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Program: Bachelor of Science, third year,

Subject: Botany,

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Paper code: BOC-108,

Paper title: Cytogenetics and plant breeding,

Title of the unit: Cell cycle,

Module name: Meiosis and its significance.

Outline: Meiosis and its stages, Significance of meiosis.

Learning outcomes: Defines meiosis, Differentiates between the different stages. Understanding the significance of meiosis.

First let's see what meiosis is:

It is reductional cell division which occurs in germ cells of sexually reproducing eukaryotes resulting in formation of the four haploid gametes or daughter cells.

In this picture you can clearly see the mother cell has 2N number of chromosomes. After meiosis process is complete, it forms four daughter cells which have exactly half the number of chromosomes i.e. N number of chromosomes.Iit forms four haploid gametes.

Stages of meiosis:

Meiosis shows two distinct phases i.e.: meiosis-I and meiosis-II.

Meiosis-I is a reductional division. In this there is reduction of chromosome number from parent cell

to the daughter cells.

In meiosis –II there is no change in the chromosomes. The chromosome number remains same as

that of parent cell in both the daughter cells.

In the beginning of meiosis-I, there is a interphase-I in which a very important phenomena of replication occurs. Between meiosis-I and meiosis-II, there is a short resting phase called as interkinesis, but no replication of DNA occurs in this stage.

 Stages of meiosis-I,

Meiosis-I shows four distinct stages, i.e.

Prophase-I, metaphase-I, anaphase-I, and telophase-I.

Stages of prophase-I:

Prophase-I is the longest phase.

It shows five different sub-stages i.e. Leptotene, zygotene, pachytene, Diplotene and Diakinesis.

In the beginning of meiosis the cell is in the interphase-I or pre-meiotic interphase.

Replication of DNA and an increase in cytoplasmic contents takes place. At this time we see nucleus showing distinct nuclear envelope and nucleolus, as can be seen in this picture. Chromatids shows minimum degree of condensation and remains dispersed in the form of chromatin network

First stage of prophase-I is leptotene, chromatin gradually starts condensing to form the chromosomes as seen in the picture. Chromosomes appear slender thread like structure. Nuclear envelope and nucleolus remains distinct.

Next stage is zygotene, pairing of homologous chromosomes occurs. This phenomenon is also referred as synapses. It occurs lengthwise in zipper like fashion, starting from centromere or from the chromosomal ends. Both the homologous chromosomes in a pair are hold together by proteins complex which is known as syneptinemal complex. Two homologous chromosomes together are called as by bivalents.

In the next phase i.e. pachytene, bivalents twist around one another, resulting in separation of sister chromatids.

But they remain attached together at the centromere. Bivalents now appear as tetrad with four chromatids. Very important phenomena of crossing over occur between overlapping non- sister chromatids.

 In these phenomena there is exchange of chromosomal segments between the non- sister chromatids.

nucleolus and nuclear membrane begins to disintegrate.

In the next phase i.e. Diplotene, a repulsive force develops between centromeres of homologous chromosomes and they start moving away from each other. They do not completely separate from

each other but remain connected at a point called chiasmata. This phenomena is called is terminalization.

At the end, nuclear membrane continues to disintegrate and nucleolus disappears completely.

The last phase of prophase -I is Diakinesis. In this, chromosomes get more condensed. nucleus,

and nuclear membrane disappears completely and spindle fibers begins to appear from both the poles.

In metaphase-I spindle fibers gets attached to the centromere of bivalents and move them to the equatorial plate.

Bivalent chromosomes have their centromeres directed towards opposite poles with their arms towards the equator.

In the next phase i.e. anaphase-I, homologous chromosomes separate from each other and move towards opposite poles.

 So half the number of chromosomes move towards each pole. Thus, reduction in chromosome number occurs at this stage.

In Telophase-I decondensation of chromosomes occurs. At each pole nuclear membrane and nucleolus reappears. Thus two daughter nuclei are formed with half the number of chromosomes then the mother cell.

Cytokinesis may or may not occur after telophase-I.

Cytokinesis-I is also called as successive cytokinesis.

In plants it occurs by cell plate method.

Thus two daughter cells are formed with half the number of chromosomes then the mother cell or the parent cell.

Interphase-II or interkinesis is a very short phase between telophase-I and prophase -II. In many cases it is absent and cell from telophase-I directly moves to prophase-II.

A little despiralization of chromatin is observed but no replication of DNA occurs in this stage.

Stages of meiosis-II

Meiosis –II shows four important stages, i.e. prophase-II, metaphase-II, anaphase-II and telophase-II.

In prophase-II, condensation of chromatin occurs resulting in the formation of short and thick chromosomes.

Further, each chromosome splits into chromatids but remain 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.

This you can clearly see in the given picture.

In Metaphase-II spindle fibers in each cell extends from both the poles and gets attached to the

centromere of each chromosome. It aligns all the chromosomes at the equatorial plate. At the end, centromere of each chromosome divides so that each sister chromatids gets its own centromere.

In anaphase-II repulsive force develops between daughter centromeres followed by the contraction of chromosomal fibers.

Two sister chromatids of each chromosome separates and moves towards two poles. The separated chromatids are now called as daughter chromosomes.

In telophase-II, the daughter chromosomes at both the poles condense to form the chromatin network.

Nucleoli and nuclear envelope reappears. Spindle fibers disappear.

Thus 4 haploid nuclei are formed.

This is followed by cytokinesis-II.

In cytokinesis-II cell plates are formed between the two daughter nuclei.

Thus at the end of meiosis, four haploid gametes, or four daughter cells are formed with exactly half the number of chromosomes then the mother cell.

Significance of meiosis:

Meiosis process in sexually reproducing organism leads to the formation of haploid gametes.

It helps to maintain constancy in the chromosomes from generation to generation.

It helps to bring genetic variation within the species.

These are the references.

Thank you.