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বিস্‌মিল্লাহির রাহ্‌মানির রাহীম

উদ্ভাস

একাডেমিক এন্ড এডমিশন কেয়ার

Class 11: Biology 1st paper (Chapter 02)

Cell Division

Lecture B-05

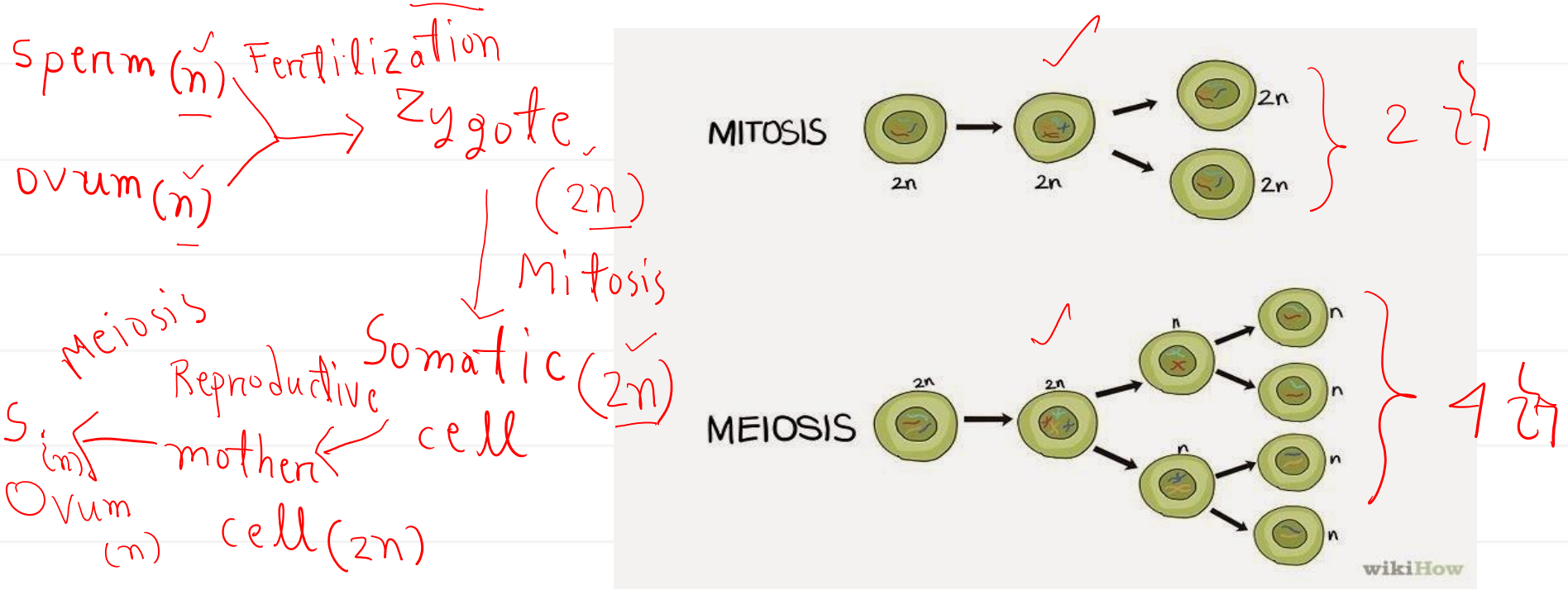
Cell Division

- It is the process by which a parent cell divides into two or more daughter cells.
- Walter Flemming (1882) first of all observed the cell division in marine salamander *Triturus maculosa*.

A species of salamanders

Types

- Cell division is of three types:
  - Amitosis or Direct cell division
  - Mitosis or Equational cell division
  - Meiosis or Reductional cell division



Poll Question:01

Which of the following contributes in formation and growth of reproductive organs ?

(a) Meiosis

(b) Mitosis

(c) Amitosis

(d) All of the above

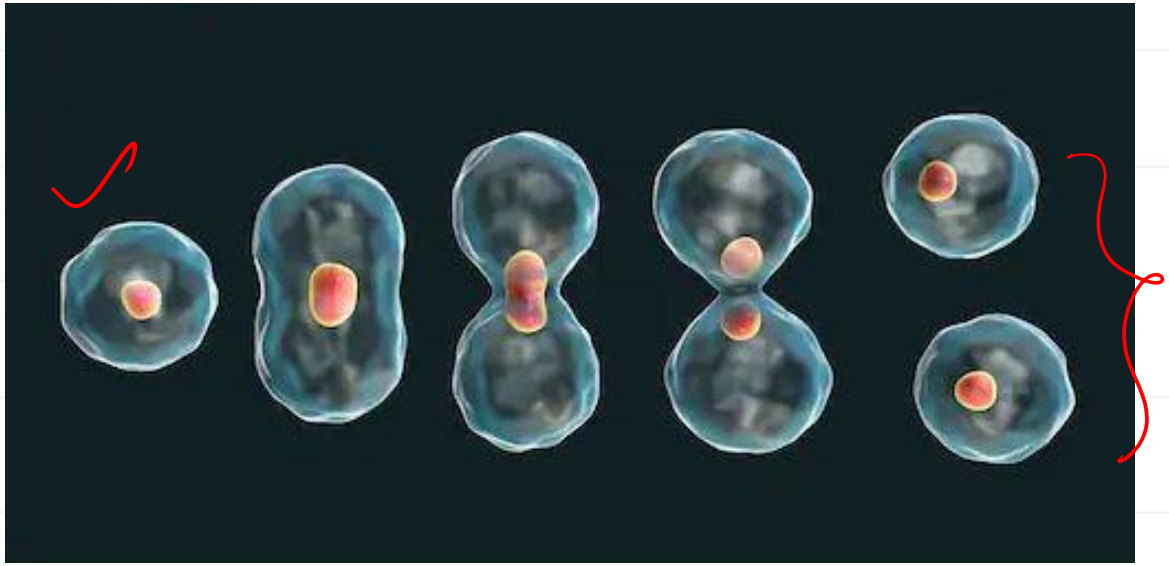
Amitosis

- The nucleus and cytoplasm of a mother cell divide directly without any complex intermediate stage to form two daughter cells.
- Amitosis occurs in some unicellular organisms like yeast, amoeba .
- The binary fission of bacteria is somewhat similar to amitosis.

Virus ??

Ans: Acellular

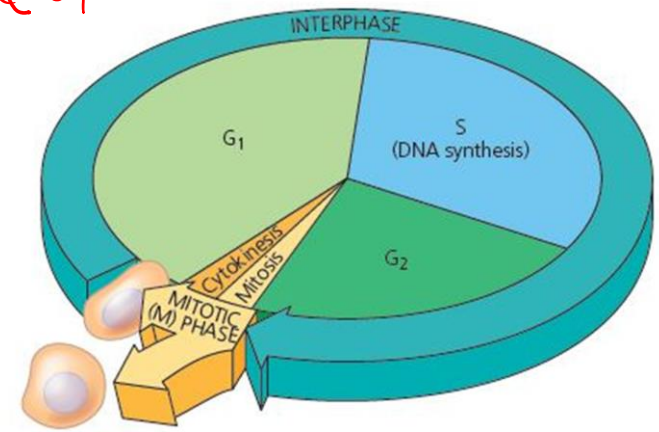
Fungus



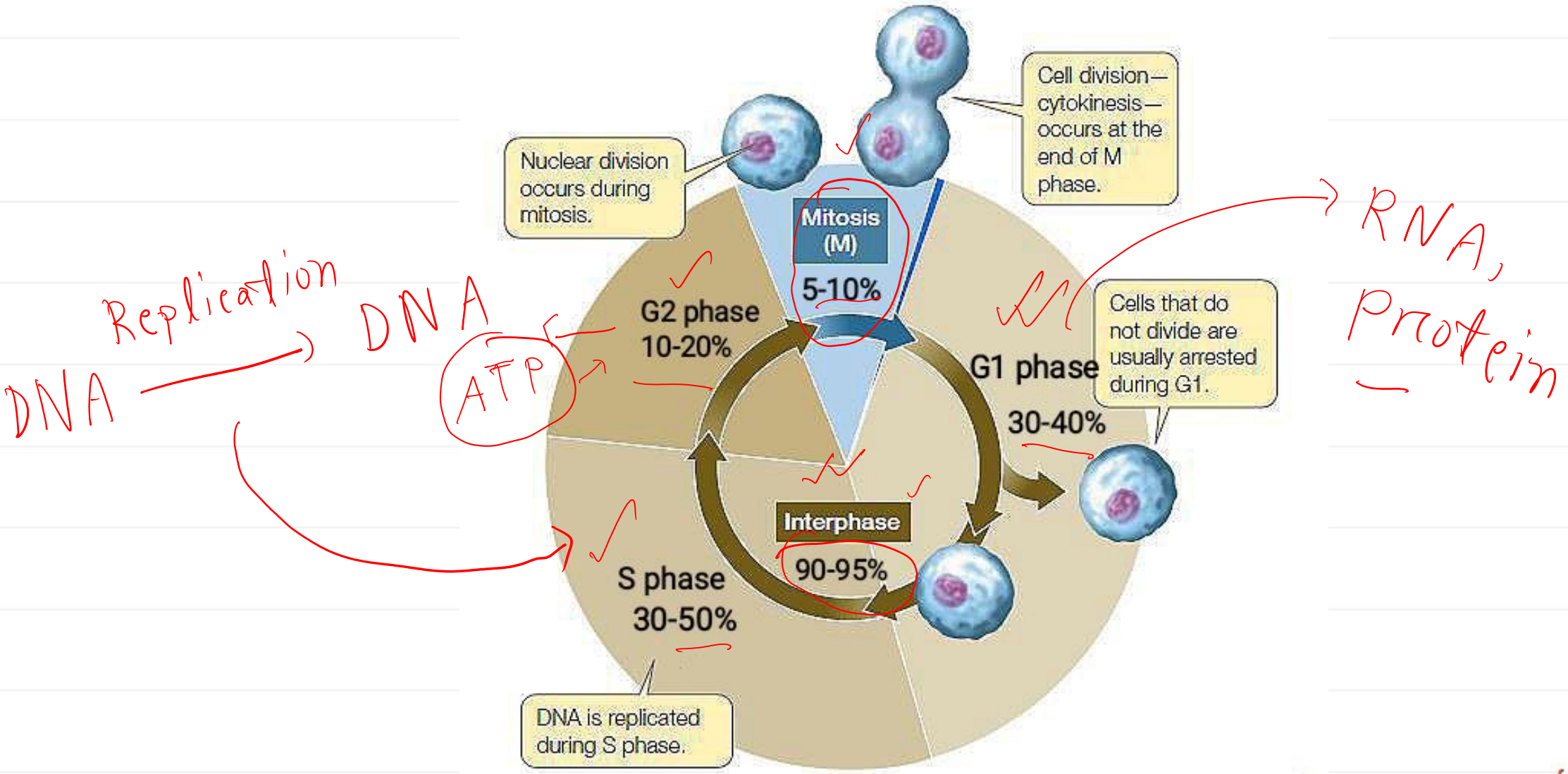
Amitosis

Cell Cycle

- The cell cycle consists of creation , growth and later , division of a cell
- Howard & Pelc proposed the existence of four periods in the cell cycle
- Cell cycle falls under two main stages:
  1. Mitotic Phase or Mitosis: The state of cell division.
  2. Interphase:The intermediate stage between two M. phase.

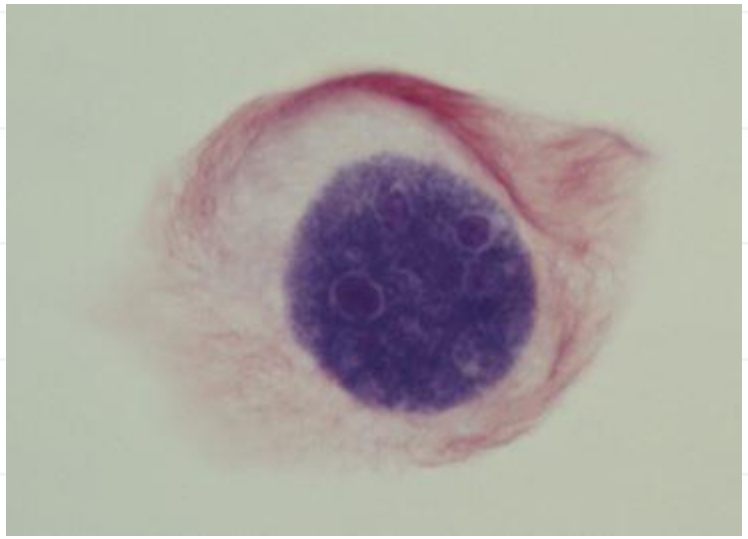


Cell Cycle Diagram



Interphase

- During interphase the nucleus of a cell is called metabolic nucleus .
- All types of preparations are made during interphase to complete the M. phase.
- It comprises of the 90-95% duration of the cell cycle.
- It has three stages :
  a. G_1 phase
  b. S phage
  c. G_2 phase



Interphase

G1 Phase

G_1 phase:

- It covers the 30-40% duration of cell cycle.
- First, a protein called cyclin is formed, which combines with Cdk to accelerate and control the speed of the whole process.
- At this phase all the necessary proteins, RNA and DNA replication components are made.
- The cell that no longer divides is bound to the G1 phase until its death.

S Phase & G2 Phase

S Phase (covers the 30-50% duration of cell cycle):

- The main task is to replicate the DNA strands in the nucleus.

DNA → DNA

G_2 Phase (covers the 10-20% duration of cell cycle):

- The main function is the synthesis of microtubules.
- The centrosome divides into two.
- The energy (ATP) required for cell division is generated.
- A protein called Maturation Promoting Factor (MPF) is required to enter mitosis from G2.

Cellular Organelles

Poll Question: 02

In which phase of the cell cycle DNA is synthesized?

(a) G1 phase

(b) G2 phase

(c) S phase

(d)Mitosis

Importance of Interphase

- Whether the cell will participate in subsequent cell division is determined at the beginning of the interphase.
- Proteins, RNA and DNA replication components that are necessary for cell division are made here.
- DNA replication takes place.
- Synthesis of microtubules occurs.
- The energy (ATP) required for cell division is generated.
- If there is no interphase , the cell division will not take place.

Poll Question: 03

Meiosis cell division occurs in ___

(a) Gametes

(b) Germ cell

(c) Somatic cell

(d) Cardiac cell

Mitotic Phase or Mitosis

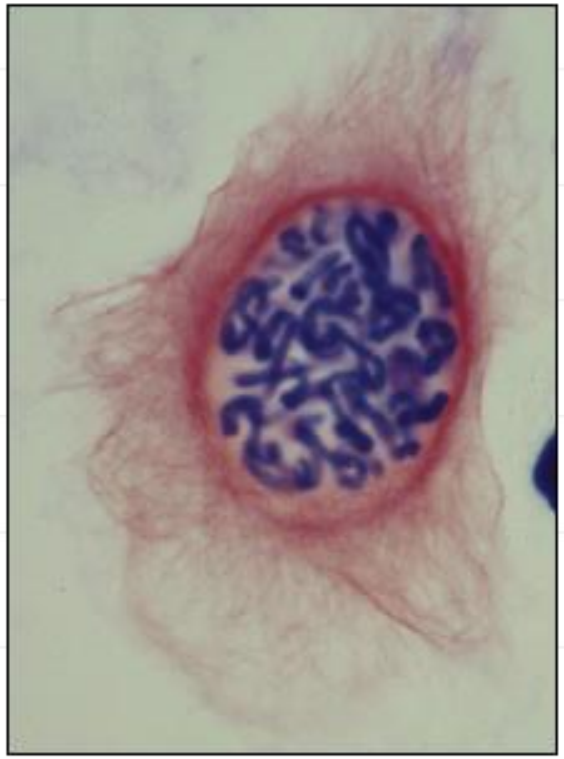
- It comprises of the 10-20% duration of cell cycle.
- Schleicher was the first to observe such a division of the nucleus and named it karyokinesis. Walther Flemming later coined the term 'mitosis' for this type of complete cell division.
- Where does mitosis occur ?
  a. Animal and plant somatic cell
  b. Meristematic tissues of the plant, apical meristems of roots and stems, cambium.
  c. Formation and growth of reproductive organ.

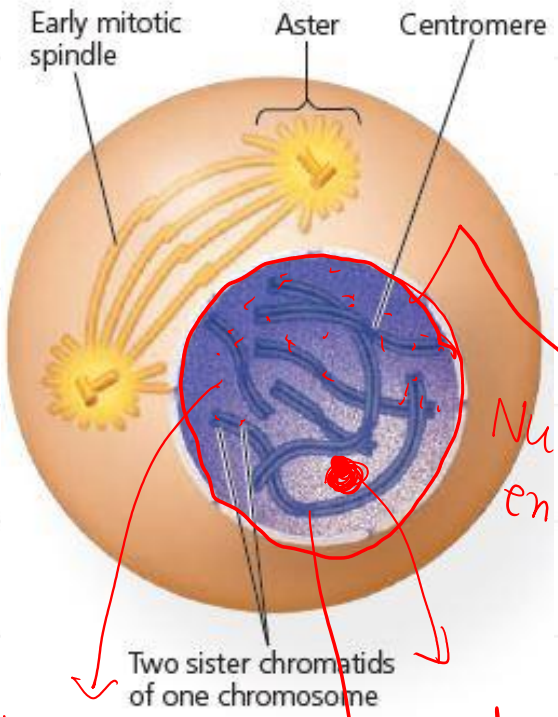
Stages of Mitosis

- The whole process of mitosis cell division is divided into two main stages :
  a. Karyokinesis : division of the nucleus
  b. Cytokinesis : division of the cytoplasm
- Mitosis mainly refers to karyokinesis .For purpose of description it is divided into 5 phases:

1. Prophase
2. Prometaphase
3. Metaphase
4. Anaphase
5. Telophase

Prophase

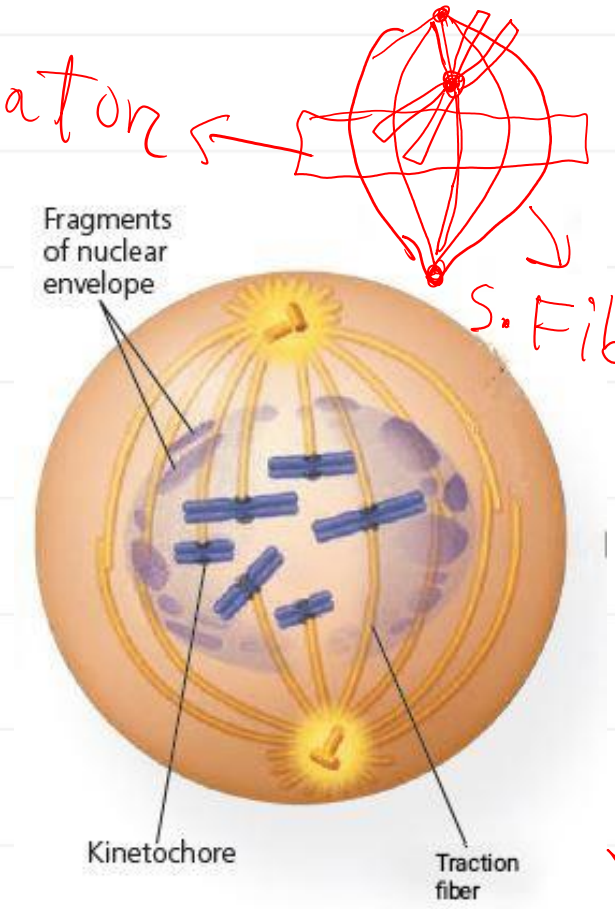




Prophase

- The longest stage of mitosis.
- The chromosomes begin to dehydrate.
- As the prophase progresses, chromosomes become shorter and thicker.
- By the end of prophase, the nuclear envelope and nucleolus starts to disappear.
- Each chromosome splits lengthwise into two identical threads. Each of these threads is called a chromatid.
- The formation of spindle fiber starts .

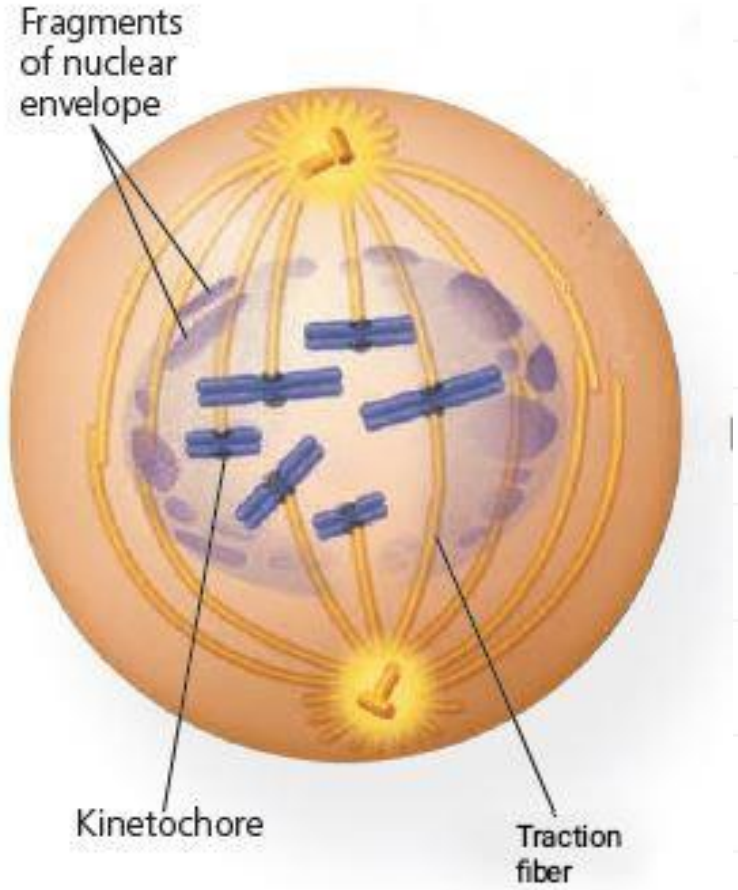
Pro–metaphase



Pro–metaphase

- At the very beginning nuclear envelope and nucleolus disappear completely.
- The plane that is equidistant from the poles of spindle apparatus is called equator or equatorial plate.
- The fibers of the spindle apparatus are called spindle fibers.
- The chromosome gets attached to some of the spindle fibers. These fibers are called traction fiber.

Pro–metaphase



Pro–metaphase

- The chromosomes start moving towards the equatorial plate by chromosomal dance.
- The spindle fiber binds to the kinetochore protein in the centromere.
- In addition to the formation of the spindle apparatus in the animal cell, the centriole radiates aster rays.

Poll Question: 04

‘Chromosomal dance’ is the characteristic feature of___

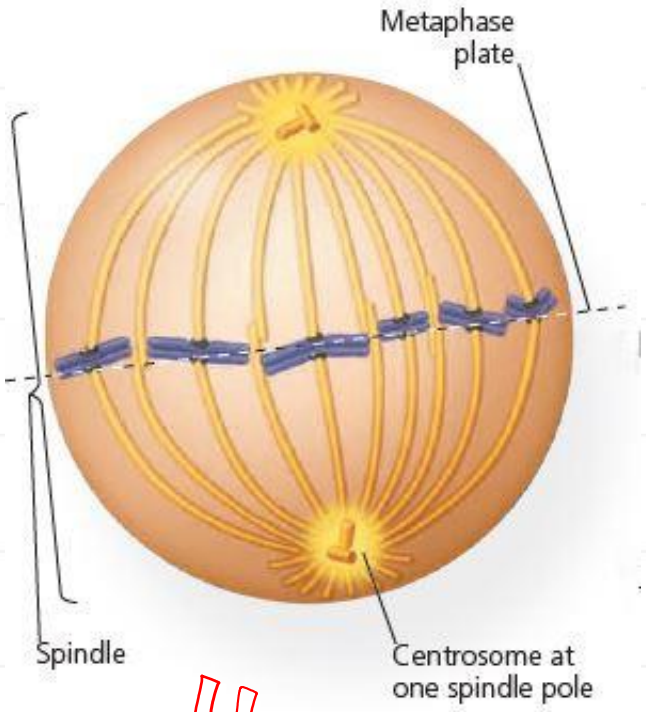
(a) Prophase

(b) Pro-metaphase

(c) Metaphase

(d) Telophase

Metaphase

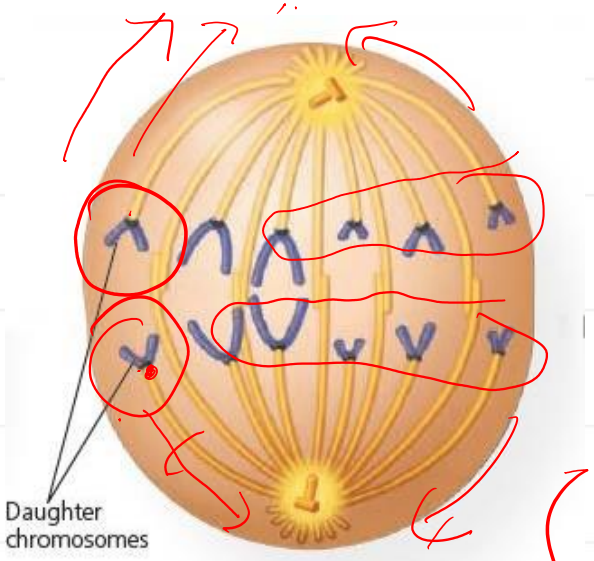


Metaphase

- All the chromosomes are located in the equatorial plate of the spindle apparatus at the beginning of this stage. The movement of chromosomes to the spindle equator early in metaphase is called metakinesis.
- The chromatids are the most thick and short at this stage.
- At this stage the number, size and shape of chromosomes can be determined.
- The centromere of each chromosome divides longitudinally into two.

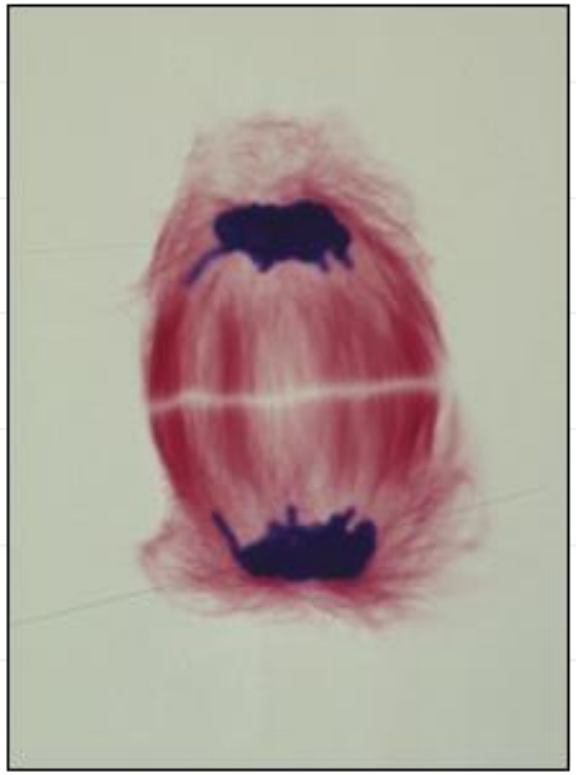
Anaphase

Anaphase

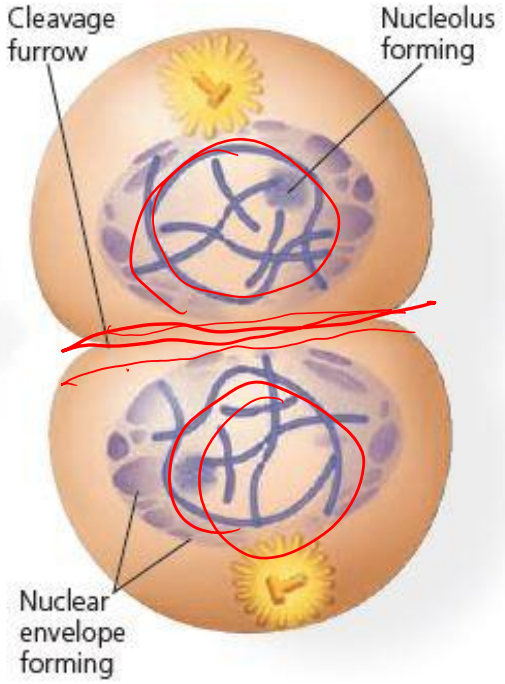


- As a result of the division of centromere each chromatid turns into a daughter chromosome.
- The daughter chromosomes start moving towards the pole from the equatorial plate.
- During movement toward the pole, each daughter chromosome resembles the shape of English letter ‘V’(metacentric), ’L’(submetacentric), ’J’(acrocentric) or ‘I’(Telocebtric).
- This phase ends when the daughter chromosomes reach the poles.

Telophase

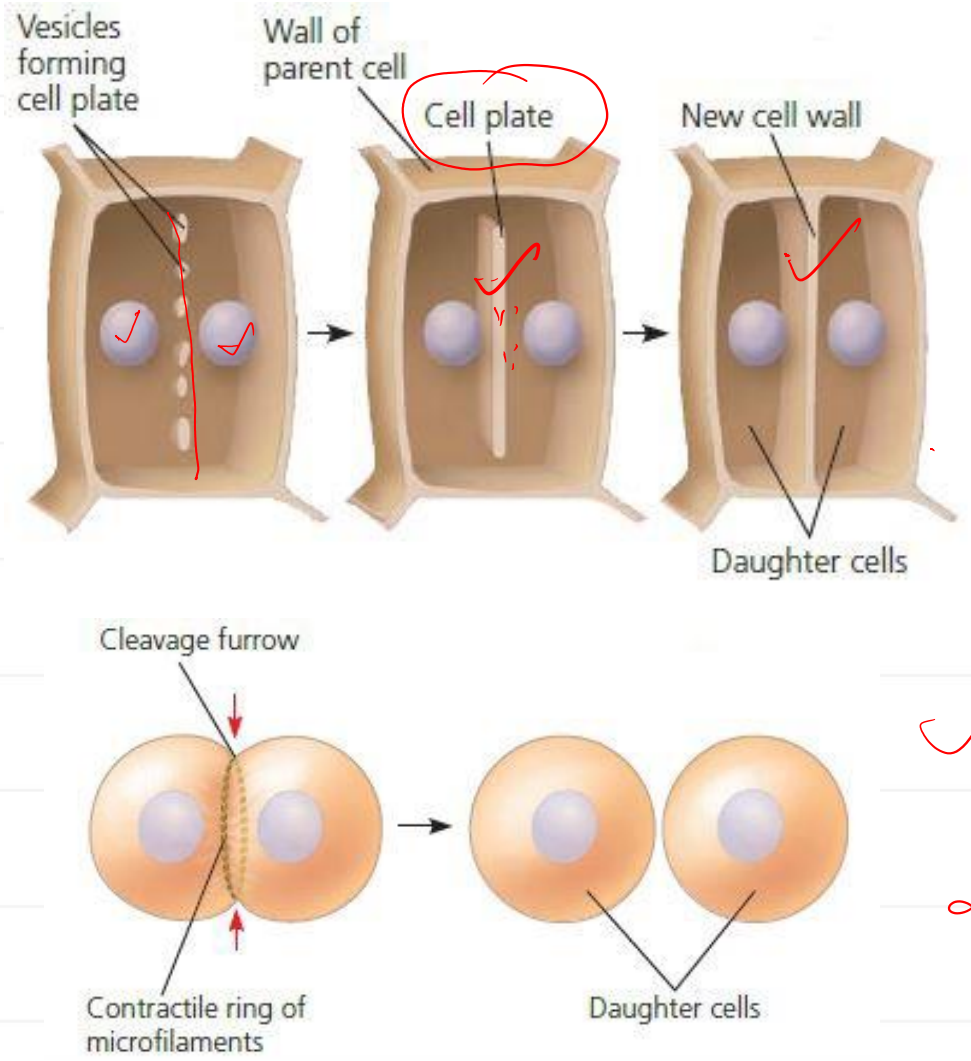


Telophase



- At this stage the daughter chromosomes occupy the opposite poles.
- The chromosomes are hydrated again. Thus they again become long and thin.
- The nucleolus and the nuclear envelope reappear at each pole. This results in the formation of a daughter nucleus at each pole of the parent cell.
- The spindle fibers disappear gradually.

Cytokinesis



Cytokinesis

- Cytokinesis occurs in plant cells by the formation of cell plates and cell walls.
- Phragmoplast and tiny vesicles from the endoplasmic reticulum all together form cell plates.
- Hemicellulose and other substances accumulate on the cell plate to form the cell wall.
- In animal cells, cytokinesis starts by the appearance of a shallow groove or furrow in the cytoplasm at the equator of the spindle. Slowly it deepens and constricts the cytoplasm and the cell divides into two parts. Actin and myosin help in furrowing.

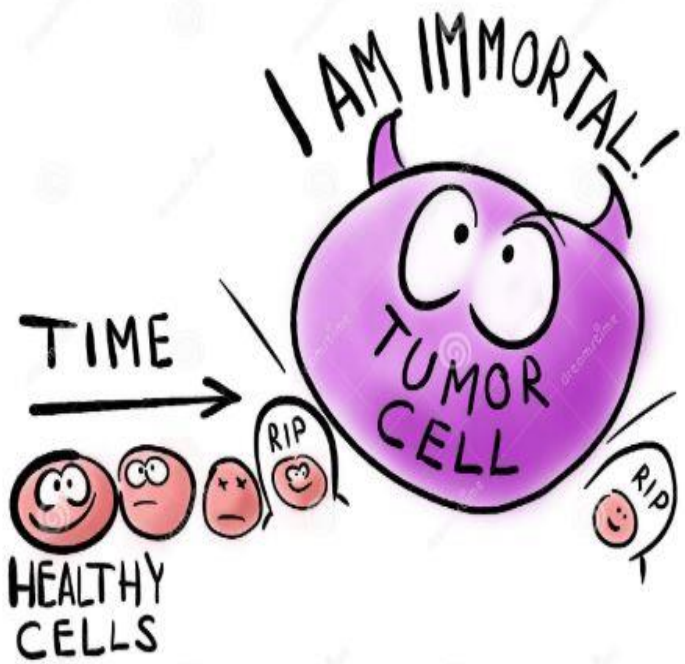
Importance of Mitosis

- Physical growth
- Asexual reproduction
- Formation of genital organ and multiplication of sex-cell
- Maintain the size and shape of the cell
- Regeneration
- Ensure equal number of chromosomes in daughter cell
- Cell replacement
- Restoring wear and tear Regeneration
- Maintain the nuclear and cytoplasmic balance

Mitosis contributes to the growth of root tissue

Mitosis contributes to the regeneration of a lizard's tail.

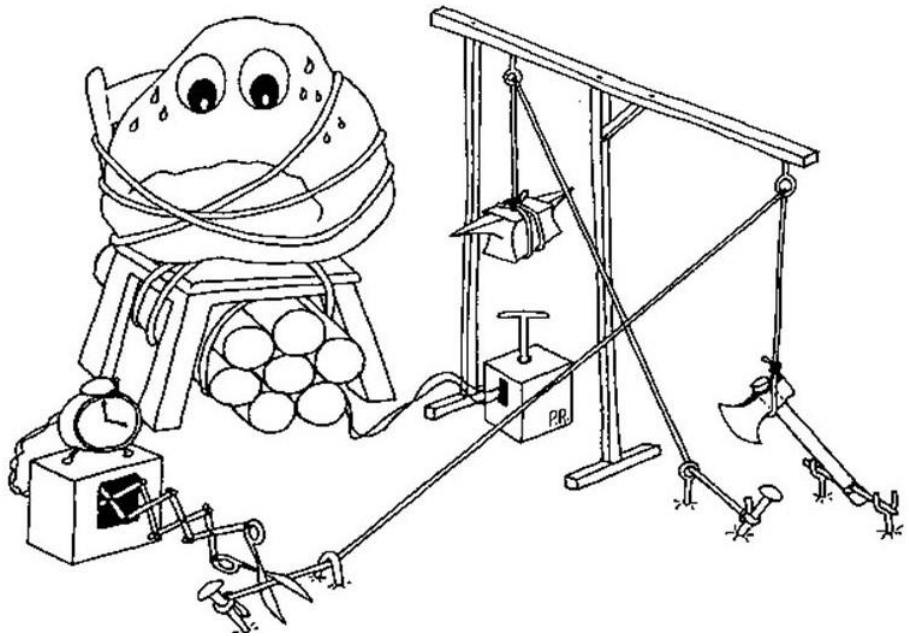
Uncontrolled Mitosis



- Two types of proteins control the cell cycle - protein kinase and cyclin.
- In cancer cell, cyclin-Cdk loses its control over cell cycle.
- A protein called P^{53} prevents cell from dividing. When it is defective, the cell loses control over the cell cycle. This leads to cancer.
- Tumor formation is called oncogenesis.
- An oncogene is a gene that destroys the cell cycle.
- Mutagens are chemicals that leads to cancer.
- Metastasis is the spread of a pathogenic agent or tumor from an initial site to a different site within the host's body.

Cell death

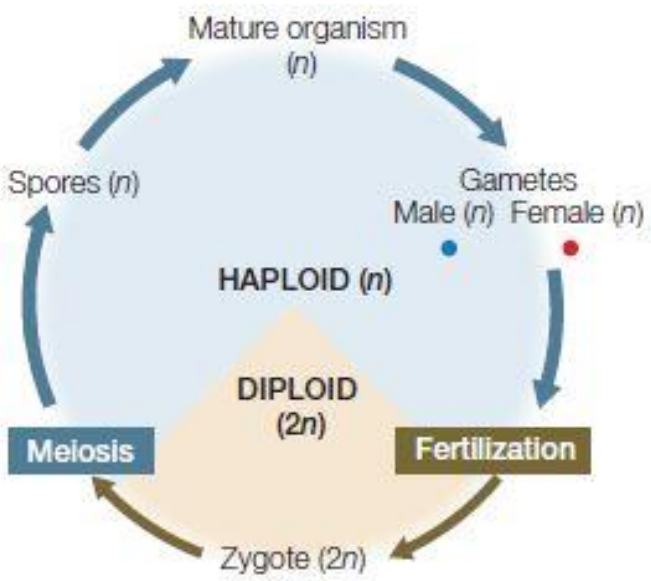
- Cell death occurs in two ways
  a. Necrosis : It is the death of cells due to toxic substances or lack of nutrients.
  b. Apoptosis : It is genetically programed cell death.



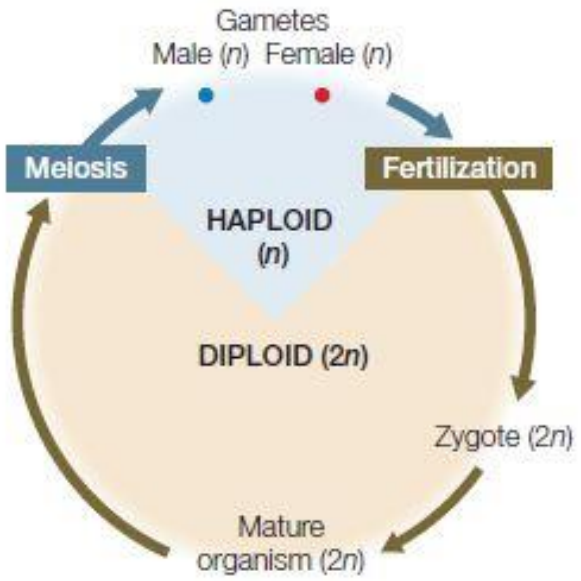
Apoptosis

Meiosis

- It is a special type of cell division where diploid number of chromosomes in mother cell is reduced to haploid in the daughter cells.
- Here, chromosomes divide once while the nucleus divides twice.
- Four haploid daughter cells result from one diploid mother cell.



Meiosis in **haploid** organism



Meiosis in **diploid** organism

Where does meiosis occur ?

- In haploid organism meiosis takes place in zygote after fertilization.
- In diploid organism meiosis takes place in germ cell before fertilization.

Stages of meiosis

- Meiosis cell division is divided into two main stages:
  1. Meiosis-1: Here chromosome number is reduced to half. So it's called reductional division.
  2. Meiosis-2: Here chromosome number remains the same. So it's called equational division.
- Each of these two stages is divided into 4 sub-stages: prophase, metaphase, anaphase, telophase.

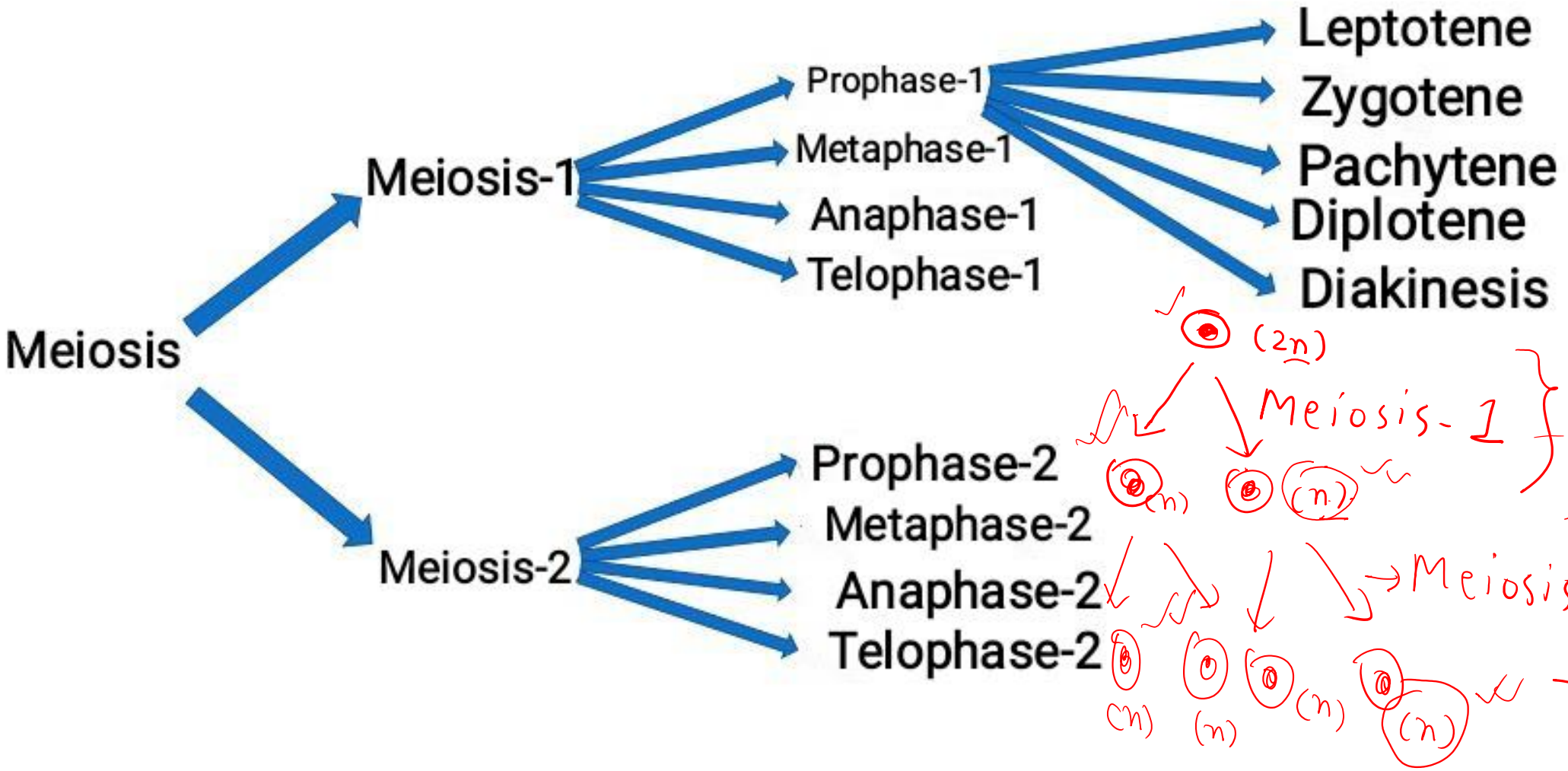
Stages of meiosis-1

- Prophase-1
- Metaphase-1
- Anaphase-1
- Telophase-1

Stages of meiosis-2

- Prophase-2
- Metaphase-2
- Anaphase-2
- Telophase-2

Stages of meiosis

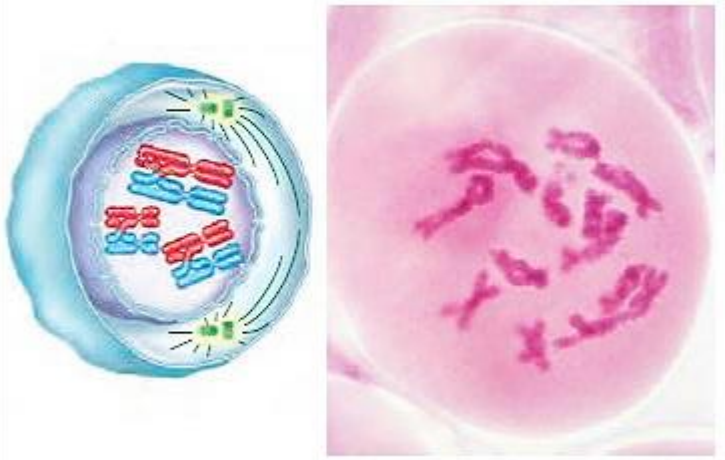


Meiosis–1

Prophase – 1

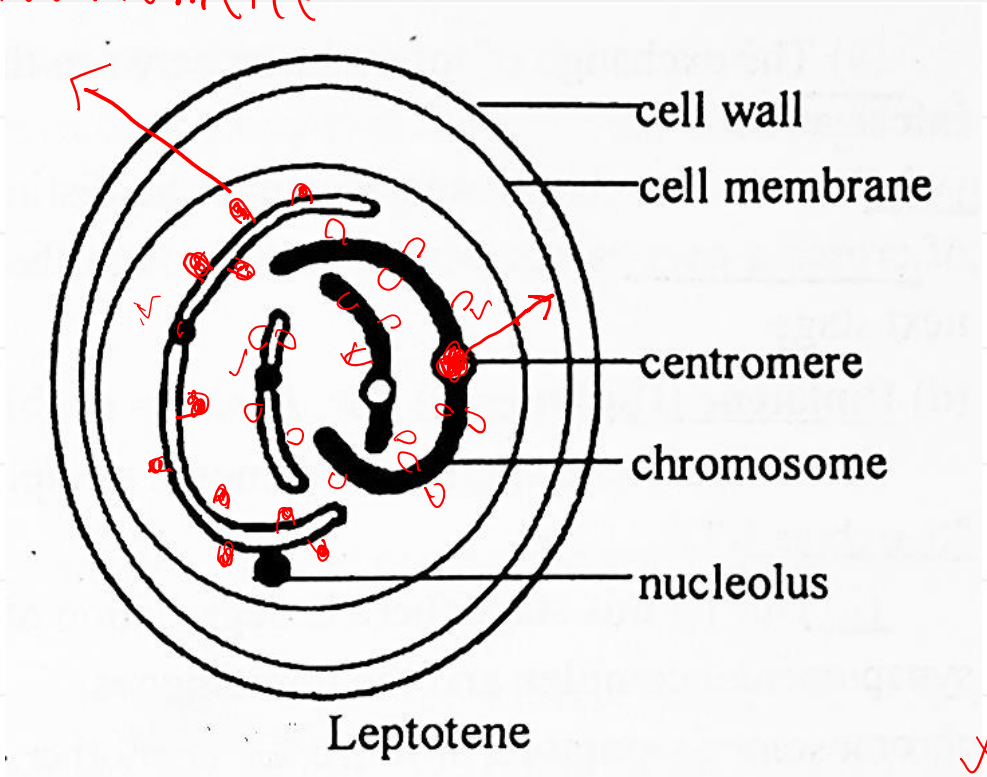
It is divided into the following phases:

1. Leptotene
2. Zygotene
3. Pachytene
4. Diplotene
5. Diakinesis



Prophase – 1

Leptotene

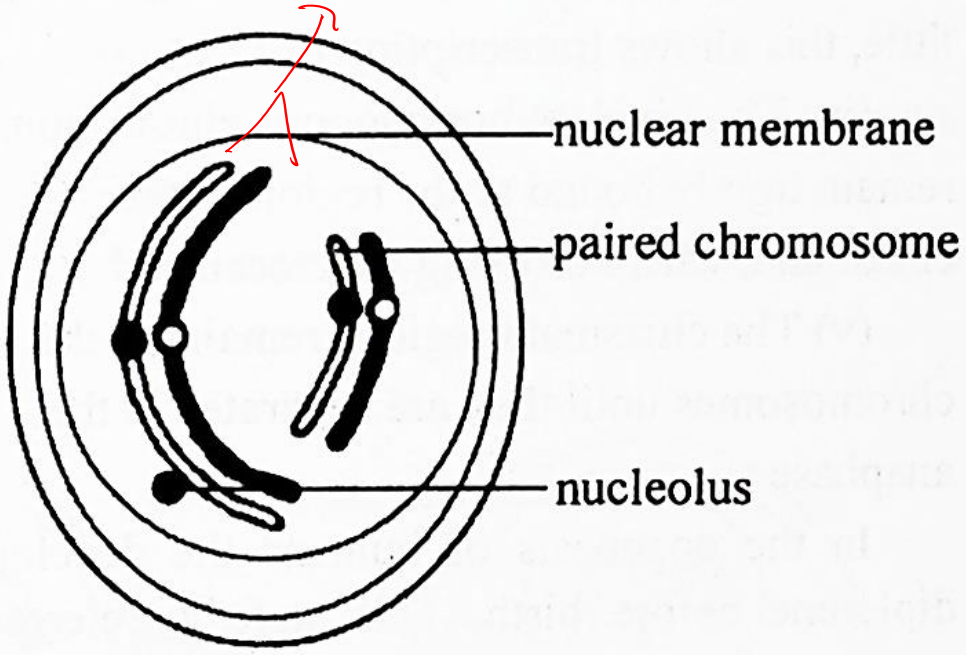


Leptotene

Leptotene

- Dehydration causes the chromosomes to shrink . As a result, the chromosomes become more visible under light microscope.
- Chromomeres appear in the chromosome.
- The chromosomes remain undivided and long.
- In the animal cell, the centromeres usually come together in a place close to the nuclear envelope, so the chromosomes look like a bouquet together.

Zygotene



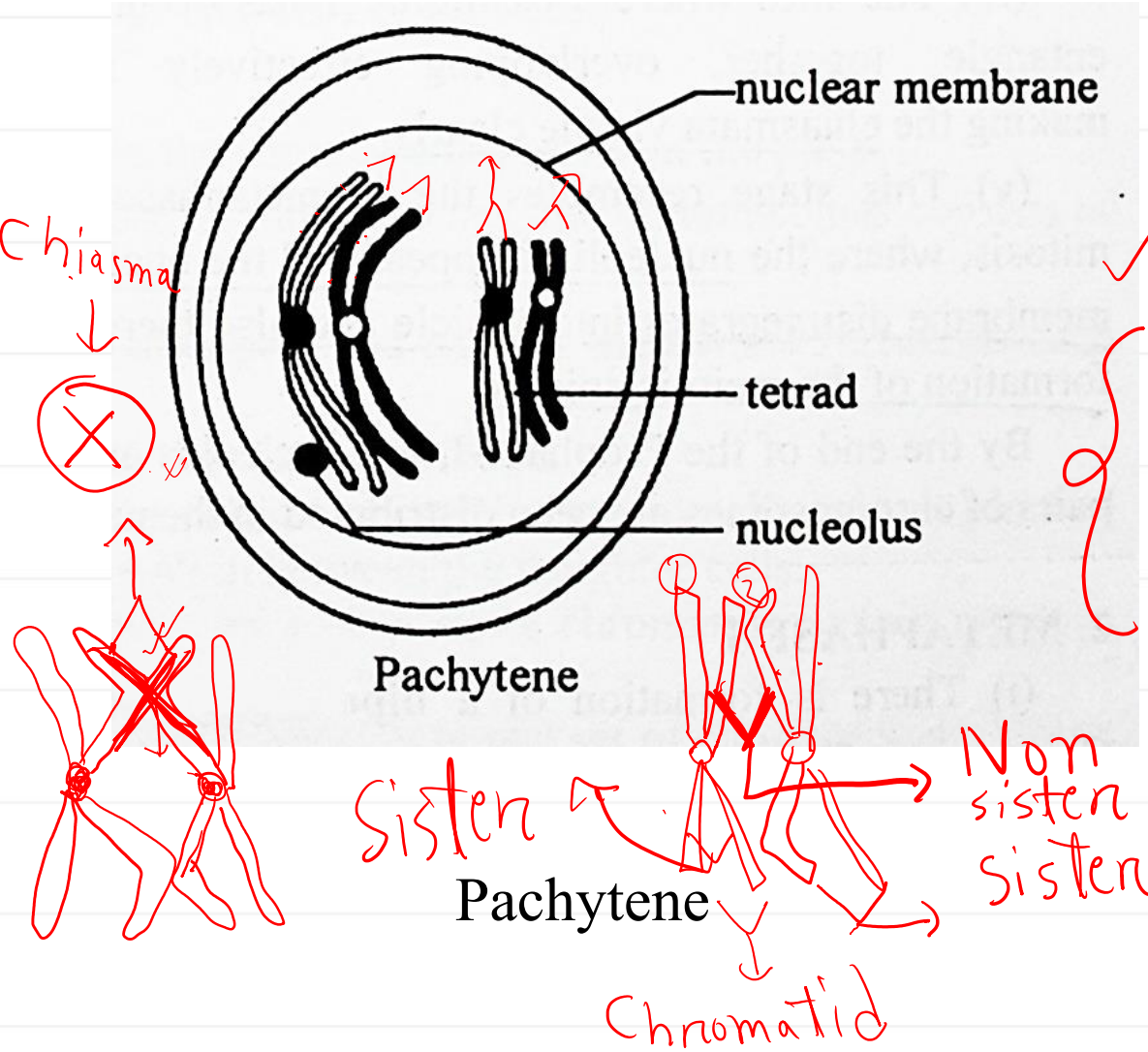
Zygotene

- Homologous chromosomes pair up.
- The formation of a pair between two homologous chromosomes is called synapsis.
- Each pair of chromosomes is called bivalent. The number of bivalent in a cell is half of the number of chromosomes.

Zygotene

bivalent = Pair of chromosome

Pachytene



- Each chromosome in a bivalent splits lengthwise except the centromere into two chromatids . So there will be four chromatids and two centromere in a bivalent. This condition is called tetrad.
- The two chromatids of the same chromosome are called sister chromatids. But if they come from two separate chromosomes of a homologous pair(bivalent), they are called non-sister chromatid.
- Chiasma is formed between two non-sister chromatids.
- An exchange of genetic material occurs between two non-sister chromatids at chiasma. It is called crossing over.

Poll Question: 05

In which of the following phase crossing over takes place ?

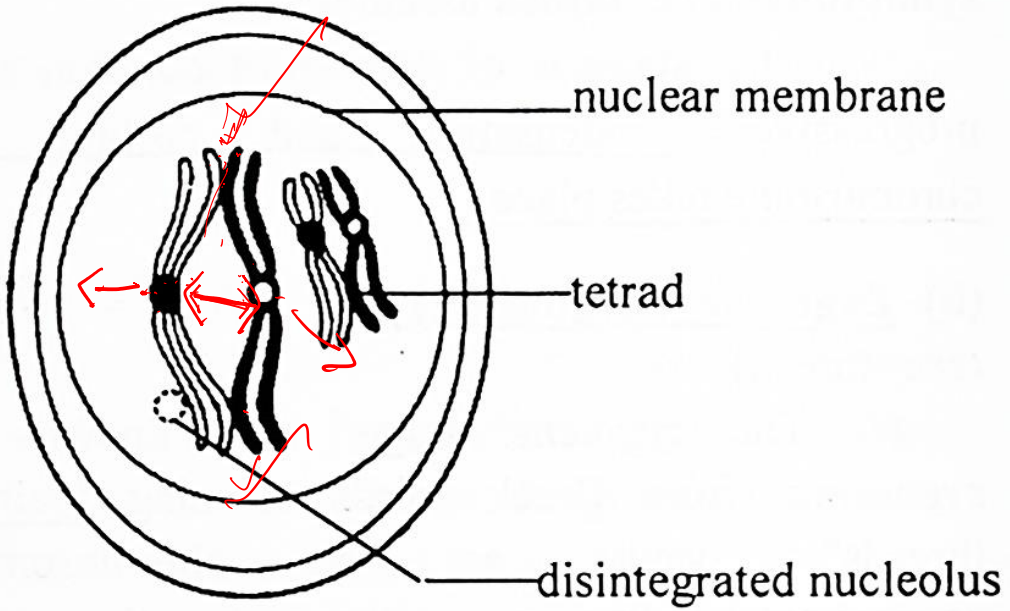
(a) Leptotene

(b) Zygotene

(c) Pachytene

(d) Diplotene

Diplotene

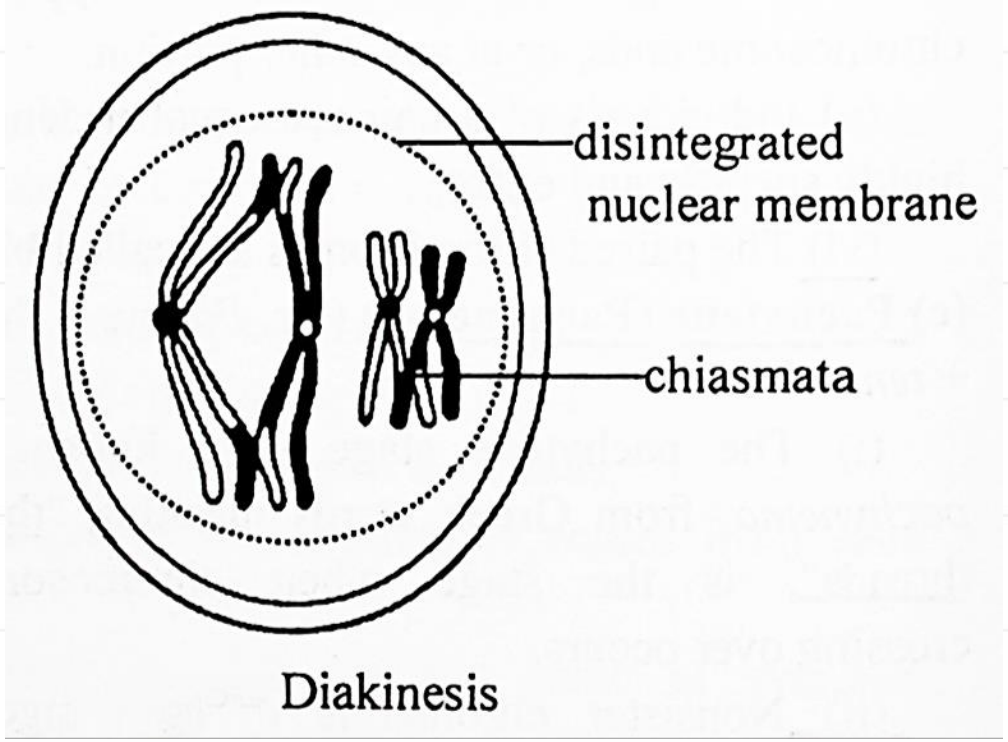


Diplotene

- Mutual repulsion begins between the two chromosomes of a bivalent. So, they try to move in the opposite direction. But this repulsion is interrupted in chiasmata.
- A loop is formed between the two chiasmata due to repulsion.
- Normally the loop is positioned at an angle of 90°.But if there is only one chiasmata the angle will be 180°.
- The chiasmata gradually moves towards the edges. It is called terminalization.

Diplotene

Diakinesis



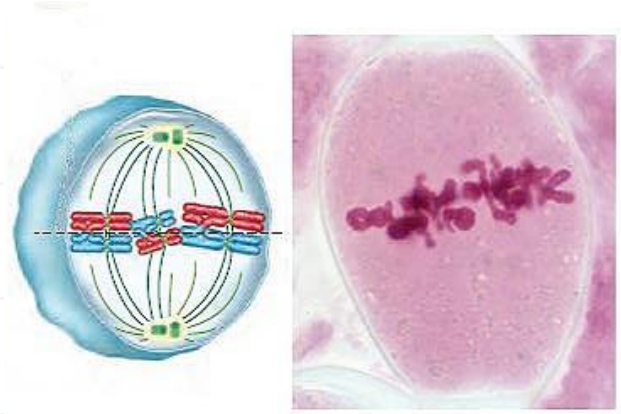
- The chromosomes become shorter and thicker.
- Terminalization still continues.
- At one point the bivalent moves from the center of the nucleus to the periphery.
- Later the nucleolus and the nuclear envelope disappear . In animal cell the centrioles reach the poles.

Diakinesis

Meiosis–1

Metaphase-1

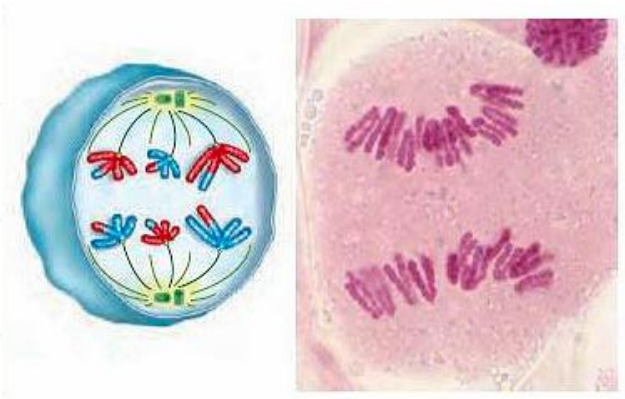
- Each centromere of the bivalent faces towards its pole and equidistant from the equator.
- The chromosome gets attached to traction fibers.
- In this phase, centromere doesn't split like mitotic metaphase.
- Loop is created between the chromosomes.



Metaphase–1

Anaphase-1

- The homologous chromosomes are separated. Then the two bivalent chromosomes move toward the opposite pole.
- The chromosome resembles the shape of English letter 'V'(metacentric), 'L'(submetacentric), 'J'(acrocentric) or 'I'(Telocebtric).



Anaphase–1

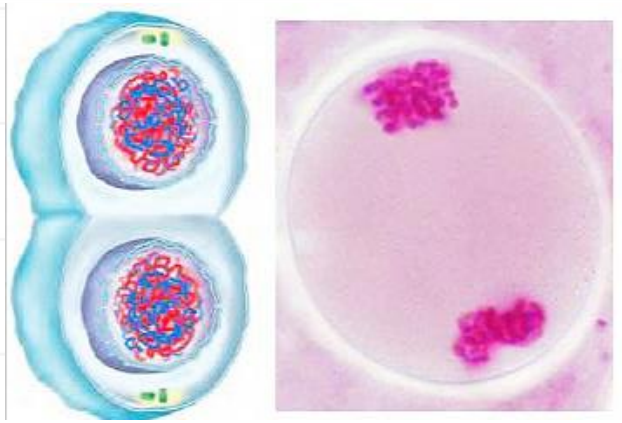
Meiosis–1

Telophase-1

- The nucleolus and the nuclear envelope reappear at each pole.
- The chromosomes are hydrated

Interkinesis or cytokinesis-1

- It is the intermediate stage between meiosis-1 and meiosis-2.
- Necessary proteins and RNA are produced here.
- DNA replication doesn't occur.

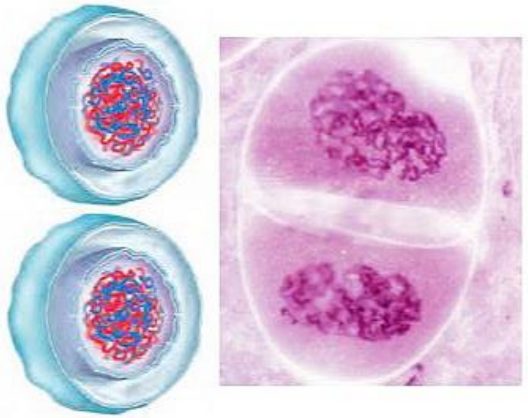


Telophase–1

Meiosis–2

Prophase-2

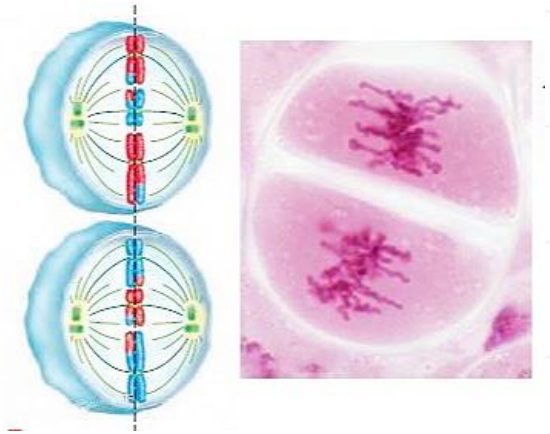
- The chromosomes are dehydrated again. So they become shorter and thicker.
- The chromosomes split into chromatids.
- Later the nucleolus and the nuclear envelope disappear .



Prophase–2

Metaphase-2

- Spindle apparatus is formed.
- Chromosomes occupy the equatorial plate of the spindle apparatus.
- Later the centromere splits into two .

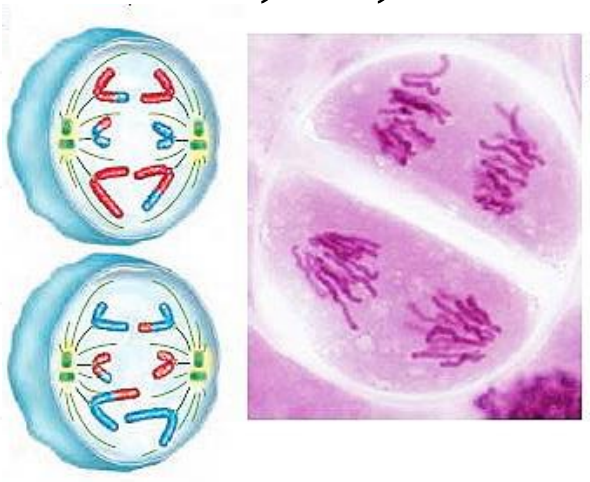


Metaphase–2

Meiosis–2

Anaphase-2

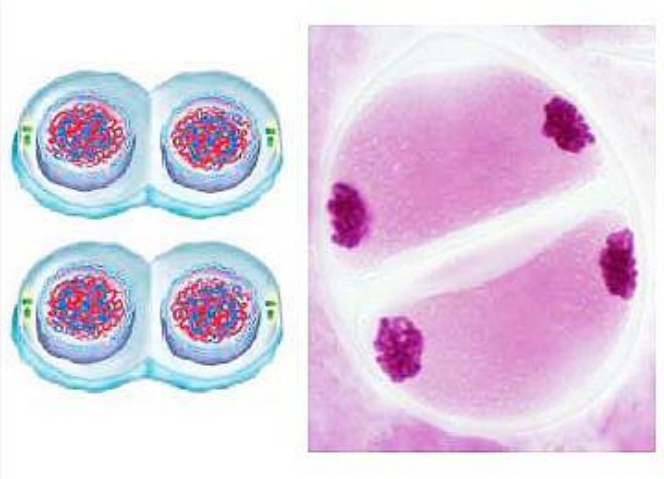
- The division of the centromere results in the complete separation of the two chromatids of a chromosome.
- When the chromatids move towards the pole, they resembles the shape of English letter ‘V’, ’L’, ’J’ or ‘I’.



Anaphase–2

Telophase-2

- The nucleolus and the nuclear envelope reappear at each pole.
- The chromosomes are hydrated

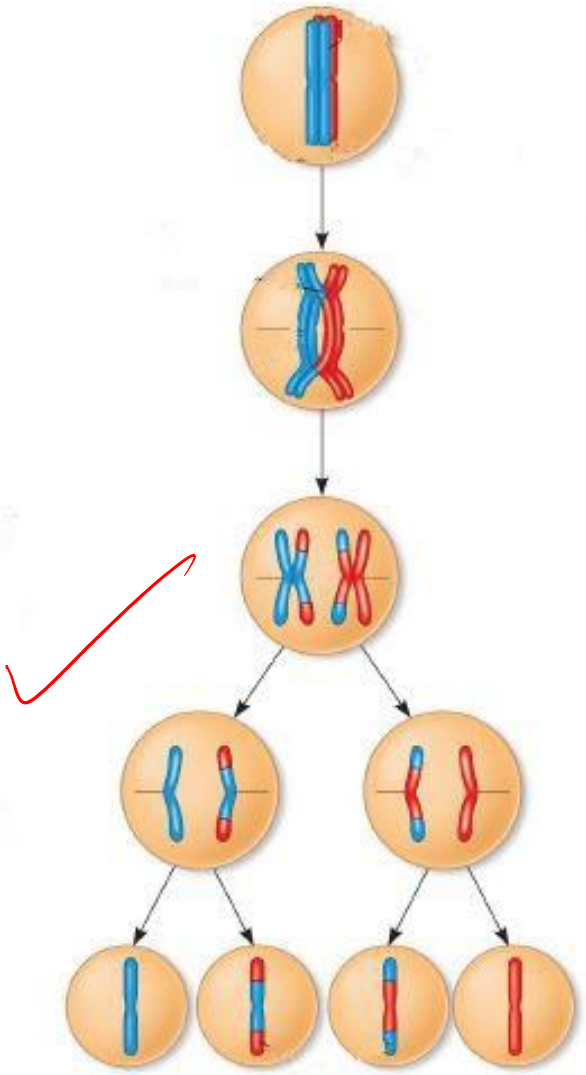


Telophase–2

Importance of Meiosis

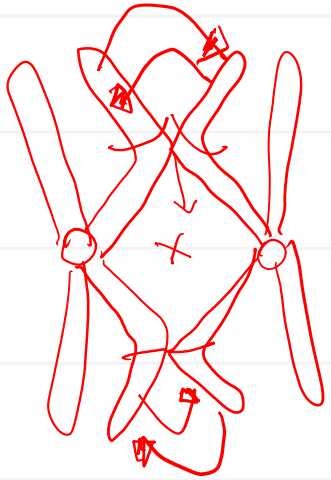
- Production of gametes
- Assortment of chromosomes
- Restoring chromosome number
- Reduction in chromosome number

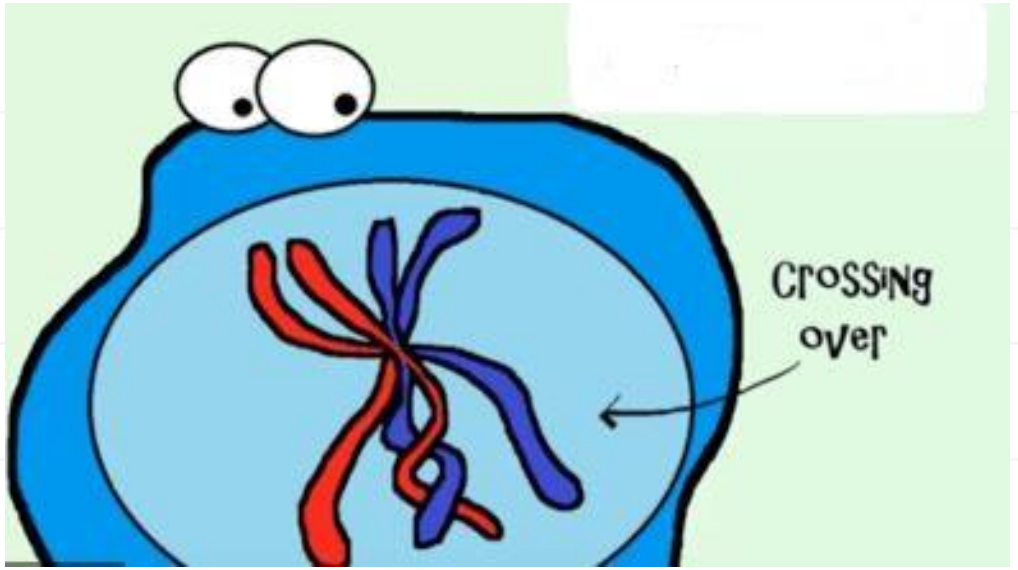
- Combinations of genetic material
- Production of variation
- Alteration of generation
- Mendel’s law



Crossing Over

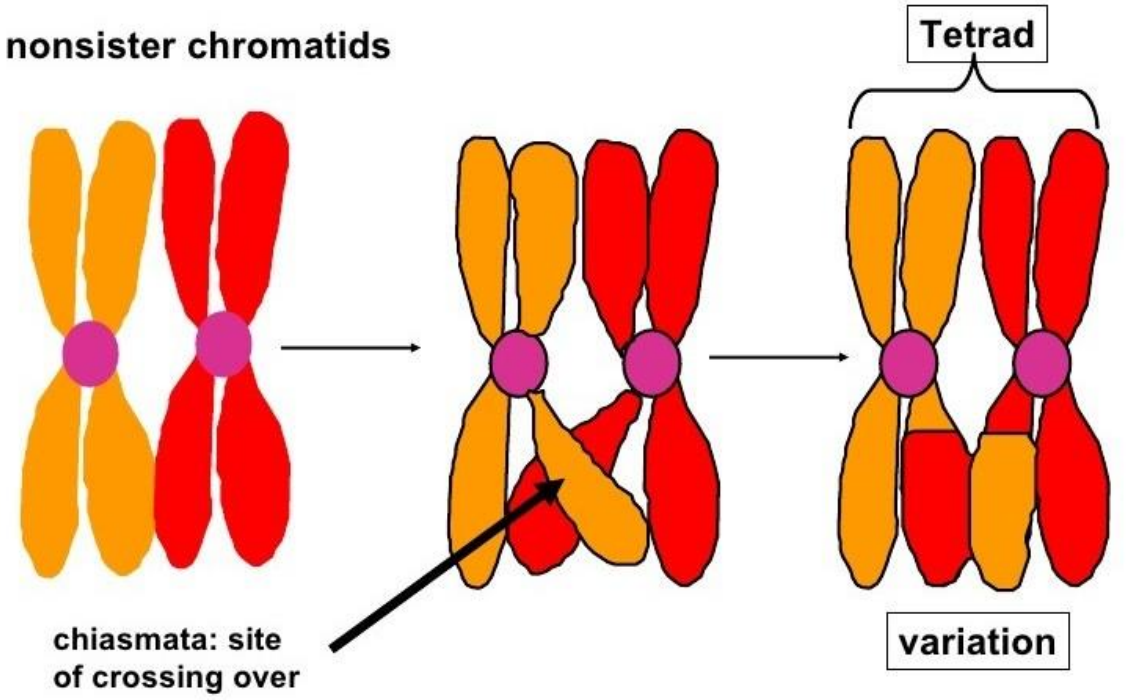
- It is an exchange of genetic material between two non-sister chromatids of two homologous chromosome during pachytene of meiosis.
- Crossing over was first described by T. H. Morgan in 1909 in the cell division of maize plant.





Mechanism of Crossing Over

- At first, the two non-sister chromatids break down along the same spot (due to endonuclease).
- Then one part of a non-sister chromatid is reattached to the other non-sister chromatid under the influence of ligase-enzyme. This results in chiasmata.
- Then the exchange of chromatids ends with terminalization.



Importance of Crossing Over

- It produces new individuals having new combinations of traits.
- It has helped in establishing the concept of linear arrangement of genes.
- mapping of chromosomes
- determining the location of the genes
- Selection of useful recombination by geneticists has brought about green revolution

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স্বপ্ন জয় তোমারই হবে

ঊদ্ভাস-উন্মেষ শিক্ষা পরিবার