Definition: - The cell is defined as, the structural & functional unit of living organism. or the cell can also define as, a unit mass of living substance i e protoplasm delimited by a semipermeable membrane and capable of growth & reproduction.

Robert Hook (1635- 1703) an English man who first discovered the internal structure of a thin slices of cork with the help of a microscope constructed by him. He observed honey comb like structure or porous or box like compartment. He named them as 'cells'. The cell comes from Latin word "cellula" means hollow space or little room or small compartment. Antonie Van Leeuwenhoek, a Dutch scientist (1632 – 1723) first time invented compound microscope that magnify the object 270 to 300 times. First time Leeuwenhoek observe living cell. He observed living cell like bacteria, protozoa, sperm cells and yeast cell.

Cell Theory:

Matthias Scheliden (1938) critically studied plant tissues and made first statement which is called cell theory. Theodor Schwann studied animal tissue. The Scheliden and Schwann collectively proposed cell theory. The cell theory in its modern form includes the following three principles:

1. The cell is the basic unit of structure of plants and animals. All organisms are composed of one or more cells. The life processes and heredity occur within the cell or cells.
2. The cells are smallest living things. The cell is a basic unit of organization of all organisms.
3. All cell arrives from pre-existing living cells.

General Properties of Cell

A typical cell shows following properties

1. The cell is surrounded by cell membrane which separates the cell from outside worlds.
2. The cell activities are directed by nuclear region.
3. The volume of the cell is filled with semisolid matrix called the cytoplasm.
4. The genetic materials in all cells consists of nucleic acid.
5. The nucleic acids and proteins are synthesized on the same plan in all the cells.
6. During cell division hereditary characters are transmitted in the form of nucleic acids.
7. In bacterial cell, cytoplasm contains different chemicals like sugars, aminoacids and proteins. The cells of higher organisms like plants and animals also contains these chemicals.
8. The cells of higher organisms contain many organized structures called cell organells which include mitochondria, ribosomes, lysosomes, Golgi body, centrosomes and plastids (only in plant cells). These organelles involved in various life processes like respiration, photosynthesis, secretion etc.
9. The cytoplasm s of cells contains vacuoles which are bound by membrane. They are distinct in plant cells and indistinct in animal cells. The vacuoles act atas reservoirs of secretary and excretory products of cell metabolism.
10. The cell acts on self-contained unit of the metabolic processes of life. The cell is always (independent) even if its forms a specialized tissue in a multicellular body.

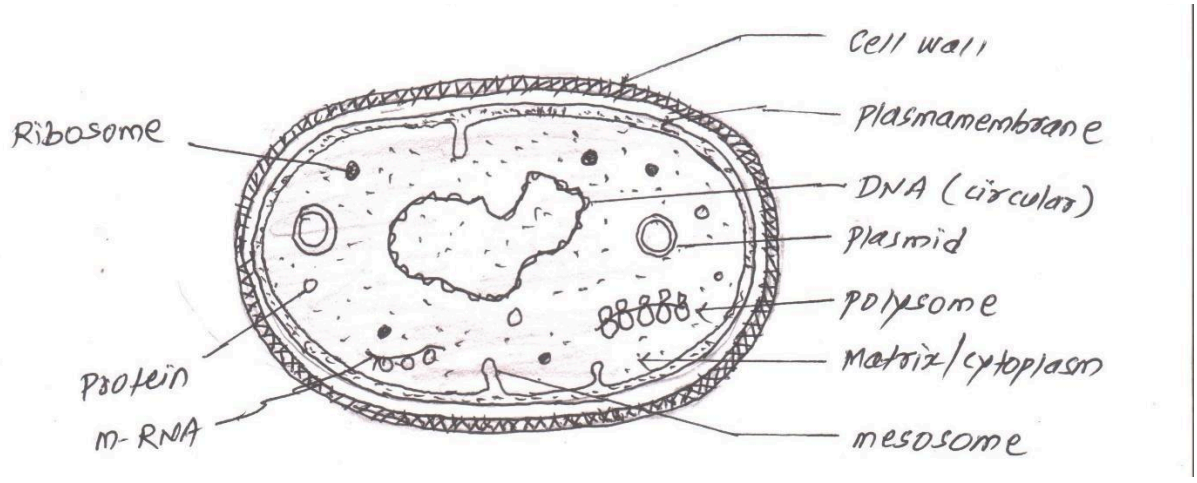
Characteristics of Prokaryotic and Eukaryotic cell :-

The cell biologist classified the cell on the basis of presence or absence of a functional or true nucleus in the cell; there are two types of cell in the cellular organism.

a) Prokaryotic cell and b) Eukaryotic cell. The body of all living organism like bacteria, blue green algae, plant & animal except viruses has cellular organization i.e the organism are made up of cells called cellular organization.

Characteristics of Prokaryotic cell:-

1. Cell size of prokaryotic cell is about 1 to 10 um.
2. The capsule is composed of mucopolysacharides.
3. Cell wall is non cellulosic.
4. Plasmamembrane is simple.
5. Endoplasmic reticulum, Golgi complex, Lysosome, Mitochondria and chloroplast are absent.
6. True Nucleus and Nuclear membrane absent.
7. Nucleolus is absent.
8. Mitochondria absent but respiratory enzyme is present in cell membrane.
9. Chloroplast is also absent but photosynthetic enzymes in plasamamembrane.
10. Ribosome is present – 70s type
11. Genetic material is DNA and histone protein not mixed with DNA.
12. Chromosome is single, circular, with double stranded DNA.
13. Extra nuclear DNA is present in the form of plasmid.
14. Cell division is only by fission.
15. Cytoskeleton is absent.
16. Sensitivity to antibiotics is different in various organisms.
17. Examples of prokaryotic cell are **Bacteria** & Blue green algae.



Characteristics of Eukaryotic cell:-

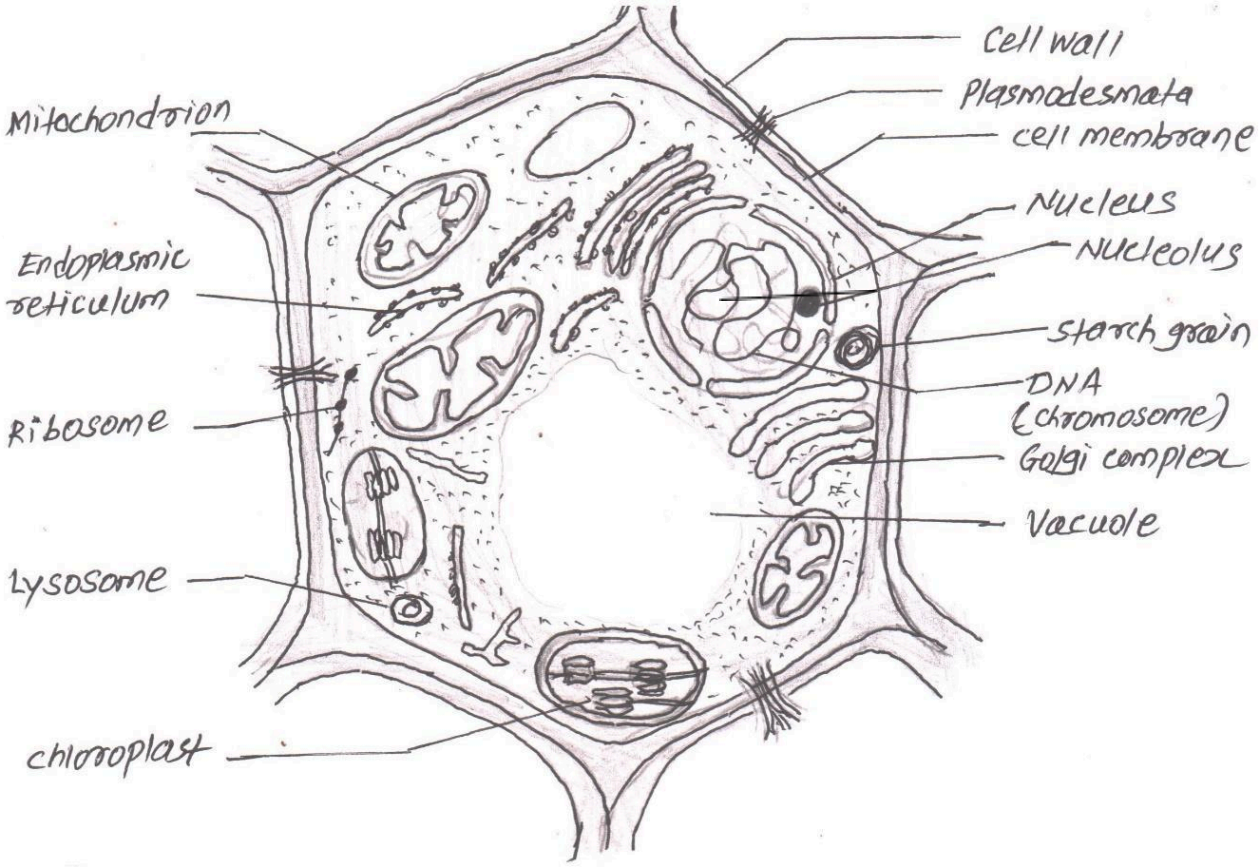
1. Cell size of eukaryotic cell is about 10 to 100 um.
2. The capsule is absent.3. Cell wall is cellulosic in plant cell and absent in animal cell .
4. Plasmamembrane is complex.
5. Endoplasmic reticulum, Golgi complex, Lysosome, Mitochondria and chloroplast are present.
6. True Nucleus and Nuclear membrane present.
7. Nucleolus is also present. 8. Ribosome is present – 80s type

9 The respiratory enzyme is present in Mitochondria.

10. Photosynthetic enzymes in chloroplast and chloroplast with *cllorophyll a* and *chlo. b.*
11. Genetic material is DNA and DNA with histone protein.
12. Chromosome more linear, with double stranded DNA.

13. Extra nucluear DNA is present in Mitochondria and chlotoplast.
14. Cell division is by mitosis & meiosis.15. Cytoskeleton is present.
16. Sensitivity to antibiotics is absent.
17. Examples of eukaryotic cells are Algae, Fungi, Bryophytes, Pteridophytes, Angiosperm , Gymnosperm and Animals

Eukaryotic cell : e.g. Plant Cell



Comparative account of Prokaryotic and Eukaryotic Cell:-

Sr. No	Characters	Prokaryotic cell	Eukaryotic cell
1	Cell size	1 to 10 um	10 to 100 um
2	Capsule	It is composed of mucopolysacharides	Absent
3	Cell wall	Non cellulosic	Cellulosic in plant cell & absent in animal cell.
4	Plasmamembrane	Simple	Complex
5	E. Reticulum	Absent	Present
6	Golgi complex	Absent	Present
7	Lysosome	Absent	Present
8	Mitochondria	Absent	Present
9	Vacuole	Absent	Present
10	Ribosome	Present – 70 s type	Present – 80 s type
11	Chloroplast	Absent but photosynthetic enzymes in plasamamembrane	Present in plant cell with chlorophyll a & b
12	Nucleus	True nucleus absent	True nucleus present.
13	Nuclearmembrane	Absent	Present
14	Nucleolus	Absent	Present
15	Genetic material	DNA & RNA	DNA
16	DNA	Histone protein not mixed with DNA	DNA with histone protein
17	Chromosome	Single circular double stranded DNA	More chromosome, linear, double stranded DNA
18	Extra nucluear DNA	Present in the form of plasmid	Present in chloroplast & mitochondrion
19	Cell division	Only by fission	By mitosis & meiosis
20	Respiratory enzyme	Present in cellmembrane	Present in mitochondria.
21	Cytoskeleton	Absent	Present
22	Sensitivity to antibiotics	Different in various organism	Absent
23	Examples	Bacteria & blue green algae	Algae,fungi,bryo,pterido,angio, Gymno,&animals

Cell Cycle:

It is considered as the complex series as phenomenon by which cellular material is divided equally between daughter cells.The cycle shows two phases

1) Interphase i e non dividing phase &

2) M-phase i e dividing phase.

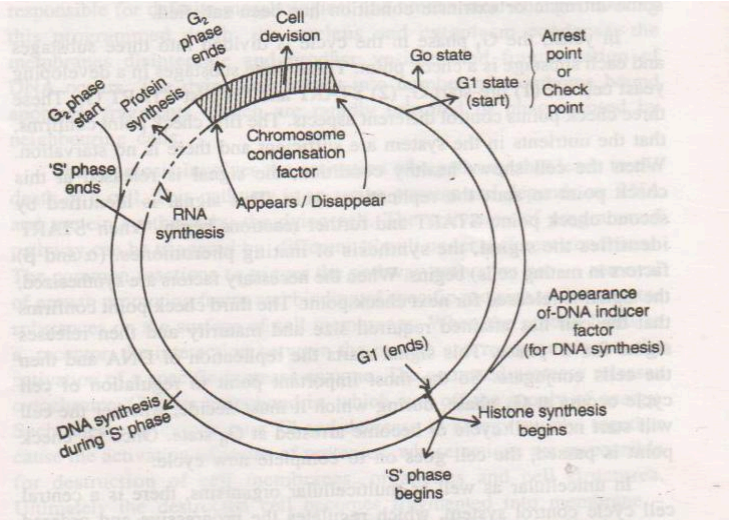
1) Interphase:- During the period of division some distinct changes occur and they can be observed by light microscope.The interphase is resting phase & cell spends most of its life span in this phase.In this phase many biochemical activities occurs,which are required by a cell to undergoes successful division. It comprises 3 sub phases i.e a) G_1-Phase b) S-phase & c) G_2-phase.

a) G_1 –phase:- It is first gap phase.This phase is characterized by synthesis of RNA & protein. The enzyme and substrates required for DNA synthesis (I e in 's'phase) are synthesized during this phase. Ribosomal units produced in nucleolus. Non dividing cells are permanently in G 1 phase. Duration of this phase may variable from 25 to 50 % of total interphase.

b) S-phase:- During this phase DNA synthesis takes place as a result chromosome duplicate or replicate.In G_1 phase the chromosomes posses single chromatid but in G_2 due to DNA synthesis two sister chromatids are still in uncoiled & extended state. Hence sister (two) chromosome are not visible under light microscope. All the histones are synthesized in this phase.It occupies about 35 to 40 % time of interphase. Cell division will not proceed if **'s**' phase is inhibited. Therefore s phase is most important in interphase.

c) G_2 phase: - This period is in between the end of **s** phase & beginning of prophase. In this phase RNA & proteins synthesis continuous. Protein synthesized in this period are important for the entry of cell in to M-phase. The duration of this period is 1 to 4 hours.

2) M-phase:- M means mitosis or meiosis i e divisible phase. The cycle is controlled by both nucleus & cytoplasm. In multicellular organism some cells after their growth is complete become permanent and carry out specific physiological function such cells lost their capacity to undergoes division & become arrested in G_1 phase. cell with arrested growth remains with drawl from cell cycle in G_0 state. In cell cycle of uni or multicellular organism for each event control the entire mechanism of cycle. The points at which signals are necessary called as check point. The two important check points are in G_1 and at the end of G_2 phase.



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Cell Cycle showing check point

Apoptosis:-

The process of natural death which is required to stop the function of protoplasmic system and remove such unwanted cells by genetically controlled reaction is called apoptosis or Programmed Cell Death (PCD).This process provide essential control over cell number and maintain natural balance in all organs or cell.Apoptosis is differ from pathological cell death which is due to infection or any disease to the cell.

Mechanism :- During this programmed cell death, the nucleus and cytoplasm condense the membrane disintegrate. The dying cell breaks in to number of membrane bound apoptotic fragments which are rapidly phagocytosed by neighboring cell. The apoptosis involve the activation of pathway that leads to the death of cell. The common reaction of the activation are removal of growth promoting factors and binding of specific protein to the receptor substance on the surface of the cell membrane. When the protein binds to the receptor, a specific protease enzyme activated, the activated protease release cytochrome – C from mitochondrion which stop the supply of energy. Due to this the cell membrane, cell organelle are destructed. The destructed cell becomes fragmented which are phagocytosed by the surrounding cells. Apoptosis has been studied in some animals. In plant organ during senescence & during growth of embryo it has been observed.

Significance of apoptosis :-The apoptosis kill the cells for three different reasons.

1) For proper development and to maintain stability.
2) For protective in function.
3) For aging or senescence process.

The cells which are generally killed by apoptosis are –

1) Cell having no function.
2) Cell that are produced in excess than the requirement of the organ.
3) The cell which are not healthy & show improper development.
4) Cell which are harmful. Such cells are killed by apoptosis.

Cell Division

The cell division is a complex process in which cellular material is divided and equally distributed into daughter cells. The cell division in eukaryotic organism consists of two internal process: nuclear division i.e. karyokinesis and cytoplasmic division i.e cytokinesis.

The undergoes the cell division termed as parent cell and the cells formed from the parent cell termed as daughter cell. There are mainly two types of cell divisions 1) Mitosis and 2) Meiosis.

Mitosis

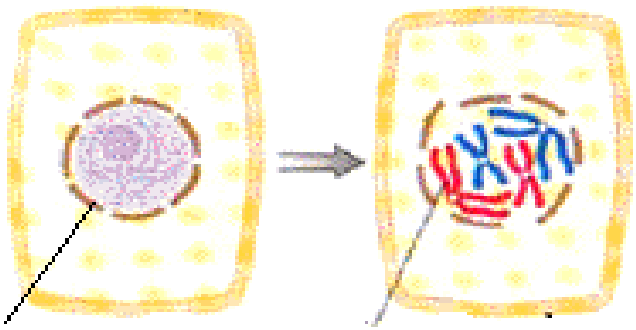
The process of cell division in which the chromosomes are duplicated and distributed equally into daughter cells is called mitosis. The mitosis is occurred in somatic or vegetative cell. The continuity of chromosome number is maintained in the body cells. In mitosis from a parent cell two daughter cells are produced. Turpin in 1826 reported the cell division. W. Flemming in 1880 introduced the term mitosis. The Strassburger in 1882 a German Botanist described the cell division in the Plant cell.

Progressive Stages of Mitosis: -

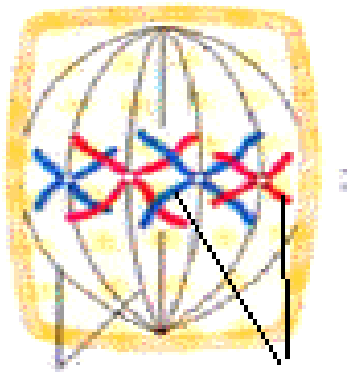
Mitosis is continuous and progressive process. For sake of convenience mitosis is divided into four phases or stages. These phases are, a) Prophase b) Metaphase c) Anaphase d) Telophase and finally cytokinesis. When the cell is not in division state it is in interphase.

Interphase: - This is not a stage of mitosis but it is preparatory phase of mitosis. This phase is also called as resting phase because no visible changes occur. But the cell in this phase is more active, the RNA, protein and DNA are synthesized in this phase. The interphase is in between two mitotic phases. This is divided into G1, S and G2 phase. The DNA is duplicated or synthesized in S phase. The nucleus contains coiled, delicate threads called chromatin fibre; nuclear membrane and nucleolus are intact.

a) Prophase:- This is first and longest mitotic stage . The size , viscosity and refractivity of cell is increases. The chromatin fiber start to condense becomes thicker and chromosomes are formed. In condensation process the length of chromatin fibre decreases and width increases. Due to duplication of DNA in interphase each chromosome is with two chromatids. Each chromatid contains a DNA with a centromere. The chromosomes are associated to plasmamembrane. The centrioles are dividing into two and move to opposite pole in animal cell. The centrioles are absent in plant cell. In lower plant and animal around the centriole shows aster. The aster is fibrillar structure originating from cytoplasm. The spindle fibres are formed between two poles. The spindle fibers are gel like fibers. At the end of prophase the nuclear membrane and nucleolus are disappear. The cell then passes into the next stage i.e. metaphase.

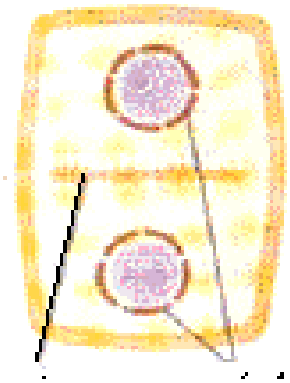


2) Metaphase:- The chromosomes are reach at equatorial region are appears like plate like structure called metaphasic plate. The chromosomes are sharply defined and best observed at this stage. The spindle fibres are long, delicate thread like structure.They are cytopplasmic in origin.The centromere of each chromosome attached to spindle fibre called chromosomal spindle fibre some spindle fibre attaches from one pole to another called continuous spindle fiber while fiber attaches to one chromosome to another is interzonal spindle fiber. These spindle fibers, centrioles and aster are collectively called spindle apparatus. The chromosomes are shorter and thickest during this phase. The RNA synthesis stops in metaphase.

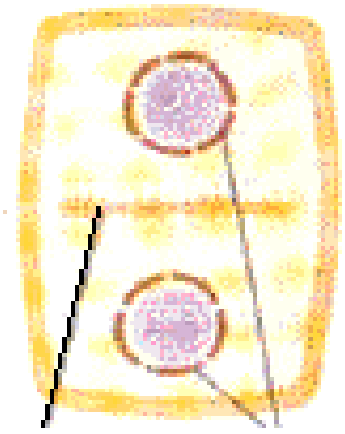


3) Anaphase:- The centromere are replicate and the spindle fibre pull each sister chromatid to opposite pole due to pulling force. The separated chromatids are now called chromosomes. The chromosomes move to opposite pole of the cell. The causes of this movement is not clear. Due to movement the two sets of chromosomes are becomes separate, each set goes to opposite pole. During migration of chromosomes towards pole the chromosomes appears as rod shaped (actrocentric) or V shaped (Metacentric) or L shaped (submetacentric). Anaphase goes shortest period in mitosis.

4) Telophase:- At each pole the chromosomes form a close group. The chromosomes begins to uncoil and becomes chromatin fiber. The spindle fiber start to disappear and nuclear membrane reappears around each group of chromosomes. The nucleoli reappear at certain point of chromosome in the two groups. In animal cell the centriole and aster goes to their original position.The nuclear sap reappears and each nucleus increases in size. The two distinct nuclei are formed this process is karyokinesis.



Cytokinesis:- Division of cytoplasm and formation of two cell is called cytokinesis. In plant cell the granules of endoplasmic reticulum golgi body are deposited at the center of cell and form a plate like structure called cell plate. The cell plate grows from middle to periphery and ultimately joins the cell wall resulting in two cells. In this way two daughter cell with equal chromosome numbers are formed. Each daughter cell has same number of chromosomes and becomes similar to parent cell. In animal cell the cytokinesis occurs simultaneously along with telophase while in plants it takes place after the telophase.



Significance of Mitosis:-

1) Mitosis maintain constant chromosome number in species.

2) Production of large number of cells result in growth and development of the organism. It results in increasing the length and girth of organ.

3) It maintains the volume surface ratio of a cell.

4) Mitosis also helps in wound healing i.e in replacement of destructed cells thereby helping in body repair.

5) It responsible for qualitative and quantitative distribution of hereditary material to daughter cells.

6) It maintain nuclear and cytoplasmic balance i.e nucleoplasmic index in the cell.

7) Multiplication of asexually through mitosis.

Meiosis:

The term Meiosis was coined by J.B. Farmer and J.E.Moore in 1905. Mitosis means to reduce. The particular species show a constant number of chromosomes from generation to generation. Meiosis is characteristic of gamete forming organisms. Meiosis is only occurs in reproductive cell. In sexual reproduction male and female gamete unite to form zygote. These male and female gametes are formed by reduction division and each one contains half number of chromosome number required for formation of zygote. That means the chromosome number maintain constant from generation to generation only due to meiosis. Meiosis is a reduction cell division as the chromosome number is reduced to half in daughter cells. Usually, meiosis is occurring in diploid cell. In meiosis from a parent cell four haploid daughter cells are formed.

Progressive stages in meiosis:

Meiosis has two successive division namely A) Meiosis-I and B) Meosis-II. Meiosis I is reductional division producing two haploid nuclei from a single diploid nucleus. Whereas Meiosis-II is an equational division which separates the sister chromatids of product of meiosis I.

A) Meiosis I: The stages of **Meiosis I :** a) Prophase-I ------ i) Leptotene
ii) Zygotene
iii) Pacytene
iv) Diplotene
v) Diakinesis

b) Metaphase-I

c) Anaphase-I

d) Telophase-I

e) Interphase.

a) Prophase-I: The prophase-I is longest stage and several changes takes place in this stage. The prophase I again divide in to sub stages on the basis of the changes.

i) Leptotene ii) Zygotene iii) Pacytene iv) Diplotene v) Diakinesis

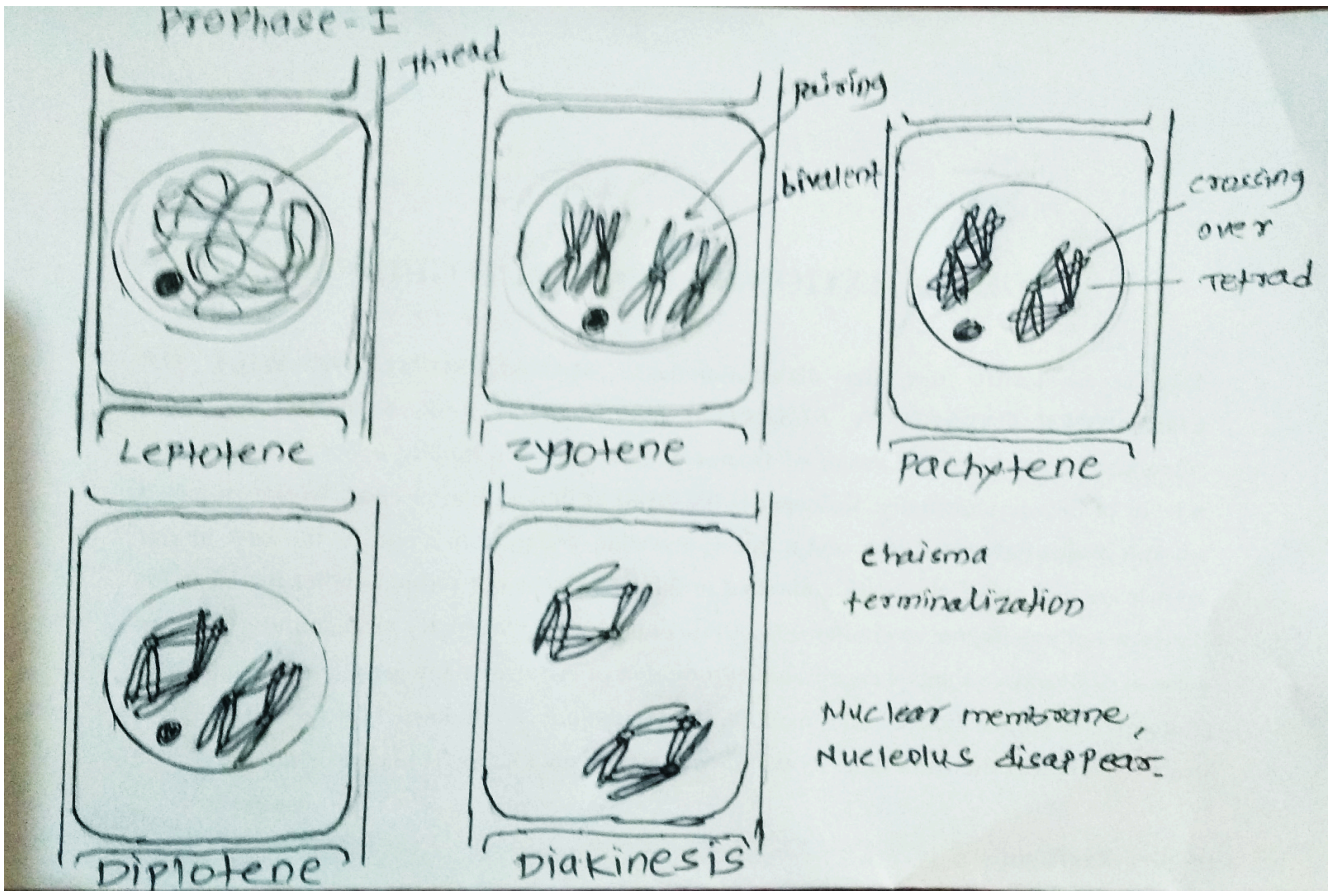
i) Leptotene:- In leptotene the nuclear volume increases. The slightly condensed chromosome appears long thread like. All these in nucleus and appears like a ball of knitting wool. RNA synthesis takes place.

ii) Zygotene: In this stage the initiation of pairing between homologous chromosomes are takes place and ends when pairing is completed. The pairing of homologous partners is throughout their length called synapsis. Due to **synapsis** each pair of homologous chromosomes forms a structure called bivalent. Specific nucleoproteins are synthesized.

iii) Pachytene: In this phase further condensation of chromosomes and pairs become shorter and thicker. Now each of the two bivalents becomes visible during in this stage. Each bivalent is consists of two sister chromatids. Thus, each bivalent shows four chromatids. There fore the bivalents are called tetrad. The crossing over between homologous chromosomese takes place during this stage. The **crossing over** responsible for exchange of chromatin material or genetic material. The nucleolus and nuclear membrane still intact.

iv) Diplotene: - The homologous chromosomes in bivalent begin to move away from each other. The two homologous of each bivalent are found to be attached with each other at one or more points called chiasma. In this stage chiasmata move slowly towards the end of the homologous chromosomes, this movement is known as chiasma terminalization i.e chaismata moves towards terminal position of chromosome. The chromosomes are further condensed and becomes thicker.

V) Diakinesis:- The chiasmata only present at the terminal region of bivalent. The nuclear membrane and nucleolus completely disappear. The bivalent s are move towards periphery of the cell. The spindle fiber organized. In this way the prophase is completed.



b) Metaphase-I:-

All the bivalent are migrate to the equatorial plane. The spindle fiber are get attached to the centromere of each of the two homologous chromosomes in a bivalent. Thus two centromeres of each bivalent are now found lying on opposite sides of the equatorial plate. Now these chromosomes begin to separate from each other.

c) Anaphase-I:-

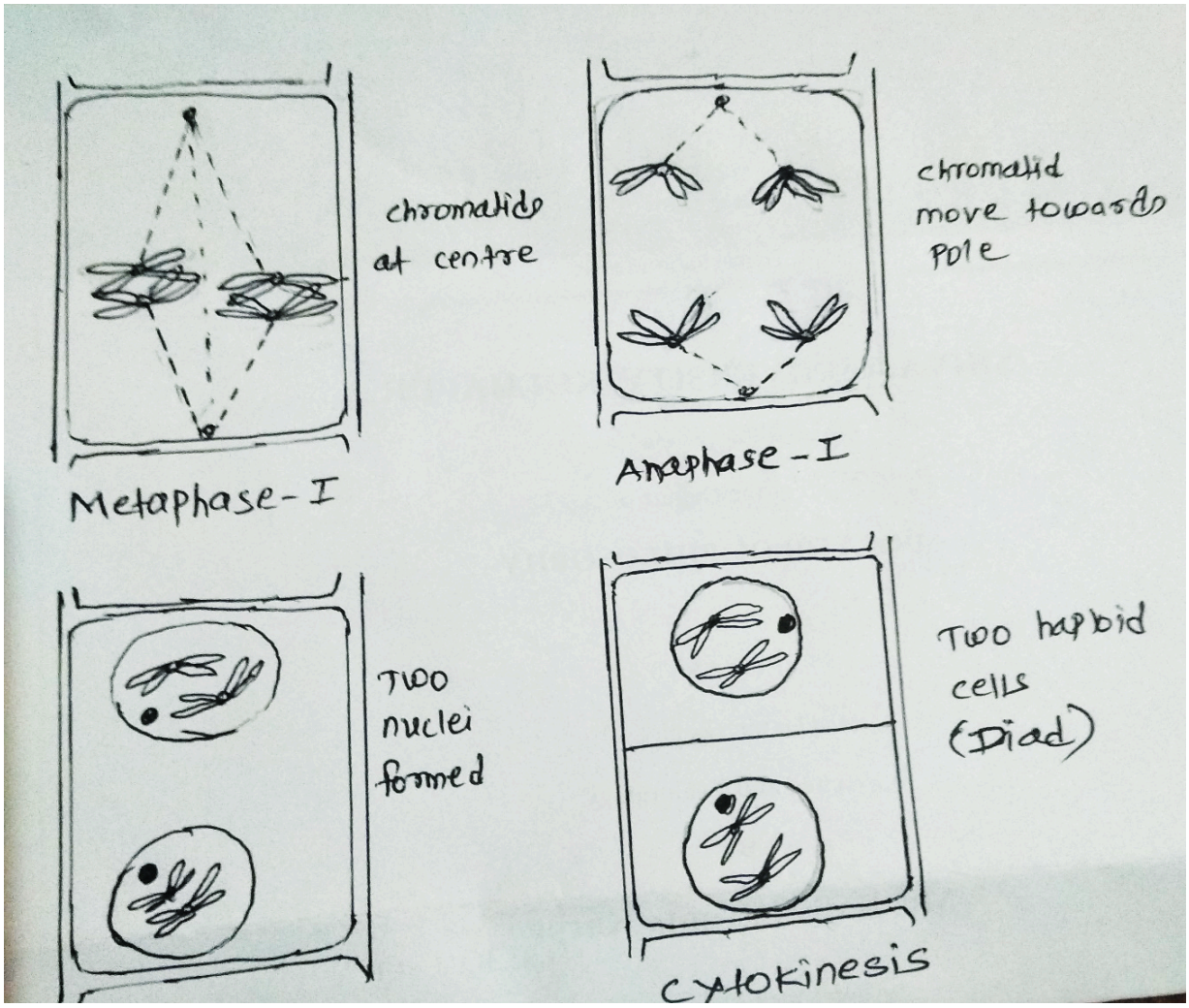
During this phase the homologous chromosomes in each bivalent move towards the opposite poles and as a result the number of chromosomes at each of the two poles of a cell is reduced to exactly half(n) of the original number in the cell i.e. diploid chromosome number (2n). Thus, at the end of anaphase-I, the chromosomes present in the mother cell get separated into two identical groups, each group with half number of the original number in the cell.

d) Telophase-I:-

During this phase the chromosome persist for some time in the condensed state. The nucleolus and nuclear membrane reappear around each group of chromatids, leads to two separate nuclei. The spindle fibres do not disappear completely.

c) Interphase: -

The interphase occurs for short duration. There is no synthesis of DNA. The chromosomes do not uncoil as they already have at the end of telophase.



B) Meiosis-II:-

The meiosis II is similar to mitosis. The DNA does not duplicate,the two daughter nuclei pass through four stages namely i) Prophase:II, ii) Metaphase;II, iii) Anaphase-II, and iv) Telophase-II. This is similar to mitosis therefore this stage is called meiotic mitosis.

i)Prophase-II:-

During prophase II there is no coiling between sister chromatids. The chromosomes are much condensed so they appear more thick. At the end of this stage nucleolus and nuclear envelope disappear and there is spindle apparatus formation.

ii) Metaphase-II:

The two sister chromatids of each chromosome distinctly get separated from each other due to repulsion force between them but remain attached at the centromere. The chromosomes are move towards equatorial plane. The spindle fibre attached to centromere. The chromosomes become more thicker and shorter.

iii) Anaphase-II:

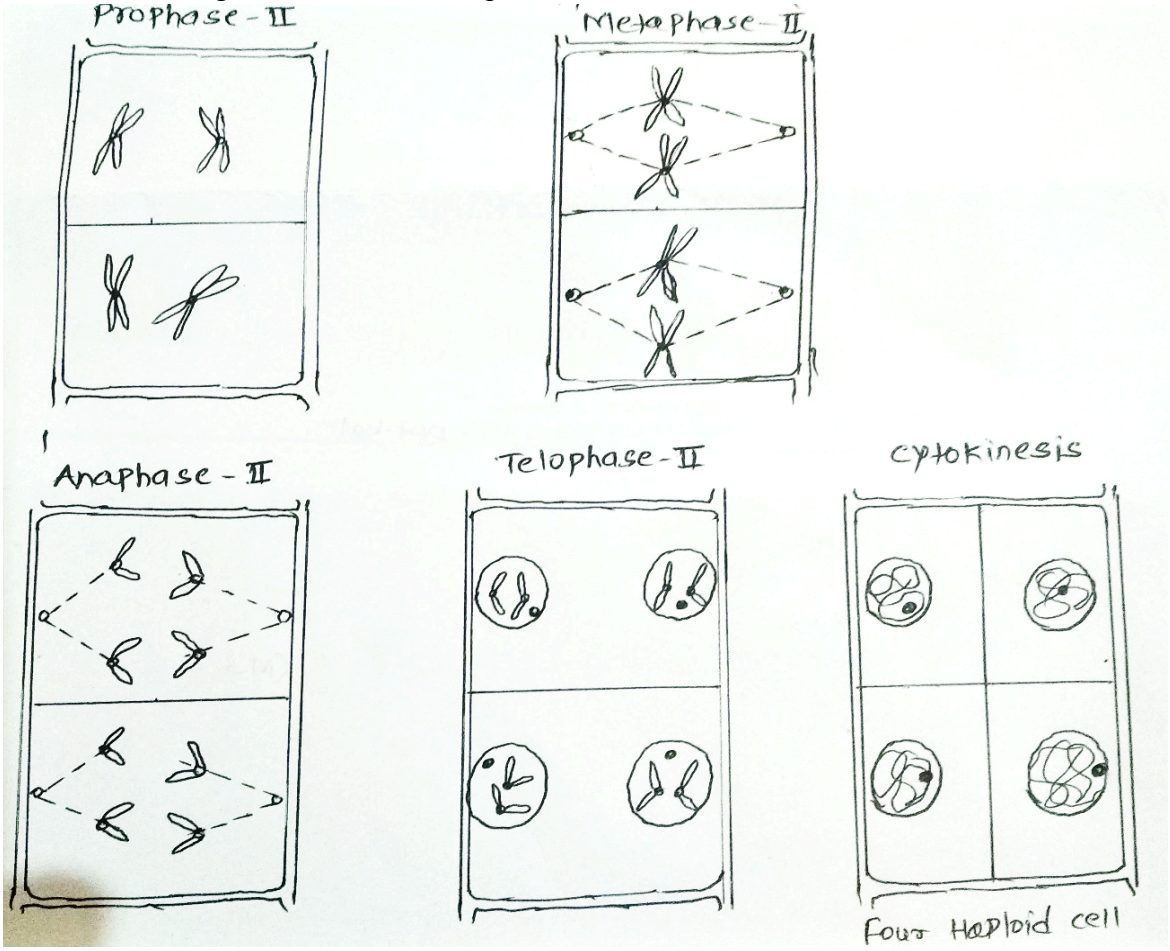
During this stage the two sister chromatids of each chromosome move away from each other to opposite poles, as the centromere region splits longitudinally into two halves. Therefore, chromosomes with only half centromere moves to the pole.

iv) Telophase-II:-

This stage begins as the sister chromatids of chromosomes reach to opposite poles. As the chromatids reaching the pole, the chromatids get uncoiled so that appear like a ball of knitting threads. The nuclear envelope is organized around chromosomes and the nucleolus reappear.

V) Cytokinesis: -

At the end of telophase II, the cytoplasm of each of the two cells of dyad divides into two and as a result one parent cell produces four haploid daughter cells after completion of the two meiotic divisions. Thus four daughter cells inside the parent cell wall form the structure called tetrad.



Significance of Meiosis:

1. Meiosis maintain the constant and definite number of chromosomes in the organisms. Thus, the diploid chromosome number remain constant from one generation to next generation in the system produced by sexual reproduction. Therefore, the sexual reproduction in plants and animals became possible only due to meiosis.
2. Due to crossing over the exchange of gene and thus causes genetical variations essential for evolution among the species.
3. Meiosis provides the basic material i.e variation for evolution.
4. The crossing over results in formation of combination of chromosomes and ultimately different combination of characters in all the daughter cells.

5. Parental characters are reshuffled due to which every gamete developing from the daughter cell shows a distinct set of characters.