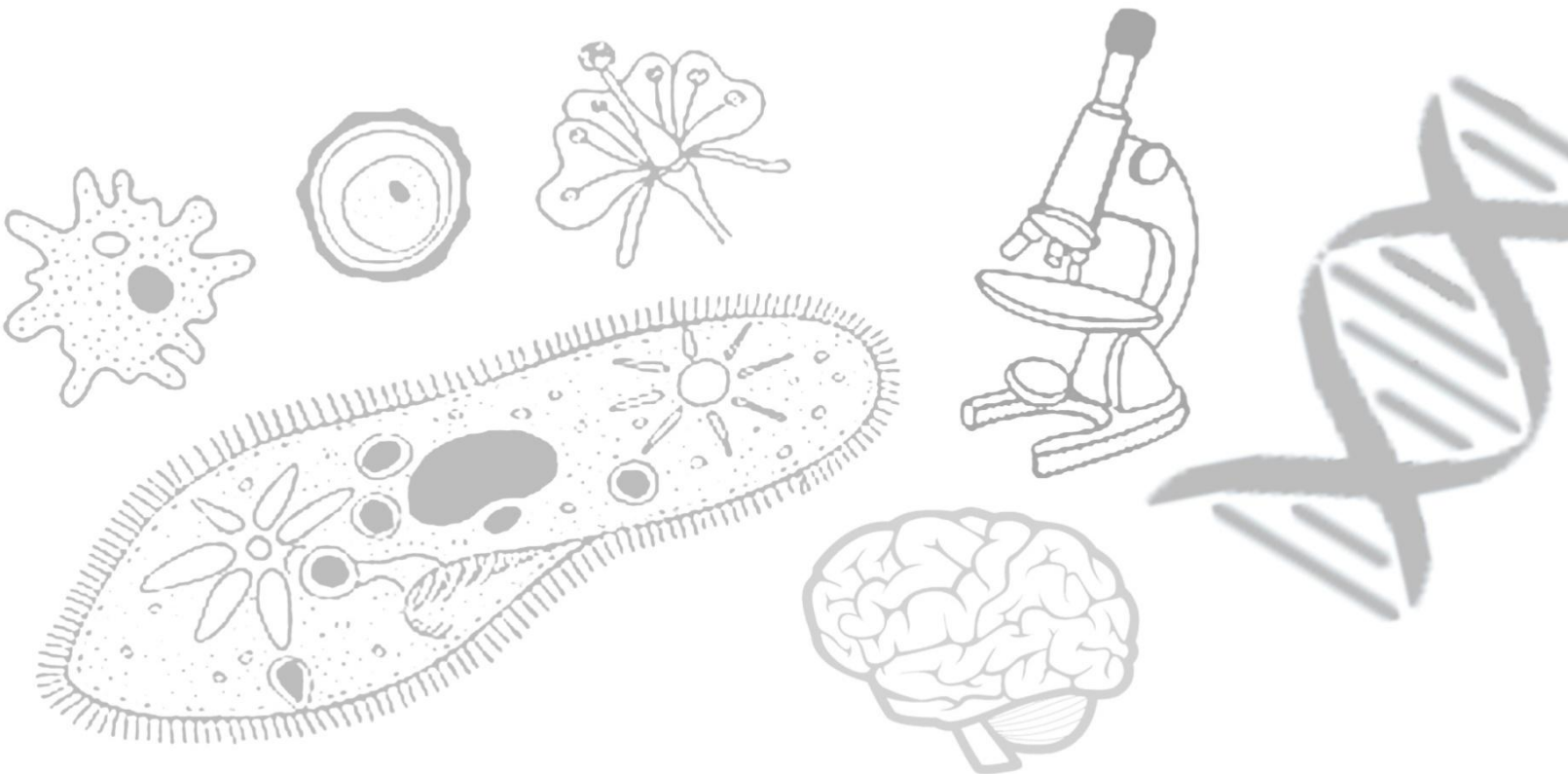
BIOLOGY



Cell Cycle

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Phases of Cell Cycle

- Cell division is a complex, dynamic and continuous process in all living organisms.
- The processes of cell division, DNA replication and cell growth have to occur in a coordinated manner to ensure correct division and formation of progeny cells containing intact genomes.
- The sequence of events by which a cell duplicates its genome and synthesises all other cell contents and eventually divides into two daughter cells is called the cell cycle.

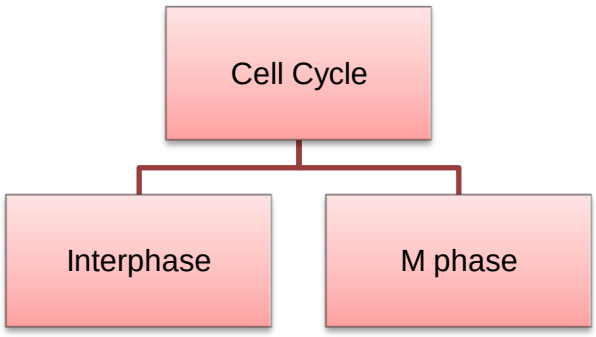
DID YOU KNOW ?

The cell cycle was described by Howard and Pele in 1953.

- The period between two successive cell divisions is called the generation time. It depends on the type of cell and the external factors such as temperature, food and oxygen supply.

Bacterial cells	Epithelial cells of intestine	Onion root tip cells	Mammalian cells	Yeast cells
20 minutes	8-10 hours	20 hours	24 hours	90 minutes

- A typical eukaryotic somatic cell has two main stages—a long undividing state called the interphase also known as the intermitosis or I phase and a shorter phase of nuclear division called the mitotic or M phase. These main phases are followed by a still shorter phase of cytoplasmic division known as cytokinesis.



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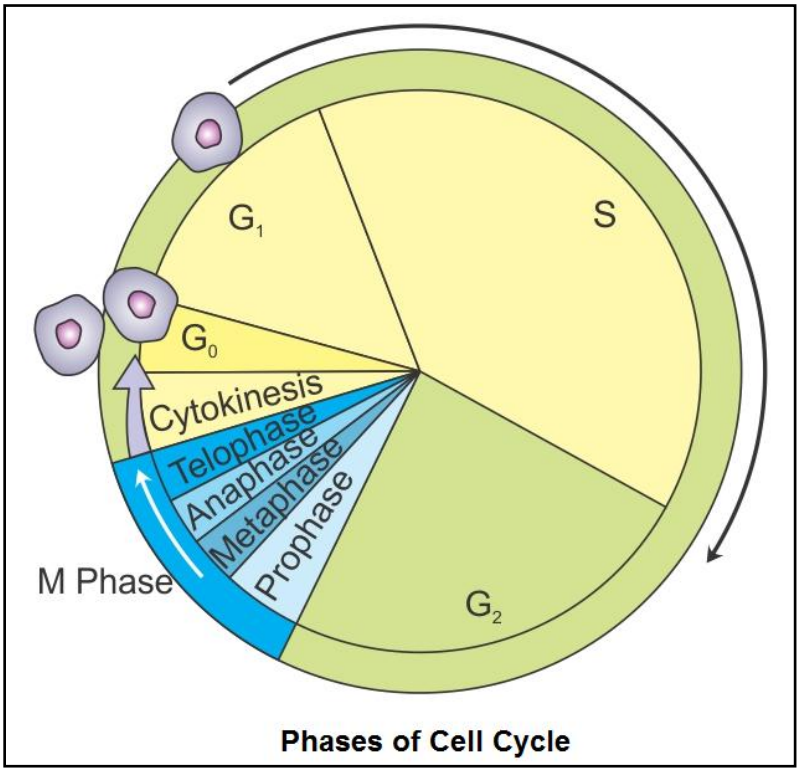

Phases of Cell Cycle

- Various phases of the cell cycle are regulated by proteins, cyclins and cyclin-dependent protein kinases (CDKs).
- The CDKs phosphorylate proteins using ATP resulting in the breakdown of nuclear membrane.
- Two regulatory mechanisms called check points are carried out by these CDKs. The first check point lies between the G1 and S phases and the second check point lies between the G2 and M phases.
- The check points take decisions about the progress of cell division.

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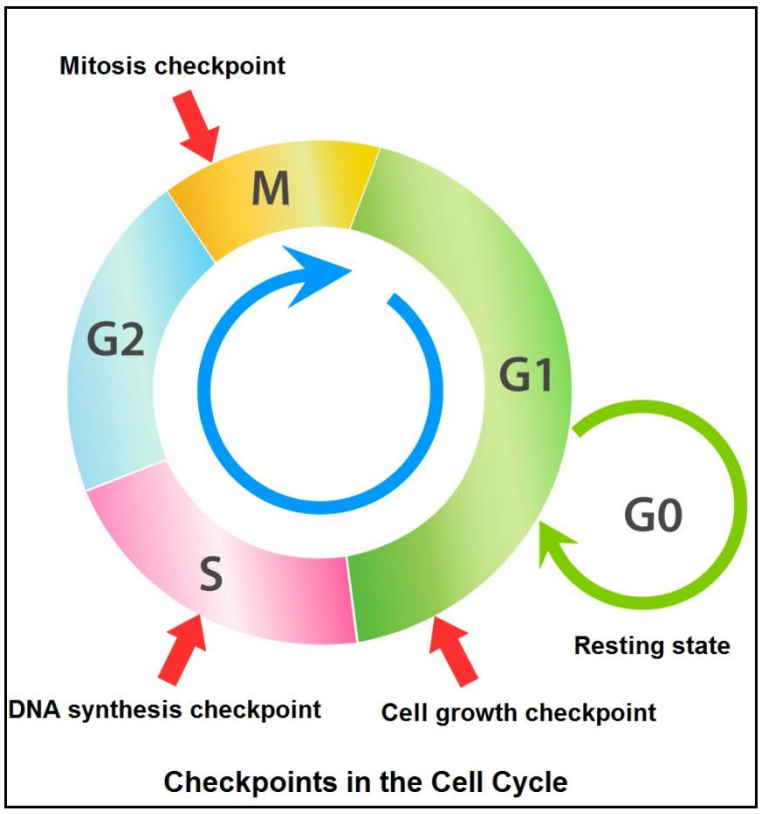
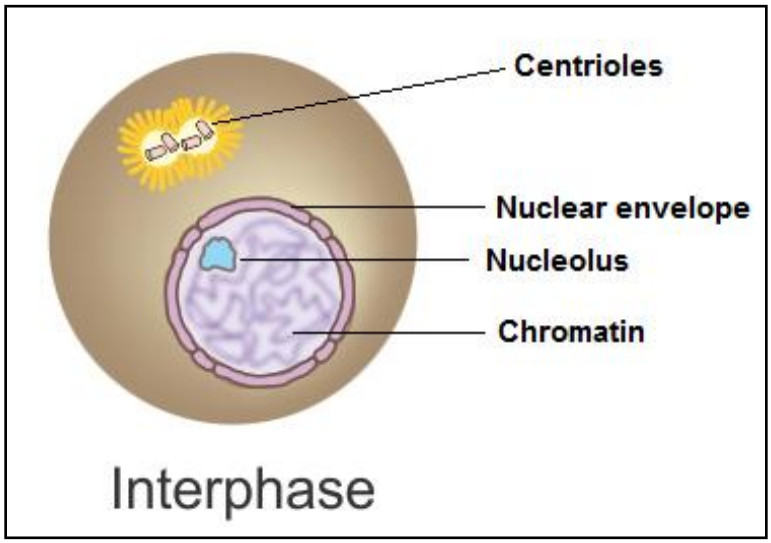


Checkpoints in the Cell Cycle

Interphase

- Interphase involves a series of changes which take place in a newly formed cell and its nucleus before it gets ready for division again. It is also called intermitosis.
- Interphase generally accounts for 95% of the total duration of the cell cycle.
- It is the preparatory phase and a period of great metabolic activity.



- In this stage, the nucleus and the cytoplasm remain metabolically and synthetically very active.
- During this phase, DNA replication, synthesis of nuclear histones, division of centrioles to form a new pair of centrioles, synthesis of energy-rich compounds and synthesis of RNA and proteins take place.
- The nuclear envelope remains intact.
- Chromosomes appear in the form of long, coiled, indistinctly visible chromatin fibres.
- The size of the nucleolus increases because of the accumulation of rRNA and ribosomal proteins.

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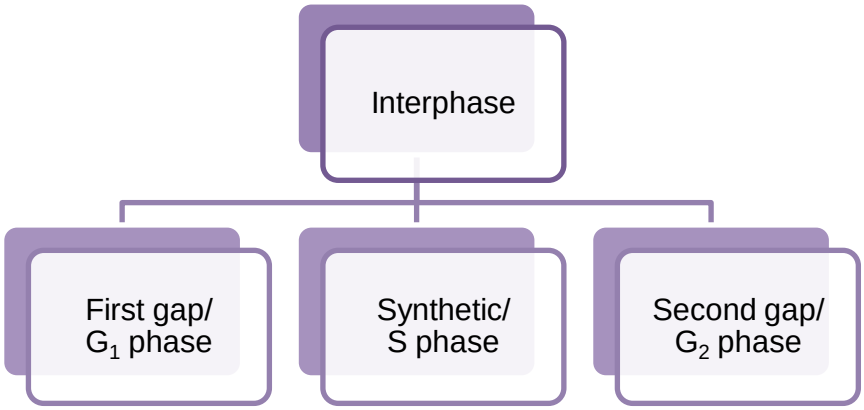
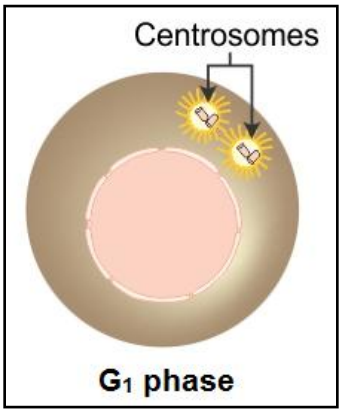
- Interphase is further divided into three periods—first gap or G_1 phase, synthetic or S phase and second gap or G_2 phase. Duration of these phases is different in different organisms.



G_1 Phase (Post-mitotic Gap Phase)

- The G_1 phase is the interval phase between mitosis and the initiation of DNA replication.



Biochemical Changes which Occur during the G_1 Phase:

The cell grows to its maximum size to prepare for DNA replication.
Synthesis of new proteins and RNA takes place.
Transcription of rRNA, tRNA and mRNA occurs during this phase.
Nucleotides, amino acids and energy-rich compounds such as ATP are formed.
No change occurs in the DNA content of the cell.

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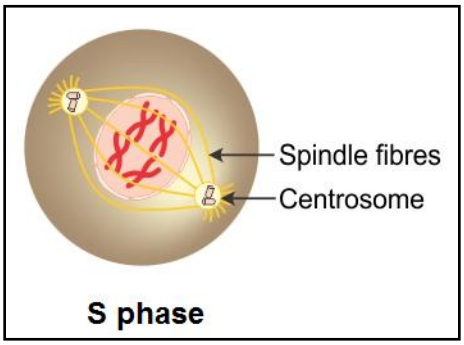
- The duration of the G_1 phase is highly variable. The cells which divide frequently have a shorter G_1 phase, while the cells which divide less frequently have a longer G_1 phase.
- The G_1 phase can be terminated by various stimuli. However, when a cell has completed the G_1 phase and enters the S phase, it cannot be terminated.

G_0 phase or Quiescent Stage

It is the stage of inactivation of cell cycle due to unavailability of mitosis inducing factors and energy rich compounds. The cells remain metabolically active. They do not grow or differentiate. The cells function as reserve cells which can join cell cycle any time. The cells in this stage proliferate depending on the requirement of the organism. Some of the G_0 phase cells such as fibroblasts, which help in healing of wounds, grow and divide on the demand of the body. Some types of cells such as nerve cells, skeletal muscle cells etc. do not divide after attaining full differentiation and finally die.

S Phase or Synthetic Phase

- During the S phase, synthesis or replication of DNA occurs on the template of the existing DNA strand.



Biochemical Changes which Occur during the S Phase:

The amount of DNA per cell doubles, but there is no change in the chromosome number of the cell.

DNA replication occurs in the nucleus, and the centriole duplicates in the cytoplasm.

Histone proteins are synthesised and associate with each DNA strand forming nucleosomes.

Some non-histone proteins are also synthesised during this phase.

- The S phase is called the invisible phase of the cell cycle as replicated chromosomes are not visible at this stage.
- The S phase lasts for 6–8 hours. When the S phase begins, the cell must undergo mitosis.

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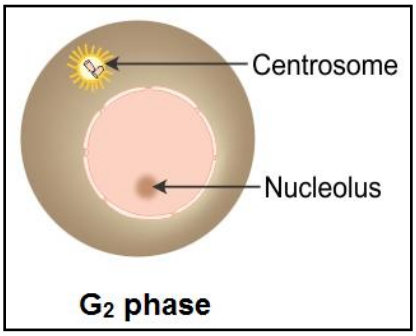
G_2 Phase or Pre-mitotic Gap Phase

- The G_2 phase is a stage of further growth of the cell and preparation for its division.



Biochemical Changes which Occur during the G_2 Phase:

Synthesis of RNA and proteins continues.

Spindle protein synthesis and aster formation take place.

Cytoplasmic organelles such as centrioles, mitochondria and Golgi apparatus are assembled and stored in small vesicles.

Synthesis of some protein kinases for the regulation of cell division also takes place.

- The G_2 phase lasts for 2–5 hours.
- Some proteins formed in the G_2 phase cause condensation of chromosomes to initiate mitosis.

DID YOU KNOW ?

An interphase cell is sometimes described as a resting cell. However, this is not true. In fact, interphase is the most active period of the cell. It is also called the energy phase.

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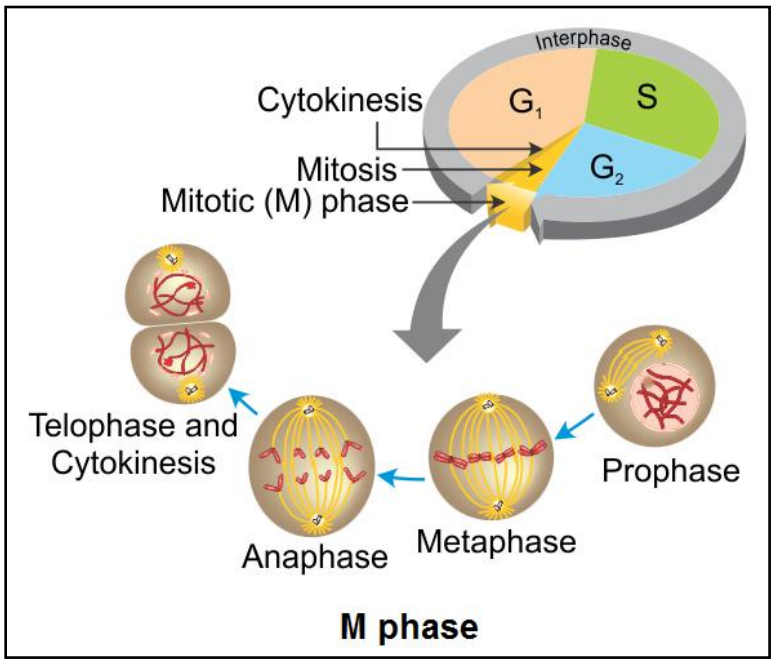
M Phase or Mitotic Phase

- The mitotic or M phase follows interphase. It starts with nuclear division, corresponding to the separation of daughter chromosomes (karyokinesis) and usually ends with the division of the cytoplasm (cytokinesis).
- After karyokinesis, mitosis is followed immediately by an equal division of the cytoplasm, dividing the cell organelles and macromolecules approximately equally between the daughter cells.
- Cytokinesis is followed by the separation of two diploid daughter cells.



- The M phase lasts for only about an hour.
- After completion of mitosis, the daughter cells may enter the G_1 phase of the next cell cycle or the G_0 phase.

In animal cell, mitosis is called amphiastral.
In plant cell, mitosis is called anastral.
If mitosis is extranuclear, it is called eumitosis.
If mitosis is intranuclear, it is called premitosis.

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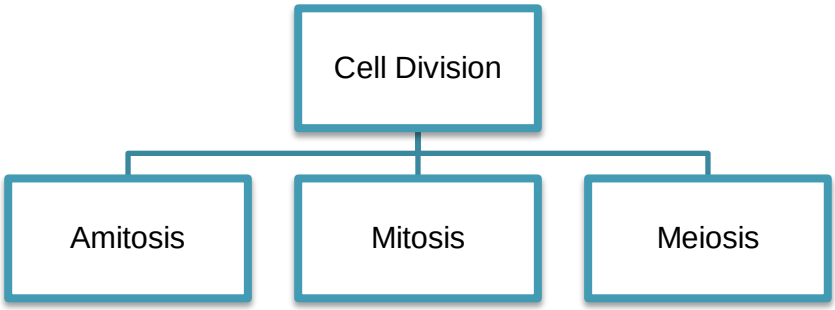
Cell Division

What is Cell Division?

- Cell division is an essential feature in all living organisms.
- In unicellular organisms, cell division is necessary to increase the number and to maintain continuity of life. In multicellular organisms, it brings about growth, development, repair, maintenance and reproduction.

Modes of Cell Division



Amitosis

- Amitosis is a method of asexual reproduction which occurs in acellular organisms such as bacteria, protozoa, old cells, mammalian cartilage cells and in foetal membranes.
- Amitosis is also called direct cell division.

DID YOU KNOW ?

Amitosis was first discovered by Robert Remak in 1841 in the red blood cells of chick embryo.

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Stages in Amitosis

The nucleus of the cell elongates.

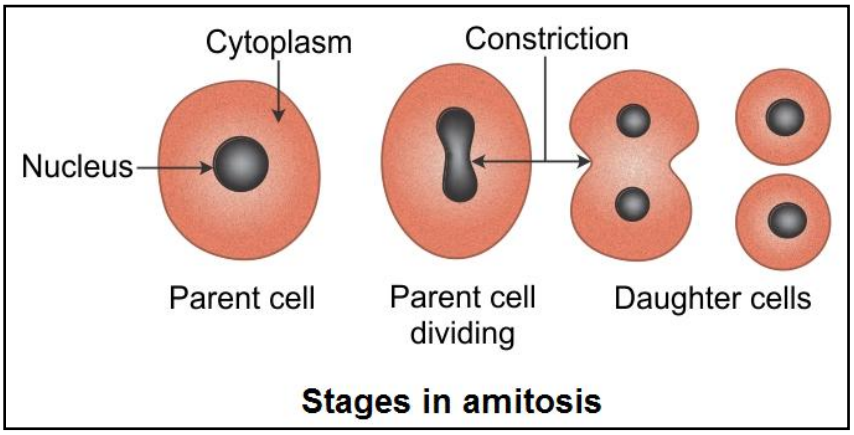
A constriction appears in the nucleus which gradually deepens and divides the nucleus into two daughter nuclei.

A constriction appears in the cytoplasm which divides the cytoplasm and the nuclei into two daughter cells, each with a nucleus.

Formation of spindle and distinct chromosomes does not occur.

The nuclear envelope remains intact.

The daughter cells receive approximately equal amounts of nuclear and cytoplasmic material.



Stages in amitosis

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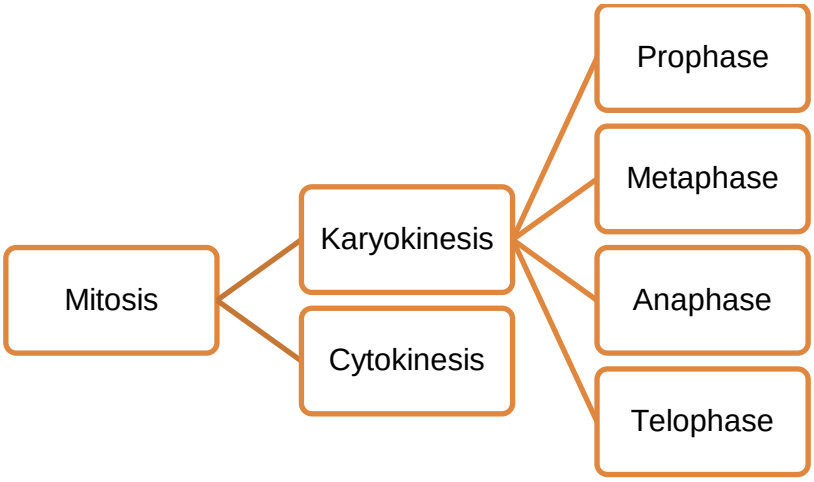
Mitosis

- Mitosis is a common method of cell division.
- It occurs in the somatic cells of animals, and hence, it is also called somatic division.
- In plants, it takes place in the meristematic tissues and during the growth of leaves, flowers and fruits.
- Mitosis is the division of the parent cell into two identical daughter cells, each with a nucleus which has the same amount of DNA, same number and type of chromosomes and same hereditary information as in the parent cell. Hence, mitosis is regarded as equational division.
- Mitosis is an elaborate process which involves a series of significant changes in the nucleus and in the cytoplasm.

Events in Mitosis



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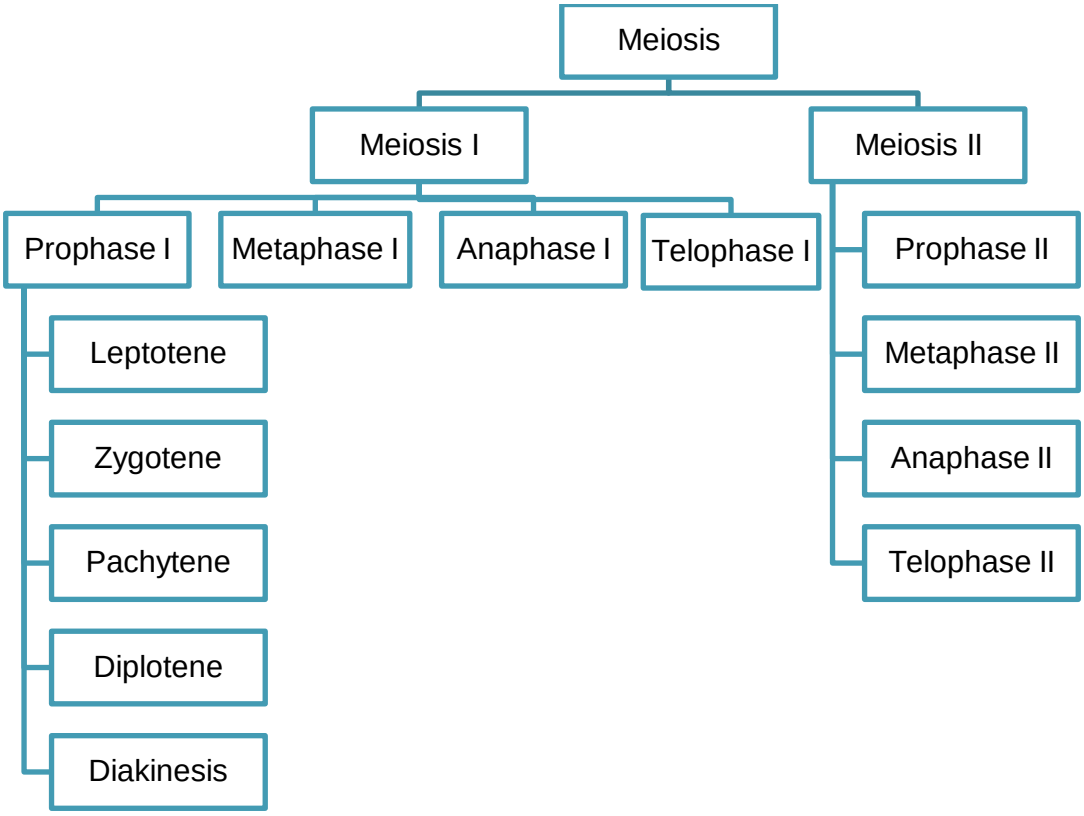
Meiosis

- Meiosis takes place only in certain types of cells and occurs only at a particular time.
- Sexually reproducing organisms undergo meiosis, and some special cells in multicellular organisms undergo meiosis instead of mitosis at a specific time in the life cycle.
- Meiosis produces gametes in animals, some lower plants and various protists and fungi. It forms asexual reproductive bodies called spores in higher plants which give rise to gamete-producing structures which produce gametes by mitosis.

Events in Meiosis



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Factors Controlling Cell Division

Cell Size	•Cells capable of division grow for some time, attain a particular size and then undergo division.
Karyoplasmic Ratio	•Increase in cell volume disturbs the karyoplasmic ratio. •It stimulates the cell to divide.
Mitogens	•Mitogens are factors which trigger cell division. •A common plant mitogen is cytokinin. •Common human mitogens are lymphokines, epidermal growth factor (EGF) and platelet-derived growth factor (PDGF).

Significance of Cell Division

Cell Multiplication	Continuity	Asexual Reproduction	Formation of Multicellular Organisms
Growth	Cell Size	Genetic Similarity	Repair
Regeneration	Sexual Reproduction	Reshuffling of Genetic Traits	Mutations

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