

MEIOSIS

The term meiosis was coined by J.B. Farmer in 1905. This type of division is found in organisms in which there is sexual reproduction. The term has been derived from Greek word; Meioum = diminish or reduce. The cells that undergo meiosis are called meiocytes. Three important processes that occur during meiosis are:

1. Pairing of homologous chromosomes (synapsis) at Zygotene of Prophase-I
2. Formation of chiasmata and crossing over at Pachytene of Prophase-I
3. Segregation of homologous chromosomes (or separation of alleles) at Anaphase-I

Both crossing over and segregation contribute to genetic recombination (that is, new gene combination). The first division of meiosis results in reduction of chromosome number to half and is called reduction division. The first meiotic division is also called heterotypic division. Two haploid cells are produced at the end of first meiotic division and in the second meiotic division, the haploid cells divide mitotically and results in the production of four daughter cells (tetrad), each with haploid number of chromosomes. In a tetrad, two daughter cells will be of parental types and the remaining two will be recombinant types. The second meiotic division is also known as homotypic division. Both the meiotic divisions occur continuously and each includes the usual stages viz., prophase, metaphase, anaphase and telophase. Meiotic cell cycle involves the following stages: Interphase: Meiosis starts after an interphase which is not very different from that of an intermitotic interphase. During the premeiotic interphase DNA duplication occurs during the S phase I.

Meiosis-I:

(1) **Prophase-I:** It is of a very long duration and is also very complex. It has been divided into the following sub-stages:

a) **Leptotene or Leptonema:** Chromosomes at this stage appear as thin thread like structures that are loosely interwoven like a loose ball of wool. In some species, on these chromosomes, bead-like structures called chromomeres are found all along the length of the chromosomes.

b) **Zygotene or Zygonema:** It is characterized by pairing of homologous chromosomes (synapsis), which form bivalents. The paired homologous chromosomes are joined by a protein containing frame work known as synaptonemal complex. The bivalents have four strands

c) **Pachytene or Pachynema:** The chromosomes appear as bivalents. At this stage, exchange of segments between non-sister chromatids of homologous chromosomes known as crossing over occurs. During crossing over, only one chromatid from each of the two homologous chromosomes takes part. The nucleolus still persists.

d) **Diplotene or Diplonema:** At this stage further thickening and shortening of chromosomes takes place. Homologous chromosomes start separating from one another. Separation starts at the centromere and travels towards the ends (terminalization). Homologous chromosomes are held together only at certain points along the length. Such points of contact are known as chiasmata and represent the places of crossing over. The process of terminalization is completed at this stage.

e) **Diakinesis:** Chromosomes undergo further condensation. The bivalents appear as round darkly stained bodies and they are evenly distributed throughout the cell. The nuclear membrane and nucleolus disappear.

2) **Metaphase-I:** The spindle apparatus gradually organizes. The centromeres of a bivalent are connected to the poles through the spindle fibres. The centromeres of the bivalents are arranged on either side of the equator and this type of orientation is called co-orientation.

3) **Anaphase-I:** From each bivalent, one chromosome move to opposite poles (disjunction). Each chromosome possesses two chromatids. The centromere is the first to move to the pole. Each pole has a haploid number of chromosomes. Hence separation of homologous chromosomes (separation of alleles) occurs in this phase.

4) **Telophase-I:** Nuclear membranes are formed around the groups of chromosomes at the two poles. The nucleus and nucleolus are re-organized.

II. Meiosis-II: The second meiotic division is similar to the mitotic division and it includes the following four stages:

1) **Prophase-II:** The chromosomes condense again. The nucleolus and nuclear membrane disappear. The chromosomes with two chromatids each become short and thick

2) **Metaphase-II:** Spindle fibres appear and the chromosomes get arranged on the equatorial plane(auto-orientation). This plane is at right angle to the equatorial plane of the first meiotic division.

3) **Anaphase-II:** Each centromere divides and separates the two chromatids, which move towards the opposite poles.

4) **Telophase-II:** The chromatids move to the opposite poles The nuclear envelope and the nucleolus reappears. Thus at each pole, there is re-organization of haploid nucleus. Cytokinesis: The division of cytoplasm takes place by cell plate method in plants and by furrow method in animals. The cytokinesis may take place after meiosis I and meiosis II separately or sometimes may take place at the end of meiosis II only.

Significance of Meiosis Meiosis plays a very important role in the biological populations in various ways as given below:

1. It helps in maintaining a definite and constant number of chromosomes in a species.
2. Meiosis results in production of gametes with haploid (half) chromosome number. Union of male and female gametes leads to formation of zygote which receives half chromosome number from male gamete and half from the female gamete and thus the original somatic chromosome number is restored.
3. Meiosis facilitates segregation and independent assortment of chromosomes and genes.
4. It provides an opportunity for the exchange of genes through the process of crossing over. Recombination of genes results in generation of variability in a biological population which is important from evolution points of view.
5. In sexually reproducing species, meiosis is essential for the continuity of generation. Because meiosis results in the formation of male and female gametes and union of such gametes leads to the development of zygotes and thereby new individual.