CHAPTER 12
THE FUNDAMENTAL UNIT OF LIFE : CELL

NOTES

- **Cells** are the smallest structural and functional units of every living organism.
- The term Cell is derived from the Latin word ***cella*** meaning "a little room".
- The cellular size is usually less than 100µm i.e. beyond limit of resolution of our naked eye. Therefore, we need microscope to observe cellular world.
- **Zacharias Janssen and Hans** invented Compound Microscope.
- **Robert Hooke** discovered Cell in 1665.
- **Anton Von Leeuwenhoek** discovered free living cells in 1674 (Father of Microbiology).
- **Robert Brown in 1831** discovered Nucleus.
- **Matthias Jakob Schleiden** in 1838 and **Theodor Schwann** in 1839 proposed Cell theory which states that all the plants and animals are composed of cells and cell is the basic unit of life.
- **Rudolf Virchow** in 1885 presented ***"Omnis cellula-e- cellula"*** means that "all cells arise from pre-existing cells".
- **Knoll and Ruska** invented electron microscope in 1932 and makes possible to observe cells and its various organelles. The shape of the cell is usually related with its specific function.

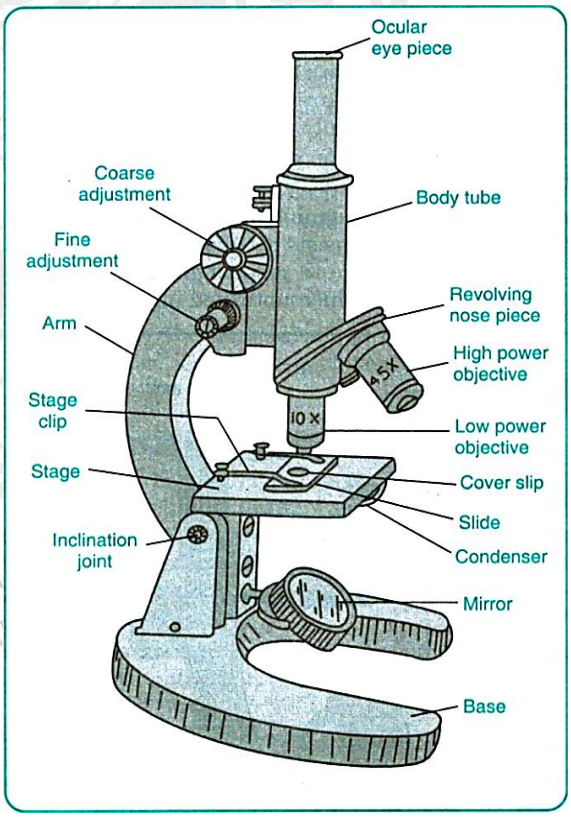


Fig. A schematic picture of a Compound Microscope

Structural organization of a cell: A typical eukaryotic cell has three important parts – **(i) Cell Membrane or Plasma Membrane, (ii) nucleus and (iii) cytoplasm.**

Cell Membrane or Plasma Membrane: It is the outermost thin, living, flexible and selectively permeable covering of animal cells and inner to cell wall in plant cell; composed of lipids and proteins. It separates contents of cell and also controls movement of substances in and out of cells.

- **Osmosis** is the passage of water from the region of higher concentration (of water) to the region of lower concentration (water concentration) through a selectively permeable membrane (semi-permeable).
- **Diffusion** is the net movement of molecules from the region of higher concentration to a region of lower concentration.

Nucleus is a large, dark coloured, spherical or oval shaped body that contains hereditary information. It controls activities of a cell and also plays important role in cell division and reproduction.

- **Gene** is a functional segment of DNA and the basic physical and functional unit of heredity.
- **Eukaryotes** have true nucleus while **Prokaryotes** lack true nucleus instead a nucleoid is present, without a nuclear envelope (but has a single, circular chromosome).

Cytoplasm is the space between plasma membrane and nucleus filled with semifluid substance.

Cell organelles are microscopic structures that perform specific cellular functions. Examples: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Mitochondria, Nucleolus, Plastids, Vacuoles, etc.

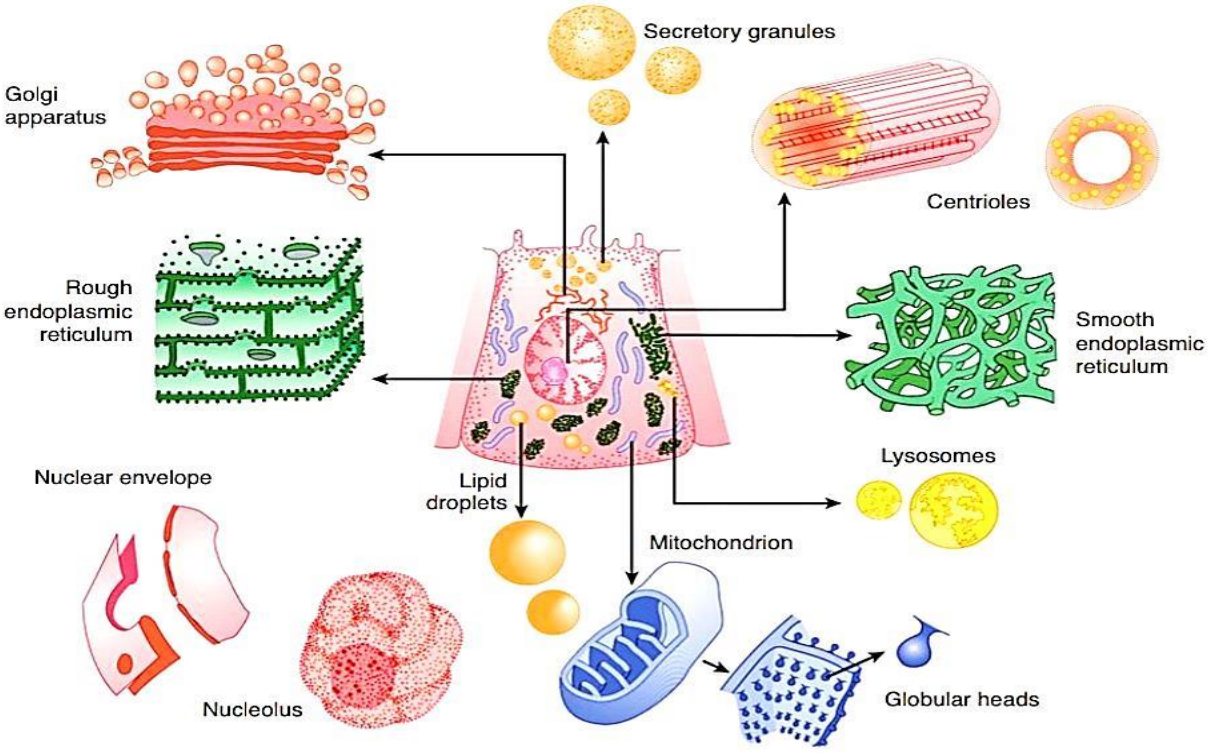


Fig: Diagrams showing microscopic structures of Cell Organelles

Cell wall is a rigid and protective covering of a plant (composed of **cellulose**), fungi (composed of **chitin**) and bacterial cell (composed of **Peptidoglycan/Murein**). Apart from protection, it provides structural strength to the cell.

Endoplasmic Reticulum (ER) is a complex network of membrane-bound tubes and sheets. There are of two types ER: **(a) Smooth Endoplasmic Reticulum (SER)** and **(b) Rough Endoplasmic Reticulum (RER).**

- **ER** not only helps in transport proteins and fats within the cell but also, as a cytoplasmic framework for biochemical activities.
- **Smooth Endoplasmic Reticulum (SER)** lacks ribosomes and helps in lipid biosynthesis (membrane formation), detoxification of drugs and poisons.
- **Rough Endoplasmic Reticulum (RER)** has ribosomes attached to their surface and are predominantly found in active cells engaged in protein synthesis.

The Golgi apparatus, first described by Camillo Golgi, consists of flattened membrane bound vesicles in stacks called **cisternae**. It is often connected with ER and form portion of endomembrane system. It performs storage, modification and packaging of substances (manufactured in the cell). Moreover, it is involved in formation of complex sugar and lysosomes.

Lysosomes are single membrane bound small spherical vesicles functioning as a waste disposal system, contain digestive enzymes for intracellular digestion. The lysosomal enzymes are made by RER. It also helps in digesting bacteria, food and old aged organelles as well as self-digestion by bursting it and inducing death of cell.

- Lysosomes are known as **suicide bags** of the cell as they contain powerful **hydrolases/hydrolytic enzymes** within them, can burst and bring about digestion of its own cell and rupture the cell membrane /cell wall and causing death of its own cell i.e. **autolysis.**

- **Mitochondria** are usually cylindrical doubled membranous organelles which take part in cellular respiration producing energy in the form of ATP and known as **"Power House of the Cell"**.
- **Mitochondrion** has its own **DNA**, **ribosomes** and capable of making some of their own protein also known as **semi-autonomous organelle.**

Plastids are also large sized double membrane bound organelles found only in plant cells.

- They include: (a) **Chloroplast** (b) **Chromoplast** (c) **Leucoplast**

Chloroplasts contain chlorophyll (found in leaves) and they perform photosynthesis. They have their own **DNA, ribosomes** and are capable of making some of their own proteins also known as **semi-autonomous organelle.**

- **Chromoplasts** are variously coloured containing carotenoids (found in flowers, fruits, seeds, etc.) - attract pollinator and help in dispersal of fruits and seeds.
- **Leucoplasts** are colourless plastids that store reserve food (found in storage parts e.g. tubers, corms) and also found in roots.

Ribosomes (non-membranous) are ***the site of protein synthesis*** and are called **protein factories.**

Cytoskeleton consists of protein filament such as microtubules, intermediate filaments and microfilaments. It helps in maintaining the structure, function and behavior of the cell.

Vacuoles are storage sacs filled with liquid or solid contents and waste products. Its membrane is called **tonoplast.**

Significance of single-membranous vacuoles :

- Providing structural support of membrane-bound sacs within the cytoplasm of a cell.
- Serving functions as storage, waste disposal, protection and growth.

Cell Division: The process by which a parent cell divides into two or more daughter cells.

It includes division of nucleus called **karyokinesis** followed by division of cytoplasm called **cytokinesis.**

- **Cell division** is of three types**: (a) Amitosis (b) Mitosis (c) Meiosis**
- **Amitosis** is known as direct nuclear division in which the nucleus constricts in the middle into a dumb-bell form of approximately equal size, then the membrane of cytoplasm divides into two daughter cells.
- **Mitosis** is a type of cell division in which the parent cell divides to produce two genetically identical daughter cells having same number of chromosomes as the parent cell, also known as **equational division**.

It occurs in the somatic cells through 4 successive stages –

Prophase, Metaphase, Anaphase and Telophase and it is followed by the division of the cytoplasm or cytokinesis, forming two daughter cells.

- **Meiosis** is a type of cell division in which chromosome number of the parent cell is reduced to half in their four daughter cells. It occurs in the reproductive cells.

Meiosis has **2- divisions: (Meiosis-I and Meiosis-II)**

- **Chromosomes** are thread like structures composed of DNA (Deoxyribo Nucleic Acid), RNA (Ribo Nucleic Acid) and protein, present in the nucleus. According to the position of centromere, chromosomes are of four types – **Telocentric, Acrocentric, Metacentric** and **Sub- metacentric.**

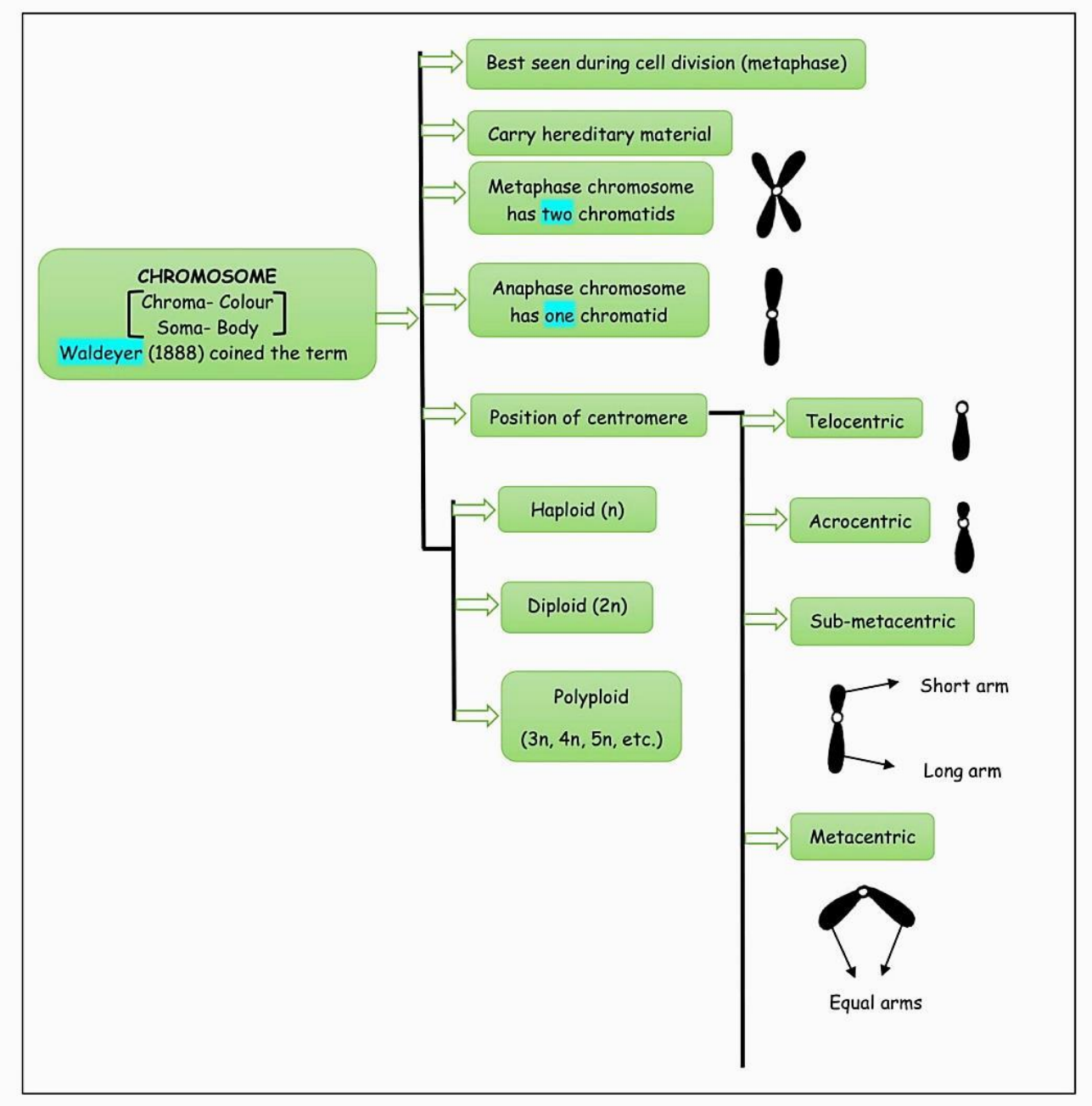


Fig: Figure showing the position of centromere of four types of chromosomes (Mitosis and Meiosis)

- **Prophase**: Nuclear envelope and nucleolus break down, shortening and condensation of chromatin into chromosome, each chromosome consists of two chromatids.
- **Metaphase**: Nuclear envelope and nucleolus completely disappears, Chromosomes with two chromatids arrange themselves at the equator with spindle fibres attached to the centromere.
- **Anaphase**: Centromere divides longitudinally, daughter chromosomes separate and move to opposite poles. Chromatids migrate towards the opposite pole.
- **Telophase**: The two daughter nuclei is formed, chromosomes become elongated to form chromatin. Nuclear envelope and nucleolus reappear (also known as reconstruction phase). Spindle fibres disappear around the poles.

- **Cytokinesis**: The division of cytoplasm is known as cytokinesis; in animal cells it occurs by **furrow method** while in case of plant cells it occurs by **cell plate formation.**

Meiosis: The type of cell division in which four daughter cells having half the number of chromosomes as compared to the parent cell are formed is known as meiosis and it is otherwise known as reductional division. It involves two divisions namely **Meiosis - I** and **Meiosis –II**. The first division is reduction division while the second division is equational division.

Meiosis I

- **Prophase-I** (More complicated, prolonged and divided into five sub-phases :
  - **(i) Leptotene (seen thin thread chromosomes here)**
  - **(ii) Zygotene (pairing of chromosomes i.e. synapsis)**
  - **(iii) Pachytene (crossing over)**
  - **(iv) Diplotene (chiasmata formation)**
  - **(v) Diakinesis (terminalization, most condensed chromosome threads)**
- **Leptotene(Leptonema):** Nucleus enlarges, Shortening and condensation of chromatin into filamentous chromosome.
- **Zygotene(Zygonema) :** *Pairing* of homologous chromosome occurs and is known as **Synapsis**, a pair of synapsed chromosomes known as *bivalent* is formed.
- **Pachytene(Pachynema):** *Tetrad* formation occurs, **crossing over** takes place.
- **Diplotene(Diplonema) :** Shortening and thickening of chromosome continues, homologous chromosome separates except at points called **chiasmata.** (Chiasma is the point where crossing over takes place).
- **Diakinesis :** Chiasmata shifted to the terminal ends of chromosomes and is known as **terminalization.**

- **Significance of Mitosis :** Growth, reproduction (in unicellular organism) and replacement of old and damaged cells by producing new cells.
- **Significance of Meiosis :** Gamete formation, maintaining definite number of chromosomes in a species and source of variation.

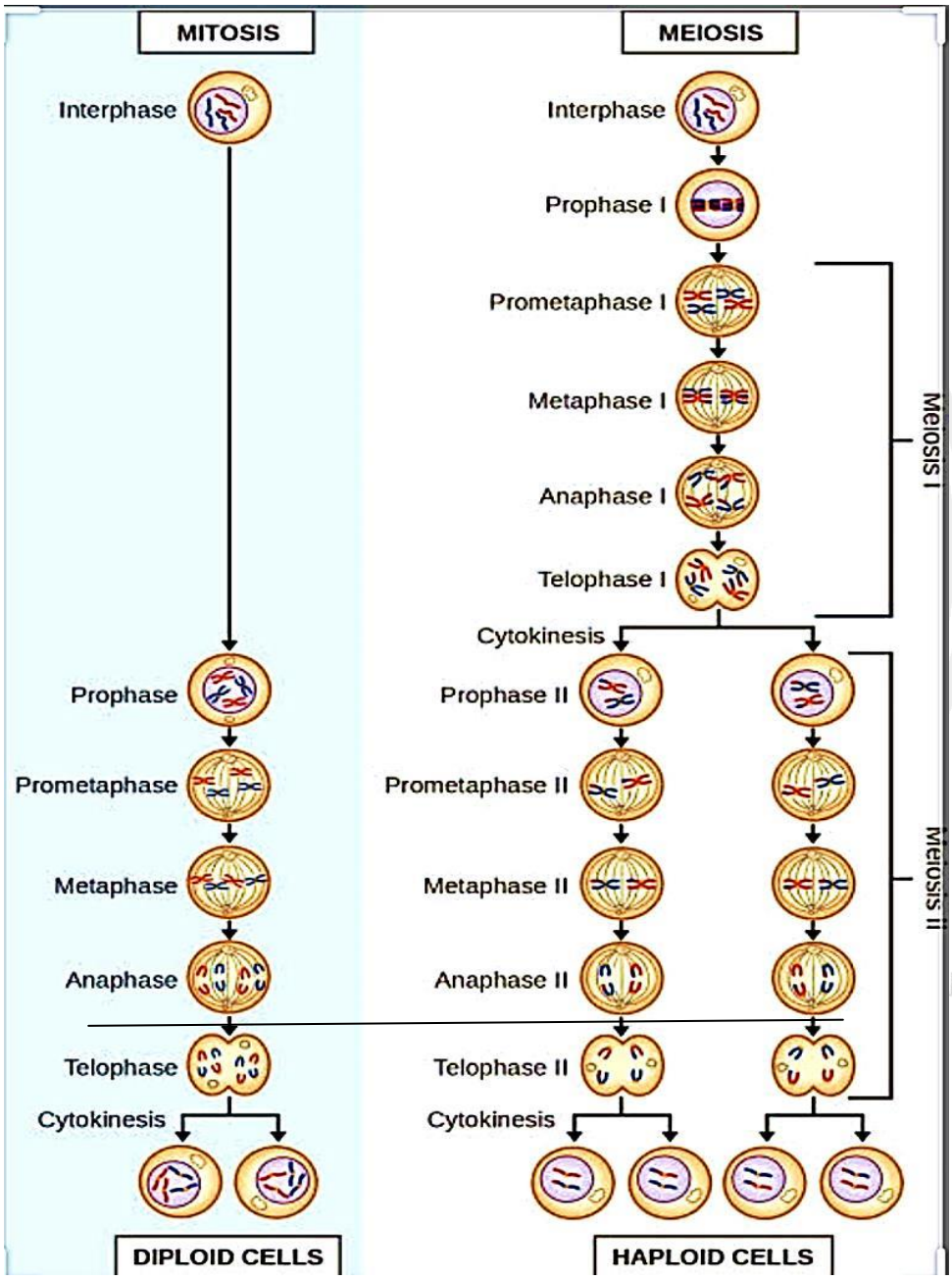


Fig. A diagrammatic representation showing different stages of Mitosis and Meiosis

Difference between Plant Cell and Animal Cell

S. No	Plant cell	Animal Cell
1	Usually they are larger than animal cells	Usually smaller than plant cells
2	Cell wall present in addition to plasma membrane and consists of middle lamellae, primary and secondary walls	Cell wall absent
3	Plasmodesmata present	Plasmodesmata absent
4	Chloroplast present	Chloroplast absent
5	Vacuole large and permanent	Vacuole small and temporary
6	Tonoplast present around vacuole	Tonoplast absent
7	Centrioles absent except motile cells of lower plants	Centrioles present
8	Nucleus present along the periphery of the cell	Nucleus at the centre of the cell
9	Lysosomes are rare	Lysosomes present
10	Storage material is starch grains	Storage material is a glycogen granules

Structures and Functions of Cell Organelles

Organelle	**Structure** – physical properties, like shape, color, and location	**Function** – job or role an organelle does for the cell
Cell Membrane (Plasma Membrane)	Surrounds the cytoplasm and other organelles	Allows things to enter and exit the cell; gets rid of waste
Cell Wall	Rigid; surrounds plant cells	provides support, protection
Nucleus	Houses chromosomes / DNA – the genetic code (heredity material)	Control center, tells other organelles what to do
Cytoplasm	Gel-like liquid that fills the cell	Provides suspension to organelles so they move around easier
Mitochondrion (Mitochondria)	Double membrane organelle with inner folds	Converts glucose molecules into energy
Chloroplast	Filled with chlorophyll; Contains stacks of discs	Site of photosynthesis – which makes food for plant cells
Vacuole	Much larger in plant cells than animal cells	Storage site of water, nutrients, and waste
Lysosome	Small, circular organelle that contains enzymes	Digest old cells parts; Aids with removal of waste

Comparison between Mitochondria and Chloroplasts

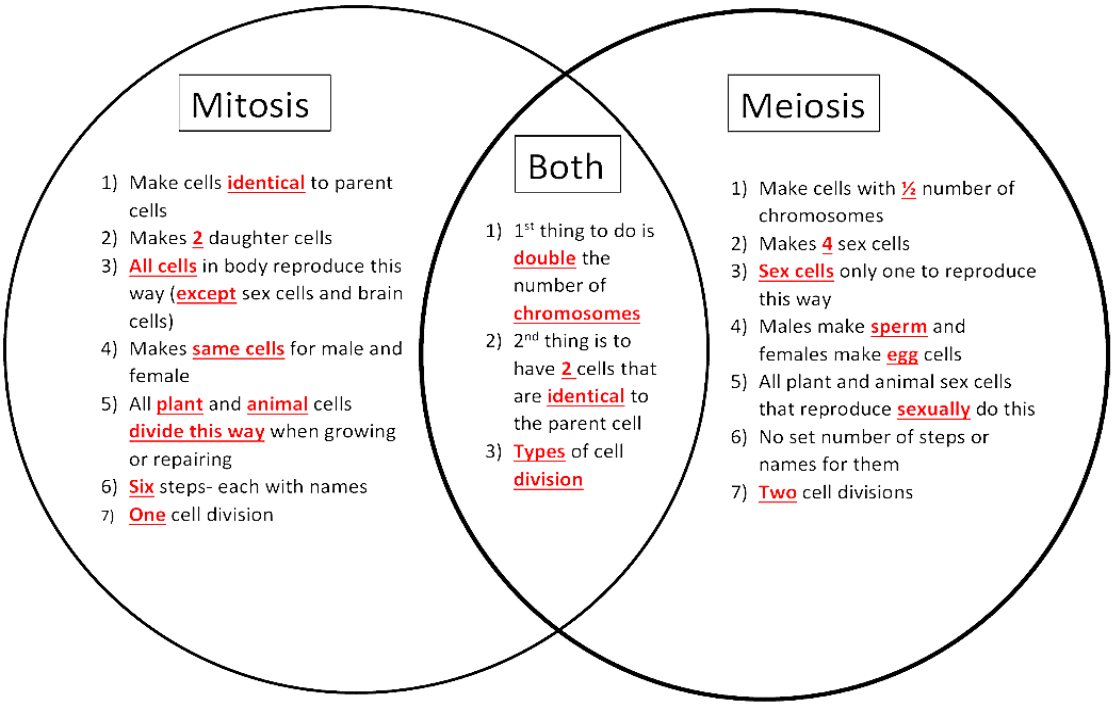
Similarities:

- Both are surrounded by two membranes and present only in eukaryotic cells.
- Both contain their own DNA and ribosomes.

Differences:

Chloroplast	Mitochondria
➢ Larger, discoid-shaped, restricted to plants cells. ➢ Inner membrane smooth, Cristae absent. ➢ Thylakoids present ➢ Site for photosynthesis.	➢ Smaller, cylindrical in outline, found in all aerobic cells. ➢ Inner membrane produces cristae. ➢ Thylakoids absent ➢ Site for aerobic respiration.

A Venn Diagram showing Similarities and Difference between Mitosis and Meiosis



Points to remember

- *Amoeba* and *Chlamydomonas* are the two unicellular organisms.
- *Amoeba* acquires its food with the help of pseudopodia through endocytosis.
- Amino acids, sugars, organic acids and proteins are stored in vacuoles.
- Chromosomes are made up of DNA and protein.
- When a cell is kept in hypertonic solution, it results in exosmosis following the shrinkage of cytoplasm due to the fluid goes out of the cell.
- Smooth Endoplasmic Reticulum plays an important role in detoxifying many poisons and drugs.
- The proteins are synthesized by Rough ER as RER has ribosomes attached on the surface and ribosomes are responsible for protein synthesis.
- Golgi Body is involved in repackaging of many biomolecules.
- Silver nitrate solution is used to study Golgi Body by Camillo Golgi.
- Chloroplast is also called as Kitchen of the cell as food is produced in plants chloroplasts.
- Ribosomes are non-membranous cell organelle.
- Nucleus – Control room of the cell
- Mitochondria – Power house of the cell
- Chloroplast – Kitchen of the cell
- Lysosomes – Digestive bag of the cell/Scavengers of the cell
- Endoplasmic Reticulum – Transporting channels of the cell
- Golgi Apparatus – Packaging and Dispatching unit of the cell
- Vacuole – Storage sacs of the cell
- ATP - Energy currency of the cell

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