# Meiosis

The meiosis is a process of cell division by which the chromosomes are reduced from the diploid to the haploid number. It takes place in all sexually reproducing organisms. Haploid sex cells are produced from the diploid cells in meiosis.

**'Meiosis' consists of two successive divisions of the diploid mother nucleus, that are:**
(i) meiosis division I in which the diploid chromosome number (2n) is reduced to haploid chromosome number n, and

(ii) meiosis division II which is a mitotic division.

**Meiosis Division I:**
In this division the chromosomes are reduced to half, and therefore this is a reduction division.

**Meiosis division I is divisible into four major stages (Prophase I, metaphase I, anaphase I and telophase I) which are briefly discussed below:**
**1. Prophase I:**
This is a complicated and prolonged phase of meiosis which can be subdivided further into five sub-stages, i.e., leptotene, zygotene, pachytene, diplotene and diakinesis.

**The important features of all these five sub-stages are under-mentioned:**
**(a) Leptotene:**
The diploid nucleus enlarges in volume. The chromosomes appear as long, thin and single threads which soon begin to coil. Several small, bead-like granules (chromomeres) appear in each thread-like chromosome. The centriole duplicates and each daughter centriole migrates towards the opposite poles of the cell. On reaching at the poles each centriole duplicates and thus, each pole of the cell possesses two centrioles.

**(b) Zygotene:**
In this zygotene stage, the pairing of homologous chromosomes takes place. The homologous chromosomes come together, get themselves arranged side by side, and form pairs or bivalents. This pairing is also called synapsis. The pairing chromosomes soon begin to shorten and get thickened, but there is no actual fusion. The specificity for pairing is mediated by the axes of

chromosomes which are involved in the formation of a specialized structure called synaptinemal complex (or synaptonemal complex).

**Three types of synapsis have been recognised which are as follows:**

**(i) Procentric pairing:**

In procentric synapsis the pairing starts at the centromeres. This is procentric synapsis.

**(ii) Proterminal synapsis:**

In proterminal synapsis, the pairing of homologous chromosomes starts from the end and proceeds towards their centromeres. This is proterminal synapsis.

**(iii) Localised or Random pairing:**

In this type of synapsis the pairing of homologues occurs at several points at random. Synapsis continues along the length of chromosomes until it is complete and no unpaired region is left.

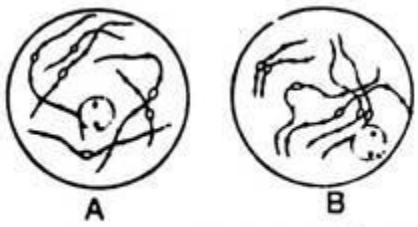


*Fig. 310. Leptotene (A) and zygotene (B) stages.*

**(c) Pachytene:**

In this stage the chromosomes become shorter, thicker and get splitted into chromatids linked at the centromeres. From a pair of each homologous chromosomes are thus produced four chromatids and closely joined together in one complex unit called a bivalent. During pachytene stage an important genetic phenomena called 'crossing over' takes place. The crossing over involves the mutual exchange of hereditary material between two homologous chromosomes. The crossing over accompanied by the chiasmata formation. Identification of the homologous chromosomes can be made in pachytene, which is a long stage of prophase I.

*Fig. 311. Pachytene stage.*

**(d) Diplotene:**

In diplotene stage the homologous chromosomes repel each other because of force of attraction between two homologous chromosomes decreases. The two homologous chromosomes thus separated from each other, however not completely because both remain united at the point of interchange or chiasmata.

*Fig. 312. Diplotene stage.*

Further coiling and shortening of chromosomes is also seen in late stage of diplotene which soon changes into diakinesis.

**(e) Diakinesis:**

In this last stage of the first meiotic prophase the chromosomes are shortest and thickest. The nuclear membrane starts disintegrating. The nucleolus also disintegrates and disappears. The chromosomes bivalents move towards the periphery, of the nucleus and remain connected only at the points of chiasmata. The chromosomes are finally released into the cytoplasm. During diakinesis the chiasma move from the centromere towards the ends of the chromosomes and the intermediate chromosomes diminish. This type of movement of the chiasmata is know is chiasmaterminalization. The chromatids still remain connected by the terminal chiasma and these exist upto the metaphase.

*Fig. 313. Diakinesis stage.*

**2. Metaphase I:**

Two major events of metaphase I include complete disintegration of nuclear membrane and the formation of spindle. All the chromosomes, each along with

their two chromatids, move to the equatorial region of the newly formed spindle.

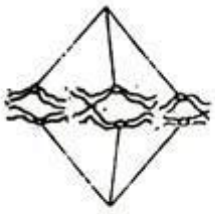

*Fig. 314. Metaphase I of meiosis I.*

Differing from the metaphase stage of mitosis, the centromeres of chromosome pairs in metaphase stage of meiosis I become attached with the spindle fibres near the equatorial region. The centromeres remain clearly apart from each other and face the opposite poles while the arms of the chromosome pairs lie towards the equator.

**3. Anaphase I:**

There is first a repulsion and then movement of the two centromeres of the homologous chromosomes towards the opposite poles of the spindle in anaphase I. A centromere carries either a paternal or a maternal chromosome to one pole but not both the chromosomes. This actually reduces the chromosome number from diploid (2n) to haploid (n), which is the main feature of meiosis of reduction division.

**4. Telophase I:**

A nuclear membrane develops around each group of homologous chromosomes present on the two opposite poles in the form of a compact group in telophase I. The nucleolus reappears. Both the so formed daughter nuclei contain haploid number (n) of chromosomes, and each chromosome contains a pair of chromatids.

Both the daughter nuclei may or may not be separated by a plasma membrane and soon pass on to the next division, i.e., meiosis division II.

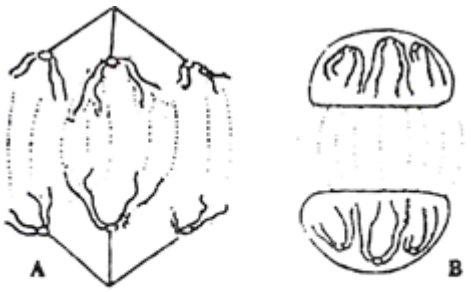


*Fig. 315. A, Anaphase I of meiosis I; B, Telophase I of meiosis I.*

**Meiosis Division II:**

This division includes almost all the phases found in mitosis.

**Four different phases which constitute meiosis division II are prophase II, metaphase II, anaphase II and telophase II, and main events of all these four phases are discussed below:**

**1. Prophase II:**

The chromosomes split into chromatids in both the haploid nuclei and cells formed after meiosis division I. The splitted chromatids remain connected only at the centromeres. The chromosomes start coiling and become shorter and thicker. The nuclear membrane and nucleolus start disintegrating and some spindle fibres also start appearing.

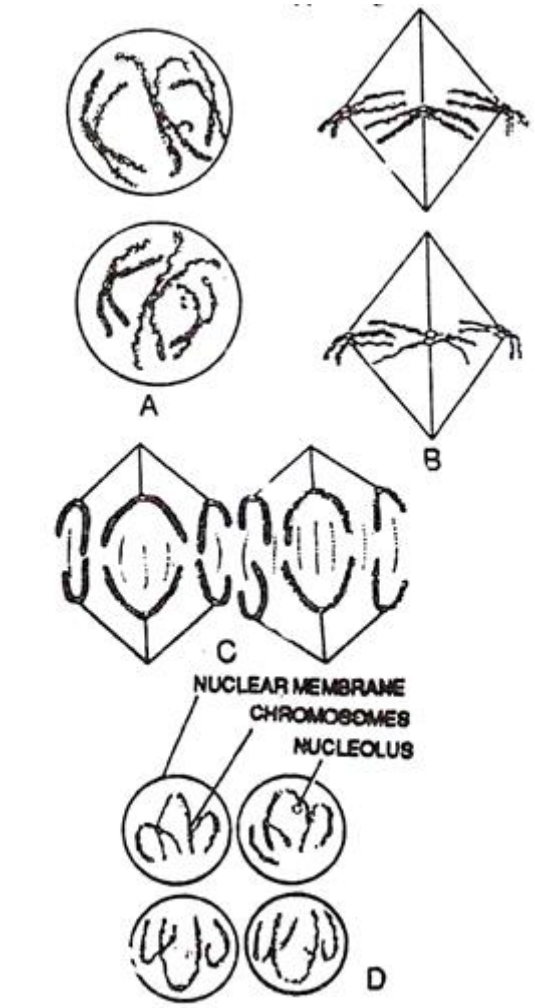

*Fig. 316. Stages of meiosis II. A, Prophase II; B, Metaphase II; C, Anaphase II; D, Telophase II.*

**2. Metaphase II:**

During metaphase II, the chromosomes get arranged on the equator of the newly formed spindle. The centromere divides into two and thus each chromosome produces two daughter chromosomes. The microtubules of the spindle are attached with the centromere of the chromosomes.

**3. Anaphase II:**

In this phase, the two sister chromosomes of each pair start to move towards the opposite poles of the spindle due to the contraction of chromosomal microtubules and stretching of interzonal microtubules of the spindle fibres.. They are being drawn towards the opposite poles by their centromeres.

**4. Telophase II:**

During Telophase II, the endoplasmic reticulum forms the nuclear envelop around the chromosomes and the nucleolus reappears due to synthesis of ribosomal RNA and also due to accumulation of ribosomal proteins. After

karyokinesis, four cells are formed by cytokinesis, and the nucleus in all these so formed four young cells contain haploid number (n) of chromosomes. In this way, four haploid cells are resulted from a single diploid cell in the process of meiosis.

**Significance of Meiosis:**

(i) Meiosis is necessary part of the life cycle of sexually reproducing animals and plants as it helps in restoring the definite number of chromosomes, the characteristic of a species.

(ii) The crossing over of genes between homologous chromosomes helps in exchange of genes leading to formation of new recombinants.

(iii) Meiosis is most essential for the completion of life cycle of a plant as it brings a change from diploid to haploid generation.