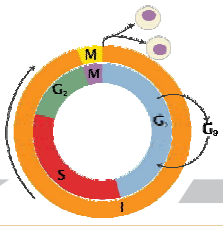


Chapter - 10

Cell Cycle and Cell Division

Points To Remember

Cell cycle : The sequence of events by which a cell duplicates its genome, synthesises the other constituents of the cell and eventually divides into two daughter cells.

Phases of cell cycle
- Interphase (G_1 phase + S phase + G_2 Phase)
- M Phase (Mitosis phases)
  - Karyokinesis (division of nucleus)
  - Cytokinesis (division of cytoplasm)

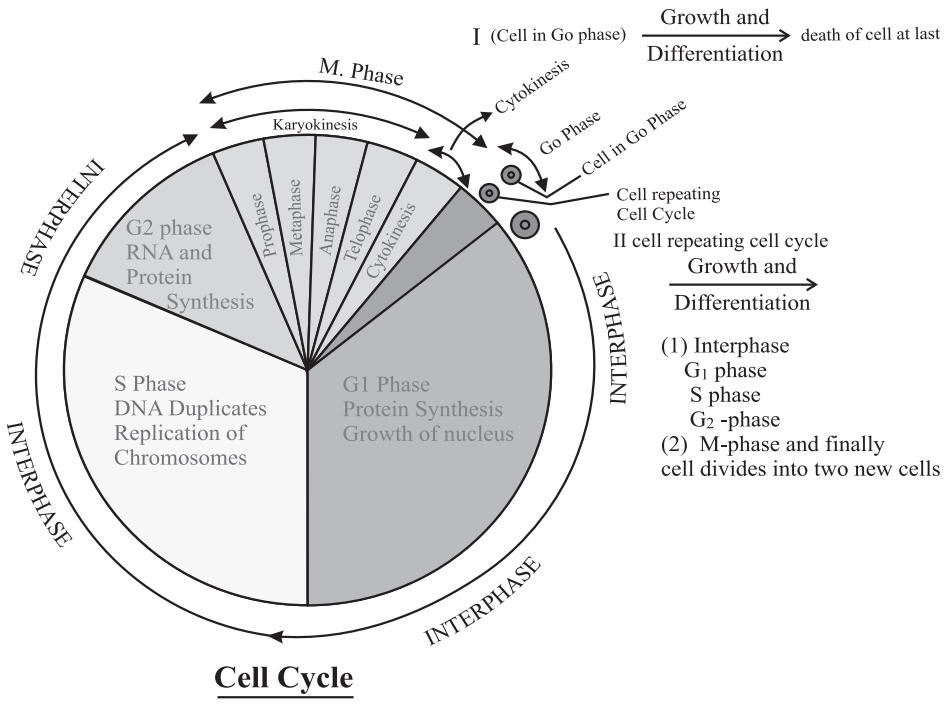
Interphase : (Resting Phase)

- **G_1 Phase :** Cell metabolically active and grows continuously but does not replicate DNA
- **S Phase :** DNA synthesis occurs, DNA content increases from 2C to 4C, but the number of chromosomes remains same *i.e.,* 2*n*.
- **G_2 Phase :** Proteins are synthesised in preparation for mitosis while cell growth continues.

M Phase (Mitosis Phase) : Starts with nuclear division, corresponding to separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm, (cytokinesis).

Quiescent stage (G_0) In adult animal cells that do not divide and exit G_1 phase to enter an inactive stage called G_0. Cells at this stage remain metabolically active but do not proliferate.

e.g., Heart cells

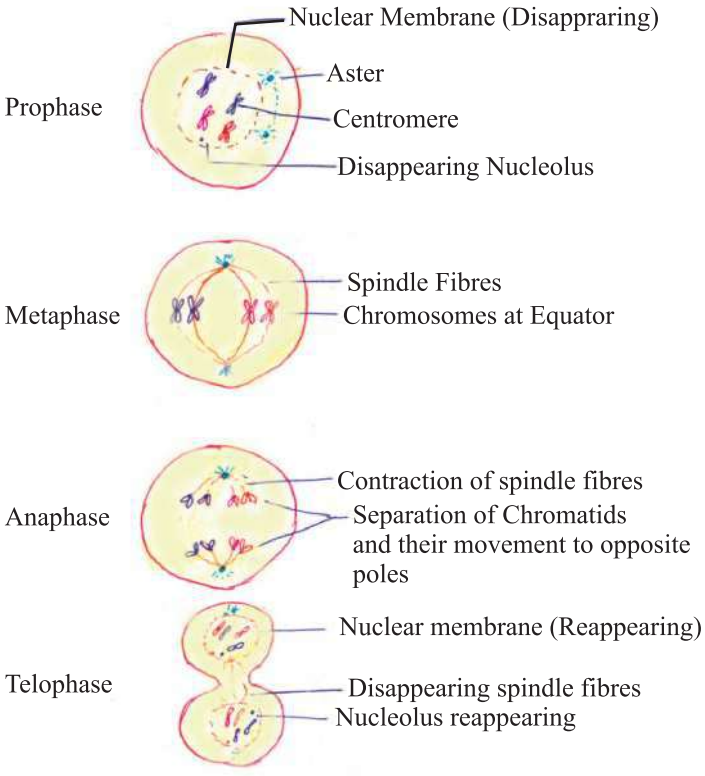


Cell Cycle

Mitosis

Since the number of chromosomes in the parent and progeny cells is the same, it is called as equational division. Mitosis is divided into four sub stages.

1. **Prophase :** (i) Replicated chromosomes, each consisting of 2 chromatids, condense and become visible.
   (i) Microtubules are assembled into mitotic spindle.
   (iii) Nucleolus and nuclear envelope disappear.
   (iv) Centriole moves to opposite poles.
2. **Metaphase :** (i) Spindle fibres attached to kinetochores (small disc-shaped structures at the surface of centromere) of chromosomes.
   (ii) Chromosomes line up at the equator of the spindle to form metaphase plate.
3. **Anaphase :** (i) Centromeres split and chromatids separate.
   (ii) Chromatids move to opposite poles due to shortening of spindle fibres.
4. **Telophase :** (i) Chromosomes cluster at opposite poles.
   (ii) Nuclear envelope assembles around chromosomes clusters'.
   (iii) Nucleolus, Golgi Complex, E.R. reappear.



Stages of Mitosis

Cytokinesis : The division of protoplast of a cell into two daughter cells after karyokinesis (nuclear division)

Animal Cytokinesis :

Appearance of furrow in plasma membrane which deepens and joins in the centre, dividing cell cytoplasm into two.

Plant cytokinesis : Formation of new cell wall begins with the formation of a simple precursor — **cell plate** which represents the middle lamella between the walls of two adjacent cells.

- When karyokinesis is not followed by cytokinesis, a multinucleated condition arises. This is called **syncytium.**

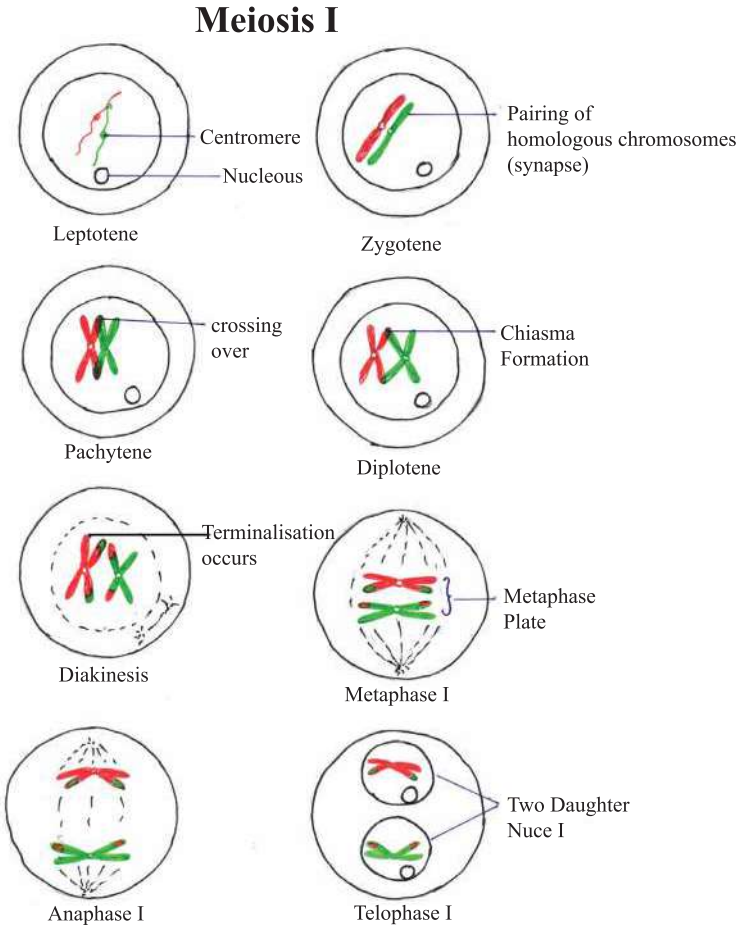
Significance of Mitosis :

1. Growth/addition of cells.
2. Maintenance of surface/volume ratio. Maintain Nucleo–cytoplasmic ratio.
3. Maintenance of chromosomes number.
4. Regeneration.

5. Reproduction in unicellular organisms, lower plants and some insects.
6. Repair and wound healing.
7. Vegetative reproduction in plants takes place by mitosis.

Meiosis :

- Specialised kind of cell division that reduces the chromosomes number by half. Hence it is called reductional division.
- Occurs during gametogenesis in plants and animals.
- Involves two sequential cycles of nuclear and cell division called Meiosis I and Meiosis II.
- It results in 4 haploid daughter cells.
- Interphase occurs prior to meiosis which is similar to interphase of mitosis except the S phase is prolonged.



Meiosis I

Prophase I : Subdivided into 5 phases.

(i) Leptotene :

- Chromosomes make their appearance as single stranded structures.
- Compaction of chromosomes continues.

(ii) Zygotene :

- Homologous chromosomes start pairing and this process of association is called synapsis.
- Chromosomal synapsis is accompanied by formation of Synaptonemal complex.
- Complex formed by a pair of synapsed homologous chromosomes is called bivalent or tetrad.

(iii) Pachytene : Crossing over occurs between non-sister chromatids of homologous chromosomes. The enzymes involved in the process is 'recombinase'. Recombination between homologous chromosomes is completed. Exchange of genetic material.

(iv) Diplotene : Dissolution of synaptonemal complex occurs and the recombined chromosomes separate from each other except at the sites of crossing over. These X-shaped structures are called **Chiasmata.** In oocytes of some vertebrates diplotene can last for month or years.

(v) Diakinesis : Terminalisation of chiasmata.

- Chromosomes are fully condensed and meiotic spindles assembled.
- Nucleolus disappear and nuclear envelope breaks down.

Metaphase I : Bivalent chromosomes align on the equatorial plate.

- Microtubules from opposite poles of the spindle attach to the pair of homologous chromosomes.

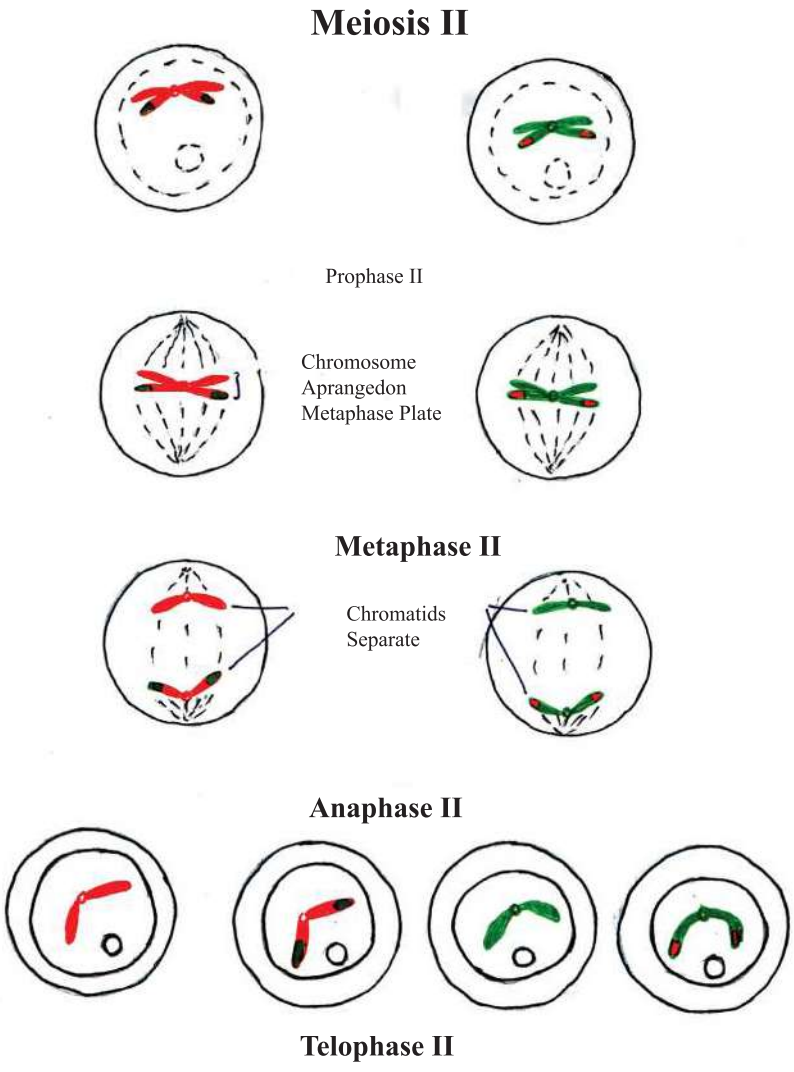
Anaphase I : Homologous chromosomes, separate while chromatids remain associated at their centromeres.

Telophase I :

- Nuclear membrane and nucleus reappear.
- Cytokinesis follows (dyad of cells).

Interkinesis : Stage between two meiotic divisions, (meiosis I and meiosis II) generally short lived, No replication of DNA during this.

Meiosis II: (It resembles the normal mitosis).



Prophase II

- Nuclear membrane disappears.
- Chromosomes again become compact.

Metapahse II

- Chromosomes align at the equator.
- Microtubules from opposite poles of spindle get attached to kinetochores of sister chromatids.

Anaphase II

- Simultaneous splitting of the centromere of each chromosome, allowing them to move towards opposite poles of the cell, by shortening of microtubules attached to kinetochores.

Telophase II

- Two groups of chromosomes get enclosed by a nuclear envelope.
- Cytokinesis follows resulting in the formation of tetrad of cells *i.e.,* 4 haploid cells.

Significance of Meiosis

1. **Formation of gametes :** In sexually reproducing organisms.
2. **Genetic variability : Variations are very important for evolution.**
3. **Maintenance of chromosomal number :** By reducing the chromosome number in gametes. Chromosomal number is restored by fertilisation of gametes.

Questions

(SRT) Select Response Type Question (1 mark each)

1. Karyokinesis is the division of
   (a) nucleus (b) chromosome
   (c) cytoplasm (d) protoplasm
2. Cytokinesis is the division of
   (a) nucleus (b) chromosome
   (c) cytoplasm (d) protoplasm
3. Pairing of homologous chromosomes occurs during
   (a) zygotene (b) diplotene
   (c) diakinesis (d) metaphase

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer Questions (1 mark each)

4. Name the stage of meiosis during which synaptonemal complex is formed.
5. What is Go phase of cell cycle ?
6. Where does mitosis take place in plants and animals ?

Short Answer Questions-I (2 marks each)

7. Differentiate between cytokinesis of plant and animal cell.
8. What is Chiasmata ? State its significance.
9. Differentiate between chromatin and chromatid.

10. Give the terms for the following :
    (a) The period between 2 successive mitotic divisions.
    (b) Cell division in which chromosome number is halved.
    (c) Phase in cell cycle where DNA is synthesised.
    (d) Division of nuclear material.
11. What happens during S phase of interphase ?
12. Distinguish between metaphase of mitosis and metaphase I of meiosis.
13. What will be the DNA content of a cell at G_1 after S and G_2 if the content after M phase is 2C.

Short Answer Questions-II (3 marks each)

14. Differentiate between mitosis and meiosis.
15. List the significance of mitosis.
16. Describe the following :
    (a) Synapse (b) Bivalent (c) Leptotene

Long Answer Questions (5 marks each)

17. With the help of labelled diagram, explain the following :
    (a) Diplotene (b) Anaphase of mitosis
    (c) Prophase I of meiosis
18. What is cell cycle ? Explain the events occurring in this cycle.
19. With the help of labelled diagrams, explain various stages of mitosis cell division.
20. (a) Write a note on significance of meiosis.
    (b) Differentiate between anaphase 1 of meiosis and Anaphase of mitosis.
    (c) In which phase of interphase duplication of DNA will occur ?

Answers

(SRT) Select Response Type Question (1 mark each)

1. (a) Nucleus 2. (b) cytoplasm 3. (a) zygotene

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answers (1 mark each)

4. Zygotene.
5. Cells which enter a stage where they are metabolically active but no longer proliferate.

6. Plant – Meristematic tissue; Animals–somatic cells.

Short Answers-I (2 marks each)

7. Refer 'Points to Remember'.
8. Refer 'Points to Remember'.
9. **Chromatin Chromatid :**
   (a) Diffuse, deep staining hereditary material longitudinally split half of a chromosome, light staining hereditary material.
   (b) Metabolically inert Metabolically active.
10. (a) Interphase
    (b) Meiosis
    (c) S phase
    (d) Karyokinesis
11. Refer 'Points to Remember' :
12.

Metaphase	Metaphase I
(a) Chromosome align along the equator of the cell	(a) Bivalent chromosomes arrange along the equatorial plane.
(b) Figure from points to remember	(b) Figure from points to remember

13. $G_1 - 2C$, $S_1 - 4C$, $G_2 - 4C$

Short Answers-II (3 marks each)

14.

Mitosis	Meiosis
(a) Occurs in Somatic cells	(a) Occurs in germ cells
(b) Number of chromosomes remain same in daughter cells	(b) Number of chromosomes reduces to half in daughter cells.
(c) No exchange of genetic material	(c) Exchange of genetic material occurs due to crossing over
(d) Involve single division	(d) Involve two successive division

15. Refer 'Points to Remember'.
16. Refer 'Points to Remember'.

Long Answer (5 marks each)

17. Refer 'Points of Remember'.
18. Refer 'Points of Remember'.

19. Refer 'Points of Remember'.

20. (a) Refer 'Points of Remember'

(b) Refer 'Points of Remember'.

(c) During S phase or synthesis phase.

Case Study based Question (4 marks each)

21. Read the following and answer any four questions from 21 (i) to 21 (v) given below :

The sequence of events by which a cell duplicates its genome, synthesizes the other constituents of the cell and eventually divides into two daughter cells is termed cell cycle. Cell cycle is divided into interphase and M Phase. Interphase is divided into three phases- G_1 phase, S phase and G_2 phase. In G_1 phase, cell prepares proteins and enzymes. In S phase, DNA replication and centrioles duplication takes place. After S phase, chromosome number of the cell does not change but amount of DNA becomes double (4C). In G_2 phase synthesis of protein especially tubulin, which is used in the formation of spindle fibres, occurs.

21. (i) How many chromosomes and DNA content will the onion cell have in G1 phase, after completing S phase and after M phase respectively, if onion plant possess 14 chromosomes initially?

(a) 14 / 2C, 28 / 4C and 14 / 4C

(b) 14 / 2C, 14 / 4C and 14 / 2C

(c) 14 / 2C, 14 / 2C and 14 / 2C

(d) 28 / 4C, 28 / 4C and 14 / 2C

21. (ii) Choose the correct option for a human cell before it enters prophase?

	Number of Chromatids	Number of Chromosomes
(a)	46	92
(b)	46	46
(c)	92	46
(d)	92	92

21. (iii) Non-dividing cells like muscles, neurons are in _____ phase

(a) G_1 (b) G_2

(c) G_0 (d) M Phase

21. (iv) How many mitotic divisions are required to form 128 cells from a single onion root tip cell (mitosis)?

(a) 14 (b) 21

(c) 6 (d) 7

Assertion and Reason Type Questions (1 mark each)

In each of the following questions, two statements are given, one is Assertion and other is Reason. Mark the correct answer as :

(a) Both assertion & reason are true, and the reason is the correct explanation of the assertion.

(b) Both assertion and reason are true but the reason it not the correct explanation of the assertion.

(c) Assertion is true but reason is false.

(d) Both the assertion and reason are false.

22. **Assertion :** Daughter somatic cells formed by mitosis are genetically similar to parental cell.

Reason : Chromosomes do not undergo crossing over in mitosis.

23. **Assertion :** Meiosis–II is similar to mitosis.

Reason : Meiosis–I cannot occur in haploid cells.

24. **Assertion :** Interphase is called resting stage.

Reason : In interphase the cell is metabolically inactive.

Answers :

Ans. 21 (i) (b) 14 / 2C, 14 / 4C and 14 / 2C

Ans. 21 (ii) (c) 92, 46

Ans. 21 (iii) (c) G_0 phase

Ans. 21 (iv) (d) 7

Ans. 22 (a) Both assertion & reason are true, and the reason is the correct explanation of the assertion.

Ans. 23. (b) Both assertion and reason are true but the reason it not the correct explanation of the assertion.

Ans. 24 (c) Assertion is true but reason is false.