CHAPTER 01

Cell Cycle and Cell Division

In this Chapter...

- Cell Cycle
- Mitosis
- Meiosis

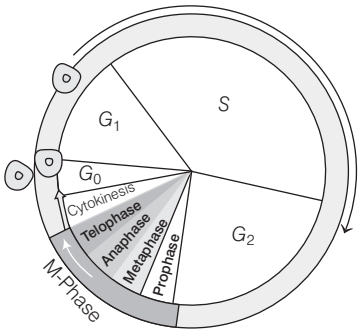
- Growth and reproduction are the characteristics of cells in all living organisms.
- All cells reproduce by undergoing cell division, i.e. division of parent cell into daughter cells. Before the division of a cell, DNA replication and cell growth take place.

Cell Cycle

The sequence of events by which a cell duplicates its genome, synthesises other constituents of the cell and then divides into two daughter cells is called as **cell cycle**.

Phases of Cell Cycle

A typical eukaryotic cell (human cell) divides once in every 24 hrs. This duration of cell cycle can vary from an organism to other organism and also from one cell type to another, e.g. yeast cell progresses through the cell cycle and divides in only about 90 min.



Diagrammatic view of a cell cycle indicating formation of two cells from one cell

The cell cycle is divided into two phases

1. Interphase

- It is the period between the end of one cell division to the beginning of the next cell division, i.e. between two successive M-phase.
- During this phase, cell prepares itself for both cell growth and DNA replication in an orderly manner. So, it is also known as **preparation phase**. It lasts for about 90-96%, i.e. more than 95% of the total duration of cell cycle.
- During cell cycle of a typical human cell, approx., one hour is taken by the dividing phase out of 24 hours duration of one cell cycle.
- Interphase is further divided into following three substages on the basis of various synthetic activities
  - **Gap 1** or **G_1-phase** The cell is metabolically active and continuously grows but does not replicate its DNA. Cell increases in size and cell organelles (except for mitochondria, chloroplast and centriole) also increase in number.
  - **Synthesis** or **S-phase** DNA replication and centriole duplication take place without any changes in chromosome number. In animal cells, during the S-phase, DNA replication begins in the nucleus and the centriole duplicates in the cytoplasm.
  - **Gap 2** or **G_2-phase** Protein synthesis and cell growth occur. RNA and protein synthesis continues. Cell organelles like mitochondria and chloroplast increase in number by duplication.

- Some cells in adult animals do not divide, e.g. heart cells and many cells divide occasionally, e.g. liver cells. These cells exit the cell cycle at G_1-phase and enter into **quiescent stage** (G_0), where they remain metabolically active, but do not divide unless required.

2. M-phase

Following the interphase, the cell enters the **M-phase** or **mitotic** or **mitosis phase**.

Mitosis

- In this type of division, the chromosomes replicate themselves and get equally distributed into daughter nuclei, i.e. the chromosome number in the parental and progeny cell (diploid) become same. Therefore, it is also known as **equational division**.
- Mitosis is also known as **somatic cell division** because it always occur in somatic cells. Mitotic cell division is seen in the diploid somatic cells in animals, whereas, in plants, mitotic division is seen in both haploid and diploid cells.
- It is known to be the phase of actual cell division, which starts with the division of nucleus, followed by the separation of daughter chromosomes, i.e. **karyokinesis** and terminates with the cytoplasmic division, i.e. **cytokinesis**.

I. Karyokinesis

- It involves the division of the nucleus.
- It is further divided into four main substages, i.e. prophase, metaphase, anaphase and telophase.

1. Prophase

This phase is known for the initiation of condensation of chromosomal material, which during the process of chromatin condensation becomes untangled and finally the **centriole** (already duplicated during S-phase of interphase) begins to move towards the opposite poles of the animal cell.

For the suitability in study we can categorise prophase as

(i) Early Prophase

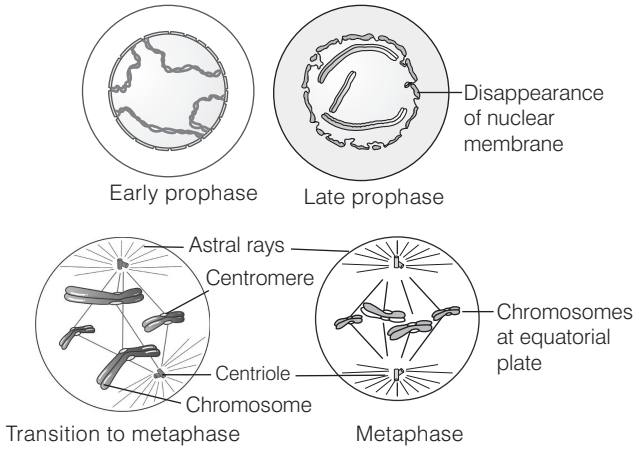
- During this phase, condensation of chromosomal material takes place in order to form a compact mitotic chromosomes composed of two chromatids, which are attached together at centromere.
- The most conspicuous change that takes place during prophase is the **formation of mitotic spindle**. The initiation of mitotic spindle assembly, the microtubules and the proteinaceous components of the cell cytoplasm helps in the completion of the process.
  The mitotic spindle is formed between the two pairs of centrioles that migrate towards the opposite poles of the cell.

(ii) Late Prophase

At the end of the prophase, i.e. during late prophase, the **nucleolus disintegrates** gradually and the nuclear envelope disappears. This disappearance marks the end of the prophase.

2. Metaphase

- It is the phase that starts after the **disintegration of nuclear** envelope in the late prophase. The chromosomes spread out through the cytoplasm of the cell and are seem to be shortest and thickest. The chromosome can be easily observed under the microscope.



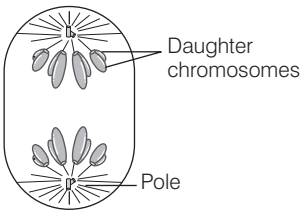
A diagrammatic view of stages in mitosis (prophase and metaphase)

- Each chromosome at this stage is made up of two longitudinal threads (sister chromatids) and are held together by the centromere. At the surface of each centromere disc-shaped structures called **kinetochores** are present, which help in the attachment of spindle fibres to the chromosomes.
- The chromosomes finally arrange themselves at the equator in one equatorial plane known as **metaphase plate**.
- Following changes are observed during metaphase
  (i) Attachment of spindle fibres to kinetochores of chromosomes.
  (ii) Movement of chromosomes to spindle equator and its alignment along the metaphase plate through spindle fibres to both poles.

3. Anaphase

- It is known to be the shortest duration phase, i.e. only of 2-3 min and is also very simple stage. At the beginning of this phase, splitting of chromosomes (that are already arranged at metaphase plate) takes place.
- The two daughter chromatids now become the chromosomes of future daughter nuclei and start migrating towards the opposite poles along the path of their chromosome fibres.

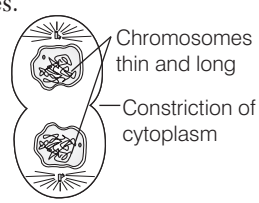
- Thus, following changes are observed during anaphase
  (i) Splitting of centromeres and separation of chromatids.
  (ii) Movement of chromatids towards the opposite poles.



Diagrammatic view of a stage in mitosis (anaphase)

4. Telophase

- This is considered to be long and complex phase like prophase the final stage of mitosis. At the onset of this stage, the spindle fibres disappear (absorbed in cytoplasm). The chromosomes decondense and further lose their individuality after reaching their respective poles.
- In general terms, the events of prophase occur just in reverse sequence during this phase.
- Now, the individual chromosome cannot be seen and the chromatin material gets collected in the form of mass in both opposite poles.
- Thus, following changes are observed during telophase
  (i) The chromosomes gradually uncoil and cluster at opposite spindle poles. Thus, their individual identity as discrete elements is lost.
  (ii) Nuclear envelope slowly reforms around the chromosomes.



Diagrammatic view of a stage in mitosis (telophase)

  (iii) Reappearance of nucleolus, Golgi complex and ER also takes place.

II. Cytokinesis

- Mitosis is accomplished by the division of the parent cell into two daughter cells and by the separation of cytoplasm into each daughter cell *via* a process called **cytokinesis**.
- In animal cells, it occurs by the appearance of a furrow in plasma membrane. The furrow deepens and joins in the centre thus, dividing the cell cytoplasm into two.
- In plant cells, due to the presence of inextensible cell wall, cytokinesis is achieved by **cell plate** formation (representing the middle lamella between two adjacent cells). It begins to form in the centre of the cell and grows outwards to meet the lateral walls.
- In some organisms, karyokinesis is not followed by cytokinesis and it results in the formation of multinucleate condition called **syncytium**, e.g. liquid endosperm in coconut.

Significance of Mitosis

- It is restricted to diploid cells only. However in some plants and social insects, haploid cells also divide by mitosis.
- It results in the production of diploid daughter cells with identical genetic combination usually, resulting in genetic stability.
- The growth of multicellular organisms is due to mitosis. It also restores the nucleocytoplasmic ratio and surface volume ratio of cells.
- Mitosis in meristematic tissues like apical and lateral cambium, results in a continuous growth of plants throughout their life.
- It helps in cell repair and regeneration of injured and lost body parts.
- It forms the basis of asexual reproduction in both plants and animals.

Meiosis

It involves two sequential cycles of nuclear and cell division called meiosis-I and meiosis-II.

I. Meiosis-I

- During this division, the homologous chromosomes of each pair separate from each other and reach separate daughter cells which thereby reduce the number of chromosomes from diploid to haploid, i.e. from $2n$ to n. Thus, it is known as **heterotypic division**.
- It is further divided into four phases, i.e. prophase-I, metaphase-I, anaphase-I and telophase-I.

Prophase-I

- It is considered to be the most complicated and prolonged phase as compared to the similar stage in mitosis.
- This phase is further subdivided into five subphases on the basis of chromosomal behaviour, i.e. leptotene, zygotene, pachytene, diplotene and diakinesis.

1. Leptotene

It is known to be the very first stage of meiotic division following the interphase.

Following features are seen during this phase

- Chromosomes become gradually visible under light microscope.
- Centrioles start moving towards opposite ends or poles and each centriole develops astral rays.
- Each chromosome is attached to the nuclear envelope through the attachment plate at both of its ends.

2. Zygotene

This is the next substage that takes place after the completion of the previous one. This is also a short-lived stage like leptotene.

Following changes are seen during this phase

- Homologous chromosomes pair up. This pairing is done in such a way that the genes of the same character present on the two chromosomes lie exactly opposite to each other. This process of association is known as **synapsis**.
- It is revealed from the electron micrographic studies that the formation of synaptonemal complex takes place by a pair of homologous chromosomes that show synapsis. The complex so formed, on account of synapsis forms a **bivalent** or a **tetrad**.

3. Pachytene

This is the stage which immediately follows zygotene where the pair of chromosomes become twisted spirally around each other and cannot be distinguished separately. This stage is comparatively long-lived as compared to the previous two stages.

Following changes are seen during this stage

- Bivalent chromosomes clearly seen as tetrads.
- In this stage, sometimes exchange of genes or crossing over between the two non-sister chromatids of homologous chromosomes occurs at the points called **recombination nodules**, which appear at intervals on synaptonemal complex. By the end of pachytene, recombination gets completed leaving the chromosomes linked at the sites of crossing over.

4. Diplotene

It is the stage of longest duration of all.
Following changes are observed during this stage

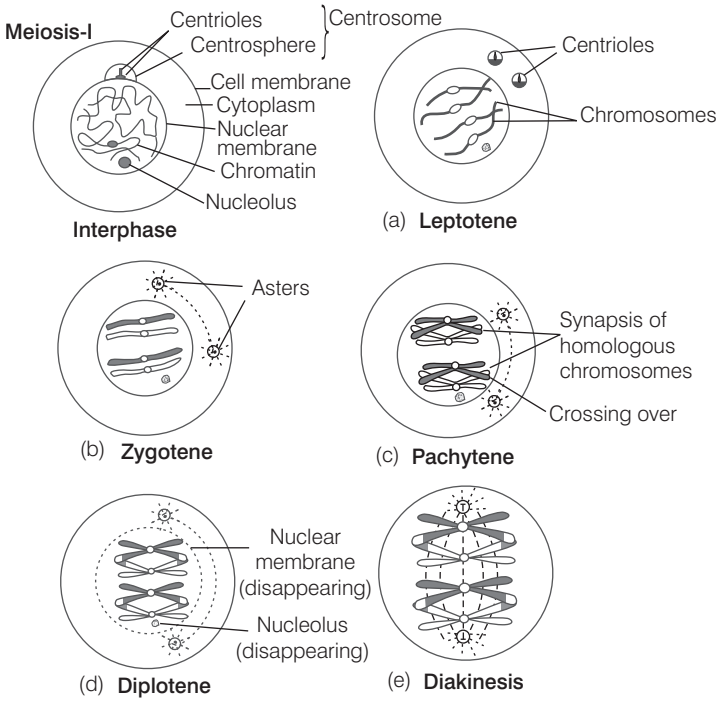
- In this, the **synaptonemal complex** appears to get dissolved, while the chromatids of each tetrad remain clearly visible.
- Recombined homologous chromosomes of the bivalents get separated and form **chiasmata** (X-shaped structures).
- Chiasmata formation is necessary for the separation of homologous chromosome which have undergone the process of crossing over.

5. Diakinesis

This is known to be the final stage of meiotic prophase-I. Also known as **terminalisation**, due to the shifting of chiasmata towards the end of the chromosomes.

Following changes are observed during this stage

- Chromosomes become fully condensed.
- Nucleolus degenerates.
- Breakdown of nuclear envelope into vesicles occurs.
- Formation of meiotic spindle (as in mitosis) in order to prepare the homologous chromosomes for separation also occurs.
- Diakinesis phase represents the transition from prophase to metaphase of meiosis-I.



Different stages of prophase-I (meiosis-I) in an animal cell

Metaphase-I

It is the stage followed by prophase (same as mitosis).

Following changes are observed during this stage

- The bivalents during this phase arrange themselves on the two parallel equatorial plates.
- The centromeres project little bit towards periphery. Since, there are two centromeres in each bivalent. Thus, each centromere is joined by chromosomal fibres.
- The fibres of the homologous chromosomes are always in the opposite directions.

Anaphase-I

- This is the next phase after metaphase-I in which homologous chromosomes break their connection with each other and get separated.
- This process of separation of homologous chromosomes is known as **disjunction**. The separated chromosomes are univalents and are also called **dyads**.
- On reaching at the end of the anaphase, the two groups of chromosomes are produced (with each having half number of chromosomes).

Note *The sister chromatid remains attached at their centromeres on the separation of the homologous chromosomes.*

Telophase-I

This is the last stage of meiosis-I in which the chromatids at each pole of the spindle usually remain uncoiled and get elongated.

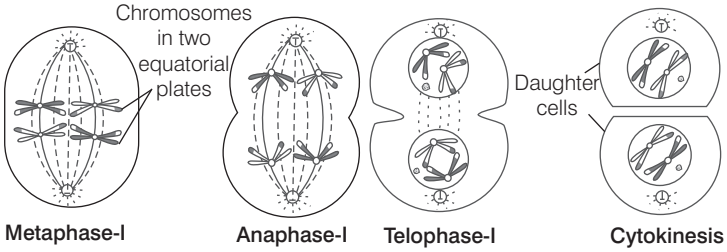
Following changes are seen during this stage

(i) Homologous chromosomes reach at their respective poles.

(ii) Reappearance of nuclear membrane and nucleolus takes place.

Cytokinesis

It is the stage during which the cytoplasm and other organelles divide into two equal halves of cells.



Stages of meiosis-I

Interkinesis

This is the stage between the two meiotic divisions, i.e. the meiosis-I and II. It is generally short-lived. During this process, no replication of DNA occurs. It is necessary for bringing true haploidy DNA in daughter cells.

It is in fact considered as incipient interphase.

II. Meiosis-II

- It is known by another term, i.e. **homotypic division**, because in this division chromosome number remains same, as produced in meiosis-I. It is initiated immediately after cytokinesis. It is often known an **equational division**. Meiosis-II also resembles a normal mitotic division in contrast to meiosis-I because it distributes chromatids to daughter cells (like mitosis).
- It also involves four substages, i.e. **prophase-II, metaphase-II, anaphase-II** and **telophase-II**, similar to mitosis except that these processes occur in two haploid cells.
- At the end of meiosis, tetrad of cells, i.e. four haploid cells are formed.

Significance of Meiosis

- It is the mechanism of conversion of specific chromosome number of each species in sexually reproducing organisms across generations.
- It leads to the formation of gametes which is important for sexual reproduction.
- It provides chance for the appearance of new gene combinations, owing to crossing over. It increases the genetic variability in the population of organisms from one generation to the next. Variations help in evolution and formation of new species.

Chapter Practice

PART 1
Objective Questions

• Multiple Choice Questions

1. Two basic stages of cell cycle are
(a) interphase and M-phase /divisional phase
(b) karyokinesis and cytokinesis
(c) prophase, metaphase, anaphase and telophase
(d) G_1, S and G_2-phases

Ans. (*a*) Cell cycle consists of two basic stages. There is a long undividing stage called interphase and a short dividing M-phase.

2. Cell growth and DNA synthesis are continuous processes that occur during cell cycle.
The given statement is
(a) True (b) False
(c) Cannot say (d) Partially true or false

Ans. (*d*) During the cell cycle, cell growth occurs continuously by continuous increase in the cytoplasmic content of the cell. However, DNA replication or synthesis is not a continuous process as it occurs during a specific stage only. Thus, given statement is partially true or false.

3. Match the following columns.

	Column I (Features)		Column II (Phases of cell division)
A.	Separation of daughter chromosomes	1.	Interphase
B.	Division of cytoplasm	2.	Karyokinesis
C.	Phase between two successive M-phases	3.	S-phase
D.	Synthesis phase	4.	Cytokinesis

Codes

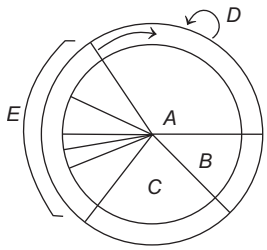
	A	B	C	D		A	B	C	D
(a)	2	3	1	4	(b)	4	1	3	2
(c)	2	4	1	3	(d)	4	2	3	1

Ans. (*c*) A–2, B–4, C–1, D–3

4. During the G_1-phase of cell division,
(a) RNA and proteins are synthesised for cell growth and subsequent DNA replication
(b) DNA and proteins are synthesised
(c) Centriole duplicates in the cytoplasm
(d) Cell undergoes duplication

Ans. (*a*) G_1 is the longest phase of the cell cycle in which cell synthesises RNAs, proteins and other biochemicals for cell growth and subsequent replication of DNA. While in G_2-phases, synthesis of RNAs, protein and ohter biochemicals for spindle formation takes place.

5. In the diagrammatic view of cell cycle, the G_0-phase is represented as



(a) *A* (b) *B*
(c) *C* (d) *D*

Ans. (*d*) In the given diagram, *D* represents the G_0-phase of cell cycle.

6. Which of the following statements is correct about mitosis?
(a) Mitosis is also known as equational division
(b) In animals, mitosis occurs in diploid somatic cells only
(c) Plants exhibit mitotic division in both haploid and diploid cells
(d) All of the above

Ans. (*d*) All statements are correct about mitosis.

7. Select the incorrect statement for prophase.

(a) Chromosomal material condenses to form compact mitotic chromosomes

(b) The assembly of mitotic spindle is initiated by the microtubules

(c) Cells at the end of prophase contain all membrane bound organelles of the cell

(d) The nucleolus or nucleoli degenerates completely

Ans. (***c***) Statement in option (c) is incorrect and can be corrected as

The nucleus, which is the membrane bound organelle in a cell gets disintegrated.

Rest statement are correct.

8. At which stage of mitosis, the two daughter chromatids separate from each other, migrate towards the opposite poles and are now referred to as chromosomes of the future daughter nuclei?

(a) Prophase (b) Metaphase

(c) Anaphase (d) Telophase

Ans. (***c***) In anaphase, the centromere of chromosomes start to divide into two forming daughter chromatids with centromere in each. Daughter chromosomes are repulsive, so they migrate toward opposite. Spindle fibres attached to the centromeres, shorten and pull the chromosomes to the poles.

9. Mitotic anaphase differs from metaphase in possessing

(a) same number of chromosomes and same number of chromatids

(b) half number of chromosomes and half number of chromatids

(c) half number of chromosomes and same number of chromatids

(d) same number of chromosomes and half number of chromatids

Ans. (***d***) Mitotic anaphase can be distinguished from metaphase in having same number of chromosomes and half number of chromatids.

10. Consider the following statements and choose the incorrect ones.

I. The duplication of centrosome occurs during S-phase of interphase.

II. Asters are the microtubules which radiate out from each centrosome.

III. Kinetochore disappears completely at the start of metaphase.

IV. Each chromosome yields four daughter chromatids during anaphase.

Codes

(a) II and IV (b) I, III and IV

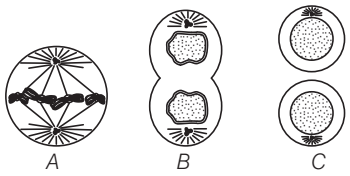
(c) II, III and IV (d) III and IV

Ans. (***d***) Statements III and IV are incorrect and can be corrected as

- Kinetochore serves as the site of attachment of spindle fibres during metaphase.
- During anaphase, each chromosome splits to yield two daughter chromatids.

Rest statements are correct.

11. See the diagrams carefully and identify the different stages of mitosis (*A*-*C*) by choosing appropriate option given below.



(a) *A*–Metaphase, *B*–Telophase, *C*–Interphase

(b) *A*–Telophase, *B*–Metaphase, *C*–Prophase

(c) *A*–Anaphase, *B*–Telophase, *C*–Interphase

(d) *A*–Telophase, *B*–Anaphase, *C*–Prophase

Ans. (***a***) *A*–Metaphase, *B*–Telophase, *C*–Interphase

12. Which of the following shows diplotene stage of cell cycle?

(a) Separation of synapsed homologous chromosomes except at the site of crossover

(b) Degeneration of nucleolus

(c) Chiasmata shifts towards chromosome ends

(d) All of the above

Ans. (***a***) The beginning of diplotene stage is marked by chiasma formation. The chiasma formation is the indication of crossing over and the beginning of separation of synapsed homologous chromosomes except at the site of crossover. The chiasma formation is associated with the process of terminalisation.

13. Match the stages of meiosis in Column I to their characteristic features in Column II and select the correct option using the codes given below.

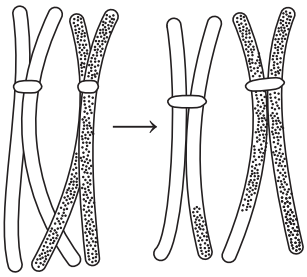
	Column I (Phases)		**Column II** (Events)
A.	Pachytene	1.	Pairing of homologous chromosomes
B.	Metaphase-I	2.	Transition from prophase to metaphase of meiosis-I
C.	Diakinesis	3.	Crossing over takes place
D.	Zygotene	4.	Chromosomes align at equatorial plate

Codes

	A	B	C	D
(a)	3	4	2	1
(b)	1	4	2	3
(c)	2	4	3	1
(d)	4	3	2	1

Ans. (***a***) A–3, B–4, C–2, D–1

14. The given figure is the representation of a certain event at a particular stage of a type of cell division. Which is this stage?



(a) Prophase-I during meiosis
(b) Prophase-II during meiosis
(c) Prophase of mitosis
(d) Both prophase and metaphase of mitosis

Ans. (***a***) The given figure shows crossing over, i.e. exchange of segments between chromosomes. It is a characteristic process that occur in the prophase-I during meiosis.

15. Crossing over takes place between which chromatids and in which stage of the cell cycle?

(a) Non-sister chromatids of non-homologous chromosomes at zygotene stage of prophase-I
(b) Non-sister chromatids of homologous chromosomes at pachytene stage of prophase-I
(c) Non-sister chromatids of homologous chromosomes at zygotene stage of prophase-I
(d) Non-sister chromatids of non-homologous chromosomes at pachytene stage of prophase-I

Ans. (***b***) Crossing over takes place between the non-sister chromatids of homologous chromosomes during the pachytene stage of prophase-I. This stage is characterised by the appearance of recombination nodules, which appear at intervals on synaptonemal complex.

• Assertion-Reasoning MCQs

Direction (Q. Nos. 1-5) *Each of these questions contains two statements, Assertion (A) and Reason (R). Each of these questions also has four alternative choices, any one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.*

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true

1. **Assertion** (A) Some cells undergo $\mathbf{G_0}$-phase due to inactivation of cell cycle.

Reason (R) Cells at this stage remain metabolically active, but no longer proliferate.

Ans. (***b***) Both A and R are true, but R is not the correct explanation of A.

$\mathbf{G_0}$-phase is the permanent or temporary exit from the $\mathbf{G_1}$-phase. Cells in this phase remain metabolically active but do not proliferate unless called on to do so depending on the requirement of the organism.

2. **Assertion** (A) In mitosis, two identical cells are produced from a single cell and karyokinesis is followed by cytokinesis.

Reason (R) Cytokinesis is of two types, i.e. by cell-furrow method and cell-plate method.

Ans. (***b***) Both A and R are true, but R is not the correct explanation of A.

Mitosis is the process by which a cell nucleus divides (karyokinesis) to produce two daughter nuclei containing identical sets of chromosomes to the parent cell. It is usually followed immediately by division of cytoplasm (cytokinesis) to form two daughter cells.

In plants, cytokinesis occurs by cell-plate formation whereas in animals, it occurs by cell furrow formation.

3. **Assertion** (A) In animal cells, cytokinesis is achieved by the appearance of a furrow in plasma membrane.

Reason (R) In plant cells, the formation of the new cell wall begins with the formation of simple precursor called cell-plate.

Ans. (***b***) Both A and R are true, but R is not the correct explanation of A.

In an animal cell, cytokinesis is achieved by the appearance of a furrow in the plasma membrane. The furrow gradually deepens and ultimately joins in the centre thus, dividing the cell cytoplasm into two. This mode of cytokinesis is called cell-furrow method.

Plants cells however, are enclosed by a relatively inextensible cell wall, therefore they undergo cytokinesis by a different mechanism. The formation of the new cell wall begins with the formation of a simple precursor called the cell plate. It represents the middle lamella between the walls of two adjacent cells. This mode of cytokinesis is called cell plate method.

4. **Assertion** (A) Diakinesis is the final stage of prophase-I.

Reason (R) Terminalisation of chiasmata occurs in diakinesis.

Ans. (***a***) Both A and R are true and R is the correct explanation of A.

Prophase-I ends with terminalisation of chiasmata during diakinesis. It represents the transition of dividing cells from prophase to metaphase.

Thus, diakinesis is the final stage of prophase-I as terminalisation of chiasmata occurs in this stage.

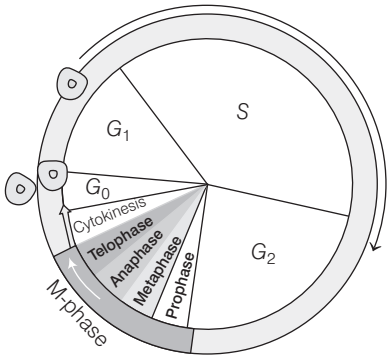
5. **Assertion** (A) In anaphase-II, chromosomes align at the equator.

Reason (R) The centromere of each chromosome splits and chromatids separate.

Ans. (***d***) A is false, but R is true. A can be corrected as In metaphase-II, the chromosomes align at the single equatorial plate.

• Case Based MCQ

Observe the given figure and answer the questions that follows.



(i) In the $\mathbf{G_0}$-phase of cell cycle,

(a) no division or metabolic activity occurs

(b) division occurs at faster rate

(c) cell is metabolically active

(d) cytokinesis occurs

Ans. (***c***) Cell entering the $\mathbf{G_0}$-phase, do not divide or multiply nor synthesise organelles, however it continues to remain metabolically active.

(ii) In a 24 hours cell cycle, maximum duration is occupied by

(a) interphase (b) M-phase

(c) karyokinesis (d) cytokinesis

Ans. (***a***) Interphase is the longest phase of cell cycle, so it occupied maximum duration in a 24 hours cell cycle.

(iii) The daughter cells formed after M-phase has

(a) increased number of chromosome

(b) same amount of DNA as in $\mathbf{G_1}$-phase

(c) decreased amount of DNA than in $\mathbf{G_1}$-phase

(d) decreased number of chromosomes

Ans. (***b***) The daughter cells formed after complete mitosis and cytokinesis will have the same number of chromosomes and same amount of DNA as their parent cells at $\mathbf{G_1}$-phase of the cell cycle.

(iv) Duplication of genetic material occurs in

(a) $\mathbf{G_1}$-phase (b) $\mathbf{G_2}$-phase

(c) S-phase (d) M-phase

Ans. (***c***) The duplication or replication of genetic material (DNA) occurs during the synthetic or S-phase of cell cycle. It ensures the equal distribution of genetic material among the daughter cells.

(v) The $\mathbf{G_2}$-phase of cell cycle,

(a) helps in chromosome doubling

(b) involved in cell growth

(c) involved in protein synthesis

(d) Both (b) and (c)

Ans. (***d***) $\mathbf{G_2}$-phase of cell cycle occurs immediately before the cell undergoes division. During this phase, cell growth continues to occur and the proteins are synthesised for the preparation of mitosis.

PART 2

Subjective Questions

• Short Answer (SA) Type Questions

1. Name three phases of interphase. Give one major event of each phase.

Ans. Three main events that occur in interphase are

(i) **$\mathbf{G_1}$-phase** is the phase during which cell becomes metabolically very active. It grows continuously and prepares itself for DNA replication. Thus, enzymes and proteins needed for this are formed.

(ii) **S-phase** is the phase during which chromosomes replicates and prepare themselves for equal distribution.

(iii) **$\mathbf{G_2}$-phase** is the phase in which synthesis of DNA gets stopped. However, formation of RNA and proteins required for mitosis takes place.

2. There occurs a process in which divisions of nucleus take place. Identify the process and also write about its different phases.

Ans. Karyokinesis involves the division of nucleus. It is a series of uninterrupted changes before forming two daughter nuclei.

Though karyokinesis is a continuous process, it has been divided into four phases. These are prophase, metaphase, anaphase and telophase.

3. What is quiescent stage of cell cycle? (**NCERT**)

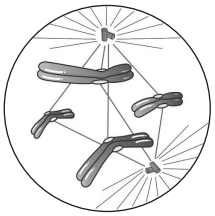
Ans. G_0 is the quiescent stage of the cell cycle. It is also known as inactive stage of the cell cycle. Cells in this stage remain metabolically active, but no longer proliferate unless they do not get instruction to do so, depending on the requirement of the organisms.

4. Differentiate between G_1 and G_2-phases.

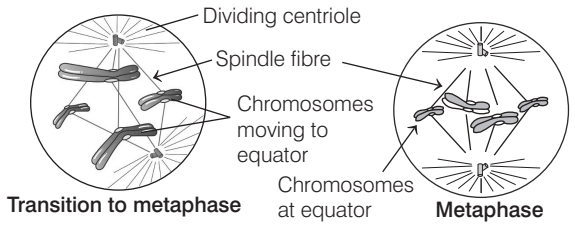
Ans. Differences between G_1 and G_2-phases are as follows

G_1-phase	G_2-phase
It is called first growth period.	It is post-synthetic phase.
Cell grows in size.	Cell prepares to go into mitotic phase.
Occurs before S-phase.	Occurs after the S-phase.
Contains N amount of DNA.	Contains 2N amount of DNA.

5. Label the diagram and also determine the stage at which this structure is visible.



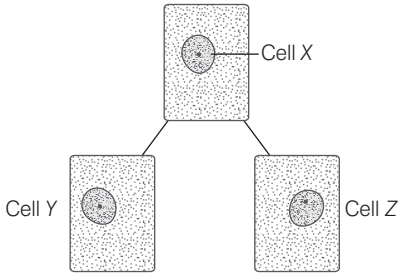
Ans. The diagram shows the transition stage between prophase and metaphase stages of mitotic cell division.



6. Comment on the statement 'telophase is reverse of prophase'. **(NCERT Exemplar)**

Ans. In prophase, the chromatin network begins to coil and appears as a long thread-like structures called chromosomes. Each chromosome consists of two chromatids that disappears from early prophase to late prophase. The nuclear membrane also starts disappearing in late prophase. In telophase, opposite poles of the chromosomes lose their identity and nuclear membrane is formed around the daughter nuclei. Nucleolus also reappears. So, it is reverse of prophase.

7. Cell '*X*' contains 24 chromosomes. It is divided by mitosis to produce cells '**Y**' and '**Z**'. Deduce how many chromosomes cell **Z** will contain after division.



Ans. The cell *Z* will also contain 24 chromosomes after mitotic division. Because mitosis is a copying process in which daughter cells have same number of chromosomes as the parent has.

8. State the role of centrioles in cell division.

Ans. Centrioles play an important role in formation of spindle during cell division. They organise the mitotic spindle and thus, help in the completion of cytokinesis. They generate the cell's cytoskeleton and help in the formation of the mitotic spindles. In organisms with flagella and cilia, the position of these organelles is determined by the mother centriole, which becomes the basal body.

9. The following statements describe the four main stages in the process of mitosis.

I. The spindle fibres breakdown and the nuclear membrane forms.

II. The chromosomes arrange themselves on the equator of the cell.

III. The spindle forms and the nuclear membrane disintegrates.

IV. The centromere splits and the sister chromatids migrate to the opposite poles of the cell.

Write the correct sequence of the stages in mitosis and also name the each stage.

Ans. The correct sequence of the stages in mitosis and also name the each stage are as follows

III (Prophase) → II (Metaphase) → IV (Anaphase) → I (Telophase)

10. Mitosis results in producing two cells which are similar to each other. What would be the consequence if each of the following irregularities occur during mitosis?

(i) Nuclear membrane fails to disintegrate

(ii) Duplication of DNA does not occur

(iii) Centromeres do not divide

(iv) Cytokinesis does not occur

Ans. (i) If nuclear membrane fails to disintegrate, the spindle fibres would not be able to reach chromosomes and they would not move towards opposite poles of the cell. In certain protozoans, such as *Amoeba*, the spindle is formed within the nucleus and this is called intranuclear mitosis or pre-mitosis.

(ii) If DNA duplication does not occur than cell might not be able to surpass S-phase of cell cycle as no chromosome formation will take place, and will not be able to enter M-(mitotic phase) or if in case it enters mitosis the cycle will cease.

(iii) If the centromeres do not divide, one of the daughter cell will receive a complete pair of chromosomes and other cell would not get any of them. This may result in trisomy.

(iv) If cytokinesis does not occur, then multinucleate condition called coenocyte, syncytium is produced, as in *Rhizopus* and *Vaucheria*, etc.

11. The following events occur during the various phases of the cell cycle. Name the phase against each of the events.

(i) Disintegration of nuclear membrane ..... .

(ii) Appearance of nucleolus ..... .

(iii) Division of centromere ..... .

(iv) Replication of DNA ..... .

Ans. (i) Prophase (ii) Telophase

(iii) Anaphase (iv) S-phase

12. Why is mitosis considered a significant event in living organisms?

Ans. The significances of mitosis cell division are as follows

(i) It helps in the production of diploid daughter cells with equal and identical genetic complement.

(ii) Mitosis helps in growth of multicellular organisms.

(iii) It also helps in maintaining a proper cell size by dividing an overgrown somatic cell and also helps in maintaining nucleo-cytoplasmic ratio.

(iv) It is helpful in cell repair mechanism, e.g. continuous replacement of the cells like that of the upper layer of the epidermis cells of the lining of the gut and blood cells.

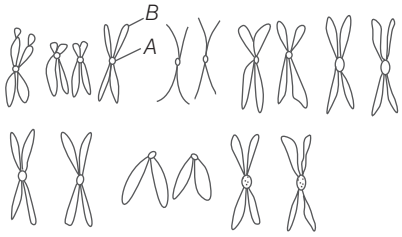
(v) It is also helpful in producing new cells for healing wounds and for regeneration.

(vi) Mitosis plays an important role in a continuous growth of plants throughout their life by mitotic divisions in meristematic tissues, i.e. the apical meristem and the lateral cambium.

13. Answer the following questions based upon the given figure.

(i) What type of division is this? Whether meiotic or/and mitotic and which stage?

(ii) What are *A* and *B*?



Ans. (i) It is a meiotic division showing synapsis and it is in the zygotene stage of prophase-I of meiosis-I.

(ii) *A*–Centromere, *B*–Chromatid.

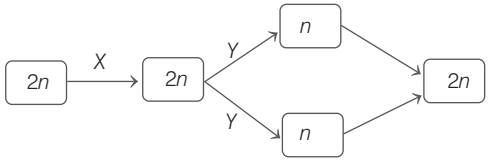
14. Discuss about the synaptonemal complex?

Ans. It is a protein complex, visible with the electron microscope that is the physical basis of the pairing of homologous chromosomes (synapsis) during meiosis. It is assembled during zygotene as homologous chromosomes pair up and it is unpaired during diplotene as homologous chromosomes separate.

15. What is chiasmata? Mention its significance also.

Ans. Chiasmata is X-shaped structure of separated bivalents of recombined homologous chromosomes. Chiasmata formation is necessary for the separation of homologous chromosomes, which have undergone the process of crossing over.

16. The diagram below represents the changes in the number of chromosomes during several processes that occur in an animal cell.



(i) Name the process of cell division occurring at **X** and **Y**.

(ii) State two differences in the behaviour of chromosomes between **X** and **Y**.

Ans. (i) *X*–Mitosis *Y*–Meiosis

(ii) Differences in between behaviour of chromosomes *X* and *Y* are as follows

(a) In *X*, there is no association of homologous chromosomes, but in *Y*, homologous chromosomes pair up together to form bivalents during prophase-I.

(b) In *X*, there is no crossing over as there is no formation of chiasmata, but in *Y*, crossing over occurs at the chiasmata whereby some genes are swapped between homologous chromosomes.

17. Give an account on stages of meiosis-I.

Ans. Stages of meiosis-I are as follows

(i) Prophase-I which is divided into five sub-stages, i.e. leptotene, zygotene, pachytene, diplotene and diakinesis.

(ii) In metaphase-I, the bivalents arrange themselves on equatorial plate with their arms on the plate, but the centromere is directed towards opposite pole. It is followed by anaphase-I.

(iii) In anaphase-I, the homologous chromosomes repel each other and move to the opposite poles with both their chromatids. In this way, each pole gets half the chromosome number of the parent cell.

(iv) Telophase-I in which the nuclear envelope and nucleolus reappear followed by cytokinesis in which the cytoplasm and other organelles get divided into two equal halves of cell.

18. During meiosis, why sister chromatids do not separate and migrate to opposite poles.

Ans. During interphase-I of meiosis, sister chromatids do not separate and migrate to opposite poles as observed in mitosis because in metaphase-I, the chromosomes are arranged in a manner that the centromeres homologous

lie on either side of metaphase plate pointing towards the opposite pole.

As a result, a chromosome is connected only to one spindle pole of its side due to the presence of a single tractile fibril. Hence, instead of sister chromatids the homologous chromosome separate apart during meiosis.

19. List the differences between metaphase of mitosis and metaphase-I of meiosis.

Ans. Differences between metaphase of mitosis and metaphase-I of meiosis are as follows

Metaphase of Mitosis	Metaphase-I of Meiosis
The chromosomes at the metaphase are arranged in such a way that the centromeres lie at the metaphase plate and the arms of chromosomes are free.	The chromosomes at the metaphase (meiosis-I) are arranged in such a way that the centromeres of homologous chromosomes lie on either side of the metaphase plate, pointing towards the opposite poles.
A chromosome is connected to both the spindle poles due to the presence of two tractile fibrils.	In metaphase-I, a chromosome is connected to only one spindle pole of its side due to the presence of a single tractile fibril.

20. Distinguish anaphase of mitosis from anaphase-I of meiosis. **(NCERT)**

Ans. Differences between anaphase of mitosis and anaphase-I of meiosis are as follows

Anaphase of Mitosis	Anaphase-I of Meiosis
Each chromosome arranged at the metaphase plate, splits simultaneously and the two daughter chromatids migrate towards the two opposite poles.	The spindle fibres contract and pull the centromeres of homologous chromosomes towards the opposite poles. So, each chromosome goes to opposite pole.
The centromere of each chromosome is towards the pole with arms of chromosome trailing behind.	The centromere is not divided, so half set of the chromosomes of parent nucleus go to one pole and the remaining half set in the opposite pole.
During this stage, (i) Centromeres split and chromatids separate. (ii) Chromatids move to opposite poles.	During this stage, (i) Homologous chromosomes separate. (ii) Sister chromatids remain associated at their centromere.

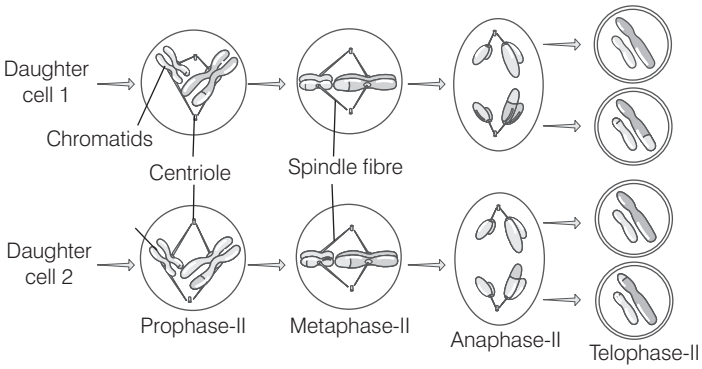
21. In which phase of meiosis are the following formed?

(i) Synaptonemal complex ..... .
(ii) Recombination nodules ..... .
(iii) Appearance/activation of enzyme recombinase ..... .
(iv) Termination of chiasmata ..... .
(v) Interkinesis ..... .
(vi) Formation of dyad of cells ..... .

Ans. (i) Synaptonemal complex **zygotene**.
(ii) Recombination nodules **pachytene**.
(iii) Appearance/activation of enzyme recombinase **telophase-I/after, meiosis-I**.
(iv) Termination of chiasmata **diakinesis**.
(v) Interkinesis **after telophase-I/before prophase of meiosis-II.**
(vi) Formation of dyad of cells **pachytene**.

22. An organism has two pair of chromosomes (i.e. chromosome number= 4). Diagrammatically represent the chromosomal arrangement during different phases of meiosis-II.

Ans.



Stages of meiosis-II

23. What is the need of meiosis in cell division?

Ans. Needs of meiosis in cell division are as follows

(i) It is essential for all sexually reproducing organisms.
(ii) It occurs in reproductive cells, so that gametes formed are haploid or have half the number of chromosomes of those cells which are directly derived from zygote.
(iii) Two types of gametes fuse during zygote formation. As a result, zygote comes to have double the number of chromosomes contained in gametes. Meiosis maintains a fixed number of chromosomes in a species by reducing it to number by half.

24. Meiosis is advantageous than mitosis as it produces variations so plays important role in evolution. What are the stages during which chances of recombination of genes are increased during meiosis? Explain these events.

Ans. Stages during which recombination of genes occurs in meiosis are

(i) Crossing over is exchanged of genes between the non-sister chromatids of homologous chromosomes. It occurs at recombination nodules during pachytene stage of prophase-I of meiosis-I and is regulated by recombinase enzyme.

(ii) Arrangement of bivalents at the equator of the spindle during metaphase-I of meiosis.

25. Discuss about the attributes. Does a chromatid require to be classified as a chromosome? **(NCERT)**

Ans. In telophase-I of meiosis-I, chromosome number becomes half, but the chromosomes are still composed of two chromatids. If crossing over occurred, these chromatids are not genetically identical. They divide in IInd meiotic division. Hence, crossing over is an attribute, which classifies chromatids as chromosome.

26. Comment on the statement' meiosis enables the conservation of specific chromosome number of each species even though the process results in reduction of chromosome number'.

(NCERT Exemplar)

Ans. Meiosis is the mechanism by which conservation of specific chromosome number of each species is achieved across generations in sexually reproducing organisms. Even though the process results in reduction of chromosome number by half, it is gradually conserved by union of male gamete (n) and female gamete (n) in next generation.
Meiosis also increases the genetic variability in the population of organisms from one generation to the next.

• Long Answer (LA) Type Questions

1. Briefly describe the significance of cell division. **(NCERT)**

Ans. Cell division is significant in the following ways

(i) **Cell Multiplication** Cell division is a mean of cell multiplication or formation of new cells from pre-existing cells.

(ii) **Continuity** It maintains continuity of living matter generation after generation.

(iii) **Multicellular Organisms** The body of a multicellular organism is formed of innumerable cells. They are formed by repeated divisions of a single cell or zygote. As the number of cells increases, many of them begin to differentiate, form tissues and organisms.

(iv) **Cell Size** Cell division helps in maintenance of a particular cell size which is essential for efficiency and control of cell activities.

(v) **Genetic Similarity** The common type of cell division or mitosis maintains genetic similarity of all the cells in an individual despite being different, i.e. structurally and functionally.

2. Differentiate the process of mitosis in plants and animals cells.

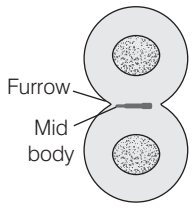
Ans. Differences between the processes of mitosis in plant and animal cells are as follows

Animal Cells	Plant Cells
Centrioles present at spindle poles.	Centrioles are absent at spindle poles.
Cytokinesis by furrowing of cytoplasm.	Cytokinesis mostly by cell plate formation.
Microfilament ring brings about cleavage.	Microfilaments have no role in cytokinesis.
Occurs nearly in all tissues.	Occurs mainly at meristems.
Cell does not change its forms or nature at the time of mitosis.	Cell becomes rounded and its cytoplasm becomes more viscous during mitosis.
Intercellular spaces appear between the daughter lamella.	Daughter cells remain adhered together by middle lamella.
Animal mitosis is controlled by certain mitogens.	Plant mitosis is usually controlled by a hormone cytokinin.
Midbody is formed at the equator of the spindle.	Equator of the spindle changes into phragmoplast.
Furrow extends centripetally.	Cell plate grows centrifugally.
Asters are formed (amphiastral).	No asters are formed (anastral).

3. The method of cytokinesis is different in animal and plant cells. Explain.

Ans. Cytokinesis is the division of protoplasms and content after nuclear division (i.e. karyokinesis) equally into the daughter cells.

(i) **Cytokinesis in Animal Cells** The cytokinesis starts at metaphase stage. The central part of mitoitc spindle changes to dense fibrous, vesicular structure called midbody. Simultaneously, microfilaments gather in the middle region of the cell below cell membrane. This induces the cell membrane to invaginate or furrow. The cells divides further by furrowing which deepen centripetally and cleave the cell into two daughter cells.

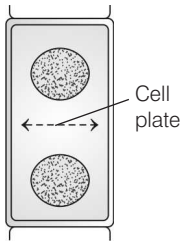


Cytokinesis in animal cells

(ii) **Cytokinesis in Plant Cells** It is different from animal cells due to the presence of a solid, rigid and inextensible cell wall. The plant cell cannot undergo cytokinesis by the furrowing method therefore, it divides by the cell plate method.

The formation of cell plate usually begins during the late anaphase or early telophase. The formation of a new wall in plant cells takes place in the centre of the cell and starts growing outward, towards the opposite sides in order to reach the already existed lateral walls.

This cell wall with the formation of simple precursor grows unite it reaches the actual cell walls. The cell plate divides the cell into two daughter cells and continues to grow and develop new cell organelles in both daughter cells.



Cytokinesis in plant cells

4. What are the various stages of meiotic prophase-I? Enumerate the chromosomal events during each stage.

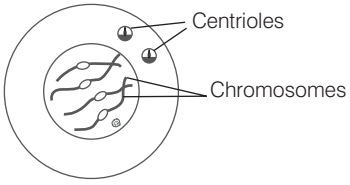
Ans. **Prophase-I** occurs over a long duration and involves several complicated changes in meiotic cell division. It is important because genetic recombination and variation in sexually reproducing organism occurs due to the events of this phase.

Leptotene

(i) The chromatin network opens out and threads become clear.

(ii) The chromosomes are thin, slender and long.

(iii) Chromosome number is diploid.



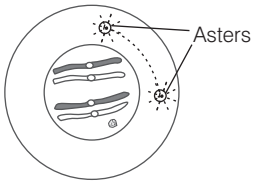
Laptotene

Zygotene

(i) Corresponding chromosomes become intimately associated.

(ii) The process of pairing is known as **synapse**. It is so exact that pairing is not merely between corresponding chromosomes, but between corresponding individual units.

(iii) The chromosomes become shorter and thicker.



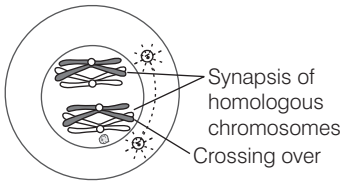
Zygotene

Pachytene or Pachynema

(i) The synaptic chromosomes become very intimately associated.

(ii) The pair of chromosomes becomes short and thick.

(iii) Crossing over occurs at this stage. Chiasmata are clearly seen.



Pachytene

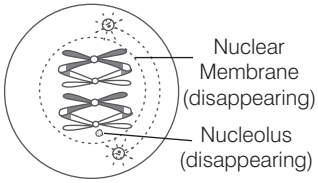
Diplotene

(i) Homologous chromosomes start separating from one another.

(ii) Chiasmata tend to slip out of the chromosomes. This is known as terminalisation of chiasmata.

(iii) Chromosomes start separating out, but the separation is not complete.

(iv) Nuclear membrane and nucleolus start disappearing.



Diplotene

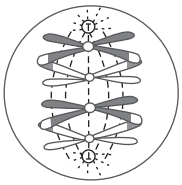
Diakinesis

(i) The bivalents condense further and get randomly distributed.

(ii) The separation of paired chromosomes is almost complete.

(iii) Terminalisation of chiasmata is almost complete.

(iv) Nuclear membrane and nucleolus disappear.


Diakinesis

5. Explain meiosis-II in an animal cell.

Ans. Meiosis-II in an animal cell explains as follows

(i) **Prophase-II** It takes short time. Spindle formation begins and the chromosomes become short. Two chromatids are joined to a single centromere. Nuclear membrane and nucleolus disintegrate.

(ii) **Metaphase-II** At the equator, the chromosomes align at the equator and spindle is formed. The centromere of every chromosome is joined to the spindle fibre and centromere also divides.

(iii) **Anaphase-II** The daughter chromosomes are formed. Chromatids move towards their poles with the spindle fibres.

(iv) **Telophase-II** Reaching at the poles, chromosomes form nuclei which are haploid (n) daughter nuclei. Again nuclear membrane is constructed. Nucleolus now becomes clearly visible.

Cytokinesis After meiosis lead to formation of four daughter cells which are haploid (n).

6. Explain, why a pair of homologous chromosomes is genetically different, but a pair of sister chromatids is genetically identical before crossing over in meiosis.

Ans. A pair of homologous chromosomes is genetically different because in a set of homologous chromosomes, one of the chromosome belongs to the male parent and the other comes from the female parent. Therefore, one of a pair will contain paternal genes and the other will contain maternal genes.

However, a pair of sister chromatids is genetically identical before crossing over as the chromatids are formed from the replication of DNA during the S-phase of interphase. DNA replication ensures that the DNA content is doubled with identical genes being copied from the original DNA. Therefore, there is no genetic variation because there is no exchange of genetic material between sister chromatids. If crossing over occurs, then it would be possible for some genes to be exchanged between the chromatids of homologous chromosomes that have chiasmata, thus leading to genetic variation.

7. Differentiate between the events of mitosis and meiosis.

Ans. Mitotic cell division results into the increase in the number of cells that have same genetic composition whereas meiosis has its importance in the life cycle of sexually reproducing organisms.

Mitosis	Meiosis
Prophase	
Prophase is of shorter duration.	Prophase-I is of longer duration while prophase-II is very brief.
Prophase is simpler and is hardly distinguishable into substages.	Prophase-I is complicated and is divisible into five substages. Prophase-II is, however very simple.
Each chromosome has two distinct chromatids.	Chromosomes of prophase-I do not show distinct chromatids.
Chiasmata are absent.	Chiasmata or visible connections between homologous chromosomes.
Metaphase	
Centromeres produce a single metaphasic plate.	A double metaphasic plate is formed by centromeres in metaphase-I, but only one in metaphase-II.
Chromosomes are independent and do not show connections.	Homologous chromosomes are interconnected. Hence, the chromosomes occur in pairs or bivalents in metaphase-I. They are however, free in metaphase-II.
A centromere is connected with both the spindle poles.	A centromere is connected to one spindle pole in metaphase-I, but both in metaphase-II.
Anaphase	
A centromere splits length-wise to form two centromeres in the beginning of anaphase.	Centromeres do not divide during anaphase-I, but do so in anaphase-II.
Anaphasic chromosomes are single-stranded.	Chromosomes are double-stranded in anaphase-I, but single stranded in anaphase-II.
Similar chromosomes move towards the opposite poles in anaphase.	Dissimilar chromosomes move toward the opposite poles both in anaphase-I and anaphase-II.
Telophase	
Telophase is longer and produces interphase nuclei.	Telophase-I is shorter and nuclei now enter the interphase.
Cytokinesis	
Cytokinesis follows every mitosis. It produces two new cells.	Cytokinesis often does not occur after first or reductional division. It is then simultaneous after second division resulting in four new cells.

• Case Based Questions

1. Direction *Read the following passage and answer the questions that follows.*

In a lecture on cell cycle and its division, the teacher taught the two basic stages of cell cycle *viz*., interphase and M-phase. She also taught about the sub-stages of each basic stage and their significance.

(i) What is an average duration of cell cycle in humans and yeast ?

Ans. The average duration of cell cycle in humans is 24 hours and in yeast, it is 90 minutes.

(ii) Mention the name of three sub-stages of interphase.

Ans. The three sub-stages of interphase are Gap 1 (G_1)-phase, Synthesis (S)-phase and Gap 2 (G_2)-phase.

(iii) What would be the amount of DNA and chromosome in each sub-stage of interphase, if the initial amount is 2C and 2*n*, respectively?

Ans. The amount of DNA and chromosomes in G_1, S, G_2-phases would be as follows

G_1-phase : 2C, 2*n*

S-phase : 4C, 2*n*

G_2-phase : 4C, 2*n*

Thus, the number of chromosomes remain the same throughout the cell cycle, but the amount of DNA gets doubled in S-phase.

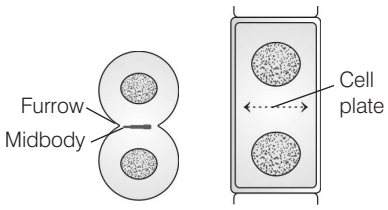
(iv) Define the terms karyokinesis and cytokinesis and when does these processes occur in cell cycle?

Ans. Karyokinesis is the division of nucleus, in which the daughter chromosomes gets separated. It occurs after the end of G_2-phase. Cytokinesis is the division of cytoplasm and it occurs immediately after karyokinesis.

(v) Which part of the human body should one use to demonstrate stages in mitosis?

Ans. All the cells in the human body are somatic cells except germinal cells in the male and female reproductive organs. The somatic cell divides by mitotic cell division for growth and regeneration. These can be used to demonstrate mitosis.

2. The cytokinesis in plant cell and animal cell during mitotic cell division is depicted in the figure given below.



Answer the questions given below.

(i) What is cell plate?

Ans. Cell plate represents the middle lamella between the walls of two adjacent cells within which actual cell wall formation takes place.

(ii) State the stage of mitosis at which the cytokinesis begins in the animal cells.

Ans. In animal cells, cytokinesis starts at metaphase. They typically divide by furrowing or by the appearance of furrow in the plasma membrane. This is also known as cleavage.

(iii) Can a cell undergo cytokinesis before it has divided its nuclear content?

Ans. No, cytokinesis occurs after karyokinesis, i.e. after the parent cell has doubled up its nuclear content for its distribution into daughter cells.

(iv) How formation of phragmoplast related to cytokinesis?

Ans. In higher plants, cytokinesis takes place by cell plate method. In this method, small vesicles of Golgi complex are assembled at the equator. Here, spindle persists for some time called phragmoplast.

(v) In which type of cell, karyokinesis is not followed by cytokinesis?

Ans. In a syncytium (multiple nucleus in a cell), karyokinesis is not followed by cytokinesis.

3. **Direction** *Read the following passage and answer the questions that follows*.

Amrita and her mother planted small seedling of plant in the soil in their garden. After few months, while playing with her friends Amrita observed that the seedlings which they planted had grown into a mature and flourishing plant. Amrita was curious to know this and asked her mother about this.

(i) Name the process that causes growth in living organisms.

Ans. Mitosis is the process, which helps in the growth of living organisms.

(ii) Discuss about the process that how growth occurs in living organisms.

Ans. Mitosis brings about growth in both multicellular and unicellular organisms. In multicellular organisms, mitosis causes overall body growth and in unicellular organism, its causes multiplication.

(iii) Analyse and write about the common site of mitosis in plants as well as in animals.

Ans. The common sites of mitosis cell division in plants are meristematic regions, e.g. stem tip, root tip, embryo, leaves, flowers, fruits, etc. In animals, mitosis occurs in skin epidermis, bone marrow and embryo.

(iv) If a tissue has 1024 cells at a given time, how many cycles of mitosis had the original parental single cell undergone? **(NCERT Exemplar)**

Ans. 10 (2^n, where **n = 10** generations). Thus, 10 cycles of mitosis are required for 2 parental cells to form 1024 cells.

(v) Can there be mitosis without DNA replication in S-phase?

Ans. Mitosis cannot occur without DNA replication in S-phase because the trigger for mitosis takes place due to the disturbance in nucleocytoplasmic ratio caused by DNA replication in S-phase.

4. Direction *Read the following passage and answer the questions that follows.*

A biology student asked his teacher that why two individuals of same population does not look similar. The teacher told him about the concept of meiosis and crossing over. The teacher also mentioned that meiosis occurs in two stages which differ significantly.

(i) When does the crossing over occur in humans and name the type of cells involved in it.

Ans. Crossing over occurs during the pachytene stage of prophase-I of meiosis-I. It occurs in the reproductive cells of human body.

(ii) Name the site at which the crossing over occur between homologous chromosomes.

Ans. Crossing over occurs at the recombination nodule. It is formed between the non-sister chromatids of homologous chromosomes.

(iii) How many daughter cells are produced at the end of meiosis-I and II, respectively?

Ans. At the end of meiosis-I and meiosis-II, two and four daughter cells are produced, respectively.

(iv) Name the stage between the two meiotic divisions.

Ans. The stage between two meiotic divisions is called interkinesis.

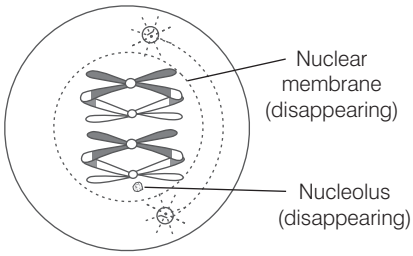
(v) Mention one striking difference between the anaphase-I and anaphase-II stages of meiosis.

Ans. Difference between the anaphase-I and anaphase-II stages of meiosis is

During anaphase-I, the homologous chromosomes separate and the sister chromatids remain intact at centromere.

Whereas in anaphase-II, the sister chromatids of the chromosomes separate due to the splitting of centromere.

5. The figure given below depicts a sub-stage in prophase of meiosis-II.



(i) 'This phase is characterised by crossing over where non-sister chromatids of homologous chromosomes exchange segments'.
Is the above statement correct? Provide reason for your answer.

Ans. The given statement is incorrect and can be corrected as

The stage depicted is diplotene. It is characterised by the formation of structure called chiasma.

(ii) The phase before this is identified as leptotene. If yes/no, provide any two characteristic features, which are related with this phase?

Ans. No, the phase before diplotene is pachytene.

Characteristic features, which are related with this phase are as follows

(a) At this stage, bivalent chromosomes appear as tetrad.

(b) Crossing over occurs in this phase.

(iii) What changes are observed in next stage?

Ans. The stage next to diplotene is diakinesis.

Following changes observed during this stage

(a) Chromosome becomes fully condensed.

(b) Nucleolus degenerates.

(iv) What type of chromosomes are called homologous pair?

Ans. Homologous chromosomes are the pair of chromosomes which comes from each parent. These are similar in length, gene position and location of the centromere.

(v) What indicate the beginning of diplotene stage of prophase-I?

Ans. In the beginning of diplotene stage of prophase-I, synaptonemal complex dissolutes and recombined homologous chromosomes separate from each other.

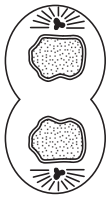
Chapter Test

Multiple Choice Questions

1. Which one is the correct sequence of a cell cycle?
(a) G_1-phase, M-phase and G_2-phase
(b) M-phase, S-phase and divisional phase
(c) G_1-phase, synthesis phase and G_2-phase
(d) M-phase, G_2-phase and divisional phase

2. What will be the DNA content and number of chromosomes in a cell after S-phase as compared to the gamete of the same organism?
(a) Same DNA content, but double chromosome number
(b) Four times DNA content, but double chromosome number
(c) Same DNA content, but half chromosome number
(d) Half DNA content, but double chromosome number

3. A stage in cell division is shown in the figure. Select the answer, which gives correct identification of the stage with its characteristics.



(a) Telophase – Nuclear envelope reforms, Golgi complex reforms
(b) Late anaphase – Chromosomes move away from equatorial plate, Golgi complex not present
(c) Cytokinesis – Cell plate formed, mitochondria distributed between two daughter cells
(d) Telophase – Endoplasmic reticulum and nucleolus not reformed yet

4. Which one of the following events does not occur during zygotene?
(a) Formation of synaptonemal complex
(b) Pairing of chromosomes
(c) Appearance of bivalents
(d) Involvement of recombinase

5. Select the option which correctly identifies the similarity between mitosis and meiosis cell division.
(a) Pairing of homologous chromosomes
(b) Required in all types of cells
(c) S-phase occurs before M-phase
(d) Separation of paired chromosomes

Assertion-Reasoning MCQs

Direction (Q. Nos. 1-3) *Each of these questions contains two statements, Assertion (A) and Reason (R). Each of these questions also has four alternative choices, any one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.*

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true

1. **Assertion** (A) Cell normally proceed to mitosis without interruption, once it enters the G_2-phase.

Reason (R) Replicated chromosomes (DNA) are distributed to daughter nuclei by a complex series of events under genetic control.

2. **Assertion** (A) Mitosis restores the nucleocytoplasmic ratio.

Reason (R) It is significant in the life of an organism, especially in the growth of multicellular organism.

3. **Assertion** (A) A cell after telophase-II does not enter another interphase.

Reason (R) Gametes or Spores are formed after telophase-II.

Short Answer Type Questions

1. (i) Two key events take place during S-phase in animal cells, i.e. DNA replication and duplication of centriole. In which parts of the cell, do these events occur? **(NCERT Exemplar)**
(ii) Distinguish cytokinesis from karyokinesis? **(NCERT)**

2. Colchicine is known to be the mitotic poison. How?

3. (i) What does a bivalent of meiosis-I consist of ?
(ii) At the following stage of meiosis, the chromosomes appear to be beaded. Can you find out the stage?

4. The second meiotic division is similar to mitosis as it results in the separation of the sister chromatids. However, it also differs from mitosis. Explain how?

Long Answer Type Questions

1. (i) Both unicellular and multicellular organisms undergo mitosis. What are the differences observed in the process between the two? **(NCERT Exemplar)**
(ii) Differentiate between S-phase and G_2-phase.

2. (i) Write brief note on the following.
(a) Synaptonemal complex (b) Metaphase plate
(ii) Name a cell that is found arrested in diplotene stage for months and years. Comment in 2-3 lines how it completes cell cycle? **(NCERT)**

Answers

Multiple Choice Questions

1. *(c)* ***2.*** *(b)* ***3.*** *(a)* ***4.*** *(d)* ***5.*** *(c)*

Assertion-Reasoning MCQs

1. *(d)* ***2.*** *(b)* ***3.*** *(a)*