Cell Cycle and Cell Division

CHAPTER 10

EXAM DRILL

ANSWERS

1. **(b) :** Cell organelles increase in number in G_2 phase.

OR

(a) : During cytokinesis in plants, small vesicles (derived from Golgi apparatus) are collected at the equator of the phragmoplast and fuse to form cell plate and new cell organelles.

2. **(d) :** Recombinase participates during pachytene stage of prophase-I. It is a multienzyme complex made up of endonulease, exonulease, unwindase, R-protein, etc.

3. **(c) :** Bouquet stage occurs in leptotene stage of prophase-I where chromosomes show peculiar arrangement. In bouquet stage, the ends of chromosomes converge towards the side having replicated centrosomes.

4. **(a)**

5. **(b) :** In metaphase of mitosis, the centromeres of all the chromosomes form an apparent plate called metaphasic or equatorial plate. Chromosomes are best visible in this phase.

6. The gap phase between the two meiotic divisions is called interkinesis.

7. During metaphase, chromosomes are moved to spindle equator of the cell and the plane of alignment of the chromosomes at this stage is referred as the metaphase plate or equatorial plate.

8. Uncontrolled mitotic division leads to cancer.

9. A chromosome is minimally coiled in interphase stage.

10. In diplotene stage, the homologous chromosomes get separated due to repulsion, but are yet held by chiasmata.

11. **(a) :** G_0 phase is known as the stage of inactivation of cell cycle. Cells in G_0 phase remain metabolically active, but do not proliferate, if do not have mitogens to enter cell division phase.

12. **(c) :** During G_1 phase, the cell is metabolically active and continuously grows but does not replicate its DNA.

13. **(d) :** Meiosis introduces variations or new combination of traits in germ cells.

14. **(a) :** Meiosis-I is reductional division as the number of chromosomes get halved. Meiosis-II is more like mitosis as the number of chromosomes remains same as produced after the end of meiosis-I.

15. **(i) (b)**

(ii) (a) : Mitosis (X) consists of two steps-karyokinesis (division of nucleus) and cytokinesis (division of cytoplasm).

(iii) (a)

(iv) (d) : Clones are produced through mitosis. A cloned plant is a genetically same copy of the parental plant. Therefore, the cloned plant will have the same number of chromosomes *i.e.*, 24 as the parent cell.

(v) (a) : Fig A is of late prophase, B is of early telophase, C is of metaphase and D is of late anaphase.

16. **(i) (b) :** P (Meiosis) consists of two cell divisions in which chromosome number is reduced to half.

(ii) (a)

(iii) (d)

(iv) (d) : G_1 phase is prior to replication. During prophase-I (first phase of meiosis *i.e.*, P) cell chromosomes are composed of two sister chromatids.

(v) (d)

17. Mitosis is called an equational division because the number of chromosomes in the parent cell and the daughter cell are the same. It occurs during the formation of somatic body cells and is hence often named as somatic cell division.

OR

(a) When nuclear division takes place without consequent cytoplasmic division it results in the formation of a large number of nuclei in a cell. This condition is called syncytium.

(b) In diplotene phase of meiosis I, chromosome become unfolded to start transcription of *m*RNA and *r*RNA to build up food reserve in the cytoplasm.

18. The beginning of diplotene is recognised by dissolution of the synaptonemal complex. The force of attraction between the two homologous chromosomes decreases and they start moving away from each other except at the site of crossovers. The point of attachment between the homologous chromosomes after the partial dissolution of nucleoprotein complex is called chiasmata. These are X-shaped structures.

19. (i) The kinetochore is a disc-shaped protein structure on chromatids where the spindle fibres attach during cell division to pull sister chromatids apart.

(ii) Colchicine arrests the cell division in cells. It is extracted from corms of *Colchicum autumnale*.

20. **(a)** Cytokinesis is the division of cytoplasm to form two daughter cells. It is the last step of M phase. It starts towards the middle anaphase and is completed simultaneously with the telophase.
(b) Amitosis is a simple method of cell division which is also called direct cell division. It occurs in metabolic nucleus of some protozoa.

21. A metaphasic chromosome is highly condensed as compared to that of the original chromatin fibre. This is due to condensation of scaffold proteins, coming together of chromatin loops and their coiling. Functional significance of shortening of chromosomes that occurs in prophase, becomes clear in anaphase. It is easier for a short, compact chromosome to move through the cytoplasm than it is for a very long, twisted interphase chromosome.

22. Crossing over is a process of exchange of genetic material or chromatid segments between two homologous chromosomes. It introduces new combination of traits or variations.

23. In plants, cytokinesis takes place by following two methods:
(i) Cleavage method : It occurs in lower plants. Cytoplasm undergoes centripetal constriction in the middle to form two daughter protoplasts, each having a single nucleus.
(ii) Cell plate method : In this case, the spindle persists for sometime, known as phragmoplast. Small vesicles produced by Golgi apparatus collect at the equator of the phragmoplast. The membrane of vesicles fuse to form film which solidifies to form cell plate.

24. Prophase is the first stage of mitosis and follows the G_2 phase of interphase.
The characteristic features of prophase are :
(i) Chromosomal material condenses to form compact mitotic chromosomes.
(ii) The mitotic spindle begins to form. The spindle is a structure made of microtubules. Its function is to organise the chromosomes and move them around during mitosis.
(iii) The nucleolus disappears.
(iv) In late prophase, the nuclear envelope breaks down. Endoplasmic reticulum and Golgi complexes are not seen under the microscope at the end of prophase.

25. **(a)** An onion root tip is a rapidly growing part of onion plant and thus many cells are in different stages of mitosis. In the preparation of slides, the onion root tips are squashed in a way that allows them to be flattened on a microscopic slide, so the chromosomes in different stages of an individual cells can be observed easily.
(b) The formation of pollen by young anther requires meiosis, which is the process different from mitosis. Thus, young anther is not suitable for study of mitosis.

26. **(a)** A chromosome consisting of two chromatids joined at their centromere which is produced after disjunction is known as dyad.
(b) The number of chromosomes doubles at the time of fertilisation due to the fusion of two gametes. If there is no mechanism to reduce the number of chromosomes in the gametes, then they will double with each generation. So the chromosome number is halved in gametes by meiosis so that original fixed chromosome number is resumed after fusion of gametes at the time of sexual reproduction.

27. Meiosis II is shorter than the typical mitotic division because of the shortening of prophase of this division. The division maintains the number of chromosomes produced at the end of reduction division. It is hence called homotypic or equational division. Though it is similar to mitosis, meiosis II is not mitosis because –
(i) It always occurs in haploid cells.
(ii) It is not preceded by DNA replication.
(iii) The two chromatids of a chromosome are often dissimilar.
(iv) The daughter cells formed after meiosis II are neither similar to each other nor similar to the parent cell.
The main function of homotypic division or meiosis II is to separate the chromatids of univalent chromosomes which differ from each other in their linkage groups due to crossing over.

28. S-phase or synthetic phase marks the period during which DNA synthesis or replication of DNA takes place. During this time the amount of DNA per cell doubles, *i.e.*, 1C to 2C for haploid cells and 2C to 4C for diploid cells. However, there is no increase in the chromosome number. Each chromosome now consists of two sister chomatids which remain attached at a common point called centromere. So, S-phase of the cell cycle is of critical importance to precisely replicating the genomic information enclosed in the nucleus of cell.

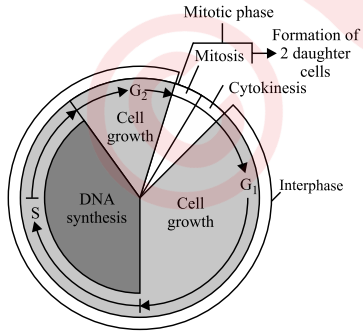
OR

We can find out whether a cell is dividing mitotically or meiotically only when we can differentiate between mitosis and meiosis. The differences are as follows:

S.No.	Mitosis	Meiosis
(i)	The cells undergoing mitosis may be haploid or diploid.	The cells undergoing meiosis are always diploid.
(ii)	It is a single division which produces two cells.	Meiosis is a double division. It gives rise to four cells.
(iii)	Interphase occurs prior to each division.	Interphase precedes only meiosis I. It does not occur prior to meiosis II.

(iv)	Subsequent mitotic divisions are similar to the earlier ones.	The two divisions of meiosis are not similar. The first one is heterotypic or reductional while the second one is homotypic or equational like mitosis.
(v)	Each chromosomes replicates in the interphase before every division.	The chromosomes replicate only once, prior to meiosis-I.
(vi)	The number of chromosomes remains the same after mitosis.	The number of chromosomes is reduced to one half after meiosis.
(vii)	The daughter nuclei or cells formed after mitosis are exactly similar to the parent one.	The daughter nuclei or cells formed after meiosis are neither similar to the parent one nor to one another.

29. Interphase is a series of changes that take place in a newly formed cell and its nucleus before it becomes capable of division again. It is also called the resting phase because there is no apparent activity related to cell division. It lasts for more than 95% of the duration of cell cycle. At the end of interphase the cell becomes ready for equitable division into two equal daughter cells. Diagrammatic representation of nucleus at interphase is as follows:



Interphase has three stages:

(i) G_1 - Phase or Gap 1 phase - It corresponds to the interval between mitosis of previous cell cycle and initiation of DNA replication. During this phase, the cell is metabolically active and continuously grows but does not replicate its DNA. It is the longest phase of interphase. RNAs and proteins are produced.

(ii) S-phase or synthesis phase - It marks the period during which DNA synthesis or replication of DNA takes place. During this time, the amount of DNA per cell doubles *i.e.*, 1C to 2C for haploid cells and 2C to 4C for diploid cells. However, there is no increase in the chromosome number. Each chromosome now consists of two sister chromatids which remain attached at a common point called centromere.

(iii) G_2 phase or Gap 2 phase - In this phase, proteins are synthesised in preparation for mitosis while cell growth continues.

OR

Mitosis is also called equational division as the number of chromosomes in the parent cell and daughter cell is the same. Mitosis occurs in the somatic body cells and is also known as somatic cell division.

This phase consists of two stages- karyokinesis (division of nucleus) and cytokinesis (division of cytoplasm).

(a) Karyokinesis : In this division, nucleus passes through a complicated sequence of events before forming two daughter nuclei. It is divided into four phases prophase, metaphase, anaphase, telophase.

(i) Prophase : It is the first stage of mitosis and follows the S and G_2 phases of interphase. The beginning of prophase is marked by the appearence of condensed chromosomes, each of which consists of two sister chromatids. The condensed sister chromatids are held together at the centromere, which is the site of eventual attachment of the spindle microtubules. The characteristic features of prophase are :

- Chromosomal material condenses to form compact mitotic chromosomes.
- The mitotic spindle begins to form.
- The nucleolus disappears.
- In late prophase, the nuclear envelope breakdown. Endoplasmic reticulum and Golgi complexes are not seen under the microscope at the end of prophase.

(ii) Metaphase : The complete disintegration of the nuclear envelope marks the start of second phase of mitosis. By this stage, condensation of chromosomes is completed and they can be observed clearly under the microscope. Small disc-shaped structures at the surface of the centromeres are called kinetochores which serve as the site of attachment of spindle fibres to the chromosomes that are moved to the centre of the cell.

The characteristic features of metaphase are :

- Two kinetochores of each chromosome are attached to microtubules from opposite spindle poles.
- Chromosomes are moved to spindle equator and the plane of alignment of the chromosomes at metaphase stage is refered to as metaphase plate or equatorial plate.

(iii) Anaphase : In anaphase, each chromosome arranged at the metaphase plate splits simultaneously and the two daughter chromatids begin their migration towards the

opposite poles. As each chromosome moves away from the equatorial plate, the centromere of each chromosome remains directed towards the pole and hence at the leading edge, with arms of the chromosome trailing behind.

The characteristic features of anaphase are:

– Centromeres split and chromatids separate.
– The daughter chromosomes move towards the opposite poles of spindle along the path of their chromosome fibres.
– Two groups of chromosomes are formed at the end of anaphase, one at each pole of spindle.

(iv) Telophase : At the beginning of the final stage of mitosis, the chromosomes at their respective poles, decondense and lose their individuality.

The characteristic features of telophase are:

– Chromosomes cluster at the opposite spindle poles and their identity is lost as discrete elements.
– Nuclear envelope assembles around the chromosome cluster.
– Golgi complex, endoplasmic reticulum and nucleolus are reformed.

(b) Cytokinesis : The completion of mitosis is usually accompanied by cytokinesis (division of cytoplasm), *i.e.*, giving rise to two daughter cells. It is signalled at the metaphase by cytoplasmic movements that bring about equal distribution of mitochondrion and other organelles into two halves of the cell. Division occurs differently in animal, plant as well as bacterial cells.

30. During telophase, events of prophase occur in reverse sequence. Prophase 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 pole of the cell. In this phase, initiation of mitotic spindle assembly, microtubular and proteinaceous components of cell cytoplasm helps in completion of the process.

At the end of the prophase, *i.e.*, during late prophase the nucleolus disintegrates gradually and the nuclear envelope disappear. This disappearance marks the end of the prophase. Reverse of prophase is the telophase. At the onset of this stage, the spindle disappears (absorbed in cytoplasm) and the chromosomes decondense and further loses their individuality after reaching their respective poles. The chromosomes gradually uncoil and cluster at opposite spindle poles thus, their individual identity as discrete elements is lost. Nuclear envelope slowly reforms around each group of chromosomes and nucleolus. Golgi complex, endoplasmic reticulum and other organelles reappear.

OR

(a) Meiosis II is initiated immediately after cytokinesis or meiosis I and is shorter than the typical mitotic division because of the shortening of prophase of this division. The division maintains the number of chromosomes produced at the end of reduction division. It is hence called equational division. The main function of meiosis II is to separate the chromatin of univalent chromosomes which differ from each other in their linkage groups due to crossing over. It can be divided into the following stages -

(i) Prophase II – The centriole migrates to opposite poles and spindle apparatus is formed. The nuclear membrane disappears by the end of this stage.

(ii) Metaphase II – Chromosomes align at the equator and the microtubules from opposite poles of the spindle get attached to the kinetochores of sister chromatids.

(iii) Anaphase II – The centromere of each chromosome divides into two so that there is one centromere for each chromatid.

The sister chromatids are separated and pulled to opposite poles by the spindle fibres. At the end of anaphase II, four groups of chromosomes are produced, each group having haploid number of chromosomes.

(iv) Telophase II – Meiosis ends with telophase II, in which the two groups of chromosomes are again enclosed by a nuclear envelope. Cytokinesis follows resulting in the formation of tetrad cells, *i.e.*, four haploid daughter cells.

(b) The difference between chromatin and chromatid is as follows:

Chromatin	Chromatid
This is a elongated uncoiled thread-like uncondensed form of heredity material found in the nucleus of a cell.	This is defined as a longitudinal half of each chromosome (condensed chromatin) found during prophase of a cell undergoing division.

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