TOPIC: CELL DIVISION:MITOSIS

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Mitosis

A German biologist **Eduard Strasburger** described mitosis for the first time in 1875. Same was described later in 1879 by **Walther Flemming** who also termed it "mitosis" in 1882.

It is the most common method of cell division in eukaryotes that takes place in somatic cells of the body and hence it is also known as somatic division. However in gonads it occurs in undifferentiated germ cells. In plants it takes place in the cells of meristematic tissues. The duration of mitosis on an average is from 30 minutes to 3 hours.

Mitosis is defined as t he division of a parent cell into two identical daughter cells each with a nucleus having the sam e amount of DNA, the same number and ki nd of chromosomes and the same hereditary instructions as the parent cell. Therefore, it is also known as the equational division. There are two main events involved in mitosis: **Karyokinesis or division of the nucleus and cytokinesis or division of cytoplasm.**

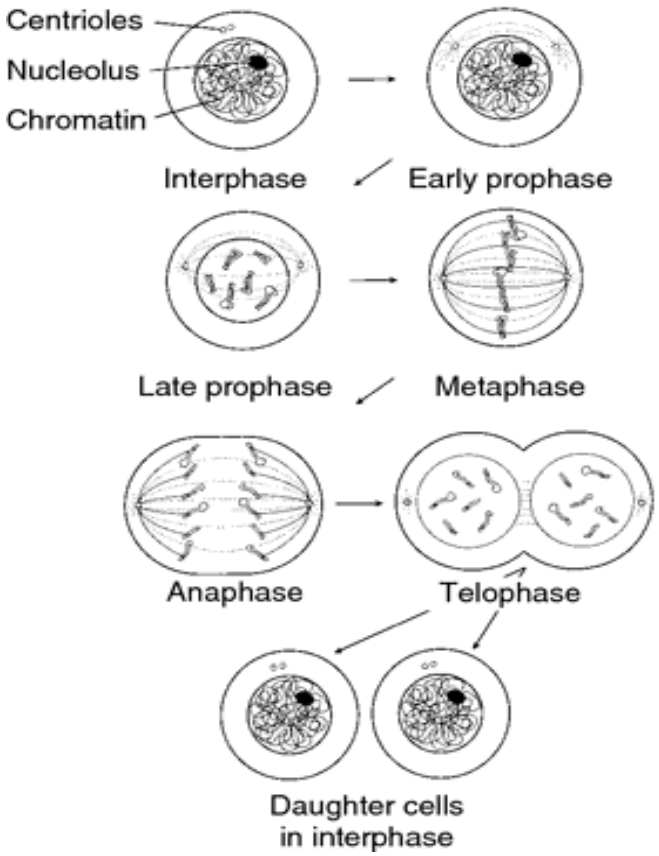

Fig. : Stages of mitosis in animal cells

Karyokinesis

In eukaryotes, karyokinesis is a complex process due to the presence of many chromosomes. It is a continuous process which may be divided into four stages: prophase, metaphase, anaphase and telophase.

- ***Prophase-*** In an inter phase cell the chromosomes are greatly ex tended and spread

  throughout the space in the nuclear compartment. Approximately 4 meters of DNA is organized into 46 dup licated chromosomes is present in the nucleus of a human G_2 cell. The prophase is long and complex that lasts for about 50 minutes. It may be divided into 3 sub stages: early prophase, middle prophase and late prophase.

  - **Early prophase-** During the early prophase of mitosis the following events take place:

  - The shape of cell becomes almost rounded and the cytoplasm becomes viscous.

The centrioles lie close to the nucleus and around them assembles the short radiating microtubules by polymerization of the tubulin dimers. Both pairs of centrioles also called **diplosomes**, start moving to the opposite ends of the cell. The microtubules surrounding each pair of centrioles appear like a star body, and are called the **aster**. The microtubules which are also termed as **astral rays**, are not in contact with the centrioles, but are separated from them by an amorphous zone of cytoplasm known as **pericentriolar cloud**. The microtubules stretching between the diplosomes moving apart increase in number and length by incorporating more tubulin dimers. Thus, asters shift the duplicated centrioles to the opposite ends of the cell from where the centriole pair will pass into separate daughter cells when cytokinesis occurs. Though the centrioles have no role in the formation of the spindle but they may be concerned with orienting the spindle.

Long microtubules assemble on one side of the nucleus to form mitotic spindle. **Microtubules are arranged in bundles called spindle fibers** and at each pole of the spindle lies the mother-daughter centriole pair.

The chromosomes that appear like threads in the nucleus gradually change into short, thick rods by loss of water and progressive coiling and become visible. Due to the duplication of DNA and chromosomal proteins during the interphase, each chromosome appears longitudinally double, consisting of two identical sister chromatids which are held together at the narrow region called **primary constriction or centromere**. Each chromatid has a disc like structure at centromere, where the spindle microtubules join it. This disc is called as **kinetochore**.

- **Middle prophase-** It includes the following events:

The chromosomes further get shorter, thicker and their chromatids become uncoiled and finally they assume their characteristics sizes and become distinguishable individually.

Nucleoli progressively become smaller and **finally disappear.** Nuclear envelope begins to breakdown into small vesicles which disperse into the cytoplasm. The lamina dissociates into its protein subunits.

- **Late Prophase-** This phase involves the following events:

The nuclear envelope breaks completely thus, releasing the chromosomes and other nuclear contents into the cytoplasm.

The spindle gains their proper shape and size.

The growing spindles push the centriole pairs to the opposite ends of the cell.

- ***Metaphase-*** The metaphase being short and simple lasts for 2 to 10 minutes and it involves the following events:

A. The spindle occupies the region of the nucleus.
The chromosomes move to the **equatorial plane** of the spindle.

Some spindle microtubules extend to and join the chromosomes. These are called chromosomal or kinetochore microtubules.

The chromosomes get aligned at the middle of the spindle in the form of a plate called **equatorial or metaphase plate**. This plate is formed by the kinetochores, the arms of the chromatids trailing away on the sides. It is at the right angles of the long axis of the spindle. During metaphase the chromosomes have fully aligned into a plate and await the separation of their chromatids.

- ***Anaphase-*** Anaphase lasts only 2 to 3 minutes and it comprises the following events:

The **sister chromatids of each chromosome slightly separate** at the primary constriction so that their kinetochores stretch towards the opposite poles of the spindle. In all the chromosomes separation of chromatids occurs almost simultaneously. The **chromatids are now referred to as chromosomes** because they are no longer held to their duplicates.

After a short time, the chromatids separate completely from their former mates, and start moving to opposite poles of the spindle. As each chromosome is being pulled by its attached microtubules,

its kinetochore leads and arms trail behind. As a result the chromosomes are pulled into V, J and I shapes, depending upon the position of the kinetochore. (Metacentric, sub metacentric or telocentric respectively)

As the chromosomes move toward their respective poles, the two poles move farther apart by elongation of spindle.
The anaphase ends when all the chromatids reach the opposite poles. Each pole of the spindle receive one chromatid from every metaphase chromosome, the two groups of chromatids have exactly the same hereditary information.

- ***Telophase-*** The telophase is long and complex and lasts for an hour or so. In this phase nucleus is reconstructed from each group of chromosomes. It involves the following events:

The **chromosomes** at each pole **unfold, and become long and slender**. Finally, they become indistinguishable as were in an interphase cell.

Nuclear envelope is **reconstructed** around each group of chromosomes gradually. First, the membrane vesicles associate with the individual unfolding chromosomes, partially enclosing each chromosome. Then they fuse to form an envelope surrounding the entire set of chromosomes at each pole. The lamina proteins re-associate simultaneously with the reconstruction of nuclear envelope and form a complete lamina within the nuclear envelope

Nucleolar material, composed of partially processed ribosomal subunits and processing enzymes, dispersed into the cytoplasm in the prophase return to the nucleolar organizer site and forms a small nucleolus. Processing of this preexisting material then continues. Transcription of new rRNA also begins at this time; it gradually speeds up until it attains the high level of characteristic of interphase cell. Along with this, the nucleolus grows and attains its normal size. The nucleolus reformed at telophase, thus contains both old and new rRNA and ribosomal proteins.

With the transformation of chromosomes into chromatin and reconstruction of nucleoli, transcription of all the three RNA types gradually becomes normal.

The spindle begins to disappear and the asters become small by depolymerization of microtubules and the centrioles take up their characteristic interphase position close to the one side of the nucleus. Short spindle microtubules persist for sometime at the spindle equator to mark the region where the cytoplasm will later divide.

Cytokinesis:-

Cytokinesis is the division of cytoplasm. It encloses the daughter nuclei formed by the karyokinesis in separate cells, thus completing the process of cell division. Cytokinesis is signaled at the metaphase by cytoplasmic movements that bring about equal distribution of mitochondria and other cell organelles in the two halves of the cell. Division occurs differently in animal cells and the plant cells.

8.3.2.3 Significance of Mitosis:-

Mitosis has manifold significance-

Maintenance of Size- Mitosis helps maintaining the size of the cell. A cell, when full grown, divides by mitosis instead of growing further.

Growth- A fertilized egg develops into an embryo and finally into an adult by repeated mitotic cell division.

Maintenance of Chromosome Number- Mitosis keeps the number of chromosomes equal in all the cells of an individual. Thus mitosis provides a complete set of genetic information to each cell, since DNA is duplicated in S phase prior to mitosis.

Repair- Mitosis provides new cells to replace the old worn out and dying cells.

Healing and Regeneration- Mitosis produces new cells for the healing of wounds and regeneration.

Reproduction- Mitosis brings about multiplication in the acellular organisms. In multicellular organisms also, it plays an important role in reproduction, asexual as well as sexual.

Evidence of Basic Relationship of Organisms- Mitosis, being essentially similar in many kinds of organisms, supports the basic relationship of all living things.

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