Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Third Year)

Subject: Botany

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Paper Title: Cytogenetics and plant breeding

Unit: Cell cycle

Module Name: Meiosis & its significance

Module No: 2

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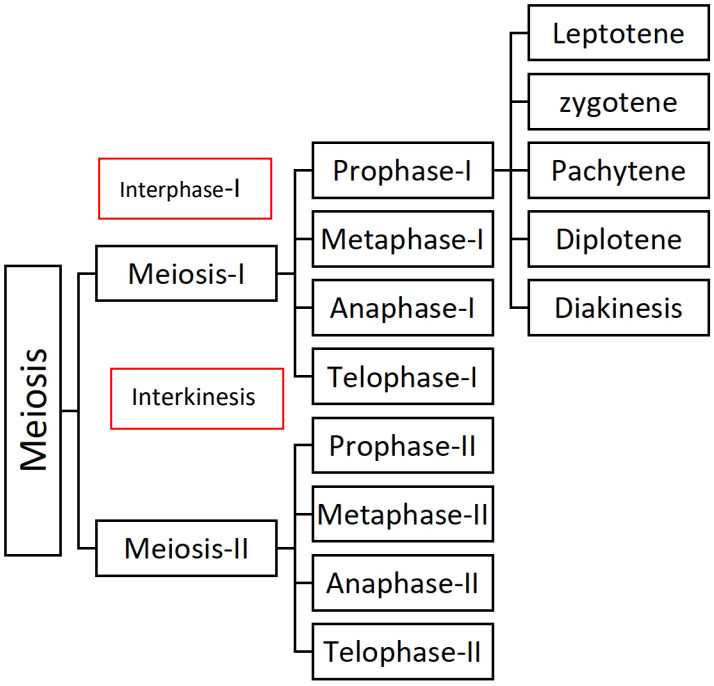
Notes:

Meiosis: It is a type of cell division which occurs in sexually reproducing eukaryotes. It occurs in germ cells resulting in formation of 4 haploid gametes/daughter cells.
In general cells in which meiosis occurs are called as meiocytes. In plants it occurs in microsporocytes (pollen mother cells) & megasporocytes (mega spore mother cells).

Stages of meiosis:



Interphase-I/Pre-meiotic Interphase: It is same as mitotic interphase**.** It consists of G1,S & G2 phases. Increase in cytoplasmic content & ***replication of DNA occurs in this stage.*** Nucleus appears distinct with prominent nuclear envelop and nucleolus. Chromatids shows minimum degree of condensation & remains dispersed in the nuclear sap in the form of chromatin network.

Prophase-I: it is the longest and most important phase of meiosis. It shows 5 different sub stages i.e. Leptotene, zygotene, Pachytene, Diplotene &Diakinesis.

Leptotene: Chromatin gradually condenses and begins to get the shape of chromosomes. At this stage chromosomes **appear as thin thread like structures** & shows presence of bead like granules on them called chromomeres. Nuclear envelop and nucleolus remains distinct**.**

Zygotene: Chromosomes continues to condense. Homologous chromosomes come close to each other & arrange themselves side by side. This phenomenon of pairing of homologous chromosomes is called ***synapsis***. It occurs due to electrostatic force of attraction between homologous pairs & hydrodynamic force created in nucleoplasm during this stage. Pairing occurs lengthwise in a zipper like fashion starting from centromere or at chromosomal ends. Complex proteins called ***syneptinemal complex*** holds these pairs together. Homologous pairs are referred as **bivalents.**

Pachytene: This stage begins only when pairing is complete**.** Chromosomes become shorter and thicker. Bivalents twist around one another resulting in longitudinal separation of sister chromatids of each chromosome. They remain attached together at the centromere. At this stage each bivalent appears four stranded and referred as **tetrad**.
Very important phenomenon of **crossing over** may occur between overlapping non-sister chromatids**.** Nucleolus and nuclear membrane begins to disintegrate.

Diplotene: Homologous chromosomes start moving away from each other due to repulsive force created between centromeres of homologous pairs. They do not completely separate from each other but remain connected at one or more points called chiasmata. Displacement of chiasmata is noticed in this stage. This phenomenon is called **terminalization.** Nuclear membrane continuous to disintegrate & nucleolus disappears completely.

Diakinesis: This is the last sub stage of prophase –I. Chromosomes appears highly contracted due to major coiling. Homologous pairs remains attached only at chiasmata. Nuclear membrane disintegrates and chromosomes are released in the cytoplasm. Spindle fibers begin to appear from 2 poles.

Metaphase-I: Nuclear membrane disappear completely.Spindle fibers gets attached to centromeres of bivalents. One centromere of each bivalent gets attached with fibers of one pole and the other centromere gets attached with the fibers extending from the opposite pole. ***Bivalents get organized along equatorial plate*** *by movement called co-orientation*. Bivalent chromosomes have their centromeres directed towards opposite poles and their arms towards equator.

Anaphase-I: Repulsion occurs between centromeres of bivalents followed by contraction of spindle fibers. It results in separation of homologous chromosomes and they move away from each other towards opposite poles. A paternal or a maternal chromosome moves to one pole but not both the chromosomes. So half number of chromosomes moves towards each pole. Thus **reduction in chromosome number** occurs at this stage.

Telophase –I: Decondensation of chromosomes occurs at each pole. Nuclear membrane and nucleolus reappears .Thus **2 daughter nuclei are formed with half the number of chromosomes than the parent cell.**

Cytokinesis-I/ successive cytokinesis: Cytokinesis may or may not occur after telophase-I. If it occurs after telophase-I it is called as successive cytokinesis. In plants it occurs by cell plate method. The Golgi vesicles fuse at the centre to form phragmoplast. It grows centrifugally & meets plasma membrane. The contents of phragmoplast solidify to become cell plate which separates the two daughter cells. **Thus 2 daughter cells are formed with ½ numbers of chromosomes than the parent cell**.

Interphase-II/Interkinesis: It's a very short phase between telophase-I & prophase-II. In many cases it is absent and cell from telophase-I directly moves to telophase-II.A little despiralization of chromatin is observed. **No replication of DNA occurs in this stage..**

Prophase-II: Condensation of Chromatin occurs resulting in formation of short & thick chromosomes. Further each chromosome splits into chromatids but remains attached at centromere. Nucleolus and Nuclear envelope starts disintegrating. The spindle fibers begins to appear mostly at right angles to the spindle of meiosis-I.

Metaphase-II: spindle fibers in each cell extend from both the poles & gets attached to centromere of each chromosome .Aligns all the chromosomes at equatorial plate. At the end, centromere of each chromosome divides so that each sister chromatid gets its own centromere.

Anaphase-II: Repulsive force develops between daughter centromeres followed by contraction of chromosomal fibers.2 sister chromatids of each chromosome separates & moves towards 2 poles. The separated chromatids are now called as daughter chromosomes.

Telophase-II: The daughter chromosomes at both the poles decondense to form chromatin network. Nucleoli and nuclear envelope reappear. Spindle fibers disappear. Thus 4 haploid nuclei are formed. This is followed by cytokinesis-II.

Cytokinesis-II: Cell plates are formed between the daughter nuclei in same way as cytokinesis-I resulting in formation of 4 haploid cells or gametes. In meiosis, 2 types of cytokinesis can be seen.
(a) Successive type: In this case, cytokinesis occurs after meiosis I and meiosis II. As a result four haploid cells are formed. In plants the cells are arranged in form of isobilateral tetrad or in a linear manner.

(b) Simultaneous type: In this case, cytokinesis does not occur after meiosis-I but occurs twice only after meiosis II. The four haploid cells arranged in form of a tetrahedral tetrad.

Significance of meiosis:

1. In sexually reproducing organisms it leads to the ***formation of haploid gametes (n).*** Fertilization restores the normal somatic (2n) chromosome number.
2. ***Maintains constancy in chromosomes*** from generation to generation.
3. Crossing over and disjunction ***bring genetic variation*** within the species. It's very important for evolution and also help in improvement of races.
4. Meiosis ***causes segregation and random assortment of genes***.
5. Meiosis causes ***conversion from sporophytic generation to gametophytic generation in plants.***