PUC 1ST YEAR –SEMESTER-2

UNIT III: Cell cycle and cell division

Module No. 17: MEIOSIS and its significance

INTRODUCTION OF MEIOSIS

Meiosis is a specialized type of cell division which occurs in the reproductive cells at the time of gamete formation. As a result of meiosis four daughter cells are formed from the parent cell and the number of chromosomes in the daughter cells is reduced to half.

Meiosis includes two successive divisions, the **meiosis I(**reduction division**)** and the **meiosis II (**similar to mitotic division**).** Each division is separated into the same five stages as in mitosis.

Meiosis I	**Meiosis II**
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

MEIOSIS I

Prophase I

It is the most complicated stage of meiosis. It is of very long duration. The prophase I is divided on the basis of chromosomal behaviour into 5 substages namely Leptotene, zygotene, Pachytene, Diplotene and Diakinesis.

Leptotene:

In leptotene stage nucleus is enlarged. The chromosomes appear as long,fine, uncoiled threads by the condensation of chromatin material. Chromosomes present beaded appearance due to the presence of chromomeres at regular intervals. Chromatids are not distinguishable. The centriole of the cell divides.

Zygotene:

During this stage the homologous chromosomes of each pair are attracted towards one another and undergo pairing. This is called synapsis. Each pair of homologous chromosomes is known as bivalent. The synapsis is equal, exact and occurs from chromomere to chromomere.

Centrioles move apart initiating the spinalle formation.

Pachytene:

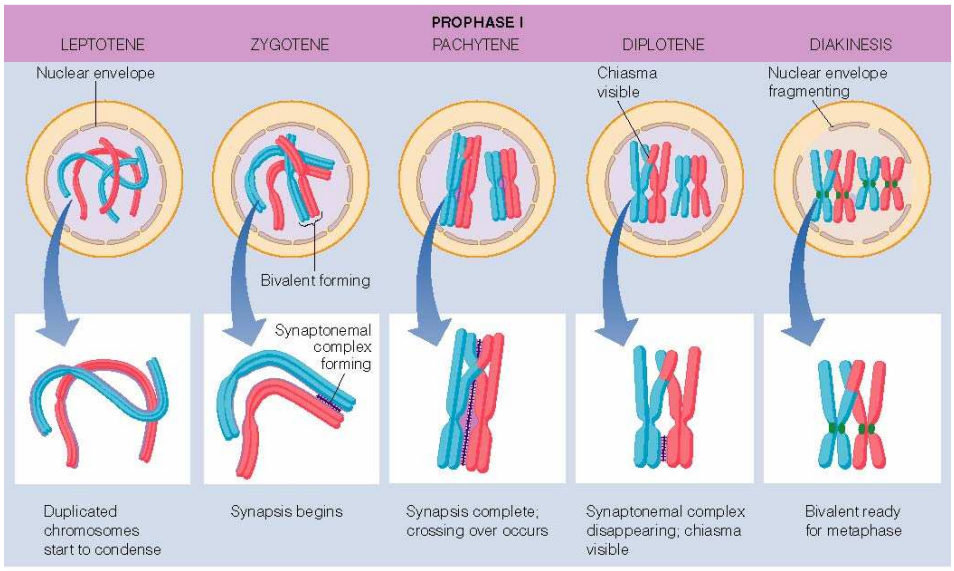
In each bivalent chromosome four chromatids appear more clearly than earlier. It is called tetrad. The two chromatids of same chromosome are called sister chromatids and those of different chromosomes called non-sister chromatids. An important event that occurs in the pachytene is crossing over, It occurs between the non sister chromotids of two homologous chromosomes. Crossing over is the exchange of genetic material between two homologous chromosomes. The point of interchange and rejoining appears x-shaped and is known as chiasma. There maybe one , two or more chiasmata in a tetrad. Crossing over leads to recombination of genetic material on the two chromosomes.

Diplotene:

At diplotene, further thickening and shortening of chromosomes take place. Homologous chromosomes start separating from one another. This separation starts at centromeres and travels along towards the ends. This kind of separation from centromere towards the end is known as " terminalization".

Diakinesis:

Terminalization is completed, chromosomes undergo complete separation. Each chromosome looks like a short, darkly stained body. By the end of diakinesis, the nucleolus disappears and the nuclear membrane disappears.



Metaphase - I:

During metaphase-I spindle is formed between the two centrioles and the chromosomes are arranged on the equator of the spindle. Their

centromeres are attached to the chromosomal fibres of the spindle. The centromeres of the chromosomes will be facing towards the poles.

Anaphase - I:

During this stage the chromosomal spindle fibres pull the chromosomes towards the opposite poles. The centromeres of homologous chromosomes donot divide. So half the number of chromosomes will migrate to the poles and actual reduction of chromosomes taking place at this stage.

Telophase I:

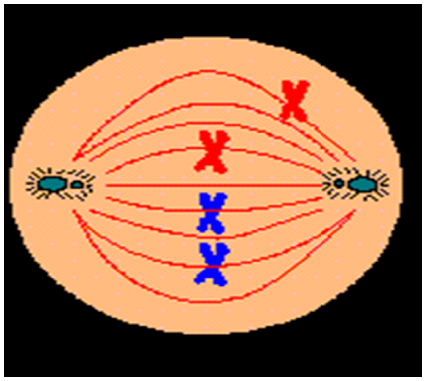
During this stage, nuclear membranes are formed around the groups of chromosomes at the two poles. The chromosomes become uncoiled and lose their identity. Nucleolus reappear. The karyokinesis may be followed by cytokinesis giving rise to two haploid cells.

MEIOSIS II

First meiotic division is followed by a second meiotic division with or without the intervening interphase. The second division is essentially a mitotic division. The various events occur in mitosis also occur here in meiosis-II with regards to chromosomes, nucleolus, cytoplasm etc. At prophase-II chromosomes are already double , each having two sister chromotids, with a single functional centromere. These chromosomes soon arrange at equator of the spindle during metaphase-II. The centromere then splits and two chromatids, which may now be called chromosomes, pass to two poles during anaphase-II . This is soon followed by telephase-II and cytokinesis. At the end of cytokinesis four

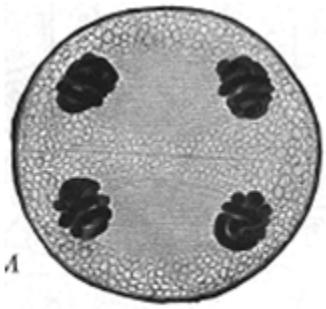
daughter cells are formed each of which will be having haploid number of chromosomes. Since the process mitosis has already been discussed in Module 16, the same will not be repeated here.

Prophase -II



Meiotic metaphase II

Anaphase-II



Telophase-II

cytokinesis

SIGNIFICANCE OF MEIOSIS

- Meiosis is the mechanism by which conservation of specific chromosome number of each species is maintained across the generations. This is possible because during meiosis the chromosomal number is reduced to half in gamets. When these gametes fuse and form zygote, again the diploid number is attained.
- Purpose of meiosis is to form haploid cells from diploid cells.
- Meiosis provides opportunities for new combinations of genes to occur in the gametes. This leads to genetic variation in the offspring produced by random fusion of the gametes.
- Maternal and paternal chromosomes independently assort, producing a large number of possible combinations.

- New species are evolved due to crossing over and genetic recombination.

Check points

1. Meiosis is a process where the number of chromosomes in the cell is reduced exactly to the half. It occurs in diploid cells to form haploid gametes during sexual reproduction.
2. Meiosis occurs in two successive stages. which are divided arbitrary for clear understanding but the events happens continuously in nature.
3. In meiosis I, the stages are referred to as prophase I, Metaphase I, anaphase I and Telophase I.
4. The prophase in again identified with four substages as Leptotene, Pachytene, Diplotene and Diakinesis. Homologous chromosomes one from each parent are aligned very closely to each other in leptotene.
5. In Pachytene, the homologous chromosomes are paired to form bivalents with four chromatids in each pair. Exchange of genetic materials takes place by crossing over of chromatids through chiasmata formation.
6. In diplotene, the separation of bivalent starts and the condensation, contraction and thickening of chromosomes occurs.
7. By the end of diakinesis, the nucleolus disappears and the nuclear envelope also breaks down and releases chromosomes into cytoplasm. The chaismata terminalizes.
8. In metaphase I, the chromosomes align in equatorial plane in pairs. The migration of chromosomes takes place in anaphase I.

9. In telophase I, the chromosomes with two groups enter the interphase stage or initiate the second division that is similar to the mitosis.
10. All the cells are haploid and have same number of chromosomes at the end of meiosis.
11. Each cell has different genetic makeup due to exchange of genetic material during this process.

QUESTIONS:

Short answer questions

1) What is Meiosis? Explain the Significance.
2) What are the different stages in meiosis?
3) What are the events in leptotene?
4) What happens during zygotene?
5) Write about pachytene and mention its significance?
6) What is the significance of diplotene and diakinesis?
7) Define (a) Synapsis (b) Chiasmata.
8) What is the main difference between mitosis and meiosis?

Long answer questions

1) Explain meiosis I in detail. What is its significance?
2) Compare mitosis and meiosis.

Multiple choice questions

1. Which statement best describes the process of crossing-over?
   A. It takes place between homologous chromosomes and results in an increased gene mutation rate.
   B. It takes place between non homologous chromosomes and results in new gene combinations.
   C. **It takes place between homologous chromosomes and results in new gene combinations**.
   D. It takes place between non homologous chromosomes results in an increased gene mutation rate.
   2. Crossing over occurs during which phase of meiosis.
   A. Prophase I
   B. Prophase II
   C. Metaphase I
   D. Metaphase II
   E. Cytokinesis

3. During what process do eukaryotic cells become haploid?
   A. S phase
   B. Anaphase of mitosis
   C. Meiosis I
   D. Meiosis II

4. Which of the following statements regarding meiosis is false?

   A. In meiosis I, whole chromosomes separate.
   B. Exchange of paternal and maternal DNA takes place in meiosis I.

C. Anaphase II leads to chromosome separation into 4 haploid cells.

D. The chromosomes replicate and number doubles.

5. Which event(s) create the most critical difference between mitosis and meiosis?

   A. Separation of sister chromatids

   B. Formation of bivalents and crossing over

   C. Replication of chromosomes and connection to the spindle

   D. Formation of the spindle

6. During which phase of meiosis the homologous chromosomes are separated

   A. Metaphase I

   B. Metaphase II

   C. Anaphase I

   D. Anaphase II

7. Which meiotic division more closely resembles mitosis

   A. Meiosis I

   B. Meiosis II

   C. Meiosis I and II, both resemble mitosis closely.

   D. Meiosis I and II, both are significantly different from mitosis.

8. Arrange the stages of meiotic prophase I below in order.

   A. **Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis**

   B. Leptotene, Pachytene, Zygotene, Diplotene, Diakinesis

   C. Zygotene, Diplotene, Diakinesis, Pachytene, Leptotene

   D. Leptotene, Zygotene, Pachytene, Diakinesis, Diplotene

9. How many daughter cells are formed from single cell in meiosis?

   A. 4

   B. 2

   C. 23

   D. 46

10. Which of the following is not a correct description of meiosis?

   A. It is a part of sexual reproduction.

   B. Cells at the start and end are identical.

   C. Four cells are formed.

   D. Cells at the start and end are different.