TERMINAL EXERCISES

1. Justify the statement that cell wall although a dead material, influences living processes inside the cell.
2. Differentiate between cell wall and cell membrane.
3. Draw Singer and Nicholson's model of cell membrane.
4. Why is cell membrane vital for the cell?
5. Draw structure of mitochondria and chloroplast as seen by electron microscope.
6. List functions of mitochondria and chloroplast.
7. Name the self – duplicating cell organelles? Why are they called so?
8. Differentiate between functions of ER, ribosomes and Golgi bodies.
9. Most organelles are membrane – bound. What is the advantage of such arrangement.
10. Differentiate between the structure and function of centriole and cilia/flagella.



11. Why are lysosomes known as "suicidal bags"?
12. What are the functions of nucleus?
13. List the cell organelles. Write in one line each, about their functions and explain the division of labour.
14. Give the point of difference between
    (i) prokaryotic and eukaryotic cell.
    (ii) plant and animal cell.
15. Why is cell termed the structural and functional unit of the organism?
16. Name the following :
    (i) The condition in which a cell has the normal paired chromosomes.
    (ii) The condition in which a cell contains only one member of each pair of chromosomes.
    (iii) The pairing of maternal and paternal chromosomes during meiosis.
    (v) The exchange of parts in homologous (maternal and paternal) chromosomes during prophase-I of meiosis.
    (vi) The point by which a chromosome is attached to the spindle fibre.
    (vii) The type of cell division that results in growth.
17. What are the sites of meiosis in a flowering plant and in a sexually reproducing animal?
18. List the sub-stages of prophase-I.
19. What is the significance of meiosis?
20. Draw a schematic diagram of various stages of the life-cycle of a cell.
21. Draw labelled diagrams of various stages of mitosis.
22. Tabulate the main differences between mitosis and meiosis.
23. Why is prophase of meiosis so prolonged and elaborate?
24. What is the difference between cytokinesis in animal cell and cytokinesis in plant cell?

## ANSWERS TO INTEXT QUESTIONS

**4.1** 1. Preexisting cells
2. Schleiden and Schwann
3. Chloroplast
4. Prokaryote - naked nucleus, no cell organelles
   Eukaryote - distinct nucleus with a cell membrane, cell organelles present

**4.2** 1. Diffusion : Movement of molecules from region of their higher concentration to region of their lower concentration.

Osmosis : Movement of water molecules across a membrane from region of their higher concentration to that of lower concentration.

2. Movement of molecules against concentration gradient that is region of lower to higher concentration by expending energy.

3. Intake of solid particles (phagocytosis)

Intake of fluid droplets (pinocytosis)

4. (i) – d (ii) – a (iii) – e
(iv) – b (v) – c

5. (i) Protection/shape

(ii) Provide communication between cells through plasmodesmata

**4.3** 1. Membrane bound bodies in the cytoplasm

2. ATP

3. Grana

4. Thylakoids

5. Because energy as ATP is generated and stored in mitochondria

6. Mitochondria

7. (i) both are semiautonomous

(ii) both contain DNA or both contain ribosomes

8. Chromoplasts

9. Chloroplast

10. They have their own DNA for production of more of themselves but cannot lead independent life.

**4.4** 1. (a) Golgi body (b) ER, (c) ER, (d) ER, (e) ribosomes

2. refer text

3. (i) internal framework, (ii) transport of substance

4. cytoplasm, ER, Nucleolus

5. ER

**4.5** 1. Beacuse the lysosome can devour organelles of the same cell

2. They help in cleaning up the cell by digesting useless matter

3. Fat metabolism

**4.6** 1. Nucleus controls all the functions of the cell as it has the hereditary information

2. (a) Chromosomes are present as a network when not dividing, that is at interphase

(b) Bearers of hereditary information as genes on them

3. Site of RNA synthesis



**4.7** 1. (i) It is a universal solvent and most chemical reaction of the cell occur in aqueous medium

(ii) It is a constituent of protoplasm

2. glucose

3. –NHCO–, between amino acid in a polypeptide bond and found in proteins

4. ATP

5. building blocks of nucleic acids, each containing a pentose sugar, nitrogenous base and phosphate

**4.8** 1. (i) Interphase - stage between two cell division;

(ii) Synthetic phase - DNA is synthesised;

(iii) Dividing phase - Mitosis in somatic cells or meiosis in the germ cells takes place.

2. (i) First growth phase; (ii) Synthesis phase;

(iii) Second growth phase; (iv) Mitosis/meiotic phase.

**4.9** 1. Interphase;

2. No;

3. (i) Prophase; (ii) Telophase; (iii) Anaphase; (iv) Metaphase

**4.10** 1. (i) zygotene (prophase I); (ii) Pachytene; (iii) Diplotene

2. Microspore/pollen mother cell and megaspore mother cell.

3. Leptotene, zygotene, pachytene, diplotene, diakinesis metaphase I, telophase I.

4. Reduction in chromosome number to half exchange of genetic material in meiosis I.