Course: B.Sc. Botany
Semester: I
Paper Code: BOT CC102
Paper Name: Biomolecules and Cell Biology
Topic: Mitosis
Faculty Name: Dr Pinky Prasad
Email: dr.pinky.prasad@gmail.com

CONTENTS

MITOSIS

Introduction

Cell division is a very important process in all living organisms. Cell division is the process by which a parent cell divides into two or more daughter cells. In eukaryotes there are two types of cell divisions namely, mitosis which takes place in somatic cells and meiosis which takes place in germ cells.

Mitosis is a mechanism by which the cell distributes the different cell components that have been replicated during the interphase to the two daughter cells in equal amounts. The continuity of the diploid set of chromosomes is maintained in mitosis. Thus, each daughter cell is genetically identical to the parent cell.

Discovery of mitosis

Mitosis was first described by Edward Strasburger in plant cells in 1875 and by Walther Flemming in an animal cell in 1879. It was termed 'mitosis' by Walther Flemming in 1882.

Occurrence of mitosis

Mitosis takes place in somatic cells (body cells) in the animals. In plants, it takes place in meristematic tissues and during the growth of leaves, flowers and fruits.

Definition of mitosis

Mitosis is the division of parent cell into two identical daughter cells, each with a nucleus having same amount of DNA, same number and kind of chromosomes. Hence, it is also known as equational division.

Stages of mitosis

Mitosis takes place in a series of five consecutive stages based on the physical state of chromosomes and spindle. These stages are- Prophase, Metaphase, Anaphase, Telophase resulting in karyokinesis (nuclear division) followed by final physical cell division through cytokinesis (division of cytoplasm).

Prophase- (chromatid coiling, nuclear disintegration and spindle formation)

Beginning of the prophase is indicated by the appearance of the chromosomes as thin threads inside the nucleus that start to condense by coiling. Each prophase chromosome contains two sister chromatids which are the result of replication of the DNA during S period of Interphase. The sister chromatids are attached to each other only at the centromere.

During early prophase, the chromosomes are evenly distributed in the nuclear cavity, but as the prophase progresses, the chromosomes approach the nuclear envelope. At the end of prophase, the nucleolus disintegrates and disappears. The nuclear envelope starts disintegrating. In the cytoplasm, the two centrioles which had replicated during S phase move towards opposite poles and spindle fibrs are formed between the asters.

Mitosis in which the spindle has centrioles and asters are called as astral mitosis found in animal cells and some lower plants. Mitosis in which centrioles and asters are absent is called as anastral mitosis found in higher plants including all angiosperms and most gymnosperms. Centrioles and asters are, therefore, not essential for the formation of the spindle.

Metaphase- (chromosomal orientation on the equatorial plane)

At the beginning of the metaphase, the nuclear envelope completely disintegrates and there is mixing of the nucleoplsm and the cytoplasm. After that the spindle fibres invade the central. The chromosomes become attached to the microtubules of the spindle through the disc shaped kinetochore situated at the centromere and come to lie in the equatorial plane.

Those fibres of the spindle that connect to the chromosomes are called chromosomal fibres, and those that extend without interruption from one pole to another are called continuous fibres.

Anaphase- (movement of sister chromatids towards the opposite poles)

In anaphase, the centromere moves apart and the sister chromatids separate. The reason for chromatid separation is degradation of the protein cohesin binding the sister chromatids by protease separase.

During anaphase, the microtubules of chromosomal fibres of the spindle shorten one third to one fifth of the original length , so that the sister chromatids begin to move towards the opposite poles. The chromosomes may assume the shape of ‘V’ with equal arms (metacentric) or ‘L’ with unequal arms (sub-metacentric).

The microtubules of the continuous fibres increase in length. Some of these spindle fibres constitute the ‘interzonal fibres’ which later on contributes in the formation of phragmoplast that transform into cell plate during cytokinesis.

Telophase-(reconstruction of daughter nuclei)

Telophase is just opposite of prophase. In telophase, the chromosomes again uncoil, the nucleolus and the nuclear envelope reappear constituting the daughter nuclei and the spindle fibres disappear.

Simultaneously, cytokinesis occurs.

Cytokinesis- (separation of cytoplasm along with the cell organelles)

During cytokinesis or cell cleavage the cytoplasm and the cytoplasmic components including the mitochondria and golgi complex are distributed.

Cytokinesis differs considerably in animal and plant cells. In animal cell, there is a constriction in the equator that gradually moves towards the centre finally resulting in the separation of the daughter cells.

In plant cell, cytokinesis starts with the formation of phragmoplast which comprises of the interzonal microtubules and golgi vesicles. This structure is transformed into the cell plate which separates the two daughter cells which remain connected with each other through plasmodesmata, the thin cytoplasmic connection traversing the cell plate. The fully developed cell plate is called middle lamella.

Within the cell plate, the primary cell wall is produced by a secretory mechanism consisting mainly of the production of pectin which is contained in the golgi vesicle. Primary cell wall is flexible to allow for the growth of the cell. A fully grown cell later forms a rigid secondary cell wall by the secretions produced by the cell.

It is interesting to note that cytokinesis in an animal cells begins at the periphery and proceeds inwards, whereas in a plant cell, it starts centrally and proceeds outwards.

Significance of mitosis

1. Genetic stability- Mitosis results in the precise equal distribution of complete set of chromosome from a parent nucleus to the two daughter nuclei. Further, it maintains an equilibrium in the amount of DNA contents in the cell.
2. Growth- Mitosis increases the number of cells resulting in increase in tissue mass and thus helps in growth.
3. Healing and regeneration- Mitosis produces new cells for healing wounds and for regeneration.
4. Repair- Mitosis provides new cells to replace the old worn out and dying cells.
5. Reproduction- Mitosis brings about multiplication in acellular organisms.

Stages of mitosis in plant cell