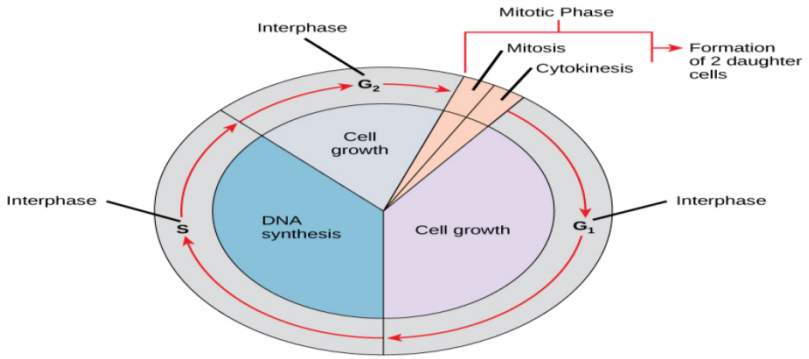
MITOSIS AND MEIOSIS
CELL CYCLE

❖The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.

❖Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth.

❖DNA replication, and division that produce two genetically identical cells.



A cell moves through a series of phases in an orderly manner. During interphase, G1 involves cell growth and protein synthesis, the S phase involves DNA replication and the replication of the centrosome, and G2 involves further growth and protein synthesis. The mitotic phase follows interphase. Mitosis is nuclear division during which duplicated chromosomes are segregated and distributed into daughter nuclei. Usually the cell will divide after mitosis in a process called cytokinesis in which the cytoplasm is divided and two daughter cells are formed.

❖The cell cycle has two major phases: interphase and the mitotic phase.

❖During interphase, the cell grows and DNA is replicated.

❖During the mitotic phase, the replicated DNA and cytoplasmic contents are separated and the cell divides.

❖Auxetic growth- an increase in cell mass

❖Multiplicative growth-increase in cell number due to cell division

❖Accretionary growth- due to accumulation of extracellular products.

• INTERPHASE

❖During interphase, the cell undergoes normal processes while also preparing for cell division.

❖For a cell to move from interphase to the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called G1, S, and G2.

G1 Phase

❖The first stage of interphase is called the G1 phase, or first gap, because little change is visible.

❖During the G1 stage, the cell is quite active at the biochemical level.

❖The cell is accumulating the building blocks of chromosomal DNA and the associated proteins, as well as accumulating enough energy reserves to complete the task of replicating each chromosome in the nucleus.

S Phase

❖Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration.

❖In the S phase, replication results in the formation of two identical copies of each chromosome sister chromatids

❖At this stage, each chromosome is made of two sister chromatids. The centrosome is duplicated during the S phase.

G2 Phase

❖In the G2 phase, or second gap, the cell replenishes its energy stores and synthesizes the proteins necessary for chromosome manipulation.

❖Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic spindle.

❖ There may be additional cell growth during G2. The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

❖The two centrosomes will give rise to the mitotic spindle, the apparatus that orchestrates the movement of chromosomes during mitosis.

❖The centrosome consists of a pair of rod-like centrioles at right angles to each other. Centrioles help organize cell division.

❖Centrioles are not present in the centrosomes of many eukaryotic species, such as plants and most fungi.

The Mitotic Phase

❖To make two daughter cells, the contents of the nucleus and the cytoplasm must be divided.

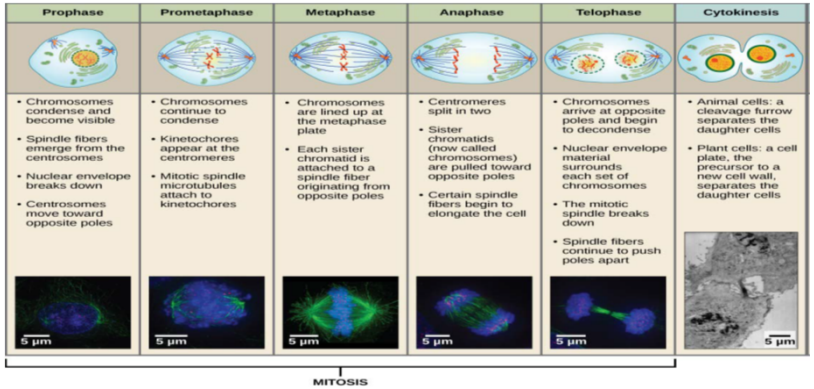
❖The mitotic phase is a multistep process during which the duplicated chromosomes are aligned, separated, and moved to opposite poles of the cell, and then the cell is divided into two new identical daughter cells.

- The first portion of the mitotic phase, mitosis, is composed of five stages, which accomplish nuclear division-prophase, prometaphase, metaphase, anaphase, and telophase.
- The second portion of the mitotic phase, called cytokinesis, is the physical separation of the cytoplasmic components into two daughter cells.

PROPHASE

- During prophase, the "first phase," several events must occur to provide access to the chromosomes in the nucleus.
- The nuclear envelope starts to break into small vesicles, and the Golgi apparatus and endoplasmic reticulum fragment and disperse to the periphery of the cell.
- The nucleolus disappears and centrosomes begin to move to opposite poles of the cell.
- The microtubules that form the basis of the mitotic spindle extend between the centrosomes, pushing them farther apart as the microtubule fibres lengthen. The sister chromatids begin to coil more tightly and become visible under a light microscope.

Stages in Mitosis



PROMETAPHASE

- During prometaphase, many processes that were begun in prophase continue to advance and culminate in the formation of a connection between the chromosomes and cytoskeleton. The remnants of the nuclear envelope disappear.
- The mitotic spindle continues to develop as more microtubules assemble and stretch across the length of the former nuclear area.
- Chromosomes become more condensed and visually discrete. Each sister chromatid attaches to spindle microtubules at the centromere via a protein complex called the kinetochore.

METAPHASE

- During metaphase, all of the chromosomes are aligned in a plane called the metaphase plate, or the equatorial plane, midway between the two poles of the cell. The sister chromatids are still tightly attached to each other. At this time, the chromosomes are maximally condensed.

TELOPHASE

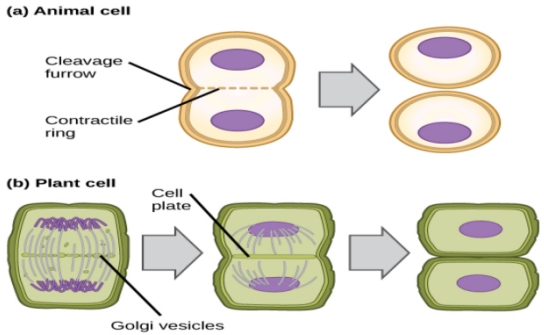
- During telophase, all of the events that set up the duplicated chromosomes for mitosis during the first three phases are reversed. The chromosomes reach the opposite poles and begin to decondense (unravel). The mitotic spindles are broken down into monomers that will be used to assemble cytoskeleton components for each daughter cell. Nuclear envelopes form around chromosomes.

ANAPHASE

- During anaphase, the sister chromatids at the equatorial plane are split apart at the centromere. Each chromatid, now called a chromosome, is pulled rapidly toward the centrosome to which its microtubule was attached. The cell becomes visibly elongated as the non-kinetochore microtubules slide against each other at the metaphase plate where they overlap.

CYTOKINESIS

- Cytokinesis is the second part of the mitotic phase during which cell division is completed by the physical separation of the cytoplasmic components into two daughter cells. Although the stages of mitosis are similar for most eukaryotes, the process of cytokinesis is quite different for eukaryotes that have cell walls, such as plant cells.



Proto-oncogenes

- The genes that code for the positive cell-cycle regulators are called proto-oncogenes. Proto-oncogenes are normal genes that, when mutated, become oncogenes-genes that cause a cell to become cancerous. Consider what might happen to the cell cycle in a cell with a recently acquired oncogene!

Significance of Mitosis

- It helps the cell in maintaining proper size
- Maintain the equilibrium in the amount of DNA and RNA in the cell
- Provides opportunity for growth and development to organs and body of organisms.

Which of the following is the correct order of events in mitosis?

- a. Sister chromatids line up at the metaphase plate. The kinetochore becomes attached to the mitotic spindle. The nucleus re-forms and the cell divides. The sister chromatids separate.
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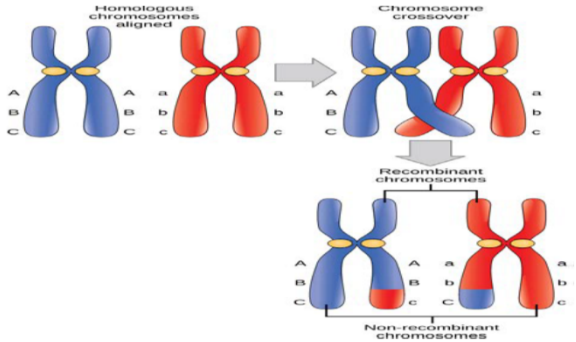
- d. The kinetochore becomes attached to the mitotic spindle. Sister chromatids line up at the metaphase plate. The kinetochore breaks apart and the sister chromatids separate. The nucleus re-forms and the cell divides.

Meiosis

- Sexual reproduction requires fertilization, a union of two cells from two individual organisms.
- If those two cells each contain one set of chromosomes, then the resulting cell contains two sets of chromosomes.
- The number of sets of chromosomes in a cell is called its ploidy level.
- Haploid cells contain one set of chromosomes. Cells containing two sets of chromosomes are called diploid.
- If the reproductive cycle is to continue, the diploid cell must somehow reduce its number of chromosome sets before fertilization can occur again, or there will be a continual doubling in the number of chromosome sets in every generation.
- Prophase-Proleptotene, Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

- The term meiosis was coined J.B Farmer in 1905
- Sexual reproduction includes a nuclear division, known as meiosis, that reduces the number of chromosome sets.
- Homologous chromosomes are matched pairs containing genes for the same traits in identical locations along their length.
- Meiocytes- These are cells where meiosis occurs.
- Meiocytes of the gonads are called Gonocytes which maybe spermatocytes in male and oocytes in female.
- The meiocytes in plants sporangium are called Sporocytes (Microsporocytes and megasporocytes)

This process is revealed visually after the exchange as chiasmata



Meiosis I

- Early in prophase I, the chromosomes can be seen clearly microscopically. As the nuclear envelope begins to break down.
- The proteins associated with homologous chromosomes bring the pair close to each other. The tight pairing of the homologous chromosomes is called synapsis.
- In synapsis, the genes on the chromatids of the homologous chromosomes are precisely aligned with each other.
- An exchange of chromosome segments between non-sister homologous chromatids occurs and is called crossing over.

- This process is revealed visually after the exchange as chiasmata
- The key event in prometaphase I is the attachment of the spindle fiber microtubules to the kinetochore proteins at the centromeres.
- The microtubules assembled from centrosomes at opposite poles of the cell grow toward the middle of the cell.
- At the end of prometaphase I, each tetrad is attached to microtubules from both poles, with one homologous chromosome attached at one pole and the other homologous chromosome attached to the other pole.
- The nuclear membrane has broken down entirely.

METAPHASE

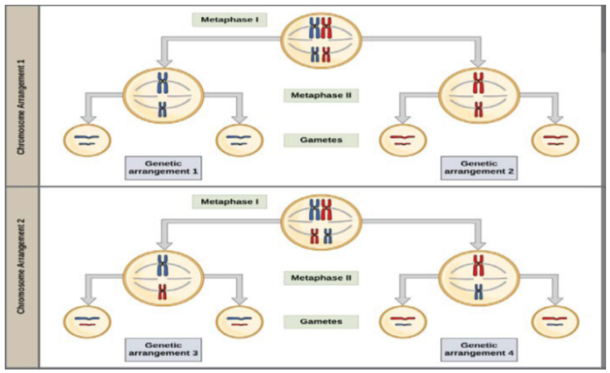
- During metaphase I, the homologous chromosomes are arranged in the center of the cell with the kinetochores facing opposite poles.
- The orientation of each pair of homologous chromosomes at the centre of the cell is random.

ANAPHASE 1

- In anaphase I, the spindle fibers pull the linked chromosomes apart. The sister chromatids remain tightly bound together at the centromere. It is the chiasma connections that are broken in anaphase I as the fibers attached to the fused kinetochores pull the homologous chromosomes apart

- In telophase I, the separated chromosomes arrive at opposite poles. The remainder of the typical telophase events may or may not occur depending on the species. In some organisms, the chromosomes decondense and nuclear envelopes form around the chromatids in telophase I.

RANDOMISATION OF HOMOLOGOUS CHROMOSOME



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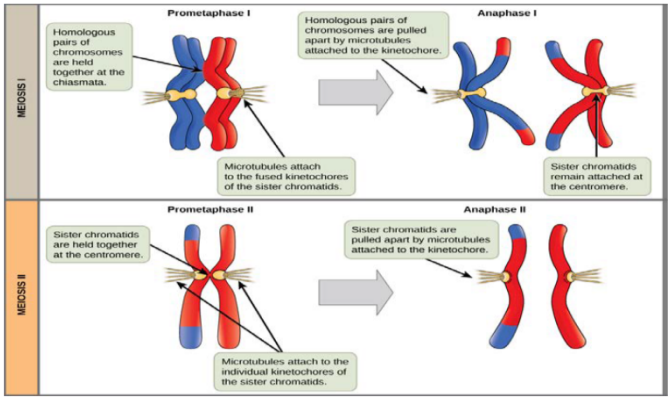
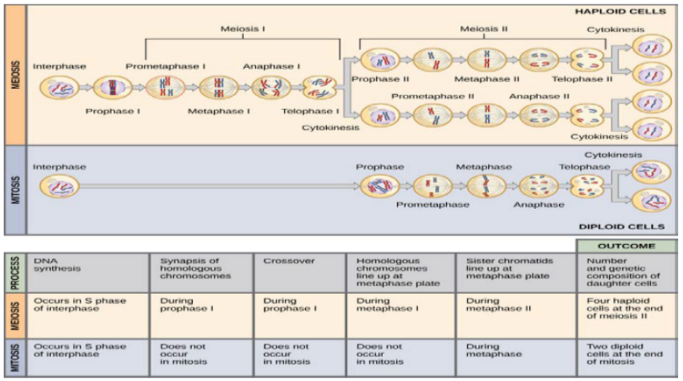


- In prophase II, if the chromosomes decondensed in telophase I, they condense again.
- If nuclear envelopes were formed, they fragment into vesicles. The centrosomes duplicated during interkinesis move away from each other toward opposite poles, and new spindles are formed.
- In prometaphase II, the nuclear envelopes are completely broken down, and the spindle is fully formed.
- Each sister chromatid forms an individual kinetochore that attaches to microtubules from opposite poles.



						OUTCOME
PROCESS	DNA synthesis	Synapsis of homologous chromosomes	Crossover	Homologous chromosomes line up at metaphase plate	Sister chromatids line up at metaphase plate	Number and genetic composition of daughter cells
MEIOSIS	Occurs in S phase of interphase	During prophase I	During prophase I	During metaphase I	During metaphase II	Four haploid cells at the end of meiosis II
MITOSIS	Occurs in S phase of interphase	Does not occur in mitosis	Does not occur in mitosis	Does not occur in mitosis	During metaphase	Two diploid cells at the end of mitosis

Meiosis and mitosis are both preceded by one round of DNA replication; however, meiosis includes two nuclear divisions. The four daughter cells resulting from meiosis are haploid and genetically distinct. The daughter cells resulting from mitosis are diploid and identical to the parent cell.

- In metaphase II, the sister chromatids are maximally condensed and aligned at the center of the cell.
- In anaphase II, the sister chromatids are pulled apart by the spindle fibers and move toward opposite poles.
- In telophase II, the chromosomes arrive at opposite poles and begin to decondense. Nuclear envelopes form around the chromosomes.
- Cytokinesis separates the two cells into four genetically unique haploid cells. At this point, the nuclei in the newly produced cells are both haploid and have only one copy of the single set of chromosomes.

- ✓A diploid cell has _____ the number of chromosomes as a haploid cell. (a) one-fourth (b) one-half (c) twice (d) four times
- ✓An organism's traits are determined by the specific combination of inherited _____. (a) cells (b) genes (c) proteins (d) chromatids
- ✓Chromosomes are duplicated during what portion of the cell cycle? (a) G1 phase (b) S phase (c) prophase (d) prometaphase
- ✓Separation of the sister chromatids is a characteristic of which stage of mitosis? (a)prometaphase (b). metaphase (c). anaphase (d) telophase

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- ✓Which eukaryotic cell-cycle event is missing in binary fission?

(a) cell growth (b) DNA duplication (c) mitosis (d) cytokinesis

- ✓FtsZ proteins direct the formation of a _____ that will eventually form the new cell walls of the daughter cells.

(a) contractile ring (b) cell plate (c) cytoskeleton (d) septum

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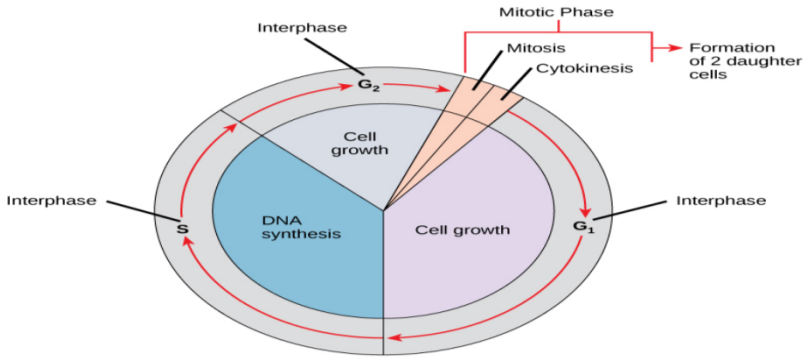

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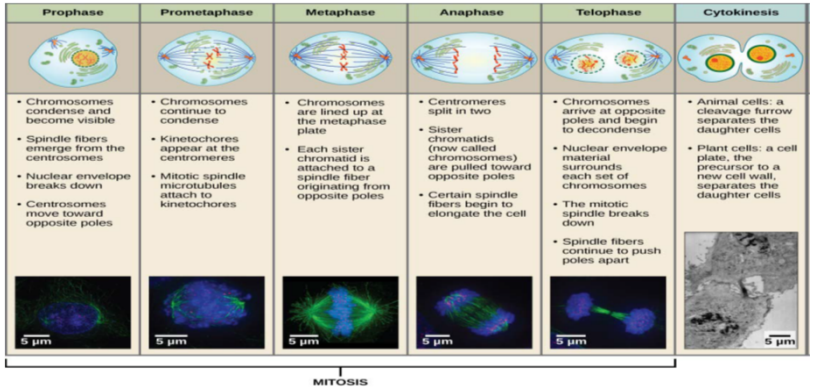
Stages in Mitosis



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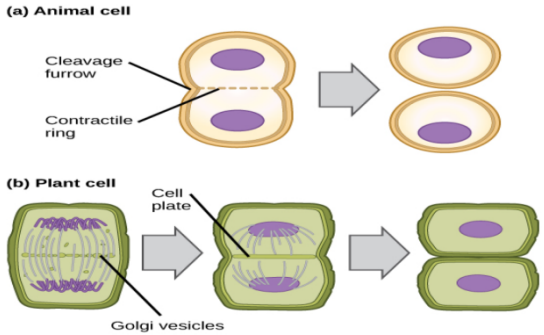

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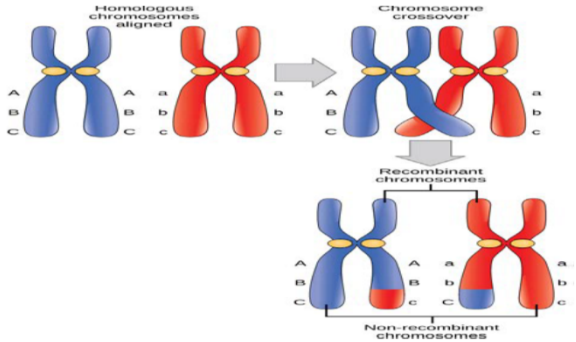

Meiosis I

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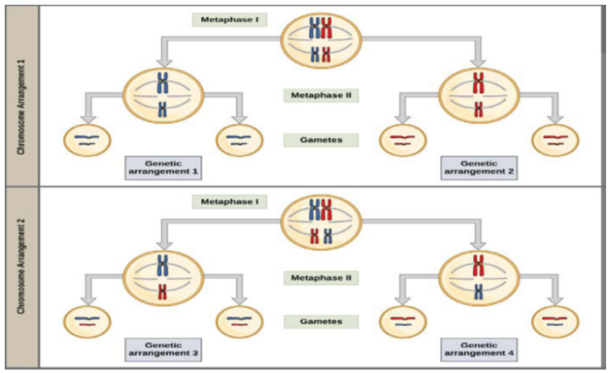

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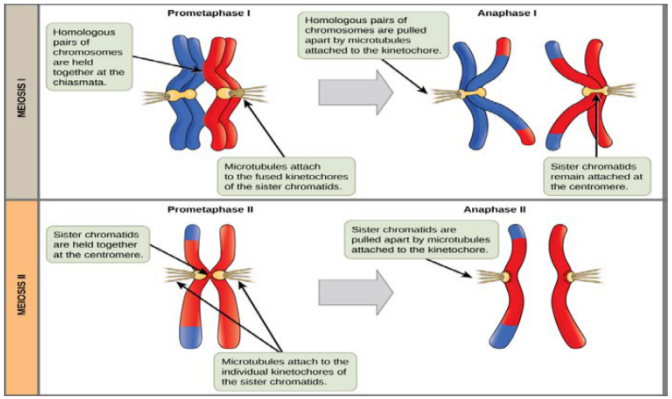

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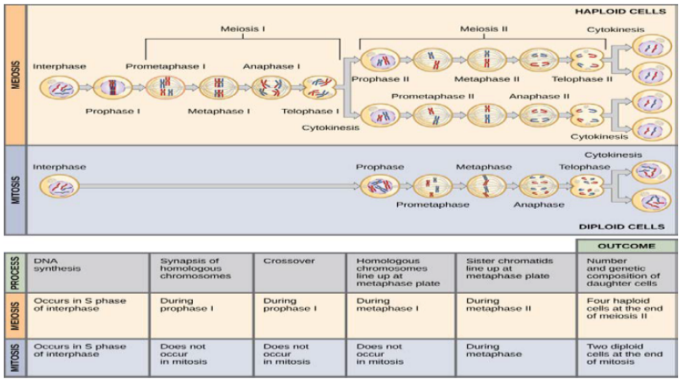

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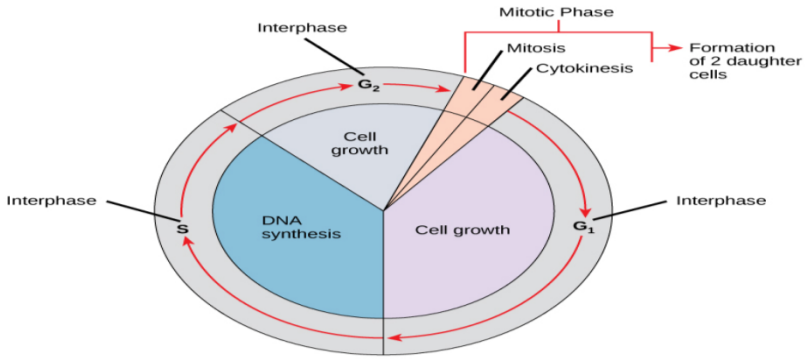
MITOSIS AND MEIOSIS
CELL CYCLE

❖The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.

❖Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth.

❖DNA replication, and division that produce two genetically identical cells.



A cell moves through a series of phases in an orderly manner. During interphase, G1 involves cell growth and protein synthesis, the S phase involves DNA replication and the replication of the centrosome, and G2 involves further growth and protein synthesis. The mitotic phase follows interphase. Mitosis is nuclear division during which duplicated chromosomes are segregated and distributed into daughter nuclei. Usually the cell will divide after mitosis in a process called cytokinesis in which the cytoplasm is divided and two daughter cells are formed.

❖The cell cycle has two major phases: interphase and the mitotic phase.

❖During interphase, the cell grows and DNA is replicated.

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❖Auxetic growth- an increase in cell mass

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❖During interphase, the cell undergoes normal processes while also preparing for cell division.

❖For a cell to move from interphase to the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called G1, S, and G2.

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❖The first stage of interphase is called the G1 phase, or first gap, because little change is visible.

❖During the G1 stage, the cell is quite active at the biochemical level.

❖The cell is accumulating the building blocks of chromosomal DNA and the associated proteins, as well as accumulating enough energy reserves to complete the task of replicating each chromosome in the nucleus.

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❖Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration.

❖In the S phase, replication results in the formation of two identical copies of each chromosome sister chromatids

❖At this stage, each chromosome is made of two sister chromatids. The centrosome is duplicated during the S phase.

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❖In the G2 phase, or second gap, the cell replenishes its energy stores and synthesizes the proteins necessary for chromosome manipulation.

❖Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic spindle.

❖ There may be additional cell growth during G2. The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

❖The two centrosomes will give rise to the mitotic spindle, the apparatus that orchestrates the movement of chromosomes during mitosis.

❖The centrosome consists of a pair of rod-like centrioles at right angles to each other. Centrioles help organize cell division.

❖Centrioles are not present in the centrosomes of many eukaryotic species, such as plants and most fungi.

The Mitotic Phase

❖To make two daughter cells, the contents of the nucleus and the cytoplasm must be divided.

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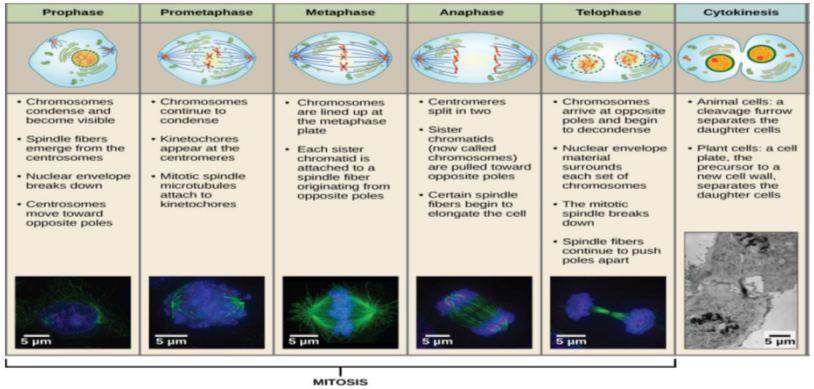
Stages in Mitosis



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METAPHASE

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TELOPHASE

- During telophase, all of the events that set up the duplicated chromosomes for mitosis during the first three phases are reversed. The chromosomes reach the opposite poles and begin to decondense (unravel). The mitotic spindles are broken down into monomers that will be used to assemble cytoskeleton components for each daughter cell. Nuclear envelopes form around chromosomes.

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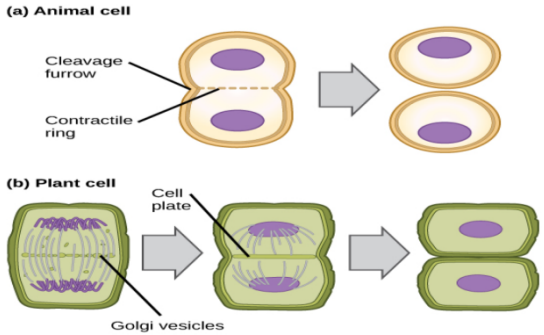
CYTOKINESIS

- Cytokinesis is the second part of the mitotic phase during which cell division is completed by the physical separation of the cytoplasmic components into two daughter cells. Although the stages of mitosis are similar for most eukaryotes, the process of cytokinesis is quite different for eukaryotes that have cell walls, such as plant cells.



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- The genes that code for the positive cell-cycle regulators are called proto-oncogenes. Proto-oncogenes are normal genes that, when mutated, become oncogenes-genes that cause a cell to become cancerous. Consider what might happen to the cell cycle in a cell with a recently acquired oncogene!

Significance of Mitosis

- It helps the cell in maintaining proper size
- Maintain the equilibrium in the amount of DNA and RNA in the cell
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Meiosis

- Sexual reproduction requires fertilization, a union of two cells from two individual organisms.
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- Haploid cells contain one set of chromosomes. Cells containing two sets of chromosomes are called diploid.
- If the reproductive cycle is to continue, the diploid cell must somehow reduce its number of chromosome sets before fertilization can occur again, or there will be a continual doubling in the number of chromosome sets in every generation.
- Prophase-Proleptotene, Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

- The term meiosis was coined J.B Farmer in 1905
- Sexual reproduction includes a nuclear division, known as meiosis, that reduces the number of chromosome sets.
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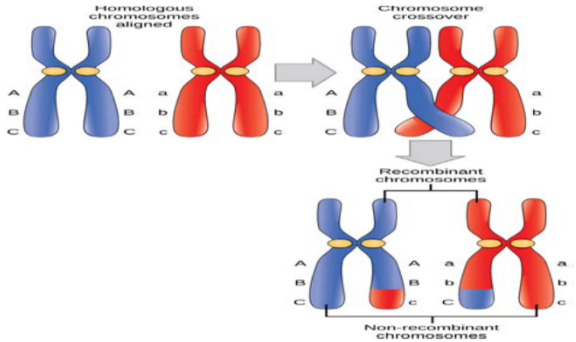

Meiosis I

- Early in prophase I, the chromosomes can be seen clearly microscopically. As the nuclear envelope begins to break down.
- The proteins associated with homologous chromosomes bring the pair close to each other. The tight pairing of the homologous chromosomes is called synapsis.
- In synapsis, the genes on the chromatids of the homologous chromosomes are precisely aligned with each other.
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- The key event in prometaphase I is the attachment of the spindle fiber microtubules to the kinetochore proteins at the centromeres.
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- The nuclear membrane has broken down entirely.

METAPHASE

- During metaphase I, the homologous chromosomes are arranged in the center of the cell with the kinetochores facing opposite poles.
- The orientation of each pair of homologous chromosomes at the centre of the cell is random.

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- In anaphase I, the spindle fibers pull the linked chromosomes apart. The sister chromatids remain tightly bound together at the centromere. It is the chiasma connections that are broken in anaphase I as the fibers attached to the fused kinetochores pull the homologous chromosomes apart

- In telophase I, the separated chromosomes arrive at opposite poles. The remainder of the typical telophase events may or may not occur depending on the species. In some organisms, the chromosomes decondense and nuclear envelopes form around the chromatids in telophase I.

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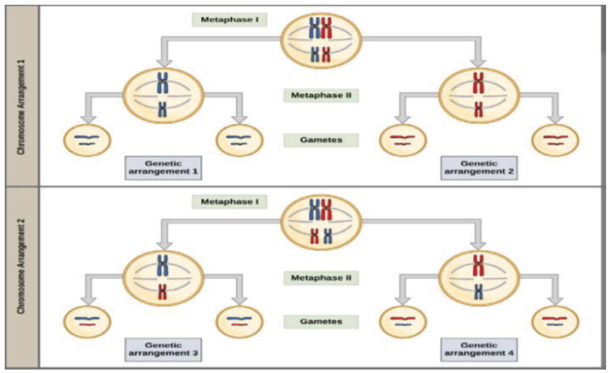

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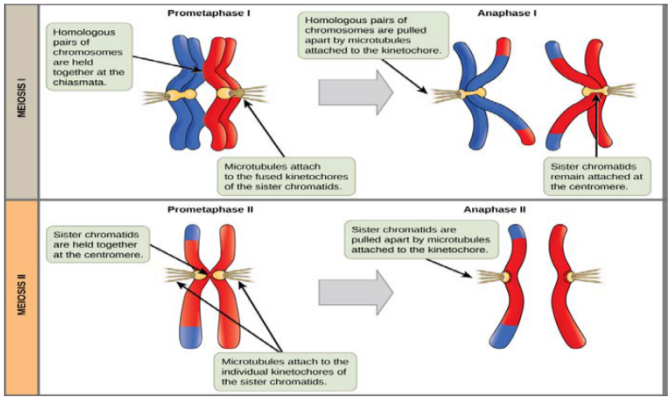

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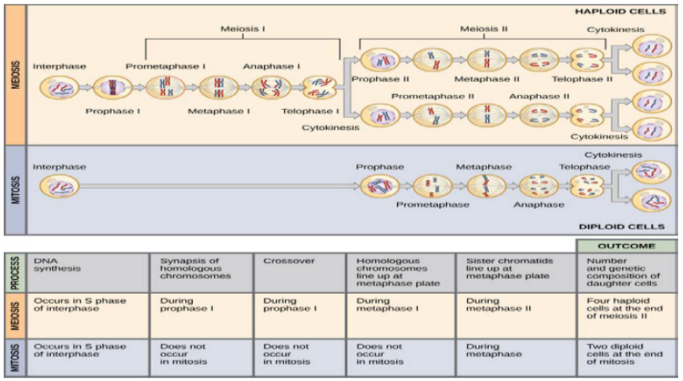

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PROCESS	DNA synthesis	Synapsis of homologous chromosomes	Crossover	Homologous chromosomes line up at metaphase plate	Sister chromatids line up at metaphase plate	Number and genetic composition of daughter cells
MEIOSIS	Occurs in S phase of interphase	During prophase I	During prophase I	During metaphase I	During metaphase II	Four haploid cells at the end of meiosis II
MITOSIS	Occurs in S phase of interphase	Does not occur in mitosis	Does not occur in mitosis	Does not occur in mitosis	During metaphase	Two diploid cells at the end of mitosis

Meiosis and mitosis are both preceded by one round of DNA replication; however, meiosis includes two nuclear divisions. The four daughter cells resulting from meiosis are haploid and genetically distinct. The daughter cells resulting from mitosis are diploid and identical to the parent cell.

- In metaphase II, the sister chromatids are maximally condensed and aligned at the center of the cell.
- In anaphase II, the sister chromatids are pulled apart by the spindle fibers and move toward opposite poles.
- In telophase II, the chromosomes arrive at opposite poles and begin to decondense. Nuclear envelopes form around the chromosomes.
- Cytokinesis separates the two cells into four genetically unique haploid cells. At this point, the nuclei in the newly produced cells are both haploid and have only one copy of the single set of chromosomes.

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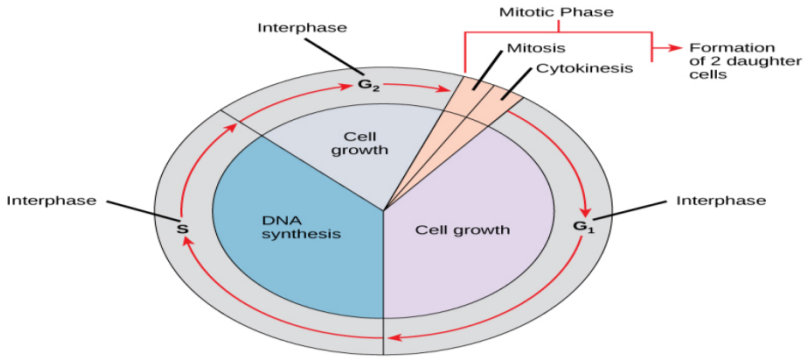

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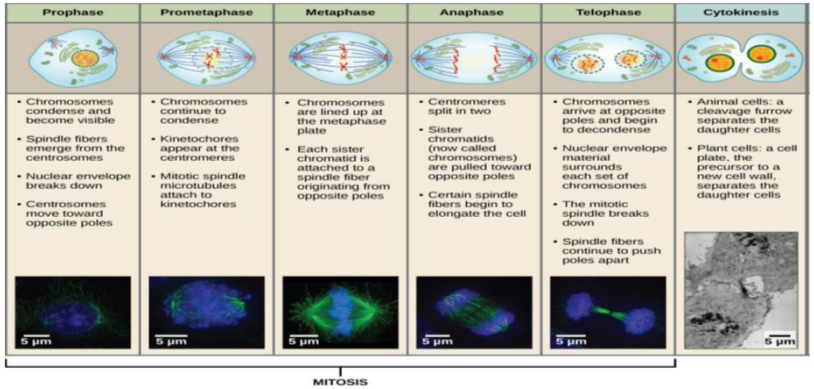

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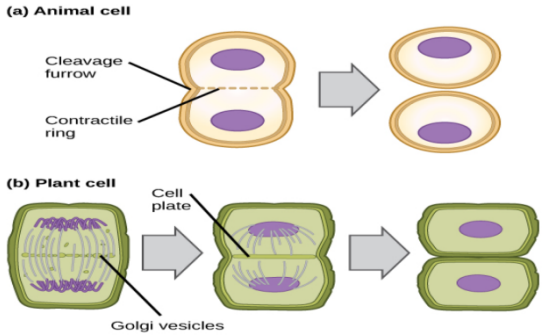

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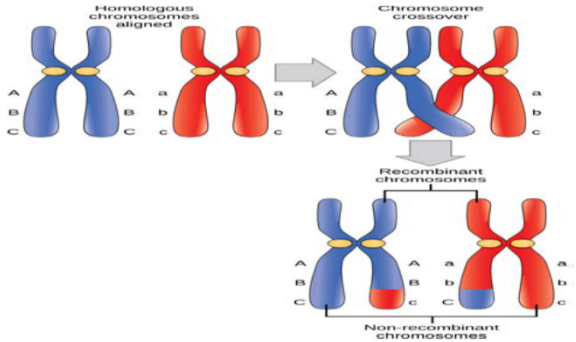

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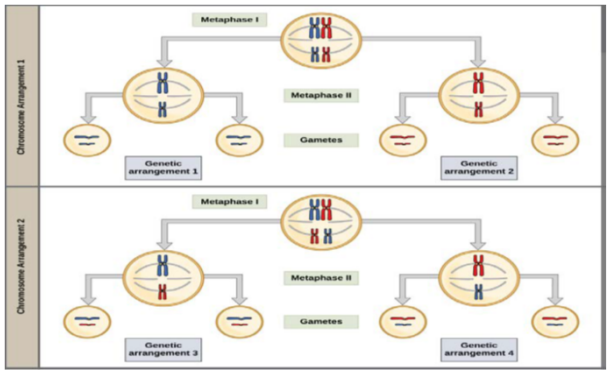

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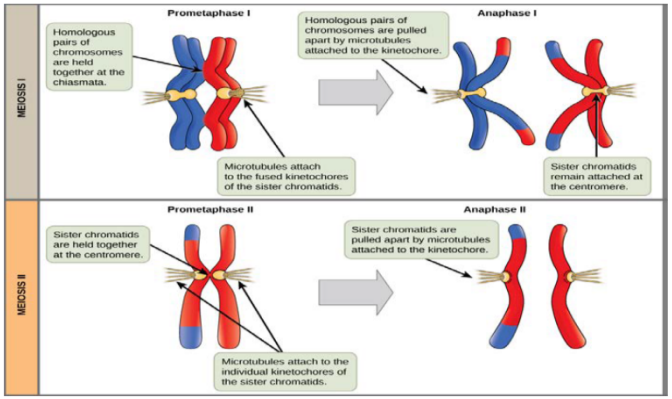

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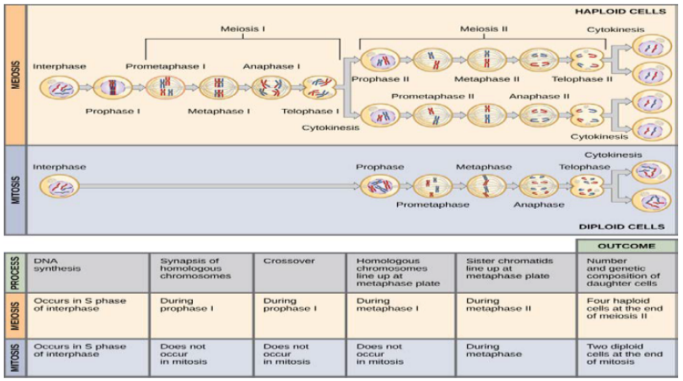

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MITOSIS	Occurs in S phase of interphase	Does not occur in mitosis	Does not occur in mitosis	Does not occur in mitosis	During metaphase	Two diploid cells at the end of mitosis

Meiosis and mitosis are both preceded by one round of DNA replication; however, meiosis includes two nuclear divisions. The four daughter cells resulting from meiosis are haploid and genetically distinct. The daughter cells resulting from mitosis are diploid and identical to the parent cell.

- In metaphase II, the sister chromatids are maximally condensed and aligned at the center of the cell.
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- ✓FtsZ proteins direct the formation of a _____ that will eventually form the new cell walls of the daughter cells.

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MITOSIS AND MEIOSIS
CELL CYCLE

❖The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.

❖Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth.

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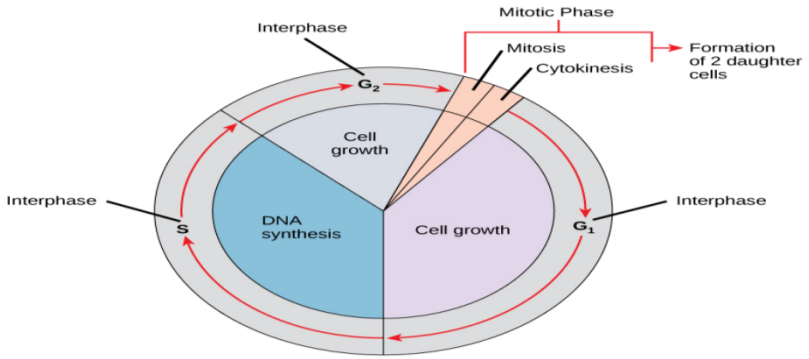

A cell moves through a series of phases in an orderly manner. During interphase, G1 involves cell growth and protein synthesis, the S phase involves DNA replication and the replication of the centrosome, and G2 involves further growth and protein synthesis. The mitotic phase follows interphase. Mitosis is nuclear division during which duplicated chromosomes are segregated and distributed into daughter nuclei. Usually the cell will divide after mitosis in a process called cytokinesis in which the cytoplasm is divided and two daughter cells are formed.

❖The cell cycle has two major phases: interphase and the mitotic phase.

❖During interphase, the cell grows and DNA is replicated.

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❖Multiplicative growth-increase in cell number due to cell division

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• INTERPHASE

❖During interphase, the cell undergoes normal processes while also preparing for cell division.

❖For a cell to move from interphase to the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called G1, S, and G2.

G1 Phase

❖The first stage of interphase is called the G1 phase, or first gap, because little change is visible.

❖During the G1 stage, the cell is quite active at the biochemical level.

❖The cell is accumulating the building blocks of chromosomal DNA and the associated proteins, as well as accumulating enough energy reserves to complete the task of replicating each chromosome in the nucleus.

S Phase

❖Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration.

❖In the S phase, replication results in the formation of two identical copies of each chromosome sister chromatids

❖At this stage, each chromosome is made of two sister chromatids. The centrosome is duplicated during the S phase.

G2 Phase

❖In the G2 phase, or second gap, the cell replenishes its energy stores and synthesizes the proteins necessary for chromosome manipulation.

❖Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic spindle.

❖ There may be additional cell growth during G2. The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

❖The two centrosomes will give rise to the mitotic spindle, the apparatus that orchestrates the movement of chromosomes during mitosis.

❖The centrosome consists of a pair of rod-like centrioles at right angles to each other. Centrioles help organize cell division.

❖Centrioles are not present in the centrosomes of many eukaryotic species, such as plants and most fungi.

The Mitotic Phase

❖To make two daughter cells, the contents of the nucleus and the cytoplasm must be divided.

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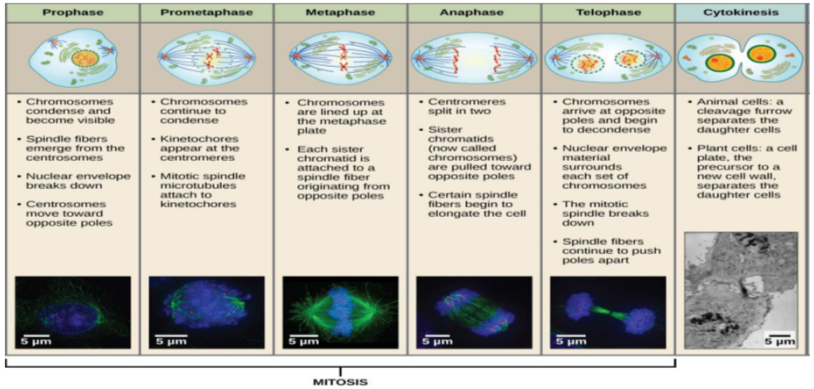

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METAPHASE

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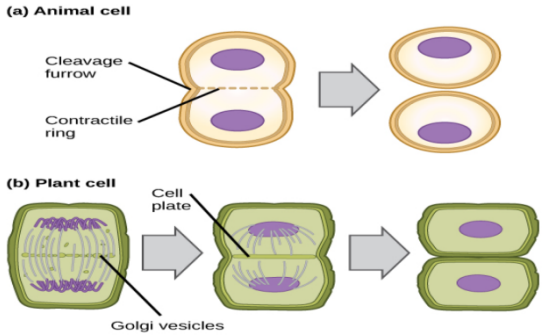

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Meiosis

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- Haploid cells contain one set of chromosomes. Cells containing two sets of chromosomes are called diploid.
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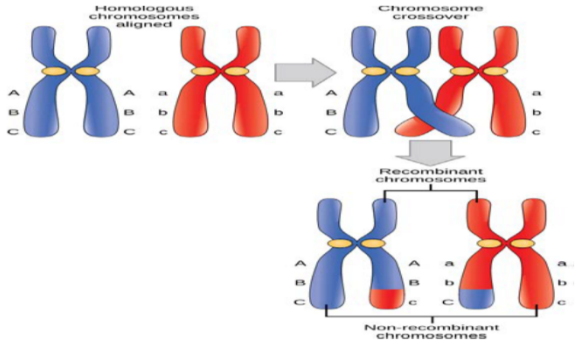

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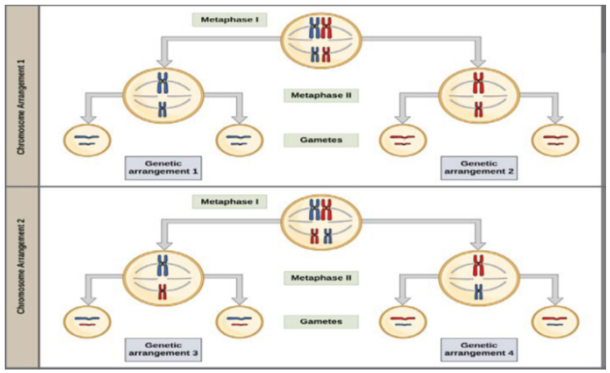

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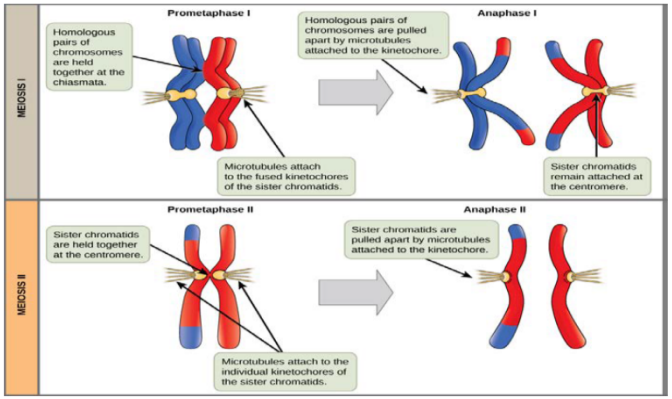

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- If nuclear envelopes were formed, they fragment into vesicles. The centrosomes duplicated during interkinesis move away from each other toward opposite poles, and new spindles are formed.
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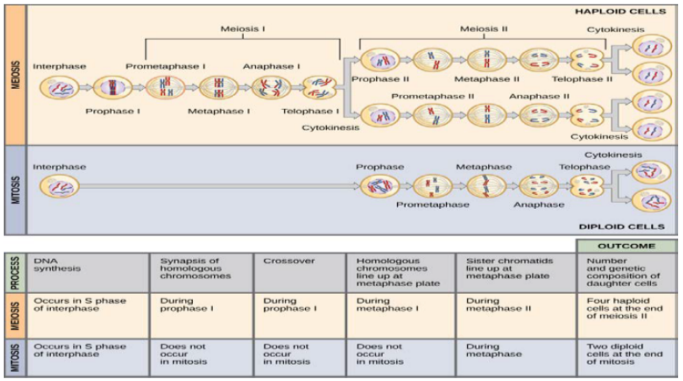

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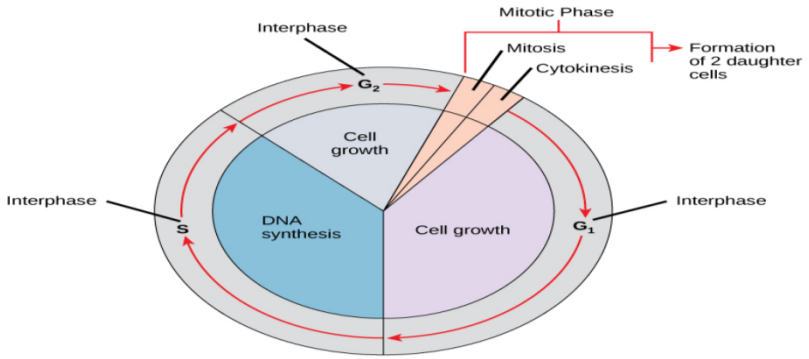

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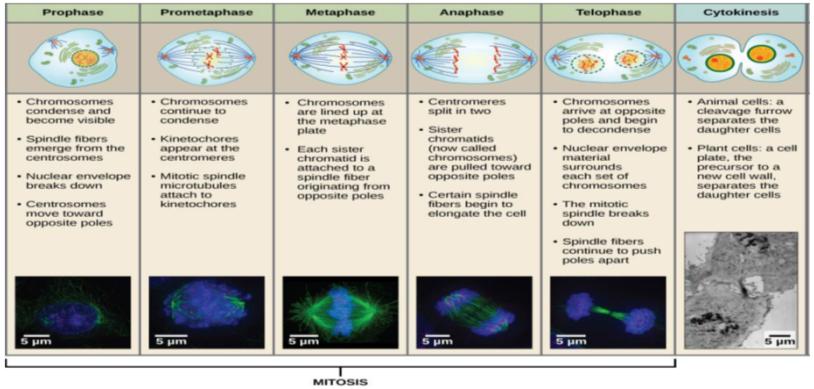

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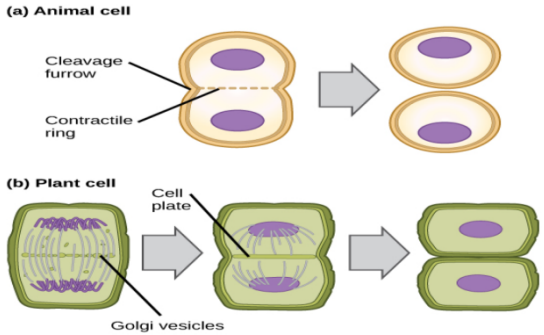

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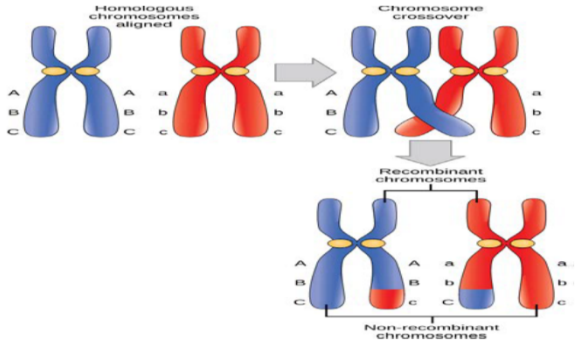

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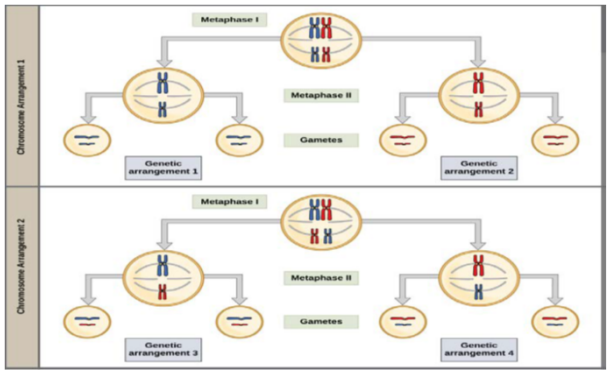

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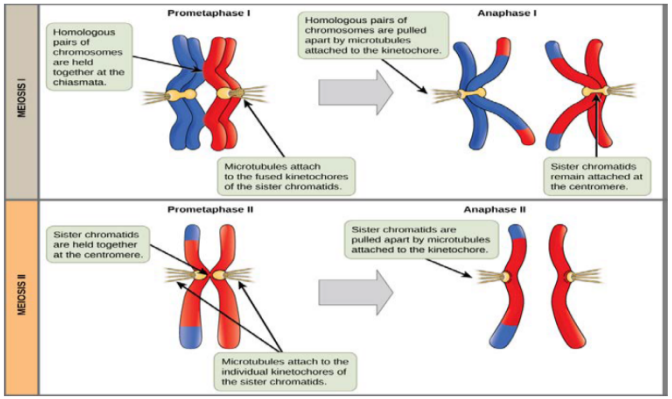

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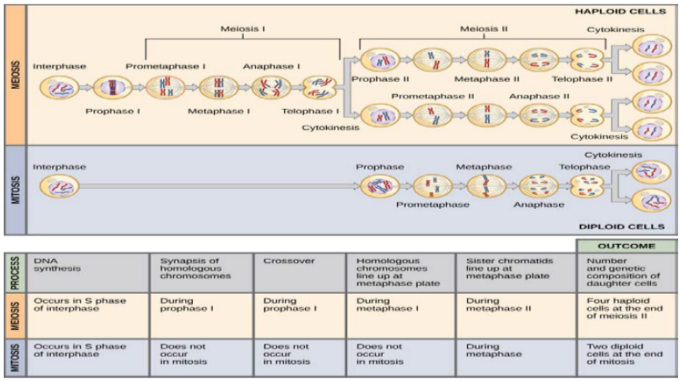

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Meiosis and mitosis are both preceded by one round of DNA replication; however, meiosis includes two nuclear divisions. The four daughter cells resulting from meiosis are haploid and genetically distinct. The daughter cells resulting from mitosis are diploid and identical to the parent cell.

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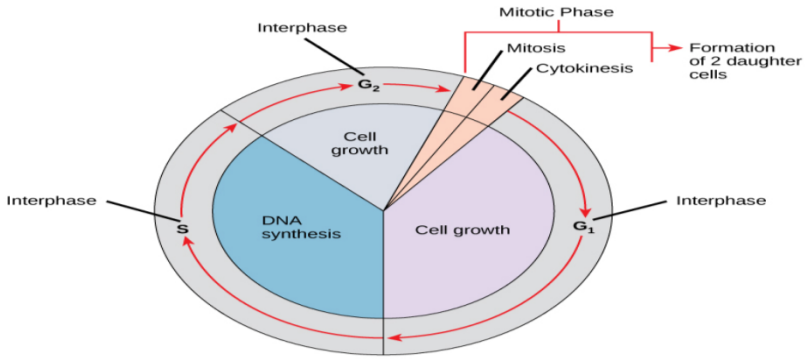
(a) contractile ring (b) cell plate (c) cytoskeleton (d) septum

MITOSIS AND MEIOSIS
CELL CYCLE

❖The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.

❖Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth.

❖DNA replication, and division that produce two genetically identical cells.



A cell moves through a series of phases in an orderly manner. During interphase, G1 involves cell growth and protein synthesis, the S phase involves DNA replication and the replication of the centrosome, and G2 involves further growth and protein synthesis. The mitotic phase follows interphase. Mitosis is nuclear division during which duplicated chromosomes are segregated and distributed into daughter nuclei. Usually the cell will divide after mitosis in a process called cytokinesis in which the cytoplasm is divided and two daughter cells are formed.

❖The cell cycle has two major phases: interphase and the mitotic phase.

❖During interphase, the cell grows and DNA is replicated.

❖During the mitotic phase, the replicated DNA and cytoplasmic contents are separated and the cell divides.

❖Auxetic growth- an increase in cell mass

❖Multiplicative growth-increase in cell number due to cell division

❖Accretionary growth- due to accumulation of extracellular products.

• INTERPHASE

❖During interphase, the cell undergoes normal processes while also preparing for cell division.

❖For a cell to move from interphase to the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called G1, S, and G2.

G1 Phase

❖The first stage of interphase is called the G1 phase, or first gap, because little change is visible.

❖During the G1 stage, the cell is quite active at the biochemical level.

❖The cell is accumulating the building blocks of chromosomal DNA and the associated proteins, as well as accumulating enough energy reserves to complete the task of replicating each chromosome in the nucleus.

S Phase

❖Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration.

❖In the S phase, replication results in the formation of two identical copies of each chromosome sister chromatids

❖At this stage, each chromosome is made of two sister chromatids. The centrosome is duplicated during the S phase.

G2 Phase

❖In the G2 phase, or second gap, the cell replenishes its energy stores and synthesizes the proteins necessary for chromosome manipulation.

❖Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic spindle.

❖ There may be additional cell growth during G2. The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

❖The two centrosomes will give rise to the mitotic spindle, the apparatus that orchestrates the movement of chromosomes during mitosis.

❖The centrosome consists of a pair of rod-like centrioles at right angles to each other. Centrioles help organize cell division.

❖Centrioles are not present in the centrosomes of many eukaryotic species, such as plants and most fungi.

The Mitotic Phase

❖To make two daughter cells, the contents of the nucleus and the cytoplasm must be divided.

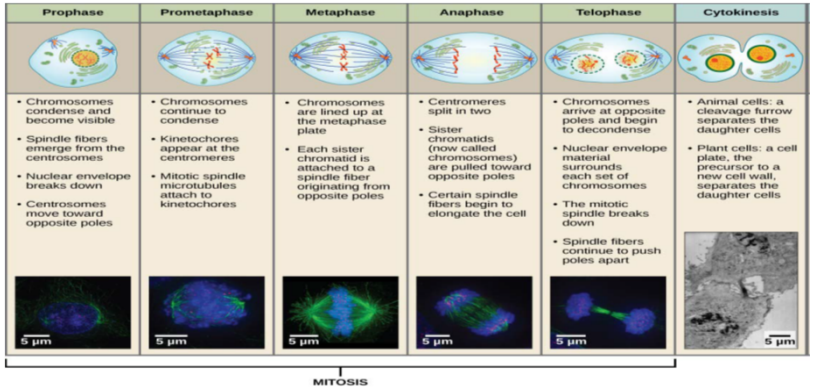
❖The mitotic phase is a multistep process during which the duplicated chromosomes are aligned, separated, and moved to opposite poles of the cell, and then the cell is divided into two new identical daughter cells.

- The first portion of the mitotic phase, mitosis, is composed of five stages, which accomplish nuclear division-prophase, prometaphase, metaphase, anaphase, and telophase.
- The second portion of the mitotic phase, called cytokinesis, is the physical separation of the cytoplasmic components into two daughter cells.

PROPHASE

- During prophase, the "first phase," several events must occur to provide access to the chromosomes in the nucleus.
- The nuclear envelope starts to break into small vesicles, and the Golgi apparatus and endoplasmic reticulum fragment and disperse to the periphery of the cell.
- The nucleolus disappears and centrosomes begin to move to opposite poles of the cell.
- The microtubules that form the basis of the mitotic spindle extend between the centrosomes, pushing them farther apart as the microtubule fibres lengthen. The sister chromatids begin to coil more tightly and become visible under a light microscope.

Stages in Mitosis



PROMETAPHASE

- During prometaphase, many processes that were begun in prophase continue to advance and culminate in the formation of a connection between the chromosomes and cytoskeleton. The remnants of the nuclear envelope disappear.
- The mitotic spindle continues to develop as more microtubules assemble and stretch across the length of the former nuclear area.
- Chromosomes become more condensed and visually discrete. Each sister chromatid attaches to spindle microtubules at the centromere via a protein complex called the kinetochore.

METAPHASE

- During metaphase, all of the chromosomes are aligned in a plane called the metaphase plate, or the equatorial plane, midway between the two poles of the cell. The sister chromatids are still tightly attached to each other. At this time, the chromosomes are maximally condensed.

TELOPHASE

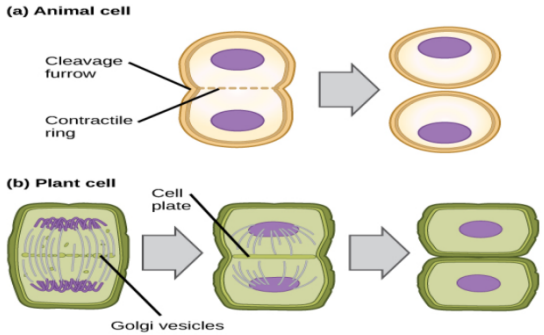
- During telophase, all of the events that set up the duplicated chromosomes for mitosis during the first three phases are reversed. The chromosomes reach the opposite poles and begin to decondense (unravel). The mitotic spindles are broken down into monomers that will be used to assemble cytoskeleton components for each daughter cell. Nuclear envelopes form around chromosomes.

ANAPHASE

- During anaphase, the sister chromatids at the equatorial plane are split apart at the centromere. Each chromatid, now called a chromosome, is pulled rapidly toward the centrosome to which its microtubule was attached. The cell becomes visibly elongated as the non-kinetochore microtubules slide against each other at the metaphase plate where they overlap.

CYTOKINESIS

- Cytokinesis is the second part of the mitotic phase during which cell division is completed by the physical separation of the cytoplasmic components into two daughter cells. Although the stages of mitosis are similar for most eukaryotes, the process of cytokinesis is quite different for eukaryotes that have cell walls, such as plant cells.



Proto-oncogenes

- The genes that code for the positive cell-cycle regulators are called proto-oncogenes. Proto-oncogenes are normal genes that, when mutated, become oncogenes-genes that cause a cell to become cancerous. Consider what might happen to the cell cycle in a cell with a recently acquired oncogene!

Significance of Mitosis

- It helps the cell in maintaining proper size
- Maintain the equilibrium in the amount of DNA and RNA in the cell
- Provides opportunity for growth and development to organs and body of organisms.

Which of the following is the correct order of events in mitosis?

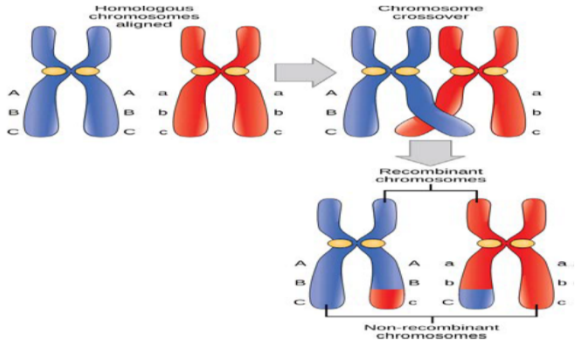
- a. Sister chromatids line up at the metaphase plate. The kinetochore becomes attached to the mitotic spindle. The nucleus re-forms and the cell divides. The sister chromatids separate.
- b. The kinetochore becomes attached to the mitotic spindle. The sister chromatids separate. Sister chromatids line up at the metaphase plate. The nucleus re-forms and the cell divides.
- c. The kinetochore becomes attached to metaphase plate. Sister chromatids line up at the metaphase plate. The kinetochore breaks down and the sister chromatids separate. The nucleus re-forms and the cell divides.
- d. The kinetochore becomes attached to the mitotic spindle. Sister chromatids line up at the metaphase plate. The kinetochore breaks apart and the sister chromatids separate. The nucleus re-forms and the cell divides.

Meiosis

- Sexual reproduction requires fertilization, a union of two cells from two individual organisms.
- If those two cells each contain one set of chromosomes, then the resulting cell contains two sets of chromosomes.
- The number of sets of chromosomes in a cell is called its ploidy level.
- Haploid cells contain one set of chromosomes. Cells containing two sets of chromosomes are called diploid.
- If the reproductive cycle is to continue, the diploid cell must somehow reduce its number of chromosome sets before fertilization can occur again, or there will be a continual doubling in the number of chromosome sets in every generation.
- Prophase-Proleptotene, Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

- The term meiosis was coined J.B Farmer in 1905
- Sexual reproduction includes a nuclear division, known as meiosis, that reduces the number of chromosome sets.
- Homologous chromosomes are matched pairs containing genes for the same traits in identical locations along their length.
- Meiocytes- These are cells where meiosis occurs.
- Meiocytes of the gonads are called Gonocytes which maybe spermatocytes in male and oocytes in female.
- The meiocytes in plants sporangium are called Sporocytes (Microsporocytes and megasporocytes)

This process is revealed visually after the exchange as chiasmata



Meiosis I

- Early in prophase I, the chromosomes can be seen clearly microscopically. As the nuclear envelope begins to break down.
- The proteins associated with homologous chromosomes bring the pair close to each other. The tight pairing of the homologous chromosomes is called synapsis.
- In synapsis, the genes on the chromatids of the homologous chromosomes are precisely aligned with each other.
- An exchange of chromosome segments between non-sister homologous chromatids occurs and is called crossing over.

- This process is revealed visually after the exchange as chiasmata
- The key event in prometaphase I is the attachment of the spindle fiber microtubules to the kinetochore proteins at the centromeres.
- The microtubules assembled from centrosomes at opposite poles of the cell grow toward the middle of the cell.
- At the end of prometaphase I, each tetrad is attached to microtubules from both poles, with one homologous chromosome attached at one pole and the other homologous chromosome attached to the other pole.
- The nuclear membrane has broken down entirely.

METAPHASE

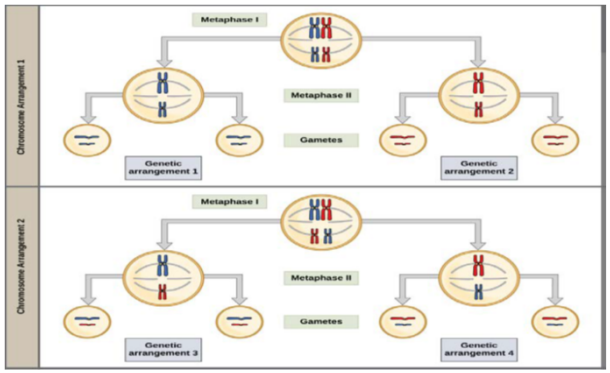
- During metaphase I, the homologous chromosomes are arranged in the center of the cell with the kinetochores facing opposite poles.
- The orientation of each pair of homologous chromosomes at the centre of the cell is random.

ANAPHASE 1

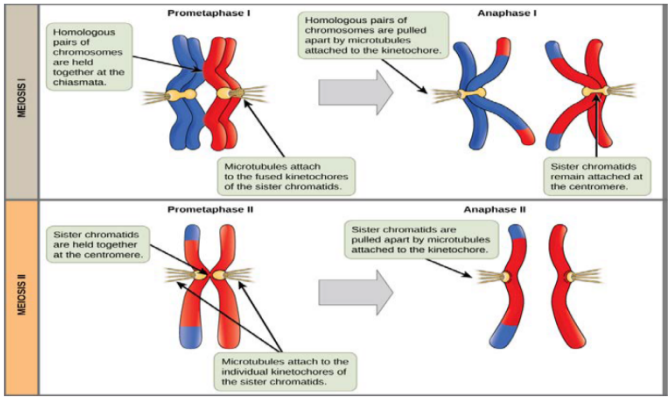
- In anaphase I, the spindle fibers pull the linked chromosomes apart. The sister chromatids remain tightly bound together at the centromere. It is the chiasma connections that are broken in anaphase I as the fibers attached to the fused kinetochores pull the homologous chromosomes apart

- In telophase I, the separated chromosomes arrive at opposite poles. The remainder of the typical telophase events may or may not occur depending on the species. In some organisms, the chromosomes decondense and nuclear envelopes form around the chromatids in telophase I.

RANDOMISATION OF HOMOLOGOUS CHROMOSOME



Meiosis II



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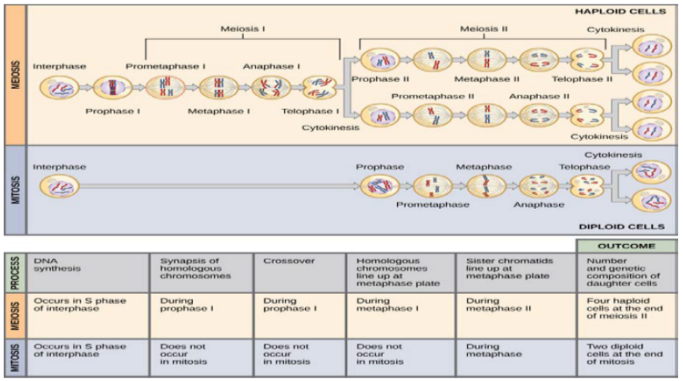

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