CHAPTER 10

Cell Cycle and Cell Division

10.1 Cell Cycle

1. Identify the correct statement with regard to G_1 phase (Gap 1) of interphase.
(a) DNA synthesis or replication takes place.
(b) Reorganisation of all cell components takes place.
(c) Cell is metabolically active, grows but does not replicate its DNA.
(d) Nuclear division takes place. *(NEET 2020)*

2. Some dividing cells exit the cell cycle and enter vegetative inactive stage. This is called quiescent stage (G_0). This process occurs at the end of
(a) M phase (b) G_1 phase
(c) S phase (d) G_2 phase.
(NEET 2020)

3. Cells in G_0 phase
(a) terminate the cell cycle
(b) exit the cell cycle
(c) enter the cell cycle
(d) suspend the cell cycle. *(NEET 2019)*

4. The correct sequence of phases of cell cycle is
(a) $G_1 \rightarrow S \rightarrow G_2 \rightarrow M$ (b) $M \rightarrow G_1 \rightarrow G_2 \rightarrow S$
(c) $G_1 \rightarrow G_2 \rightarrow S \rightarrow M$ (d) $S \rightarrow G_1 \rightarrow G_2 \rightarrow M$.
(NEET 2019)

5. During cell growth, DNA synthesis takes place on
(a) S-phase (b) G_1-phase
(c) G_2-phase (d) M phase.
(NEET-II 2016)

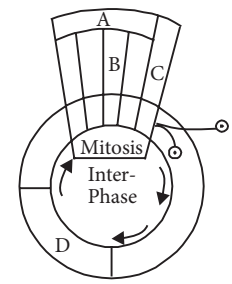
6. When cell has stalled DNA replication fork, which checkpoint should be predominantly activated?
(a) G_1/S (b) G_2/M
(c) M (d) Both G_2/M and M
(NEET-II 2016)

7. A somatic cell that has just completed the S phase of its cell cycle, as compared to gamete of the same species, has
(a) twice the number of chromosomes and four times the amount of DNA
(b) four times the number of chromosomes and twice the amount of DNA
(c) twice the number of chromosomes and twice the amount of DNA
(d) same number of chromosomes but twice the amount of DNA. *(2015 Cancelled)*

8. During which phase(s) of cell cycle, amount of DNA in a cell remains at 4C level if the initial amount is denoted as 2C?
(a) G_0 and G_1 (b) G_1 and S
(c) Only G_2 (d) G_2 and M *(2014)*

9. In 'S' phase of the cell cycle
(a) amount of DNA doubles in each cell
(b) amount of DNA remains same in each cell
(c) chromosome number is increased
(d) amount of DNA is reduced to half in each cell.
(2014)

10. Given below is a schematic break-up of the phases/stages of cell cycle. Which one of the following is the correct indication of the stage/phase in the cell cycle?



(a) C - karyokinesis
(b) D - synthetic phase
(c) A - cytokinesis
(d) B - metaphase *(2009)*

11. At what stage of the cell cycle are histone proteins synthesized in a eukaryotic cell?
(a) During G_2 stage of prophase
(b) During S-phase
(c) During entire prophase
(d) During telophase *(2005)*

12. In the somatic cell cycle
(a) in G_1 phase DNA content is double the amount of DNA present in the original cell
(b) DNA replication takes place in S phase
(c) a short interphase is followed by a long mitotic phase
(d) G_2 phase follows mitotic phase. *(2004)*

13. In which stage of cell cycle, DNA replication occurs?
(a) G_1-phase (b) S-phase
(c) G_2-phase (d) M-phase *(2000)*

14. Which typical stage is known for DNA replication?
(a) S-phase (b) G_2-phase
(c) metaphase (d) G_1-phase *(1996)*

15. In a somatic cell cycle, DNA synthesis takes place in
(a) G_1 phase (b) prophase of mitosis
(c) S-phase (d) G_2 phase. *(1994)*

10.2 M Phase

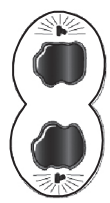
16. Which of the following options gives the correct sequence of events during mitosis ?
(a) Condensation → Nuclear membrane disassembly → Arrangement at equator → Centromere division → Segregation → Telophase
(b) Condensation → Crossing over → Nuclear membrane disassembly → Segregation → Telophase
(c) Condensation → Arrangement at equator → Centromere division → Segregation → Telophase
(d) Condensation → Nuclear membrane disassembly → Crossing over → Segregation → Telophase *(NEET 2017)*

17. Anaphase Promoting Complex (APC) is a protein degradation machinery necessary for proper mitosis of animal cell. If APC is defective in a human cell, which of the following is expected to occur?
(a) Chromosomes will be fragmented.
(b) Chromosomes will not segregate.
(c) Recombination of chromosome arms will occur.
(d) Chromosomes will not condense. *(NEET 2017)*

18. Spindle fibres attach on to
(a) centromere of the chromosome
(b) kinetosome of the chromosome
(c) telomere of the chromosome
(d) kinetochore of the chromosome. *(NEET-I 2016)*

19. Which of the following is not a characteristic feature during mitosis in somatic cells?
(a) Chromosome movement
(b) Synapsis
(c) Spindle fibres
(d) Disappearance of nucleolus *(NEET-I 2016)*

20. A stage in cell division is shown in the figure.



Select the answer which gives correct identification of the stage with its characteristics.
(a) Cytokinesis — Cell plate formed, mitochondria distributed between two daughter cells.
(b) Telophase — Endoplasmic reticulum and nucleolus not reformed yet.
(c) Telophase — Nuclear envelope reforms,Golgi complex reforms.
(d) Late anaphase — Chromosomes move away from equatorial plate, Golgi complex not present. *(NEET 2013)*

21. During the metaphase stage of mitosis, spindle fibres attach to chromosomes at
(a) kinetochore
(b) both centromere and kinetochore
(c) centromere, kinetochore and areas adjoining centromere
(d) centromere. *(Karnataka NEET 2013)*

22. A stage of mitosis is shown in the diagram. Which stage is it and what are its characteristics?

(a) Metaphase - Spindle fibers attached to kinetochores, centromeres split and chromatids separate.
(b) Metaphase - Chromosomes moved to spindle equator, chromosomes made up of two sister chromatids.
(c) Anaphase - Centromeres split and chromatids separate and start moving away.
(d) Late prophase - Chromosomes move to spindle equator. *(Karnataka NEET 2013)*

23. Select the correct option with respect to mitosis.
(a) Chromatids separate but remain in the centre of the cell in anaphase.
(b) Chromatids start moving towards opposite poles in telophase.
(c) Golgi complex and endoplasmic reticulum are still visible at the end of prophase.
(d) Chromosomes move to the spindle equator and get aligned along equatorial plate in metaphase. *(2011)*

24. At metaphase, chromosomes are attached to the spindle fibres by their
(a) satellites
(b) secondary constrictions
(c) kinetochores
(d) centromeres. *(Mains 2011)*

25. During mitosis, ER and nucleolus begin to disappear at
(a) late prophase (b) early metaphase
(c) late metaphase (d) early prophase. *(2010)*

26. Which stages of cell division do the following figures A and B represent respectively?

Fig. A

Fig. B

	A	B
(a)	Metaphase	Telophase
(b)	Telophase	Metaphase
(c)	Late anaphase	Prophase
(d)	Prophase	Anaphase

(2010)

27. If you are provided with root-tips of onion in your class and are asked to count the chromosomes, which of the following stages can you most conveniently look into?
(a) Metaphase (b) Telophase
(c) Anaphase (d) Prophase *(2004)*

28. Which one of the following precedes reformation of the nuclear envelope during M phase of the cell cycle?
(a) Decondensation from chromosomes and reassembly of the nuclear lamina
(b) Transcription from chromosomes and reassembly of the nuclear lamina
(c) Formation of the contractile ring and formation of the phragmoplast
(d) Formation of the contractile ring and transcription from chromosomes *(2004)*

29. Mitotic spindle is mainly composed of which protein?
(a) Actin (b) Myosin
(c) Actomyosin (d) Myoglobin *(2002)*

30. Best material for the study of mitosis in laboratory is
(a) anther (b) root tip
(c) leaf tip (d) ovary. *(2002)*

31. Spindle fibre unite with which structure of chromosomes?
(a) Chromocentre (b) Chromomere
(c) Kinetochore (d) Centriole *(2000)*

32. Microtubule is involved in the
(a) muscle contraction
(b) membrane architecture
(c) cell division
(d) DNA recognition. *(1998)*

33. How many mitotic divisions are needed for a single cell to make 128 cells?
(a) 28 (b) 32
(c) 7 (d) 14 *(1997)*

34. During cell division in apical meristem, the nuclear membrane appears in
(a) telophase (b) cytokinesis
(c) metaphase (d) anaphase. *(1997)*

35. Which of the following structures will not be common to mitotic cell of a higher plant?
(a) Centriole (b) Spindle fibre
(c) Cell plate (d) Centromere *(1997)*

36. Colchicine is an inhibitory chemical, which
(a) stops the functioning of centriole
(b) prevents attaching of centromeres with rays
(c) prevents the spindle formation in mitosis
(d) prevents the formation of equatorial plane. *(1996)*

37. Which of the following represents the best stage to view the shape, size and number of chromosomes?
(a) Prophase (b) Metaphase
(c) Interphase (d) Telophase *(1994)*

38. 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. *(1991)*

10.4 Meiosis

39. Dissolution of the synaptonemal complex occurs during
(a) pachytene (b) zygotene
(c) diplotene (d) leptotene. *(NEET 2020)*

40. Match the following with respect to meiosis.

(A)	Zygotene	(i) Terminalization
(B)	Pachytene	(ii) Chiasmata
(C)	Diplotene	(iii) Crossing over
(D)	Diakinesis	(iv) Synapsis

Select the correct option from the following

	(A)	(B)	(C)	(D)
(a)	(iii)	(iv)	(i)	(ii)
(b)	(iv)	(iii)	(ii)	(i)
(c)	(i)	(ii)	(iv)	(iii)
(d)	(ii)	(iv)	(iii)	(i)

(NEET 2020)

41. 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. *(Odisha NEET 2019)*

42. The stage during which separation of the paired homologous chromosomes begins is
(a) pachytene (b) diplotene
(c) diakinesis (d) zygotene. *(NEET 2018)*

43. 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		Column II
A.	Pachytene	(i)	Pairing of homologous chromosomes
B.	Metaphase I	(ii)	Terminalisation of chiasmata
C.	Diakinesis	(iii)	Crossing-over takes place
D.	Zygotene	(iv)	Chromosomes align at equatorial plate

(a) A-(iii), B-(iv), C-(ii), D-(i)
(b) A-(i), B-(iv), C-(ii), D-(iii)
(c) A-(ii), B-(iv), C-(iii), D-(i)
(d) A-(iv), B-(iii), C-(ii), D-(i) *(NEET-II 2016)*

44. In meiosis crossing over is initiated at
(a) zygotene (b) diplotene
(c) pachytene (d) leptotene.
(NEET-I 2016)

45. Arrange the following events of meiosis in correct sequence
(i) Crossing over (ii) Synapsis
(iii) Terminalisation of chiasmata
(iv) Disappearance of nucleolus
(a) (i), (ii), (iii), (iv) (b) (ii), (iii), (iv), (i)
(c) (ii), (i), (iv), (iii) (d) (ii), (i), (iii), (iv)
(2015)

46. Select the correct option.

	Column I		Column II
A.	Synapsis aligns homologous chromosomes	(i)	Anaphase II
B.	Synthesis of RNA and protein	(ii)	Zygotene
C.	Action of enzyme recombinase	(iii)	G_2-phase
D.	Centromeres do not separate but chromatids move towards opposite poles	(iv)	Anaphase I
		(v)	Pachytene

(a) A-(i), B-(ii), C-(v), D-(iv)
(b) A-(ii), B-(iii), C-(iv), D-(v)
(c) A-(ii), B-(i), C-(iii), D-(iv)
(d) A-(ii), B-(iii), C-(v), D-(iv) *(2015 Cancelled)*

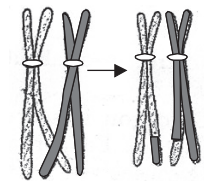
47. The enzyme recombinase is required at which stage of meiosis?
(a) Pachytene (b) Zygotene
(c) Diplotene (d) Diakinesis *(2014)*

48. The complex formed by a pair of synapsed homologous chromosomes is called
(a) bivalent (b) axoneme
(c) equatorial plate (d) kinetochore.
(NEET 2013)

49. During meiosis I, the chromosomes start pairing at
(a) zygotene (b) pachytene
(c) diplotene (d) leptotene.
(Karnataka NEET 2013)

50. During gamete formation, the enzyme recombinase participates during
(a) metaphase I (b) anaphase II
(c) prophase I (d) prophase II. *(2012)*

51. 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 *(2012)*

52. Identify the meiotic stage in which the homologous chromosomes separate while the sister chromatids remain associated at their centromeres.
(a) Metaphase I (b) Metaphase II
(c) Anaphase I (d) Anaphase II
(Mains 2012)

53. Synapsis occurs between
(a) *m*RNA and ribosomes
(b) spindle fibres and centromere
(c) two homologous chromosomes
(d) a male and a female gamete. *(2009)*

54. When paternal and maternal chromosomes change their materials with each other in cell division this event is called
(a) bivalent-forming (b) dyad-forming
(c) synapsis (d) crossing-over. *(1996)*

55. Which statement best explains the evolutionary advantage of meiosis?
(a) Meiosis is necessary for sexual reproduction.
(b) Genetic recombinations are possible from generation to generation.
(c) Meiosis alternates with mitosis from generation to generation.
(d) The same genetic system is passed on from generation to generation. *(1994)*

56. Meiosis II performs
(a) separation of sex chromosomes
(b) synthesis of DNA and centromere
(c) separation of homologous chromosomes
(d) separation of chromatids. *(1993)*

57. Number of chromatids at metaphase is
(a) two each in mitosis and meiosis
(b) two in mitosis and one in meiosis
(c) two in mitosis and four in meiosis
(d) one in mitosis and two in meiosis. *(1992)*

58. In meiosis, the daughter cells differ from parent cell as well as amongst themselves due to
(a) segregation, independent assortment and crossing over
(b) segregation and crossing over
(c) independent assortment and crossing over
(d) segregation and independent assortment. *(1991)*

59. Meiosis I is reductional division. Meiosis II is equational division due to
(a) pairing of homologous chromosomes
(b) crossing over
(c) separation of chromatids
(d) disjunction of homologous chromosomes. *(1988)*

ANSWER KEY

1.	(c)	**2.**	(b)	**3.**	(b)	**4.**	(a)	**5.**	(a)	**6.**	(b)	**7.**	(a)	**8.**	(c)	**9.**	(a)	**10.**	(b)
11.	(b)	**12.**	(b)	**13.**	(b)	**14.**	(a)	**15.**	(c)	**16.**	(a)	**17.**	(b)	**18.**	(d)	**19.**	(b)	**20.**	(c)
21.	(a)	**22.**	(b)	**23.**	(d)	**24.**	(c)	**25.**	(d)	**26.**	(c)	**27.**	(a)	**28.**	(c)	**29.**	(c)	**30.**	(b)
31.	(c)	**32.**	(c)	**33.**	(c)	**34.**	(a)	**35.**	(a)	**36.**	(c)	**37.**	(b)	**38.**	(d)	**39.**	(c)	**40.**	(b)
41.	(b)	**42.**	(b)	**43.**	(a)	**44.**	(c)	**45.**	(d)	**46.**	(d)	**47.**	(a)	**48.**	(a)	**49.**	(a)	**50.**	(c)
51.	(a)	**52.**	(c)	**53.**	(c)	**54.**	(d)	**55.**	(b)	**56.**	(d)	**57.**	(a)	**58.**	(a)	**59.**	(c)		

Hints & Explanations

1. (c) : S or synthesis phase marks the period during which DNA synthesis takes place. Reorganisation of all cellular components takes place in M-phase. This phase also start with nuclear division (Karyokinesis).

2. (b)

3. (b) : Some cells in the adult animals do not appear to exhibit division (*e.g.*, heart cells) and many other cells divide only occasionally, as needed to replace cells that have been lost because of injury or cell death. These cells that do not divide further exit G_1 phase to enter an inactive stage called quiescent stage (G_0) of the cell cycle. Cells in this stage remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism.

4. (a)

5. (a) : In S-phase (synthetic phase) of cell cycle, the chromosomes replicate. For this their DNA molecules function as templates and form carbon copies. The DNA content doubles *i.e.*, 1C to 2C for haploid cells and 2C to 4C for diploid cells. As a result duplicate sets of genes are formed. Along with replication of DNA new chromatin fibres are formed which, however, remain attached in pairs and the number of chromosomes does not increase. As chromatin fibres are elongated chromosomes, each chromosome comes to have two chromatin threads or sister chromatids which remain attached at a common point called centromere.

6. (b) : If cell has stalled DNA replication fork, it implies that it has crossed CG_1 or G_1 cyclin cell cycle check point and has entered S-phase of cell cycle, where it is preparing for chromosome replication. Afterwards it will enter G_2 phase and will soon approach second check point called mitotic cyclin (CM) which lies between G_2 and M-phase.

7. (a) : In diploid cells (somatic cells) during G_1 phase, DNA content is 2C and chromosome number is $2n$ whereas in haploid cells (gamete) during G_1 phase, DNA content is 1C and chromosome number is n. S phase is marked by replication of DNA and the amount of DNA per cell is doubled *i.e.*, it becomes 4C in somatic cells, whereas chromosome number remains same *i.e.*, $2n$. Thus, a somatic cell which has just completed S phase, will have 4C DNA content but $2n$ chromosome number, while the gamete cell has 1C DNA content and n chromosome number.

8. (c) : A cell cycle is divided into G_1, S, G_2 and M phases. G_1 or first growth phase is followed by S phase or synthetic phase. DNA replication occurs in S phase and DNA amount doubles up *i.e.*, a cell with 2C DNA in G_1 phase will now have 4C DNA. G_2 phase is second growth phase where DNA content remains 4C. M phase is the phase of division where DNA content either regains 2C level (mitosis) or becomes halved *i.e.* 1C (in meiosis). G_0 phase is the phase of differentiation where cell contains

DNA as in the same amount as its parent cell and does not divide further.

9. (a) : *Refer to answer 6.*

10. (b) : In cell cycle, there are two main phases- interphase and mitotic phase. Interphase is divided into 3 stage G_1, S and G_2. G_1 is first growth phase. S is synthetic phase and G_2 is second growth phase.

11. (b) : During S phase or synthetic phase the replication of DNA takes place. For replication of DNA, histone. proteins are required so they are also synthesized during this phase. It takes about 30%-50% of the total cell cycle.

12. (b) : *Refer to answer 11.*

13. (b) : *Refer to answer 11.*

14. (a) : *Refer to answer 11.*

15. (c) : *Refer to answer 11.*

16. (a) : Mitosis is divided into four phases : prophase, metaphase, anaphase and telophase. During prophase the indistinct and interwined DNA molecules condenses to form elongated chromosomes. The nuclear membrane disintegrates during prometaphase. During metaphase, the chromosomes align themselves at the equatorial plate. During anaphase, centromere of each chromosome divides into two so that each chromosome comes to have its own centromere. Chromatids move towards opposite poles along the path of their chromosome fibres. Finally during telophase, two chromosome groups reorganise to form two nuclei. Nuclear envelope reappears, Golgi complex and endoplasmic reticulum are reformed.
Option (c) also gives the correct sequence of events but it misses step II (nuclear membrane disassembly). Hence, is ruled out as best appropriate answer is option (a).

17. (b) : During anaphase in mitosis, sister chromatids segregate at opposite poles. Therefore, a defective APC will affect chromosome segregation.

18. (d) : Small disc-shaped structures at the surface of the centromeres are called kinetochores. These structures serve as the sites of attachment of spindle fibres to the chromosomes that are moved into position at the centre of the cell.

19. (b) : Synapsis is the process of association of homologous chromosomes. It takes place during zygotene stage of prophase I of meiosis. This stage is not seen during mitosis.

20. (c) : The figure given in the question shows a stage of mitotic cell division called as telophase stage. The individual chromosomes are no longer seen and chromatin material tends to collect in a mass at the two poles. This is the stage which shows the following key events:

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope assembles around the chromosome clusters.
- Nucleolus, Golgi complex and ER reform.

21. (a) : In metaphase, chromosomes consisting of two sister chromatids get arranged at equator. Discontinuous fibres radiate out from two spindle poles and get connected to the disc shaped structure at the surface of the centromere called kinetochores. These are known as chromosome fibres or tractile fibrils. A kinetochore is a complex protein structure that is analogous to a ring for the microtubule hook; it is the point where microtubules attach themselves to the chromosome.

22. (b) : *Refer to answer 21.*

23. (d) : The plane of alignment of the chromosomes at metaphase is referred to as the metaphase plate. The key features of metaphase are, (1) Spindle fibres attach to kinetochores of chromosomes (2) Chromosomes are moved to spindle equator and get aligned along metaphase plate through spindle fibres to both poles.

24. (c) : The key feature of metaphase is the attachment of spindle fibres to kinetochores of chromosomes. Kinetochores are disc-shaped structures at the surface of the centromeres. These structures serve as the sites of attachment of spindle fibres to the chromosomes that are moved into position.

25. (d) : During early prophase of mitosis, nucleus and cell become spheroid. Viscosity and refractivity of cytoplasm increases. DNA molecules condense to form shortened chromosome. Endoplasmic reticulum and nucleolus starts disappearing.

26. (c)

27. (a) : Metaphase is the best time to count and study the number and morphology of chromosomes. The distinctly visible chromosome arrange themselves at the equatorial or metaphasic plate. The centromeres lie at the equatorial plate while the limbs are placed variously according to their size and spiral arrangement. At prophase the chromosomes appear thin and filamentous, forming a network. So they are not very clearly visible. At telophase the chromosomes uncoil and lengthen and therefore are not clearly seen.
Anaphase also shows chromosomes distinctly and they can be counted. But during anaphase chromatids seperate and start moving towards opposite pole. So for counting chromosomes metaphase is the best stage.

28. (c) : M phase or mitotic phase is the actual division phase and formation of contractile ring and formation of phragmoplast precedes reformation of nuclear envelope. Contractile ring is belt-like bundle of actin and myosin that appears during cell division immediately below the plasma membrane. Contraction of this ring leads to the separation of the two daughter cells.

Phragmoplast is the region of plant cell cytoplasm that becomes evident in the latter stages of mitosis. It forms from the residual microtubules of the polar mitotic spindle and appears to function in transporting materials to the new cell plate forming between the daughter cells. Once the cell plate is complete, the phragmoplast is divided and gradually disappears, the cell plate finally becoming transformed into the middle lamella lying between the new cell walls.

29. (c) : A spindle of fine fibres begins to develop during prophase. It consists of microtubules which are made of protein called tubulin and certain other associated proteins. These delicate fibres radiate from the centriole and constitute aster. This option was not given in the question.

As actin and myosin are involved as contractile machinery in many non muscle cells so it can be considered as the correct answer. Myoglobin is present in muscles which can bind to oxygen.

30. (b) : Mitosis occurs both in somatic cells as well as in germ cells of the gonads. In plants mitosis occurs in the meristematic cells of root tip or shoot tip. These cells divide at a faster rate. So the root tip shows active cell division and are used in the laboratory to study mitosis.

31. (c) : *Refer to answer 24.*

32. (c) : Microtubules are unbranched hollow submicroscopic tubules of protein tubulin which develop on specific nucleating regions and can undergo quick growth or dissolution at their ends by assembly or disassembly of monomers. Microtubules form spindle during cell division. Centrioles help in cell division by forming spindle poles or microtubules. In animal cells, microfilament collect in the middle region of the cell below the cell membrane. They induce the cell membrane to invaginate.

In plant cells, cell plate is formed to separate the two daughter cells. Some of the spindle fibres called interzonal microtubules are deposited around phragmoplast. Vesicles from Golgi apparatus are deposited and coalesce on the phragmoplast to form a cell plate.

33. (c) : Mitosis is an equational division where after division each cell produces two daughter cells, therefore after 7 divisions one cell will give 128 cells in case of mitosis.

$$1 \xrightarrow{1} 2 \xrightarrow{2} 4 \xrightarrow{3} 8 \xrightarrow{4} 16 \xrightarrow{5} 32 \xrightarrow{6} 64 \xrightarrow{7} 128$$

34. (a) : In apical meristems mitotic divisions occur at a rapid rate. In late telophase of mitosis, a nuclear membrane appears on the outside from either pieces of nuclear envelope or endoplasmic reticulum. The telophase may last as long as the prophase.

35. (a) : The centrioles occur in nearly all animal cells and in motile plant cells, such as zoospores of algae, sperm cells of ferns, and motile algae. They are absent is amoebae, prokaryotic cells, higher gymnosperms and all angiosperms.

36. (c) : Colchicine is an alkaloid derived from the autumn crocus, *Colchicum autumnale*. It inhibits spindle formation in cells during mitosis so that chromosomes cannot separate during anaphase, thus inducing multiple sets of chromosomes. Colchicine is used in genetics, cytology, and plant breeding research and also in cancer therapy to inhibit cell division.

37. (b) : *Refer to answer 27.*

38. (d) : Mitotic anaphase differs from metaphase in possessing same number of chromosomes and half number of chromatids. During anaphase of mitosis, chromosomes divide at the point of centromere or kinetochore and thus two sister chromatids are formed which are called as chromosomes. While during metaphase, chromosomes become maximally distinct due to further contraction and thus size of chromosomes is measured at mitotic metaphase.

39. (c) : During diplotene in prophase I of meiosis I dissolution of the nucleoprotein synaptonemal complex occurs.

40. (b)

41. (b)

42. (b) : During diplotene, the nucleoprotein fusion complex of synapsed chromosomes dissolves partially therefore homologous chromosomes separate except in the region of crossing over.

43. (a)

44. (c) : Crossing over is a process of exchange of genetic material or chromatid segments between two homologous chromosomes. It is initiated during pachytene stage of meiosis.

45. (d) : Prophase-I of meiosis has been divided into five sub-stages which occur in the sequence as : Leptotene → Zygotene → Pachytene → Diplotene → Diakinesis. Synapsis *i.e.*, pairing of homologous chromosomes occurs during zygotene. Crossing over *i.e.*, exchange of chromatid segments occurs during pachytene. Terminalisation of chiasmata *i.e.,* shifting of chiasmata towards the ends of chromosomes and complete disappearance of nucleolus take place during diakinesis.

46. (d) :

Synapsis aligns homologous chromosomes	– Zygotene
Synthesis of RNA and protein	– G_2 phase
Action of enzyme recombinase	– Pachytene
Centromeres do not separate but chromatids move towards opposite poles	– Anaphase I

47. (a) : Pachytene stage is characterized by the appearance of recombination nodules, the sites at which crossing over occurs between non-sister chromatids of

the homologous chromosomes. Nodules contain multi enzyme complex called recombinase. Recombinase is made of endonuclease, exonuclease, unwindase, R-protein, etc.

48. (a) : During zygotene stage chromosomes start pairing together and this process of association is called synapsis. Such paired chromosomes are called homologous chromosomes. Electron micrographs of this stage indicate that chromosome synapsis is accompanied by the formation of complex structure called synaptonemal complex. The complex formed by a pair of synapsed homologous chromosomes is called a bivalent or a tetrad.

49. (a) : *Refer to answer 48.*

50. (c) : During gamete formation, the enzyme recombinase participates during pachytene stage of prophase I. This stage is characterized by the appearance of recombination nodules, the sites at which crossing over occurs between non-sister chromatids of the homologous chromosomes. Crossing over is the exchange of genetic material between two homologous chromosomes. Crossing over is also an enzyme-mediated process and the enzyme involved is called recombinase.

51. (a) : The given figure shows crossing over *i.e.*, exchange of segments between two homologous chromosomes. Crossing over is characteristic of meiosis and occurs during pachytene stage of prophase I.

52. (c) : During anaphase I, from each tetrad two chromatids of a chromosome move as a unit (dyad) to one pole of a spindle and the remaining two chromatids of its homologue migrate to the opposite pole. Thus, the homologous chromosomes of each pair, rather than the chromatids of a chromosome, are separated. As a result, half of the chromosomes, which appear in early prophase, go to each pole. Thus the paternal and maternal chromosomes of each homologous pair segregate during anaphase I independently of the other chromosomes.

53. (c) : During zygotene or zygonema of meiotic prophase I the chromosomes become shorter and thicker. The homologous chromosomes come to lie side-by-side in pairs. This pairing of homologous chromosomes is known as synapsis. A pair of homologous chromosomes lying together is called a bivalent.

54. (d) : Crossing over is responsible for inducing variability. It involves an exchange of equal segments of non-sister chromatids belonging to two different but homologous chromosomes. Crossing over takes place at four stranded stage. Only two of the four chromatids take part in crossing over. The other two are called non crossovers. Zygotene is characterized by pairing of homologous chromosomes which is called synapsis.

55. (b) : Meiosis involves exchange of genes between homologous chromosomes. So the gametes produced are genetically different from each other. Offsprings produced by the fusion of gametes therefore also show recombinations or genetic variations. These variations in the offsprings make organisms more adaptable to the environment and these have a definite role in evolution.

56. (d) : 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 produce at the end of reduction division. Hence, it is called homotypic or equational division, though it is similar to mitosis. 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.

57. (a) : Number of chromatids at metaphase is two each in mitosis and meiosis. Chromatid is a half chromosome during duplication in early prophase and metaphase of mitosis and between diplotene and the second metaphase of meiosis. After these stages chromatids are called a daughter chromosomes.

58. (a) : In meiosis, the daughter cells differ from parent cell as well as amongst themselves due to segregation, independent assortment and crossing over. Daughter cells inhibit variations. Meiosis leads to recombinations or new combinations of genes or characters as a result of crossing over. Due to these recombinations, variations are created, which have role in process of evolution.

59. (c) : The two divisions of meiosis are called the first and the second meiotic divisions. In meiosis I, the number of chromosomes are reduced from diploid to haploid condition, whereas in meiosis II, the two chromatids of each chromosomes separate from each other and go to separate daughter cells, as a result the number of chromosomes remains the same as produced by meiosis I.

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