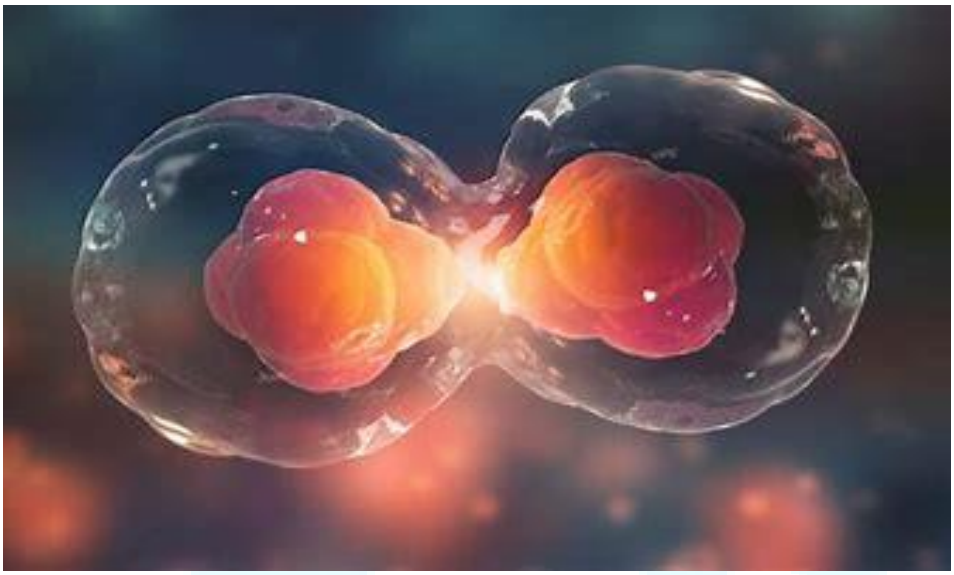
CELL DIVISION



- Cellular reproduction occurs by the production of new cells from pre- existing cells.
- It involves synthesis of cell constituents, duplication of chromosomes, nucleus and cell organelles and the division of cells.
- Cell division appears to be the fundamental mechanism of both reproduction and growth of a cell.
- There are three kinds of cell division
    1. Amitosis
    2. Mitosis
    3. Meiosis

Amitosis

- It is an unusual type of direct nuclear or cell division.
- It occurs in prokaryotes, endosperm nucleus of angiosperm, some ciliate protozoans, mammalian cartilage cell, etc
- It does not involves spindle formation, organized chromosome and nuclear events and a definite cell cycle.
- In this type, the nuclear envelope pinches off and the nucleus elongates and divides into two, followed by cytoplasmic cleavage and division of parent cell to two.
- Here the daughter nuclei formed will not be identical.
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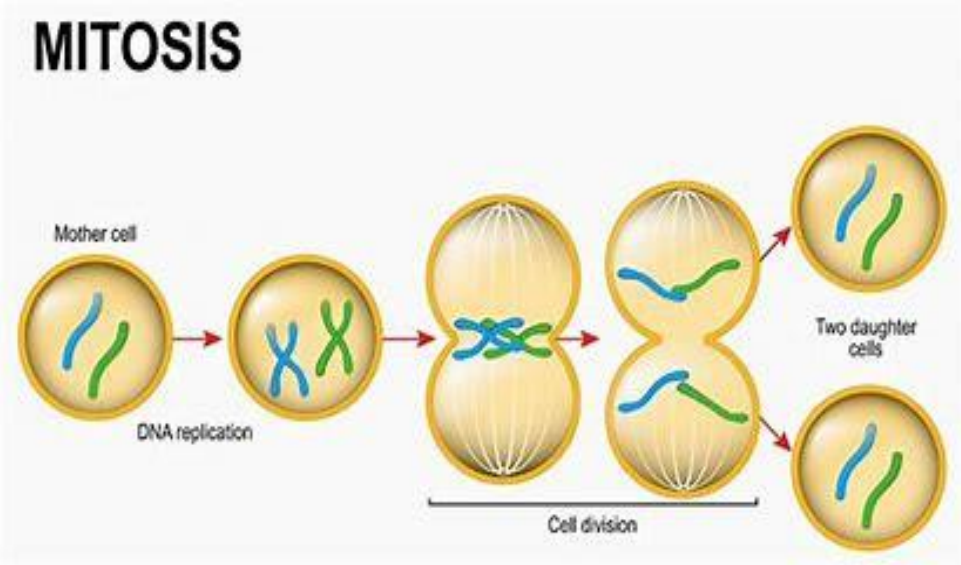
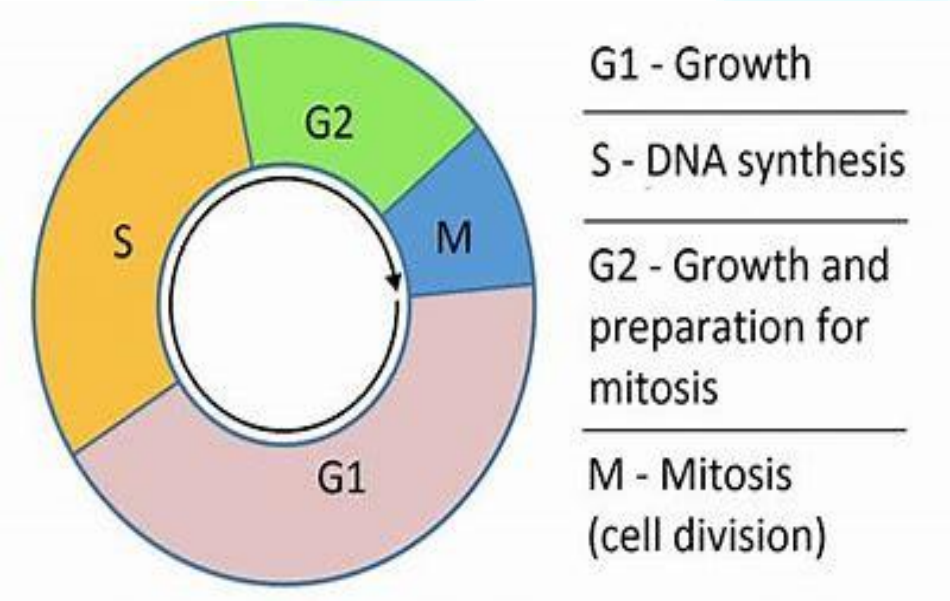
Mitosis



- Mitosis is the simpler and more common type of cell division wherein one cell divides into two identical daughter cells.
- Mitosis is the terminal stage of a cycle of events.
- Mitosis is the most common type of cell division occurring in eukaryotes. One diploid parent cell divides into two genetically identical diploid daughter cells.

- It involves two closely related process
    I. Nuclear duplication (Karyokinesis)
    II. Cytoplasmic cleavage (cytokinesis)
- The mitotic phase of a cell cycle is divided into four distinct stages:
    i. Prophase
    ii. Metaphase
    iii. Anaphase
    iv. Telophase
- Stages of cell cycle involves;



Gap I (G1)

- This is the primary stage where the cell prepares itself for division.
- There are no significant changes initiating the division here.

- This time frame is allocated towards the development of the cell for multiplication; thus, the duration may vary from cell to cell.
- Naturally, cell development through this stage will depend upon growth factors, such as nutrients, etc.

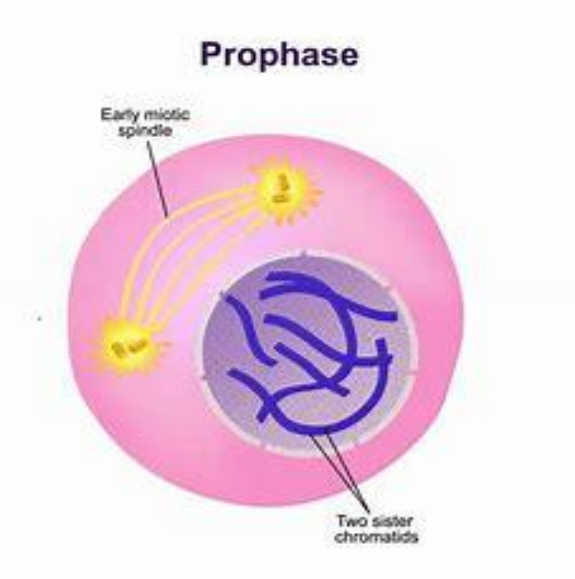
Synthesis

- This is the actual step where the cell division starts, at a very small yet important scale.
- Chromosomes start replicating inside the nucleus, so that each one has an exact identical twin.
- These two identical entities of each chromosome are called 'chromatids.'
- Any two chromatids are joint together at a single point known as the 'centromere.'

Gap II (G2)

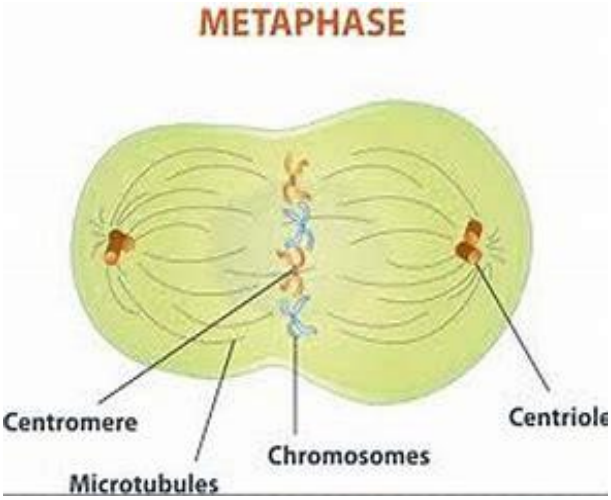
- Once the chromosomes are replicated, other cell organelles begin to replicate as well.
- So, by the end of G2, the cell has two chromosomes of each organelle.
- Though G2 is a stage of Interphase, it is not an inevitable one. Some cells are known to directly proceed to cell division without G2.

Prophase



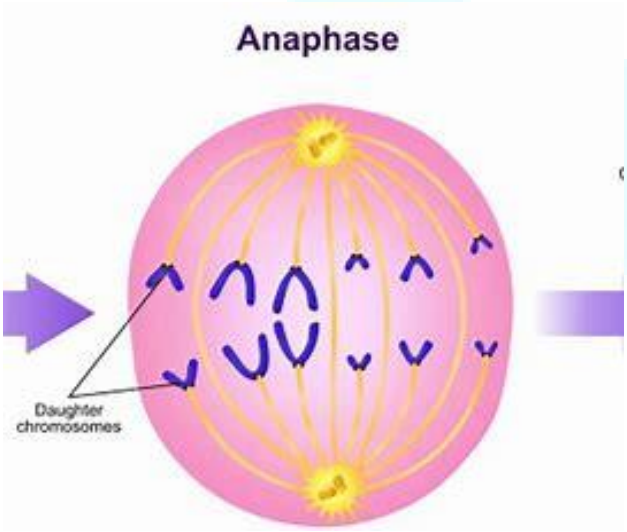
- The chromosomes begin to condense and are now microscopically visible.
- Spindle fibers (made of microtubules) begin to form from the centrioles.
- At the same time, centrioles start moving towards the opposite ends of the cell.
- Lastly, the nucleolus and nuclear membrane disintegrate, marking the beginning of metaphase.

Metaphase



- The chromosomes are positioned along the equatorial plane by the spindle fibers.
- The spindle fibers then attach onto the centromere of every chromosome pair.
- The centromere has an exact structure for the spindle fiber to attach, known as the 'kinetochore.'

Anaphase

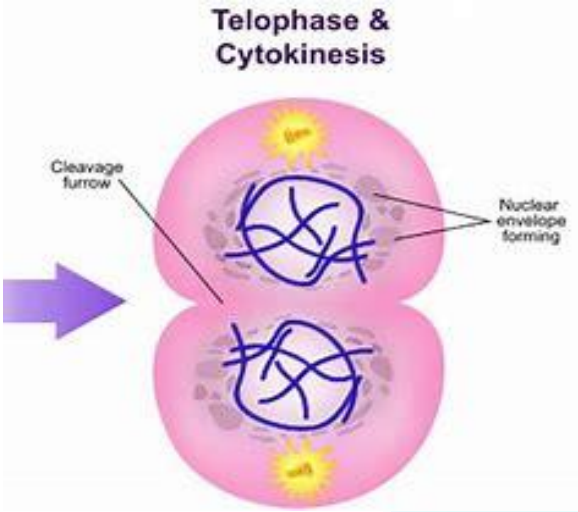


- The centromeres split due to the spindle fibers exerting pressure from the opposite ends.

- The chromosomes (only half of the initial ones) move towards opposite poles of the cell.
- The centrioles move as farther away from one another as possible.

Telophase

- Nuclear membrane starts reappearing.
- The spindle fibers begin detaching themselves from the chromosomes.
- Chromosomes begin decondensing at this stage.
- In plant cells, a line of demarcation begins to appear in the cell—the exact line of cell division, also known as the 'telophasic bundle.'

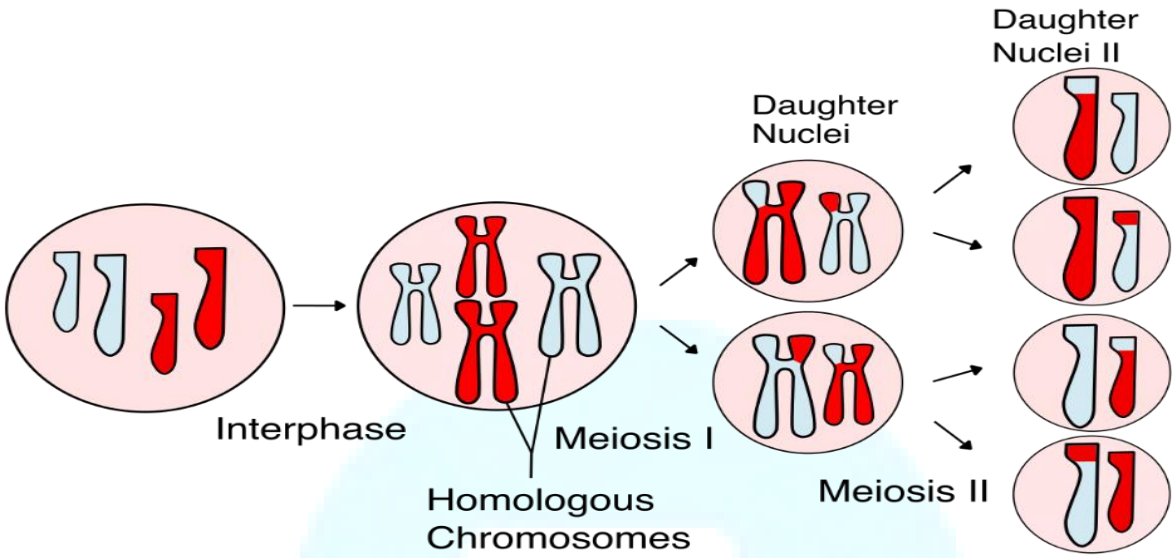


Cytokinesis

- Mitosis is technically defined as the division of the nucleus; thus, cytokinesis or cytoplasmic division is not a stage of mitosis.
- *In plant cells*: In place of the telophasic bundle, an actual cell plate develops, parting the parent cell into two halves. However, the two newly formed cells don't disjoin completely and remain stuck at the common plate.
- *In animal cells*: Two clefts develop in between the parent cell, burrowing further to actually divide the cytoplasm. Actin and myosin are filaments present in the cytoplasm which help in various kinds of cell movements. These filaments are

lined along the cell membrane during cytokinesis and they help in deepening the cleft and completing the division.

MEIOSIS



- Meiosis, on the other hand, occurs only in sexually reproducing organisms. Here, one cell undergoes two successive divisions to produce four genetically different daughter cells.
- Meiosis is the process of cell division that leads to the formation of reproductive cells or gametes in higher organisms.
- A somatic cell undergoes two successive divisions to produce four gametocyte cells, each having half the number of chromosomes as the parent cell.
- ***Meiosis I has 5 different sub-stages, known as Prophase I, Metaphase I, Anaphase I, Telophase I, and Cytokinesis I***
- ***Meiosis II has 5 different sub-stages, known as Prophase II, Metaphase II, Anaphase II, Telophase II, and Cytokinesis II***

Interphase I

- Before these four stages of cell division begin, the initial process is similar to that of Interphase in mitosis, except the substage G2.

- Cell growth and development are still the key factors initially, and once the cell is prepared for division, chromosome replication begins. Each chromosome, thus, replicates its genetic material, forming an identical twin.
- Microscopically, chromosomes now appear in the form of two sister chromatids, joint together at the centromere.

Prophase I

- At this stage, the cell has replicated its DNA material and organelles. The physical division begins with many changes occurring at the same time. Thus, for better understanding, Prophase I is demarcated into the following five sub-stages:

Leptonema (Leptotene)

- The chromosomes begin to condense and are now microscopically visible.
- It is important to note that they are still condensing and not condensed at this point.
- At this stage, each chromosome (consisting its identical chromatids) starts looking for its homogeneous pair-mate.
- *When two chromosomes are physically same in all aspects and have similar genetic coding, then one of them is said to be the homologue of the other. In other words, they are a homologous chromosome pair*.

Zygonema (Zygotene)

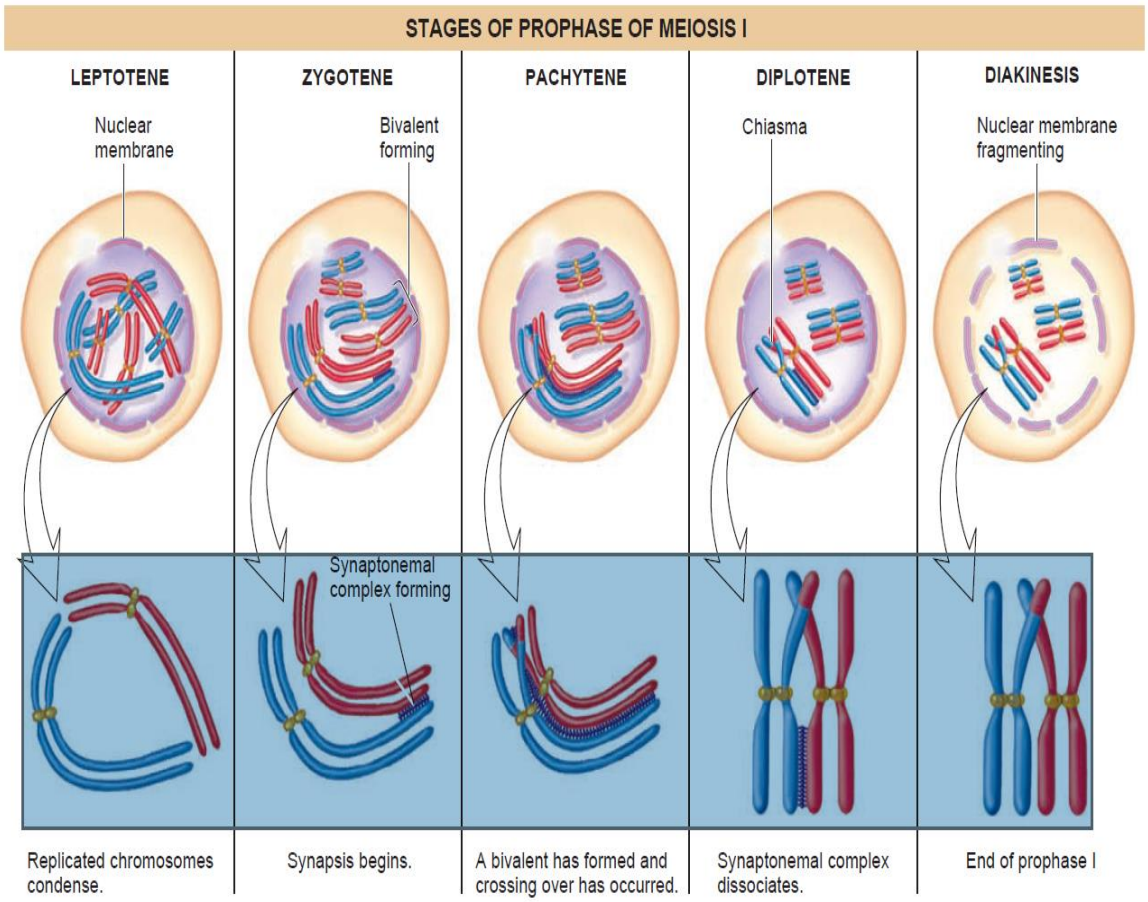
- In this stage, each chromosome finds its homologue and begins 'rough pairing.'
- Rough pairing is when these chromosomes align next to each other.
- The chromosomes continue condensing throughout this stage.
- Thereafter, the chromosomes actually begin pairing; this process is known as 'synapsis.'
- The two chromosomes are joint throughout their length by a 'synaptonemal complex.' The point where pairing begins is not specific.

Pachynema (Pachytene)

- The sister chromatids disassociate from one another in this stage, while the homologous chromosomes remain connected.
- Chromatids from homologous chromosomes may exchange genetic information by physically swapping their parts. This process is known as 'crossing over' of chromosomes, and the exact point of crossing over is called 'chiasmata.'
- It is the most important step because the genetic coding changes here, leading to a variation in the genetic information passed along to the daughter cells.

Diplonema (Diplotene)

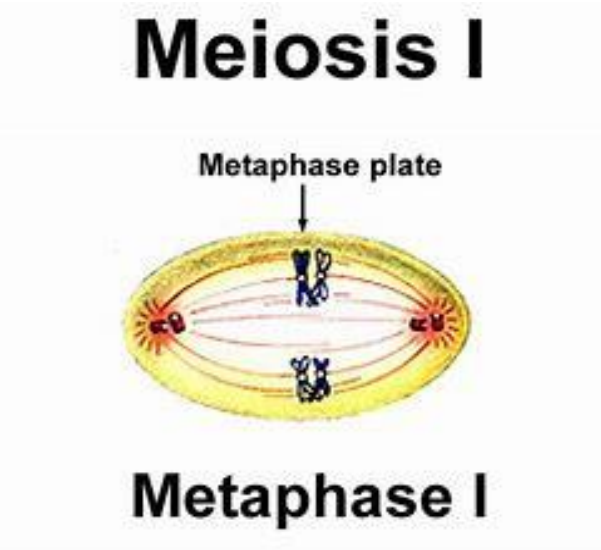
- The synaptonemal complex that holds any two chromosomes together begins to dissolve at this stage.
- Eventually, all the chromosome sets are completely detached from one another, other than the crossover section.
- In short, this common portion of the chiasmata is holding all the four chromatids together.
- Meanwhile, the chromosomes continue to condense, making them shorter.



Diakinesis

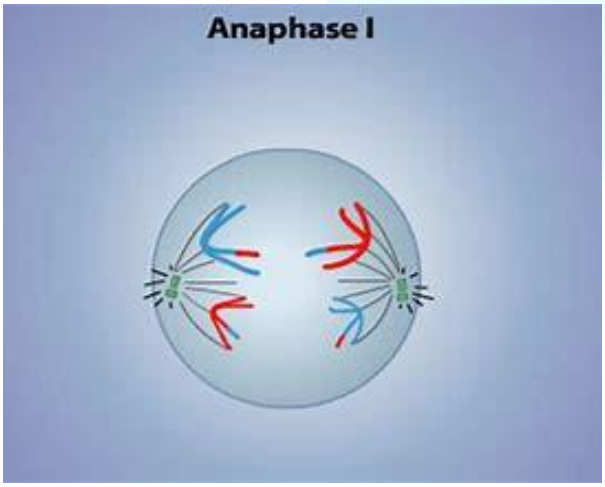
- At this stage, the chiasma begins to shift towards the end of the chromatid, as though trying to separate the bond. This continues until they reach the very end of the chromatid.
- Now spindle fibers (made of microtubules) begin to form from the centrioles of the cell.
- Lastly, the nucleolus and the nuclear membrane disintegration marks the beginning of the next step—Metaphase I.

Metaphase I



- The spindle fibers attach themselves to homologous chromosome pairs at the centromeres.
- With the nuclear membrane disintegrated, the chromosomes are free to move.
- The spindle fibers then align the chromosomes along the equatorial plane of the cell.

Anaphase I



- With the spindle fibers being pulled from opposite ends of the cells, the homologous pairs split apart. This is also known as 'disjunction.'

- Nondisjunction is when a chromosome pair does not separate, resulting in abnormal number of chromosomes and serious defects in the offspring so produced.

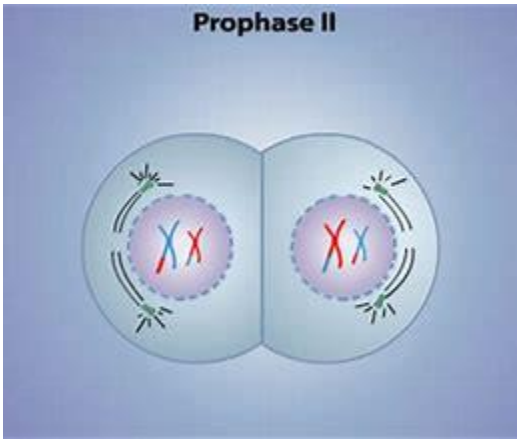
Telophase I

- With chromosomes pulled to either sides of the cell, cytokinesis takes place.
- The cell divides into two halves, each one having half the number of chromosomes as the parent cell.
- The nuclear membrane may or may not reform, and the chromosomes decondense.

Cytokinesis I

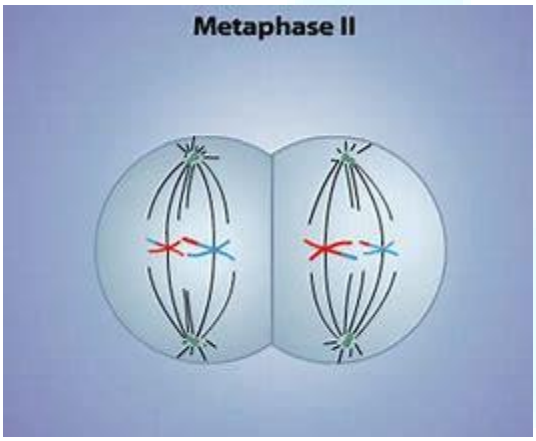
- As the name suggests, Cytokinesis literally means division of the cytoplasm or the cell body.
- Once the genetic material is replicated and segregated into different parts of the cell, the cell membrane begins pinching towards the inner side.
- A cleft is formed which gradually deepens and separates the two newly formed daughter cells.
- *As discussed earlier, plant and animal cells have a slightly different phenomenon of the cell membrane dividing the cell body.*

Prophase II



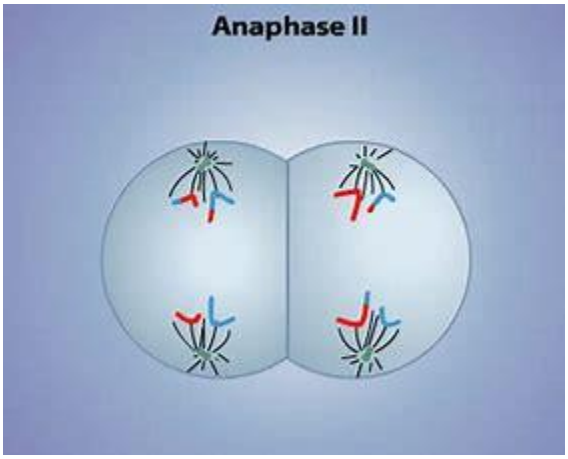
- If the nuclear membrane had reformed during Telophase I, it once again starts disintegrating for cell division.
- The chromosomes start recondensing, and the centrioles start moving towards the opposite ends of the cell.

Metaphase II



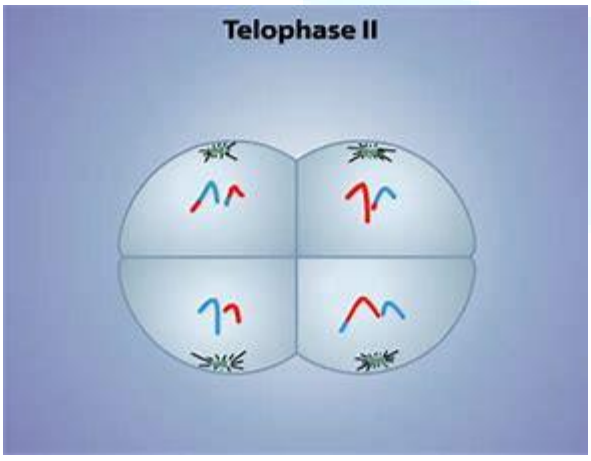
- Once again, spindle fibers arise from the centrioles and attach themselves to the centromeres at the location of the kinetochores.
- They start aligning the chromosomes along the equatorial plane of the cell by creating tension from opposite ends.

Anaphase II



- With the spindle fibers being pulled, the sister chromatids finally break and start moving in the opposite direction.
- Once the chromatids are separated from one another, they are considered as individual chromosomes.
- With the chromosomes (earlier chromatids) concentrated in different ends of the cell, cytokinesis begins.

Telophase II



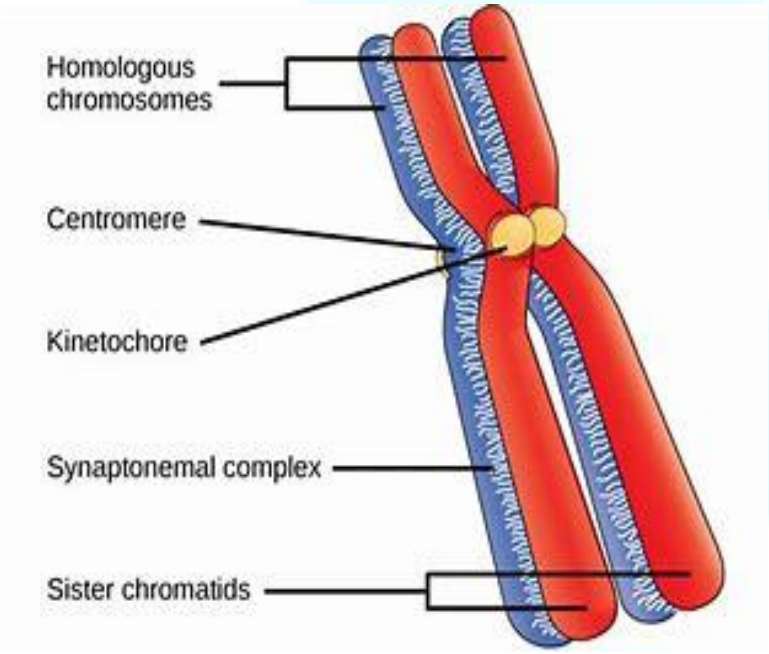
- Nuclear membrane reappears for both the to-be-daughter cells at this stage.
- The cells undergo cytokinesis to form four haploid daughter cells, each having half of the original parent cell's chromosomes.

- The daughter cell's chromosomes carry crossovers from other chromosomes, thus making each of them unique.

Cytokinesis II

- Once again, the cytoplasm divides post nuclear division to physically separate the new cells.
- The cell wall again pinches inward to create a cleavage, which in turn, deepens and forms two different cell walls for each of the daughter cells

SYNAPTONEMAL COMPLEXES



- Synaptonemal complexes (SCs) are zipper-like structures which are assembled between homologous chromosomes during the prophase of the first meiotic division.
- Their assembly and disassembly correlate with the successive chromatin rearrangements of meiotic prophase, namely the condensation, pairing, recombination and disjunction of homologous chromosomes.

- It was originally thought that SCs created the preconditions for the homologous crossing over of chromosomes by bringing corresponding parts of homologous chromosomes in close apposition.
- However, this view has been gradually undermined during recent years, and ideas about the roles of SCs have radically changed.
- SCs are now considered to be structures that both control the number and distribution of reciprocal exchanges between homologous chromosomes (cross-overs) and convert cross-overs into functional chiasmata.