RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES AND ALLIED INDUSTRIES

CELL DIVISION

MITOSIS

All cells originate through division of pre-existing cells. Bodies of all multicellular organisms are derived from unicellular zygote through repeated divisions of zygote and the cells derived through its division. The division of chromosomes and cytoplasm of a cell into daughter cells is known as 'Cell division'. The cell that undergoes division is termed as 'parent cell', while the cells derived from the division of a parent cell are known as daughter cells.

Functions fo cell division

To produce two daughter cells, which are involved in the following;

i. Growth and development of somatic tissue of organims
ii. Regeneration of damaged tissues
iii. Produciton of new tissues
iv. Reproduction
v. Keeping the size of cells within a limited range.

Two types of cell division i. Mitosis ii. Meiosis

In addition, bacterial cells divide by fission (similar to mitosis). The various events occcuring in division may be grouped into

i. Karyo kenensis - Division of chromosomes

ii. Cytokinesis - Division of cytoplasm

MITOSIS

It was first used by Fleming in 1882. In plan ts, mitosis is confined to the meristamatic, tissues of root and shoot tips, young leaves flower buds and cambium.

On the basis fo chages in the morphology of necleus and the chroomosomes, the events in a mitotic cell division are grouped into five stages;

i. Interphase
ii. Prophase
iii. Metaphase
iv. Anaphase
v. Telophase.

In fact, cell division is a continuous process in which a cell gradually progressed from one stage to another. So one stage merges into the next one.

Interphase

In this stage of cell after the telophase of previous division and before oneset of prophase of the next one. During interphase, chromosomes are fully extented and uncoiled so that they do not takeup sufficient stain. Interphase in the longest stage. In a cell undegoing mitosis every 24 hours i.e. having a cell cycle of 24 hr., interphase may occupy upto 23 hours, while the division or mitotic phase may take up onluy 1 hour.

DNA replication occurs during the middle part of interphase. This provides the basis for classifying interphase into three substages.

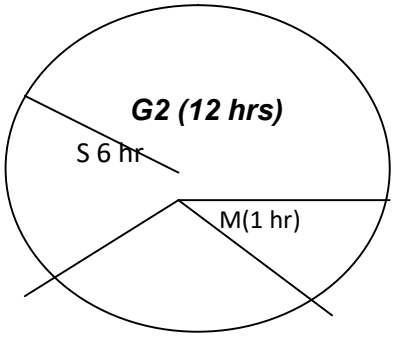
1. G1 (first gap)
2. S (Synthesis of DNA)
3. G2 (Second gap)

G1, G2 - Protein + RNA synthesis

S - DNA synthesis

M - Chromosome movement, division

Time taken in root tips fo vicia jaba.



PROPHASE

i. The appearance of define thread like strucures in nuclear is the most important event of prophase. In the beginning, chromosomes appear as a loose ball of thin wool. As prophase proceeds, chromosomes become increasingly shorter and thicker due to increased conelenstenin by mid prophase, the two chromatids of each chromosomes become visible. By the end of prophase all the chromosomes become considerably shorter and thicker.

ii. During prophase nucelolus and nuclear membrane remain present.

METAPHASE

At the end of prophase four important events take place;

i. Disappearance of nucelolus
ii. Break down of nuclear envelope and distribution of its components into E.R
iii. Appearance of spindle apprartus.
iv. Arrangements of chromosomes on a single plane called 'equatorial plate'.

The movement of chromosomes to an their orientation on the equatorial plate is termed metakinesis. The main features of metaphase are

i. Absenece of nucleolus
ii. Disappearance of nuclear membrane.
iii. Arrangement of chromosomes on the equatorial plate
iv. Shortest and thickest chromosomes (Condensation)
v. Coils are less in number and largest in diameter
vi. Presence of spindle appratus
vii. Absence of relation coiling between sister chromatids.

ANAPHASE

The two sister chromatids of each chromosomes separate and migrate towards the opposite poles of the cell. Anaphase begin when the centromeres of chromosomes appear to divide longitudinally so that the sister chromatids separate from each other and ends with the reachign of the chromosomes to opposite poles centromete in the first portion of each of the chromosomes to begin to move towards the poles.

Spindle fibres originate at two points located near the periphery of a cell and opposite to each other. These points are known as 'poles'

Chromosomes become somewhate more condensed as compared to those at metaphase, so that they appear relatively smaller in size.

TELOPHASE

Anaphase ends and Telaphase begins when sister chromatids of all the chromosomes of a cell reach the opposite poles. During telophase, the following events occur in the two groups of chromosomes collected at the opposite poles.

i. The chromosomes uncoil so that they become very long and thin and appeareed to be coiled into a loose ball of fine thread.
ii. Nucleus reappers
iii. Nucelar membrane is reorganised around each group of chromosomes.
iv. At the end of teophase, middle lamella appears at the equatorial plate of the cell.

The nuclear envelope dissociates into small elements which become part fo E.R. of the cell. During telophase, there elements reoriginate around the two groups of chromosomes and fuse to produce nucelar envelope around them.

In terms of duration, prophase in the longest stage of the division phase of cell cycle. In comparison anaphase is the shortest stage, while metaphase and telophase are considerably longer than anaphase.

CYTOKINESIS

It is complete by the end of Telophase. At the equatorial plate, elements of E.R. and products of golgi bodies organise and gives rise to cell plate and subsequently of cytoplasm begins in the centre of the cell and gradually extends outwards on each side in a plane, perpendicular to the axis of the spindle.

The two daughter cells produced by mitosis contain one nuclear eac; each nuclear has the same number of chromosomes as the parent cell. Each daughter cell enlarges in size till it becomes comparable to the parent cell.

MEIOSIS

Meiosis takes place during gamete formation and hence it is confined to reproductive cells only. As a consequence of meiosis, gamets contains only half (h) of the somatic chromosome number (2n). Therefore union between one male and one female gamete during fertilization restorers the chromosome number to the diploid (2n) state. Thus the chromosome number of a species remains constant from one generation to the next generation produced by sexual reproduction. In the absence of meiotic cell division, the chromosome num,ber of a species would be doubled in every generation, due to the fussion of male and female gametes, an impossible biological situation.

The nucleus of each cell undergoes two successive divisions referred to as the first and second meiotic division.

Pre-Meiotic Interphase

During 'S' phase of pre-meiotic interphase chromosomes replication takes place. But approximately 0.3% of the total DNA present in the nucleus does not replicate during the 'S' phase this DNA replicates during the zygotine substage of prophase I. A special stype of histone specific to cells preparing for meiosis is synthesized during S phase. This histone is not found in cells udnergoing mitosis, and it may be related to the entry of cells into meiosis.

FIRST MEIOTIC DIVISION

Significant events;

i. Pairing between homologous chromosomes.
ii. Crossing over between them during pachytene stage of prophase I
iii. Separation of homologus chromosomes and their migration to the opposite poles of a cell during Anaphase I. As a result, the two daughter nuclei produced by this division receive only half of the chromosomes present in somatic cells. For this reason, the first division is often referred as 'Reduction division'.

Prophase I - is divided into 5 sub stage viz.,

i. Leptotene
ii. Zygotene
iii. Pachytene
iv. Diplotene
v. Diakinesis

LEPTOTENE

i. There is a marked increased in the nuclear volume
ii. There is chromosome condensation so that they become visibile as fine threads like a loose ball of knitting wool. Each chromosome consists of two chromatids.

ZYGOTENE

It begings with the initiation of pairing between homologous chromosomes. The main events are as follows:

i. Paring between homologous chromosomes.
ii. Completion of replication of the remaining 0.3% DNA of each nucleus, this DNA synthesis is referred to as Z-DNA synthesis or Zygote DNA synthesis.
iii. Synthesis of a specific nucelear protein
iv. Development of the synaptenemal complex and
v. Progressive condensation of chromosomes.

Pairing of homologous chromosomes is often referred as 'Synapsis'.

Synapsis

i. May begin at both ends of a homologous pair and proceed towards its centre (or)
ii. It may begin at the centromere and progress towards the telomre (or)
iii. It may begin simultaneously at several places.

PACHYTENE

It begins when synapsis comes to an end and it ends when the homologous chromosomes begin to move away from each other. The main events are ;

i. Thre is a further condensation of chromosomes, so that chromosomes pairs become shorter and thicker.
ii. Chromosomes are easily recognisable during this stage and each invalent has four chromatids.
iii. The nucleolus is distinct and quite large.
iv. Crossing over between homologous chromosomes takes place during this stage.

DIPLOTENE

i. Homologous chromosomes of ech bivalent begin to move away from each other.
ii. The two homologous of each bivalent appear to be attached with each other at one or more points, these attachments are known as chiasma. It is believed that initially chiasma are located at the points of actual crossing over between homologous chromosomes.
iii. As diplotene progress, chiasmata, slowly move towards the ends of the homologous chromosomes; this movement is referred to as chiasma terminalization i.e. movement of chaisma towards terminal positions in the chrommosomes. Chiasma terminalization occurs mainly due to the movement of homologous chromosome away from each other.
iv. There is further condensation of chromosomes so that they become progressively shorter and thicker.

DIAKINESIS

i. Bivalents move away from each other and spread towares the peripheri cells.
ii. Nucleolus, nuclear envleope disappear.
iii. The spindle appratus is organized.
The bivalents now migrate to the equatorial plate of cells; this marks the ends of diakeninsis. Bivalents may be in the form of (1) a closed ring, (2) an open ring or (3) rod shaped.

METAPHASE -I

i. Bivalents are arranged at the metaphase plate
ii. Centomeres of the two homologues of each bivalent lie on the either side of the equatorial plate.
iii. Metaphase terminates as soon as homolgous chromosomes begin to separate from each other and to migrate to opposite poles of the cell.

ANAPHASE -I

i. Separation of the two homologous chromosomes of each bivalent marks the beginning of anaphase stage.
ii. One chromosome from each bivalent begins to migrate to one pole, while the other migrates to the opposite pole.

As a result the numbner of chromosomes at each pole is exactly half (h) and each pole receives one homologue from each of the bivalents present in a cell. Thus the reduction in chromosomes number is not only a quantitative one but a qualitative one as well. Thus at the end of AI, the chromosome present is somatic cells are effectively and precisely separated into two identical groups.

TELOPHASE -I

i. The chromosomes uncoil only partially
ii. Nuclear envelope becomes organized around the two groups of chromosomes.
iii. Nucleolous also reappears.

CYTOKINENSIS

The cytoplasm of each cell divides into two halves, with a single haploid nuclear in each half. The two halves of each cell do not separate, but they staty together, and this two celled structure is known as dyad.

SECOND MEIOTIC DIVISION / MEIOSIS II

During Meiosis II, two sister chromotids of each chromosome separate and migrate to the opposite pole. As a result, the number of chromosomes in each of the two haploid nuclei remains the same (i.e haploid)., at the end of this division. The second division of meiosis is often referred to as equational division. Sometimes, it is called as 'Meiotic Mitosis'. The second meiotic division is also divided into four stages.

i. Prophase II
ii. Metaphase II
iii. Anaphase II and
iv. Telophase II

PROPHASE - II

There is no relationsl coiling between sister chromatids

At the end, nucelus, neclear envelope disappear and spindle apparatus is organised.

Cytokinesis

Dyad divides into two parts. One parent cell produces from haploid daughter cells after meiosis. The four daughter cells present together and are known as tetrad.