MEIOSIS CEE DIVISION

WELLCOME TO ALL OF YOU

Dr Kailash Ram
Assistant Prof.- Ag Botany
Govt. Degree College, Jakhini, Varanasi (PU)

MEIOSIS DIVISION

- The term meiosis was coined by Former and Moore in 1905.
- 'Two successive spindle using nuclear division which reduces the chromosome number from diploid (2n) to haploid (n)'. It is called meiosis division, it is also known as heterotypic division, reduction division or segregational division.
- In general, meiosis take place during gamete formation and hence, it confined to reproductive cells only or reproductive organs.

SIGNIFICANCE OF MEIOSIS: Gametes contain only half (n) of the somatic chromosome number (2n). Therefore, union between one male and one female gamete during fertilization restores the chromosome number to the diploid(2n) state. This the chromosome number of a species remain constant one generation to next generation produced by sexual reproduction. Clearly, the sexual reproduction in plant and animal become possible only due to the evolution of meiotic cell division, in the absence of meiotic cell division, chromosome of a species would be double in every generation due to the fusion of male and female gametes. The various function of meiosis may be as follows:

- Production of haploid (n) gamete so that fertilization restores the normal somatic (2n) chromosome number.
- Segregation of two alleles of a gene due to pairing between the two homologues of each chromosome and their segregation at the first anaphase, since the two alleles of a gene are located in the two homologues of the same chromosome.
- Independent segregation of the alleles of different genes located in separate chromosomes due to independent orientation of different bivalents at the first metaphase.
- Recombination between linked genes due to crossing over during pachytene stage.
- Generation of genetic variation through segregation, independent assortment and recombination

STAGES OF MEIOSIS: During meiotic division, the nucleus of each cell undergo two successive division refers to as first meiotic division and second meiotic division.

PREMEIOTIC **INTERPHASE:**

- The events take place during premeiotic interphase are crucial for the entry of cells into meiotic division.
- The S phase of premeiotic interphase is longer duration than mitotic interphase in same species. Chromosome replication take place, but 0.3 % of total DNA does not replicate during this phase which replicate during zygotene of prophase I.
- The special type of histone is synthesized during S phase. It may be essential to the entry of cells into meiosis.
- During G phase of premeiotic interphase, some substances are synthesized which are also essential for entry of cell into meiosis, but these substances is not yet definitely known.
- During meiosis, although the nucleus divides twice, S phase occurs only one during premeiotic interphase. Thus during meiosis, chromosome replicate only once, while the nucleus divide twice.

FIRST MEIOTIC DIVISION

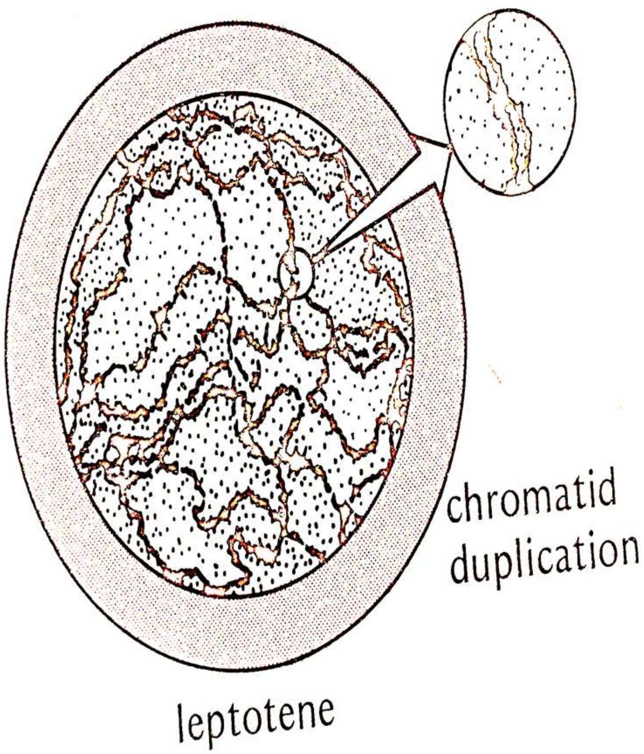
The significant events are takes place during first meiotic division such as

- pairing between homologous chromosome,
- crossing over between homologous chromosome,
- segregation of homologous chromosome and their migration to the opposite poles.
- As a result, the two daughter nuclei produce by this division, receive only half of the chromosomes, is referred to as reduction division.
- There are four substages of first meiotic division:

PROPHASE-I:

1. LEPTOTENE:

- Nucleus increase in volume.
- Chromosome become visible as fine thread due to chromosome condensation and look like a loose ball of knitting wool.
- Each chromosome consists of two chromatids since the chromosome are already replicated during premeiotic interphase.
- There is RNA synthesis from which nucleolus increase in volume.
- RNA and protein synthesis continue during this stage. Protein synthesis required for chromosome condensation.



2. ZYGOTENE:

- Pairing (synapsis) between homologous chromosome begins in this stage, and it end when pairing is complete.
- Remaining 0.3% DNA replication is complete which does not replicate during S phase of premeiotic interphase.
- Some specific nuclear proteins are synthesized also.
- Progressive condensation of chromosomes. Pairing may be begin as follows:

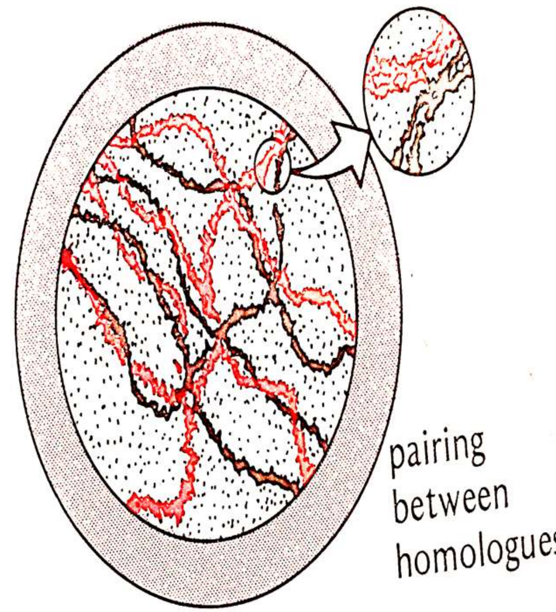
PROTERMINAL OR CENTROMERIC REGION: It may begin at the centromere and progress towards the telomeres.

PROCENTRIC OR BOTH END: It begin at both ends of homologous pair and proceed towards the centre.

INTERMEDIATE OR SEVERAL POINT: It may begin simultaneously at several places.

- Development of synaptonemal complex. As a rule, chromosome pairing occurs in two stages:

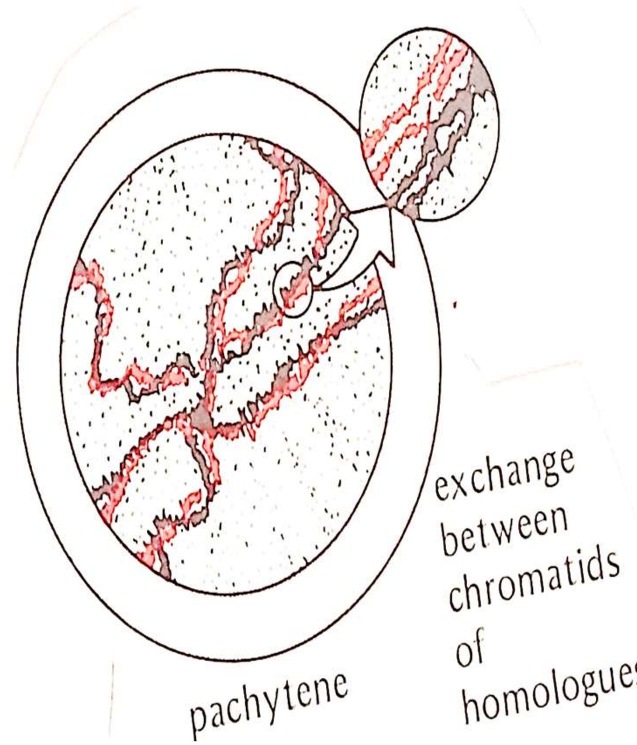
- ❖ 1. Homologous chromosomes move close to each other and stay about 1000 A away from each other.
- ❖ 2. Synaptonemal complex develops in this 1000 A region between homologous chromosome.
- ❖ Synaptonemal complex is composed of protein and its consists of three distinct elements: (i) a relatively dense central elements (ii) two dense lateral elements (iii) two less dense transverse elements.
- ❖ The function of synaptonemal complex is controversial. It has been suggested that synaptonemal complex is essential for crossing over.
- ❖ In male drosophila, synaptonemal complex is absent and there is no recombination between linked genes either.
- ❖ In some cases, synaptonemal complex is found between non homologous chromosomes as well.



zygotene

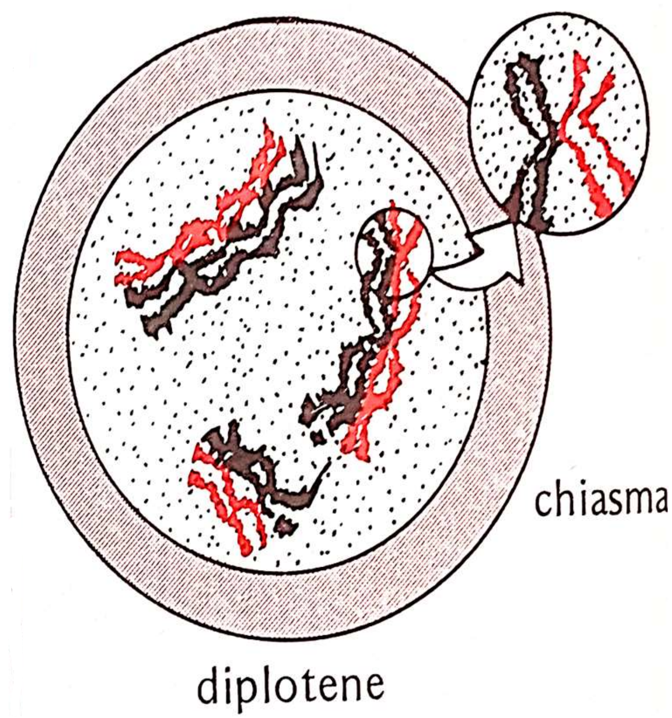
3.PACHYTENE:

- Chromosome become shorter and thicker due t further condensation in the chromosomes.
- Chromosome number is only half of the somatic chromosome number due to synapsis of homologous chromosome. The haploid (n) number of chromosome pair is referred to as bivalent in most species. Since, each of the two chromosomes of a bivalents consists of two sister chromatids, each bivalent has four chromatids , therefore bivalents are said to be in the four strand or tetrad stage.
- Chromosomes are easily recognised during this stage, e.g., in maize.
- The nucleolus is distinct and quite large, it is associated with the nuclear organiser region od set chromosome pair.
- Crossing over between homologous chromosomes takes place during this stage.
- Synaptonemal complex is believed to play a crucial role in crossing over.



4. DIPLOTENE:

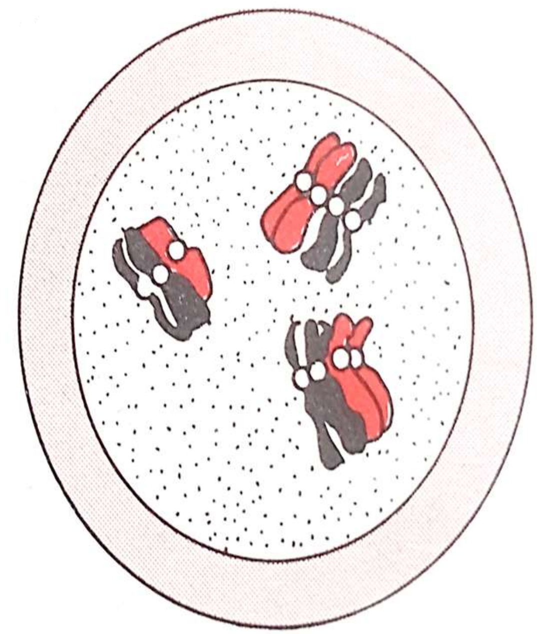
- Homologous chromosomes of each bivalent begin to move always from each other, this marks the beginning of this stage, and each bivalents become clearly visible.
- Two homologues of each bivalent attached with each other at one or more points, are called chiasma. It is believed that initially chiasma are located at the points of actual crossing over between homologous chromosomes.
- Chiasma slowly move towards the ends of the homologous chromosomes, this movement is referred to as chiasma terminalization.
- There is a further condensation of chromosome, so that they become shorter and thicker.



5. DIAKINESIS:

- After completion of chiasma terminalization, two homologous chromosome of each bivalent are now attached at or close to one or both the telomeres only.
- Chromosome become shorter and thicker due to further condensation of chromosome.
- At the end of diakinesis, bivalents move away from each other towards the periphery of the cells.
- Nuclear membrane and nucleolus disappear. Nuclear membrane elements become a parts of endoplasmic reticulum, while nucleolus elements become a parts of chromosomes.
- Spindle apparatus is organised. The bivalent, now migrate to the equatorial plate.
- Bivalents may be:

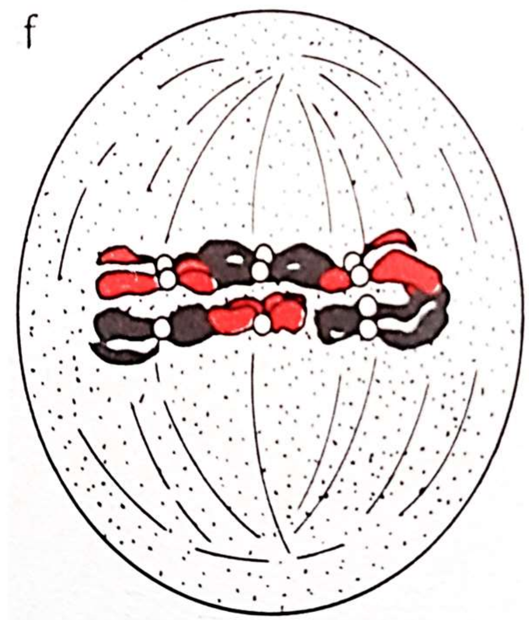
1. CLOSE RING BIVALENTS: They are generally produced by metacentric and sub metacentric chromosome, when chiasma is formed in both the arms of the homologous chromosome.
2. AN OPEN RING BIVALENTS: When chiasma is formed in only one of the two arms of metacentric and sub metacentric chromosome.
3. ROD SHAPED BIVALENTS: They are develop in acrocentric and telocentric chromosomes due to the formation of chiasma in their long arms only.



diakinesis

METAPHASE-I

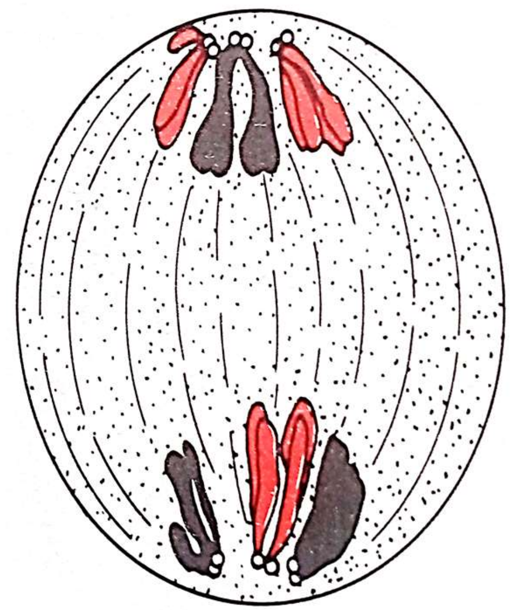
- Nuclear membrane and nucleolus disappear.
- Spindle apparatus is organised.
- All the bivalents within a cell migrate to the equatorial plate
- Bivalents arranged at metaphase plate.
- Centromeres of two homologues of each bivalent lies on the either side of the equatorial plate.
- Both the arms of bivalents are extends toward the opposite poles.
- Centromere of homologous chromosomes are attached to the spindle fibres.
- The centromere of each chromosome is structurally divided into two, but these two parts behave functionally as a single centromere



metaphase I

ANAPHASE-I

- Two homologous chromosomes of each bivalents begin separate to each other and migrate to opposite poles.
- One chromosome from each bivalent begin to migrate to one pole, while the other migrates to the opposite pole.
- At the end of anaphase-I, one chromosome from each of the bivalents gather about one pole, while the second chromosome from each of the bivalents aggregate about the opposite pole.
- As a result, chromosome number at each of the two pole is exactly (2n) of the somatic chromosome number (2n), and each pole received one homologue from each of the bivalents present in a cell.



anaphase I

TELOPHASE-I

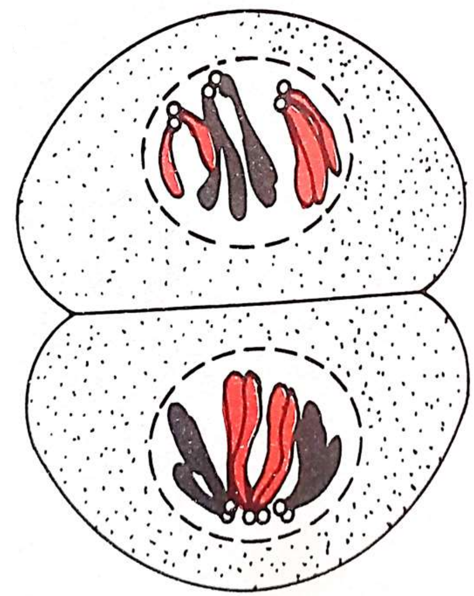
- The chromosome uncoiled only partially.
- Nuclear envelope become organised around the two groups of chromosomes.
- Nucleolus also reappears.
- In some species like Trillium, cells enter directly into the telophase-I and interphase.

CYTOKINESIS:

- In many species (e.g., maize), cytoplasm of each cell divide into two halve and give rise to two single haploid nucleus. This two celled structure is known as dyad.

INTERPHASE:

- In many species, interphase is absent after the end of first meiotic division
- But in some species, its occurs, it is very short in duration.
- It is important to note that there is no DNA synthesis during this interphase.



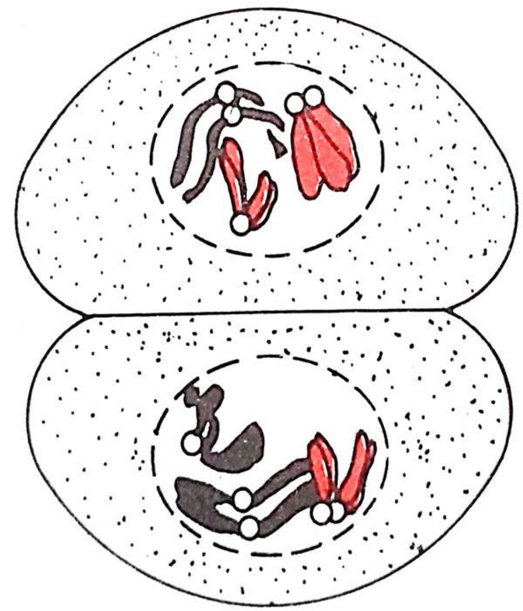
telophase I

SECOND MEIOTIC DIVISION

- In this case, cells are divided perpendicular to that of the first one. The two sister chromatids of each chromosome separate and migrate to the opposite poles.
- As a result, the number of chromosomes in each of the two haploid nuclei remain the same at the end of this division, it is referred to as equational division.
- Second meiotic division are similar process of mitosis division. Second meiotic division is also divided into four stages.

PROPHASE-II

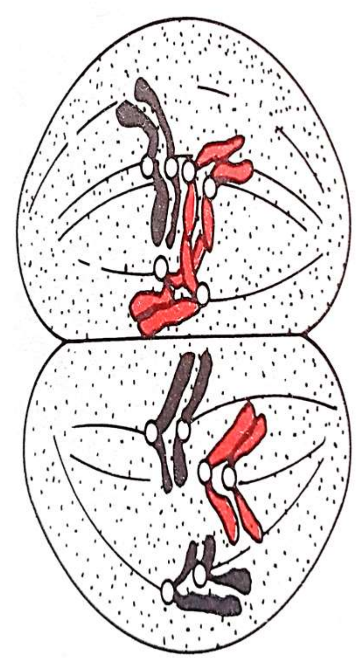
- There is no relational coiling between sister chromatids.
- The two sister chromatids of each chromosome are clearly visible.
- The chromosomes are relatively much more condenced, hence they appear shorter and thicker than in mitosis in same species.
- There is further condensation of chromosome, so that they become shorter and thicker.
- At the end of this stage, nuclear envelope and nucleolus disappear and spindle fibre is organised.



prophase II

METAPHASE-II

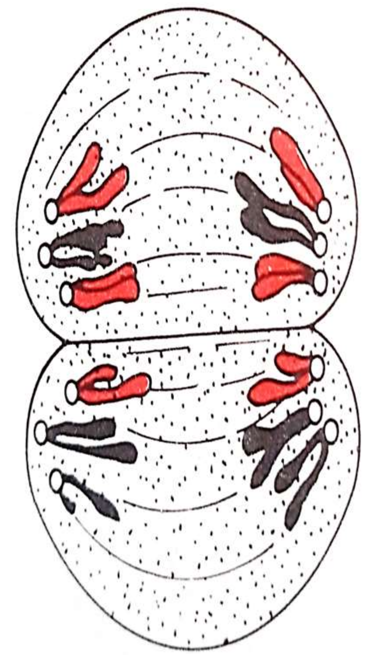
- Nuclear enveloped and nucleolus is absent and spindle fibre is present.
- Centromeres of all the chromosomes are arranged in a single plane at the equatorial plate.
- The two sister chromatids of each chromosome are distinctly separated from each other due to repulsion between them, but they remain attached at the centromeres.
- Chromosome become more condensed, shorter and thicker.



metaphase II

ANAPHASE-II

- Centromeres of chromosomes observably divide longitudinally, and the two sister chromatids of each chromosome begin to separate and move away to the opposite poles.
- This stage come to an end when sister chromatids of the chromosomes reach the opposite poles
- It may pointed out that the centromere of each chromosome is structurally divided into two during the first meiotic division itself. However the centromeres of the two sister chromatids of each chromosome become functional and divide visibly only during anaphase-II



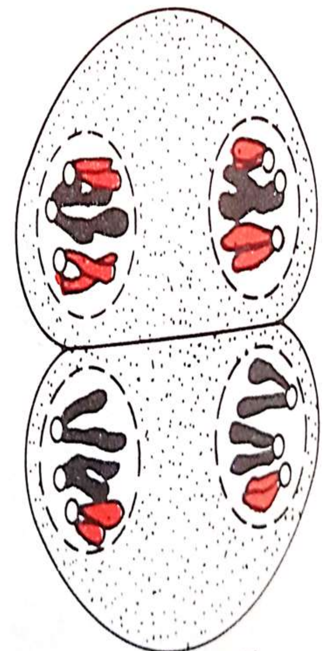
anaphase II

TELOPHASE-II

- Sister chromatids of chromosomes reach the opposite poles.
- The chromatids uncoiled so that they assume the appearance of a loose ball of thread.
- Nuclear enveloped is reorganised from the element of endoplasmic reticulum.
- Nucleolus reappears from the element of chromosomes.

CYTOKINESIS:

- The cytoplasm of each of the two cells of a dyad divide into two parts. As aresult, one parent cell produces four haploid daughter cells after completion of the two meiotic division, and are known as tetrad.
- The four haploid cell produced by meiotic division of the single cell may differentiate into gametes (in animals) or spores (plants). The spores ordinarily give rise to the gametophytic generation (the generation which produces gametes through mitosis) which may independent in lower plants and totally dependent in higher plants on the diploid sporophytic stage (the generation which give rise to the spores (meiosis). In plants, gametes are generally produced through mitosis in the gametophyte.



telophase II