Lectures of Histology

(1st Stage)
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Anatomy and Histology Department

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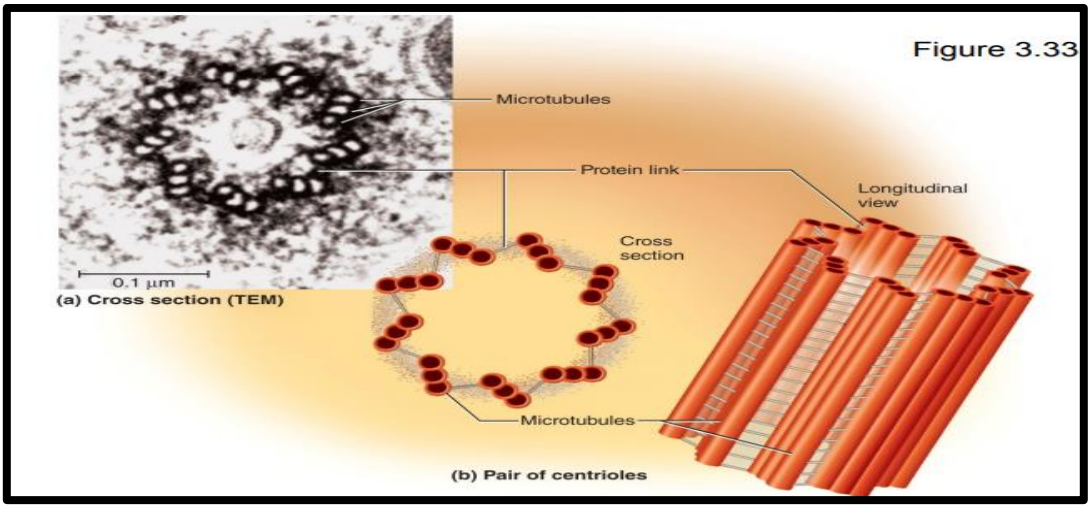
* Centrosome

Microtubule organizing center in cells. Consists of smaller bodies (centrioles). Centrosome help in organizing spindle fibers during mitosis and meiosis. It's also responsible of basal body formation which in turn formation the cilia. Microtubule of the centriole is composed of a protein tubulin and some lipids having a high concentration of ATPase enzymes.

Structure of Centrosome

It's organized in two cylindrical centrioles each one composed of nine highly organized hollow microtubules triple arranged in a circle and embedded in a dense granule or amorphous, electron dense matrix (Fig.1). The paired perpendicularly placed centrioles are located close to the nucleus. During cell division, the centrosome (has no membrane) divides into halves, which move to opposite poles of the cell, and become organizing centers for microtubules of the division spindle.



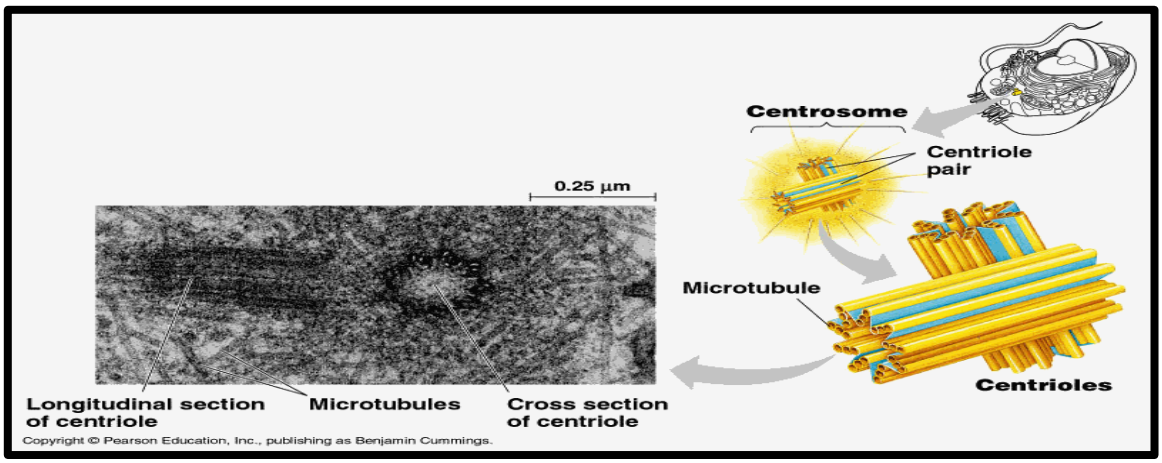
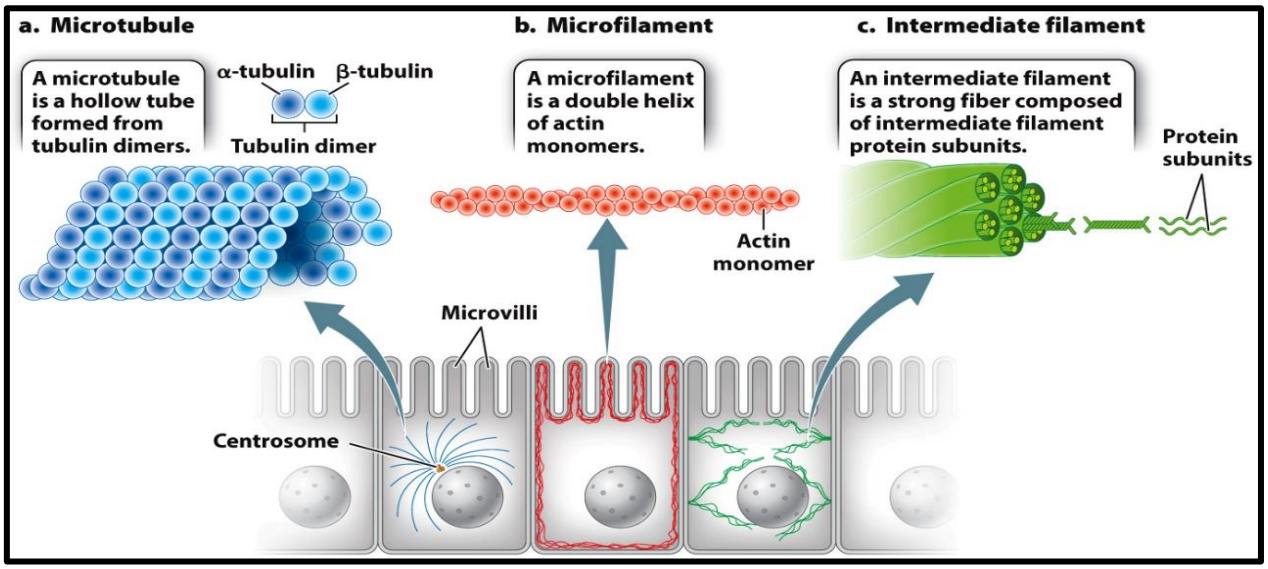


Fig. 1: Two small bundles of cytoskeleton (microtubules) arranged at right angles to one another (centrosome) and surrounded by dense cytoplasm.

The Cytoskeleton

Cell support structure, is a complex array of: microtubules, microfilaments, and intermediate filaments. These network of protein polymers determine the **shapes** of cells, play an important role in the movements of organelles and cytoplasmic vesicles (**directs movement of materials within the cell**), and also allow the movement of entire cells (Fig. 2).



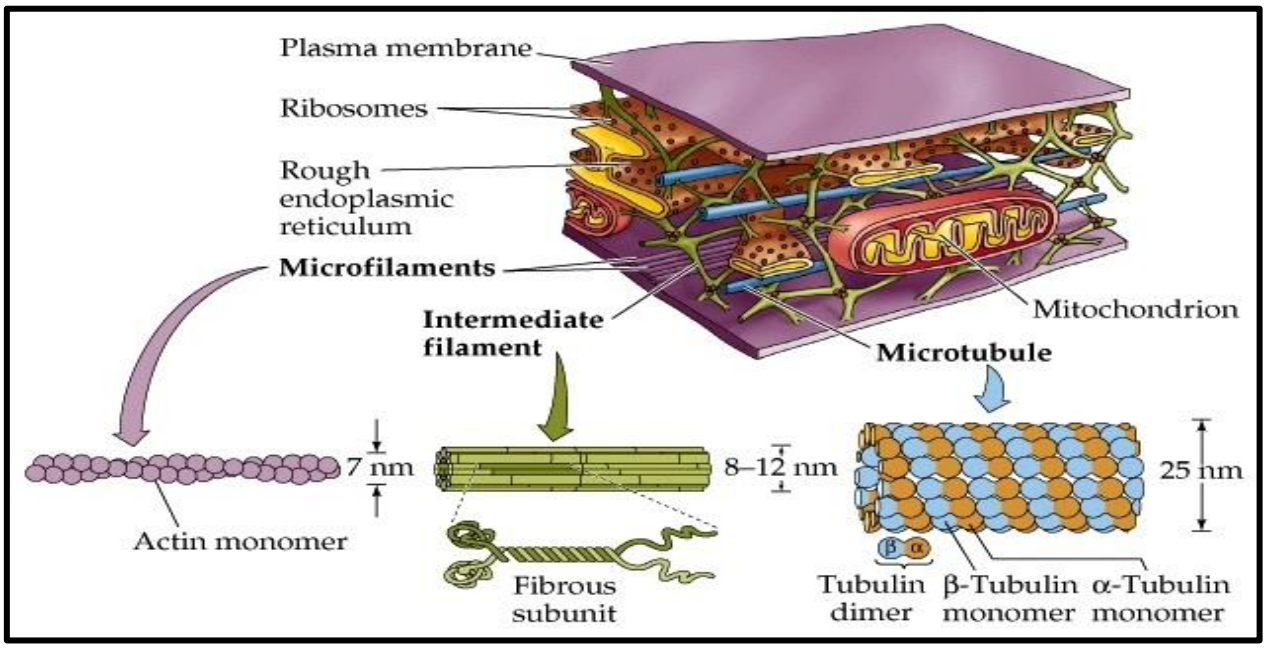


Fig. 2: The Cytoskeleton.

- **Microfilaments:** (6-7)nm thick, made of actin protein.
- **Intermediate filaments:** (8-12)nm thick, made of protein keratin.
- **Microtubules:** (25)nm thick, made of protein tubulin.

(1) Microfilaments

Composed of actin subunits, allow motility and most contractile activity in cells, by interactions with associated myosin proteins. Actin filaments are thin, shorter, and more flexible than microtubules. They are composed of globular G-actin that assemble in presence of K^+ and Mg^{2+} into a double helix. Actin-binding proteins, such as **formin**, change the physical properties of microfilaments, particularly their lengths and interactions with other structures, and this determines the viscosity of the local cytoplasm (cross-linking within networks of actin increases cytoplasmic viscosity).

(2) Intermediate filaments

Unlike microtubules and microfilaments these intermediate filaments are stable, provides increased mechanical stability to cell structure, and are made up of different protein subunits (more than a dozen proteins) in different cell types. Intermediate filament proteins with biological, histological, or pathological importance include the following:

- **Keratin:** accumulates during differentiation in process of keratinization, producing an outer nonliving layer that reduces dehydration, provides some protection from minor abrasions, and produces various hard protective structures of skin, such as nails as well as beaks, horn, and scale.
- **Lamin:** form a structural framework called nuclear lamina below the inner membrane of the nuclear envelope.

(3) Microtubules

They confer significant rigidity to help maintain cell shape. Two or more microtubules are often linked side by side by protein arms or bridges, which are particularly important in the axonemes of cilia and flagella. Microtubule stability varies greatly with cellular location and function (microtubules of **cilia** are very stable, while those of the **mitotic spindle** are short-lived).

Inclusions

Are non-living structures which are incapable of growth and multiplication. They are accumulated metabolites or other substances. Most common inclusions are transitory structures not enclosed by membrane (like: stored cellular products, glycogen granules, starch grains, pigment granules, fat droplets and crystalline forms of certain proteins, as well as, foreign bodies, viruses, intracellular bacteria, dust particles).

CELL DIVISION

Introduction

A multicellular organism starts its life as a single cell and it undergoes repeated division, thus, the growth and development of every living organism depends on the growth and multiplication of its cells. Cell increases in size due to growth and it is the characteristic feature of all the living organisms. After the cell attains maximum growth, it begins to divide. The cell division is a continuous and dynamic process, and it involves the following three stages:

1. DNA or genome replication.
2. Nuclear division or karyokinesis.
3. Cytoplasmic division or cytokinesis.

Cell division is of two types based on number of chromosomes present in the daughter cells in comparison to the dividing parent cell: mitosis and meiosis.

1. **Mitosis:** It is the multiplication of a body cell into two daughter cells of equal size and containing the same number of chromosomes as in the parent cell. It is also called somatic division.

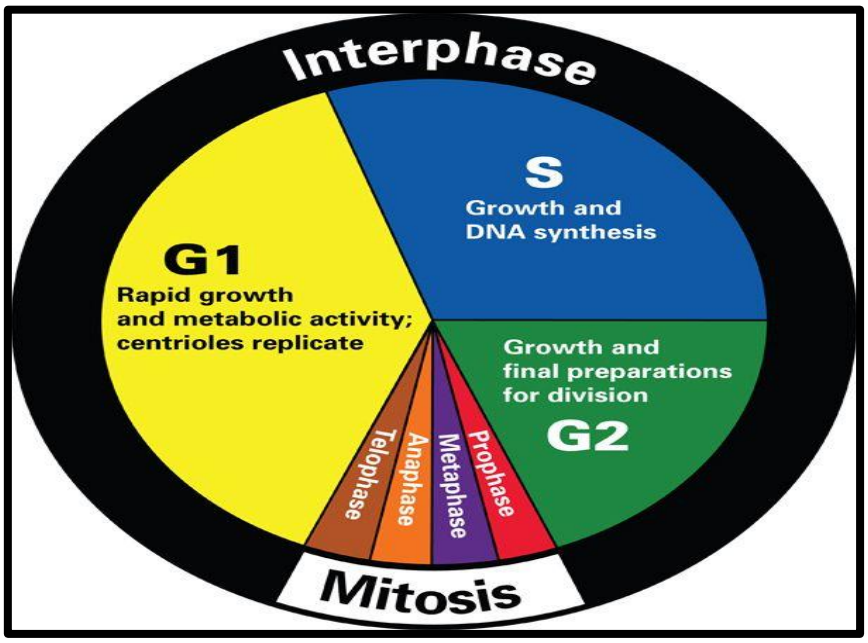
2. **Meiosis:** It occurs only in germ cells during the formation of gametes (sperm and ovum). It's a process by which double number (2N) or diploid chromosomes is reduced to its half number (1N) or haploid. It is also called reduction process.

Cell Cycle Stages

Every cell having the capacity to divide passes through a regular cycle of changes known as cell cycle which is It's a regular sequence of events that produce new cells.

* Phases of Cell Cycle

Cell cycle consists of two stages: A long un-dividing stage called **interphase** or **I-phase** and a short dividing stage called **mitotic** or **M-phase** (Fig. 3).



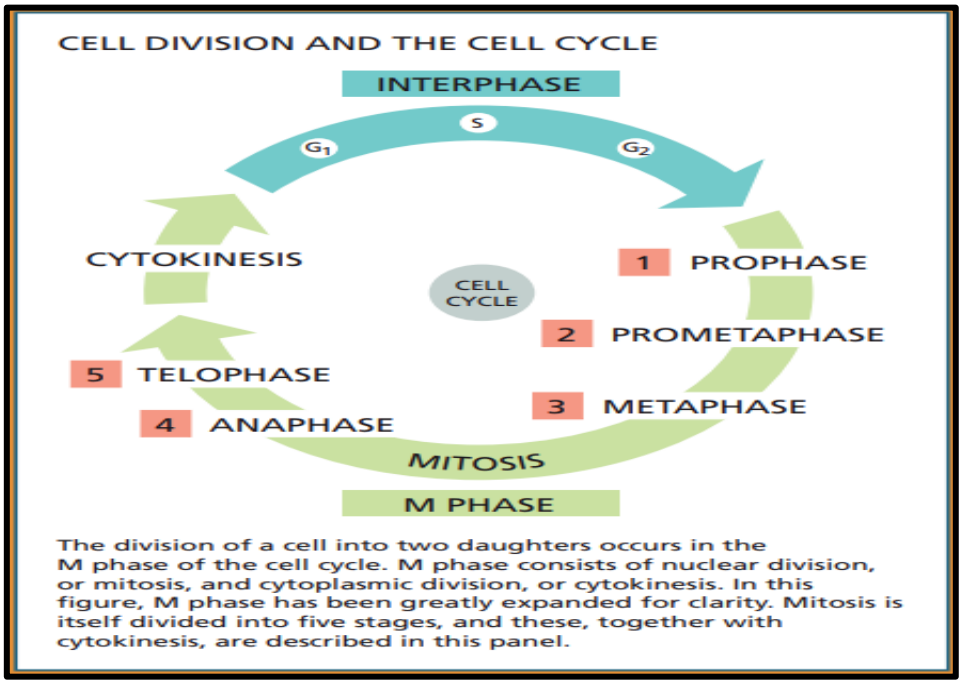


Fig. 3: The Cell Cycle.

1. Interphase: the time between the end of telophase and the beginning of the next M-phase. It is a long stage that lasts for (10-30) hours (Fig.4). Interphase is further divided into three subphases or periods: first gap/G1 phase, synthetic or S phase and second gap/G2 phase.

G1 phase: in this stage initial growth of a newly formed cell takes place. Various biological molecules (carbohydrates, proteins, lipids, including some non-histones, RNAs) are synthesized. DNA synthesis does not occur in this phase.

S Phase: duplication of each chromosome take place by replication of new DNA molecule on the template of the existing DNA. Synthesis of histone and some non-histone proteins also occur. S-phase lasts for (6-8) hours.

G2 Phase: RNA transcription and protein synthesis continues during this phase. Further growth of the cell and preparation for its division also takes place in this stage. In addition to double the cytoplasmic organelles such as centrioles, mitochondria and Golgi apparatus, proteins for spindle are synthesized and stores energy for the next mitosis. G2 phase lasts for (2-5) hours.

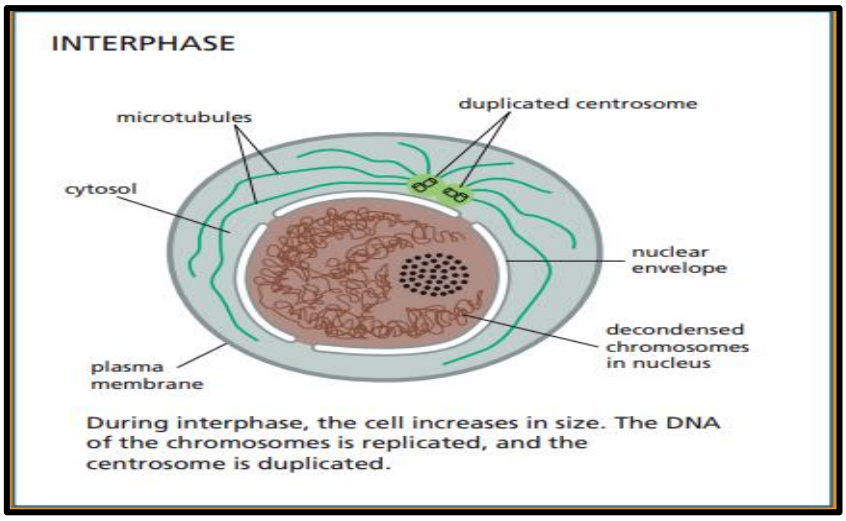
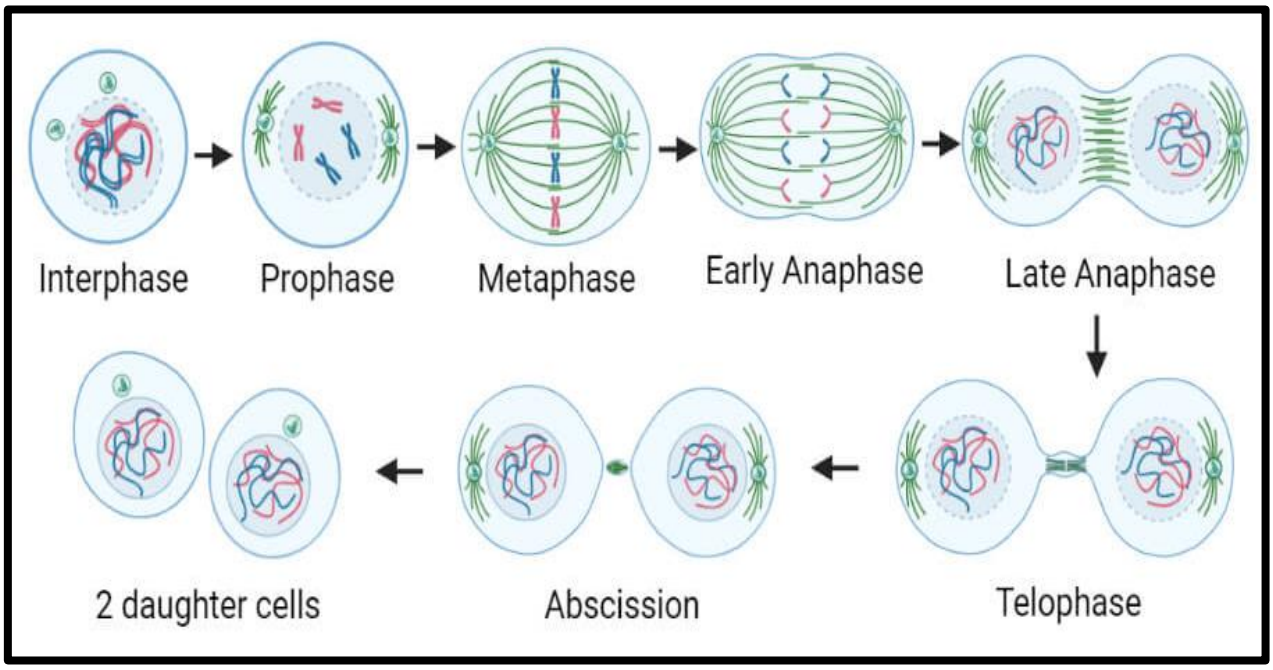


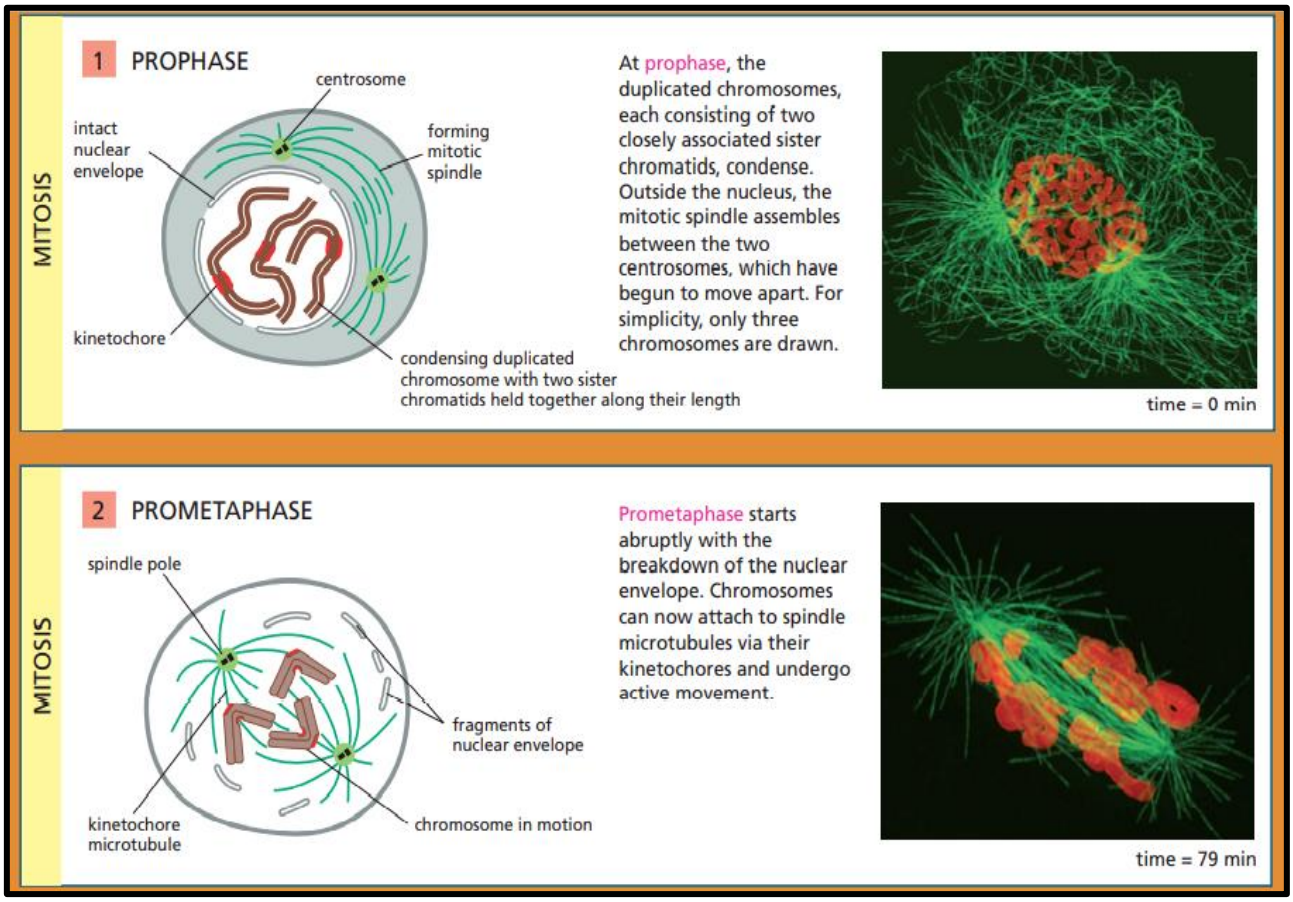
Fig. 4: Interphase.

2. Mitotic Phase: the already duplicated chromosomes are equally distributed to the daughter cells which contain the same hereditary information as the parent cell. Other cell components (organelles and molecules) are also divided approximately equally between the daughter cells, but not as precisely as the DNA. After mitosis is over, the daughter cells enter G1 phase of the next cell cycle.

* Mitosis

It's the most common method of cell division in eukaryotes that takes place in somatic cells of the body (hence it's also called somatic division), it's also known as equational division (Fig. 5).





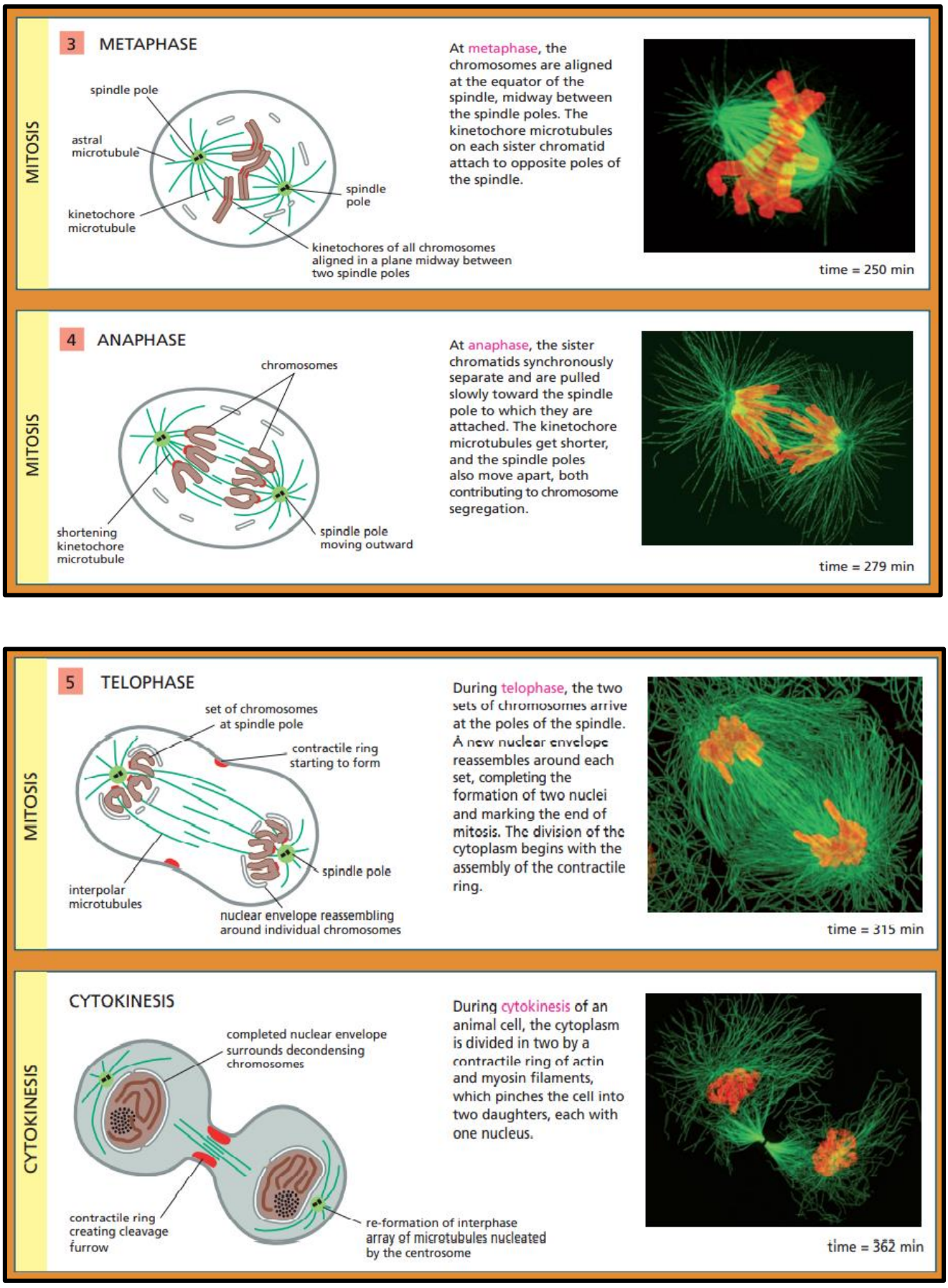
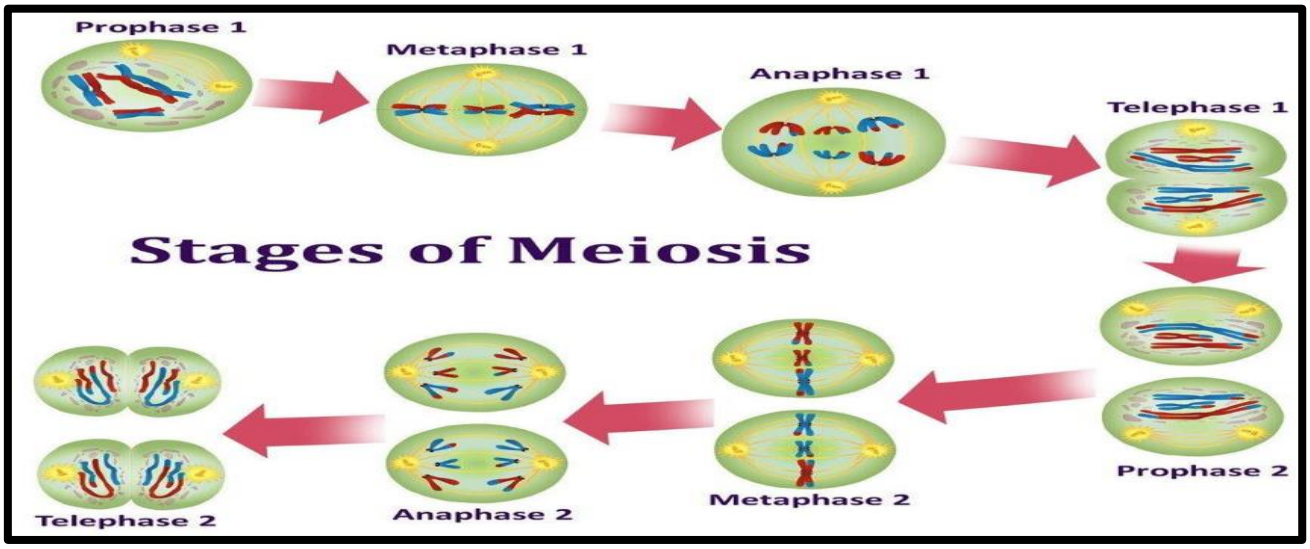
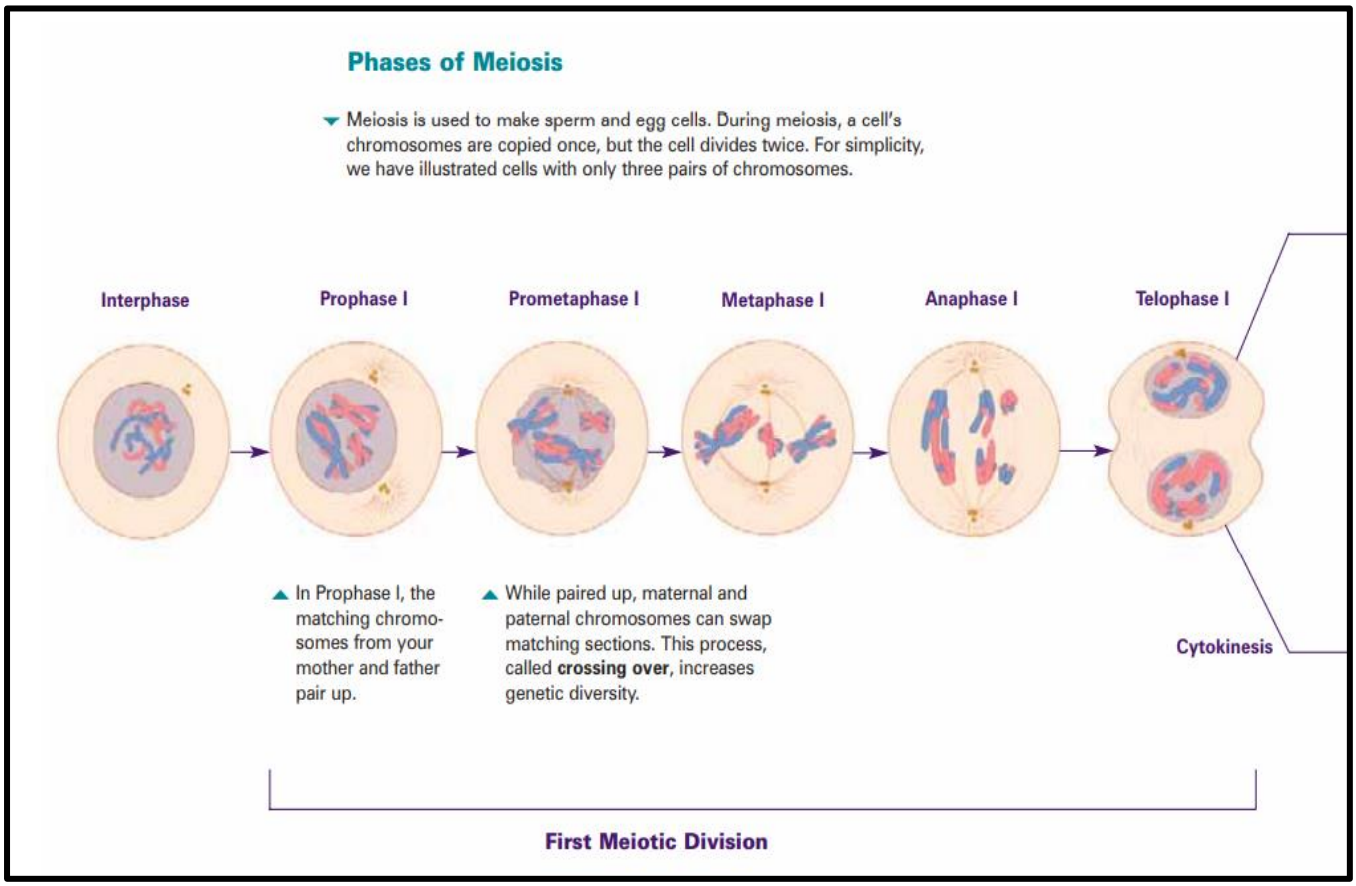


Fig. 5: Mitosis.

* Meiosis

It's confined to certain cells and takes place at a particular time. Only the cells of sexually reproducing organisms undergo meiosis. It consists of two divisions (meiosis-I and meiosis-II) that take place in rapid succession, with the chromosomes replicating only once. Thus, a parent cell produces four daughter cells, each having half the number of chromosomes and half of the nuclear DNA amount present in the parent cell. Meiosis is therefore also known as reduction division (Fig.6).





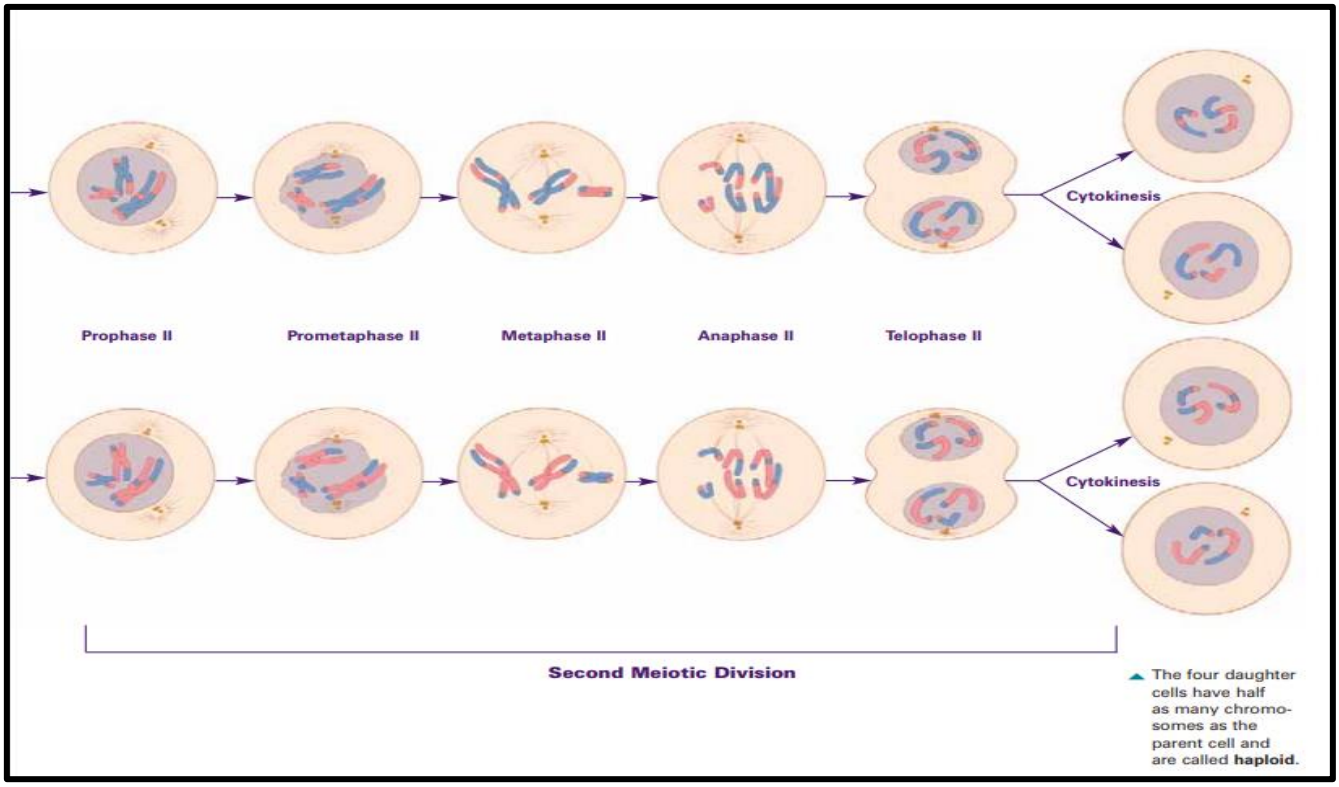


Fig. 6: Meiosis.

Comparison between Mitosis and Meiosis

No.	Mitosis	Meiosis
1	It occurs in all kinds of cells and may continue throughout life.	It occurs only in special cells (gamete mother cells or spore mother cells) and at specific times.
2	It involves a single division, resulting two daughter cells.	It involves two successive divisions, resulting four daughter cells.
3	A cell can repeat mitosis almost indefinitely.	takes place only once in a cell.
4	All mitotic divisions are alike.	Two meiotic divisions are dissimilar, first is reductional and second equational.
5	Each mitotic division is preceded by an interphase.	The second meiotic division is generally not preceded by an interphase.
6	Chromosomes replicate before.	Chromosome do not replicate before each mitotic division. second meiotic division.
7	Prophase is relatively short and simple.	Prophase-1 is very long and elaborate, comprising 5 sub phases.
8	There is no pairing of homologous chromosomes, hence no chance of crossing over.	Homologous chromosomes pair and often undergo crossing over in prophase-1.
9	No chiasmata are formed.	Chiasmata form temporarily where crossing over occurs.
10	Chromatids are genetically similar to chromosomes they arise from.	Chromatids may differ genetically from the chromosomes they arise from due to crossing over.
11	The two kinetochores of a chromosome connect to both the poles of the spindle.	The kinetochores of a chromosome connect to the same spindle pole in metaphase-I and to both the poles in metaphase-II.
12	Anaphase involves separation of chromatids of each chromosome.	Anaphase-I involves separation of homologous chromosomes. The chromatids move apart in anaphase-II.
13	Daughter cells have diploid number of chromosomes like the parent cell.	Daughter cells have haploid number of chromosomes unlike the parent cell.
14	Daughter cells divide again after interphase.	Daughter cells, if gametes, do not divide further.
15	Mitosis brings about growth, repair and healing.	Meiosis forms gametes or spores, helps maintain the number of chromosomes constant from generation to another, with variation.
16	Mitosis is much shorter than meiosis in the same animal.	Meiosis is much longer than mitosis in the same animal.
17	Cytokinesis usually follows karyokinesis.	Cytokinesis often doesn't occur after meiosis-I, but always occur after meiosis-II, forming four cells simultaneously.