MODULE 3

AIM

The aim of this module is to provide students with an introduction to meiosis.

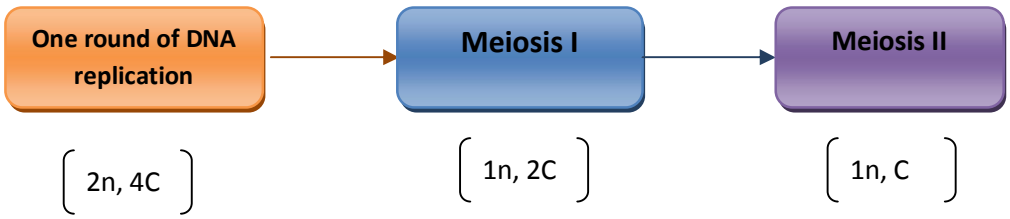
CONTENTS AND OBJECTIVES

- Introduction to meiosis
- Meiosis I
- Meiosis II
- Significance of meiosis
- How is meiosis different from mitosis

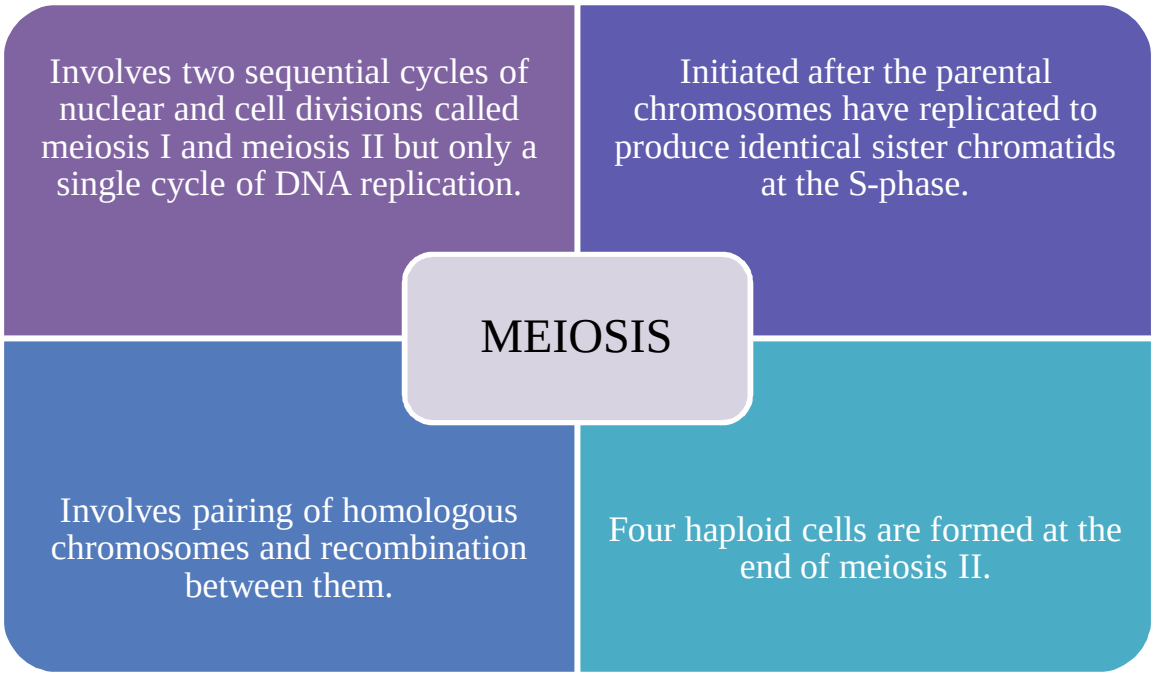
Meiosis

INTRODUCTION

- The type of cell division which reduces the chromosome number by half resulting in the production of haploid daughter cells during sexual reproduction is known as meiosis.
- In animals these daughter cells are called as gametes. However, sexually reproducing plants have an alternation of haploid and diploid generations. A haploid generation called ovule in females is produced by meiosis in flowering plants. The ovule then undergoes mitosis to produce female gamete ready for fertilization.
- The haploid daughter cells thus formed are genetically different from the parental cell.
- During meiosis, a diploid cell (having two sets of chromosomes called homologous pairs) divides twice to produce 4 haploid daughter cells (each having single set of chromosomes).
- During the process the homologous chromosome pairs separate.
- The gametes produced as a result of meiosis are eggs (in females) and sperm (in males).
- During reproduction, once the egg and sperm have united to form a zygote, the number of chromosomes is restored.
- In meiosis, there is only one round of DNA replication and two rounds of nuclear divisions (**meiosis I** and **meiosis II**).



- Meiosis I is unique to germ cells while meiosis II is identical to mitosis.
- Both meiosis I and meiosis II have several phases.
- The interphase of meiosis is similar to interphase of mitosis.
- Meiosis is not seen in bacteria because they reproduce asexually.



MEIOSIS I

- During meiosis I separation of homologous chromosomes occurs resulting in two haploid cells (n chromosomes and 2C DNA).
- It is also referred to as **reductional division.**
- Meiosis I is completed in following phases:

1. **Prophase 1**

   This is the longest phase of meiosis. During this the homologous chromosomes pair and exchange parts of chromosomes (crossing over). Crossing over is an important source of genetic variations and forms new combinations of alleles.

   It is a comparatively longer phase and characterized by many events as mentioned below:

   Leptotene- During this stage the chromosomes in the nucleus become visible under the light microscope. This phase lasts for a shorter duration and is characterized by continuous coiling and condensation of chromatin fibres.

   Zygotene- Pairing (or synapsis) of homologous chromosomes becomes visible during this stage. Synapsis is facilitated by the formation of a structure called **synaptonemal complex.** The paired chromosomes are referred to as **tetrads/bivalents.** Each bivalent has two chromosomes and four chromatids.

Pachytene- The tetrad is clearly visible with four chromatids at this stage. Crossing over between the occur and genetic information between the two homologous chromosomes is shared.

Diplotene- At this stage the synaptonemal complex dissolves and the homologous chromosomes separate from each other. However they remained connected at the sites of crossovers. This gives rise to an X-shaped structure known as **chiasmata.**

Diakinesis- The chiasmata is terminalised during this stage. By the end of diakinesis, the nuclear membrane breaks down and the nucleolus disappears.

2. **Metaphase I**

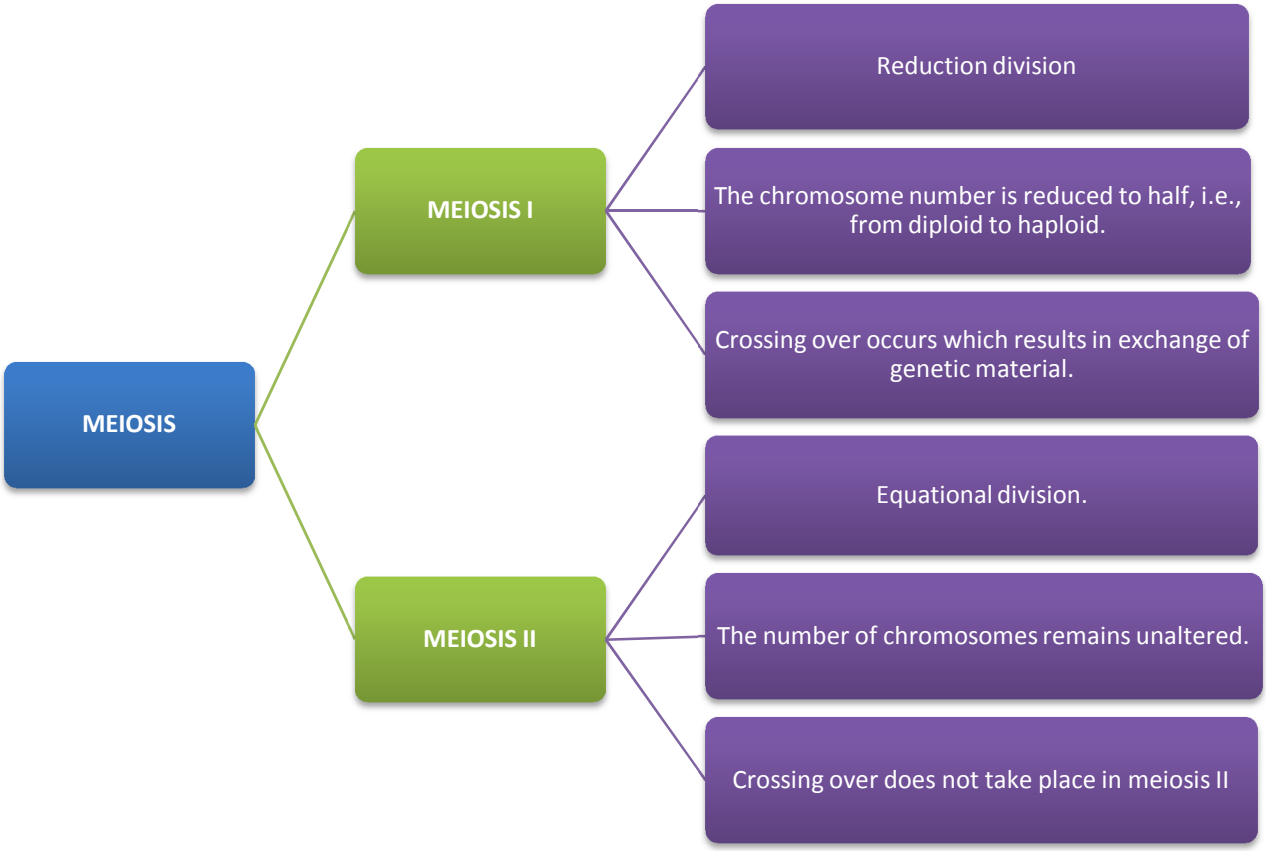
   Homologous chromosomes align at the metaphase plate at this stage. The microtubules from the opposite poles of the spindle attach to the pair of homologous choromosomes.

3. **Anaphase I**

   At this stage, the homologous chromosomes move apart towards the opposite poles. Sister chromatids remain attached at their centromeres.

4. **Telophase I**

   The nuclear membrane and nucleolus start appear again. Each daughter has exactly half the number of chromosomes but each chromosome has a pair of chromatids. The chromosomes unfold back into chromatin. This is followed by cytokinesis.



MEIOSIS II

- The second meiotic division (meiosis II) is also known as equational division.
- Meiosis II is identical to mitosis.
- There is no reduction in the chromosome number except in meiosis II four haploid daughter cells are produced.

Prophase II- Immediately after cytokinesis there is disappearance of nuclear membrane and nucleolus at prophase II. At this stage the chromosome becomes compact again.

Metaphase II- The chromosomes align at the equator and the microtubules from opposite poles of the spindle get attached to the kinetochores of sister chromatids.

Anaphase II- At this stage, the sister chromatids which are attached at the centromere get separated and move towards the opposite poles.

Telophase II- It is the last stage of meiosis. This stage is marked by decondensation and lengthening of the chromosomes and the disassembly of the spindle.

Significance Of Meiosis

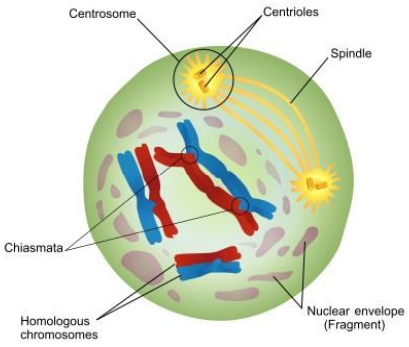
1. It ensures the same chromosome number (n) in the all the sexually reproducing organisms.
2. It helps to restrict the number of chromosomes and maintains stability of the species.
3. Crossing over which occurs between the homologous chromosomes during meiosis is a significant source of genetic variations among the offspring.
4. All four sister chromatids of homologous chromosomes segregate and go to four different daughter cells. This makes the four daughter cells genetically different.

How Is Meiosis Different From Mitosis

S.No.	Mitosis	Meiosis
1	Mitosis occurs in both sexually as well as asexually reproducing organisms.	Meiosis occurs in only sexually reproducing organisms.
2	Mitosis takes place in the somatic cells of the body.	Meiosis takes place in the germ cells.
3	During mitosis, the cell undergoes only one nuclear division.	During meiosis, the cell undergoes two nuclear divisions.
4	DNA replication takes place at interphase I.	DNA replication takes place at interphase I but not at interphase II.
5	Prophase is comparatively simple.	Prophase is little comparatively simple and is divided into further subphases.
6	Synapsis does not occur in mitosis.	Synapsis of homologous chromosomes occur at prophase.
7	Crossing over between sister chromatids of homologous chromosomes does not occur during mitosis.	Crossing over occurs between sister chromatids of homologous chromosomes.

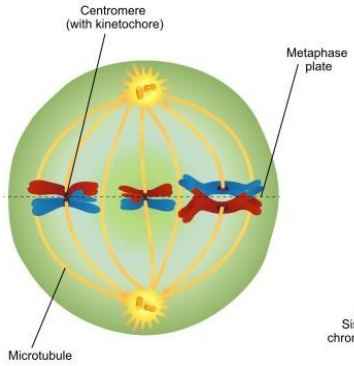
MEIOSIS I

Prophase I



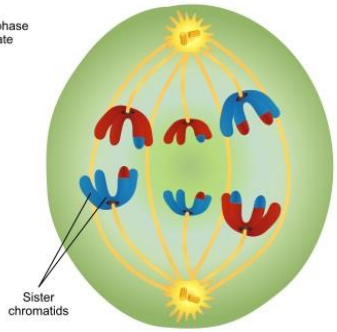
The chromosomes condense, and the nuclear envelope breaks down. Crossing-over occurs.

Metaphase I



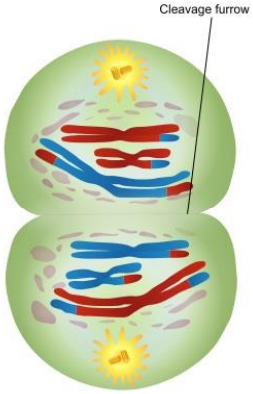
Pairs of homologous chromosomes move to the equator of the cell.

Anaphase I



Homologous chromosomes move to the opposite poles of the cell.

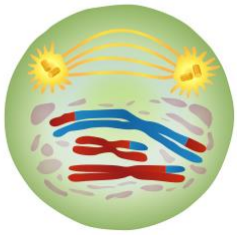
Telophase I & cytokinesis



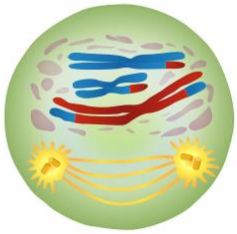
Chromosomes gather at the poles of the cells. The cytoplasm divides.

MEIOSIS II

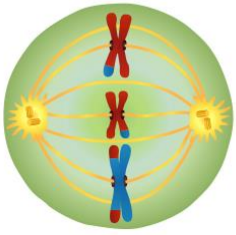
Prophase II



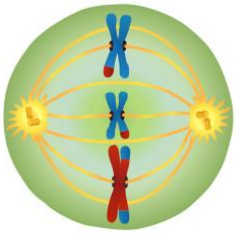
A new spidle forms around the chromosomes.



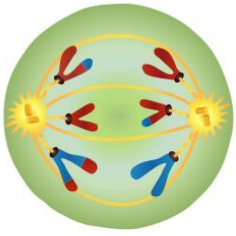
Metaphase II



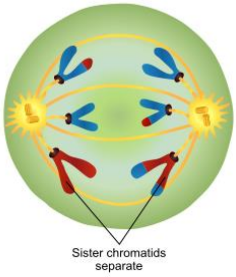
Metaphase II chromosomes line up at the equator.



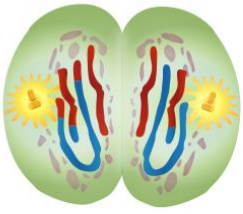
Anaphase II



Centromeres divide. Chromatids move to the opposite poles of the cells.



Telophase II & cytokinesis



A nuclear envelope forms around each set of chromosomes. The cytoplasm divides.