Cell Cycle and Cell Division

OBJECTIVE TYPE QUESTIONS

Multiple Choice Questions (MCQs)

1. Synthesis or replication of DNA in interphase takes place in phase
(a) G_1 (b) S (c) G_2 (d) M.

2. In the somatic cell cycle
(a) DNA content in G_1 phase is double the amount of DNA content 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.

3. At which stage of the cell cycle, histone proteins are synthesised in a eukaryotic cell?
(a) During G_o phase
(b) During S-phase
(c) During entire prophase
(d) During telophase

4. Mitotic phases are alphabetically arranged and numbered as follows :
Anaphase-1, Metaphase-2, Prophase-3 and Telophase-4
The correct sequence of occurrence in cell division is
(a) 1, 2, 3 and 4 (b) 3, 2, 1 and 4
(c) 4, 3, 2 and 1 (d) 2, 1, 4 and 3.

5. Mitosis is the process by which eukaryotic cells
(a) grow
(b) expose genes for protein synthesis
(c) multiply
(d) become specialised in structure and function.

6. Colchicine acts as a mitotic poison by
(a) causing fragmentation and agglutination of chromosomes
(b) inducing breakage at centromeric position of chromosomes
(c) inhibiting formation of mitotic spindle
(d) all of these.

7. The significance of mitotic division is
(a) it takes place where there is a need of increase in number of cells only
(b) it is the method of multiplication of unicellular organisms
(c) daughter cells and parent cells have the same number of chromosomes (2n)
(d) all of these.

8. The cellular structure which disappear during mitosis is
(a) plasma membrane
(b) spindle apparatus
(c) mitochondria
(d) nuclear membrane and nucleolus.

9. Enzyme responsible for fixing crossed over parts of non-sister chromatids is
(a) lipase (b) enterokinase
(c) recombinase (d) endonuclease.

10. The stage of meiosis where centromere divides for the first and the only time, ensuring separation of daughter chromosomes, occur in
(a) anaphase- II (b) telophase- I
(c) anaphase- I (d) telophase- II.

11. In which of the following stages terminalisation occurs?
(a) Zygotene (b) Pachytene
(c) Diakinesis (d) Diplotene

12. Lampbrush chromosomes are actually
(a) condensed zygotene chromosomes
(b) decondensed diplotene chromosomes
(c) condensed leptotene chromosomes
(d) decondensed pachytene chromosomes.

13. In tetrad, crossing over does not take place between
(a) non-sister chromatids of outer group
(b) sister chromatids of dyad
(c) outermost and innermost non-sister chromatids
(d) all of these.

14. Homologous pair of chromosomes resemble each other except in the case of
(a) shape and size
(b) number of genes on them
(c) alleles on the same loci
(d) all of these.

15. "G_0" state of cells in eukaryotic cell cycle denotes
(a) check point before entering the next phase
(b) pausing in the middle of a cycle to cope with a temporary delay
(c) death of a cell
(d) exit of cells from cell cycle.

16. A study is done on a mammalian cell line that has a doubling of 24 hours. These cells are synchronised in G_1 and then labelled for 2 days with BrdU (an analog of thymidine that increases the density of DNA into which it is incorporated). At the end of labelling period, chromosomal DNA is isolated from the cells and its density was analysed. Which of the patterns would be expected to be seen? (H = Heavy, L = Light).
(a) 100% H/H
(b) 100% H/L
(c) 50% H/H, 50% H/L
(d) 50% H/H, 50% L/L

17. Which is not true about mitosis?
(a) Mitosis is initiated after G_1 phase.
(b) Crossing over does not take place.
(c) Parent cell produces two daughter cells.
(d) The two daughter cells have the same number of chromosomes as in the parent cell.

18. Who coined the term mitosis?
(a) Flemming (b) Farmer
(c) Strasburger (d) Boveri

19. In which stage of cell division, the chromosomes are most condensed?
(a) Prophase (b) Metaphase
(c) Anaphase (d) Telophase

20. Division of centromere occurs in
(a) late prophase or early metaphase
(b) late metaphase or early anaphase
(c) late anaphase or early telophase
(d) late telophase.

21. Which of the following statements is true about mitosis?
(a) Daughter cells exhibit division of labour *i.e.*, perform different functions.
(b) Daughter cells are exactly similar in all respects.
(c) Daughter cells have half the number of chromosomes as compared to mother cell.
(d) Daughter cells have differences in genetic characters.

22. Which of the following statements is not true?
(a) With end of cytokinesis, mitosis is considered to be completed.
(b) In animal cell, the division starts as a furrow in the plasma membrane which deepens to progress and meet in the centre to cut out two free cells.
(c) Cytokinesis procedure is similar in both plant and animal cells.
(d) The two daughter cells are exactly similar to the parent cell in mitosis.

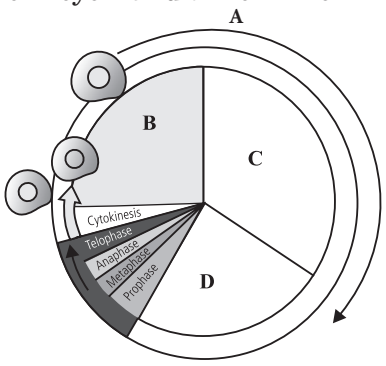
23. Select the correct statement with respect to mitosis.
(a) Chromatids separate but remain in the centre of the cell in anaphase.
(b) Chromatids start moving towards opposite poles in telophase.
(c) Golgi complex and endoplasmic reticulum are still visible at the end of prophase.
(d) Chromosomes move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

24. Reason of chromosomal movement in anaphase is
(a) astral rays (b) centrioles
(c) kinetochore (d) spindle fibres.

25. Two sister chromatids are attached with
(a) spindle fibre (b) chromocentre
(c) centromere (d) chromatid.

26. Genetic recombination consequent to crossing over is a significant feature of
(a) pachytene (b) zygotene
(c) leptotene (d) diplotene.

27. Identify A, B, C and D in the given diagram depicting cell cycle and select the correct option.



	A	B	C	D
(a)	G_0	G_1	S	G_2
(b)	G_1	S	G_2	G_0
(c)	G_1	G_0	S	G_2
(d)	S	G_0	G_1	G_2

28. Which of the following statements is correct about cell cycle?

(a) In G_1-phase, the amount of cytoplasm and DNA gets duplicated.

(b) In S-phase, the DNA replication occurs and chromosome number is doubled.

(c) DNA replication and duplication of centrioles occurs in S-phase along with histone synthesis.

(d) DNA amount is doubled and chromosome number is doubled in G_2-phase.

29. Read the given statements and select the correct option.

Statement A : The ploidy number of the cell doubles during S-phase.

Statement B : The DNA content of the cells remains the same during S-phase.

(a) Both statements A and B are true and B is the correct explanation of A.

(b) Both statements A and B are true but B is not the correct explanation of A.

(c) Statement A is true but B is false.

(d) Both statements A and B are false.

30. Which of the following statements is/are correct for meiosis?

I. Meiosis is a double division. It gives rise to four cells.

II. The cells undergoing meiosis may be haploid or diploid.

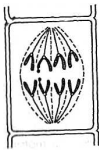
III. No bouquet stage is recorded.

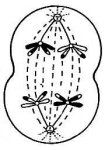
IV. Pairing or synapsis of homologous chromosomes takes place during zygotene of prophase-I and continues upto meta phase-I.

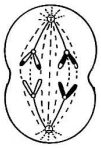
(a) I only (b) I and IV

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

31. Select the option which correctly represents the stage anaphase-I for chromosome number $2n = 4$.

(a) 

(b) 

(c) 

(d) 

32. 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.

33. Which of the following is a key event of anaphase of mitotic division?

(a) Chromosomes are moved to spindle equator and get aligned through spindle fibres to both poles.

(b) Centromeres split and chromatids separate.

(c) Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.

(d) Both (b) and (c)

34. Diplotene stage of prophase-I is characterised by

(a) dissolution of synaptonemal complex

(b) separation of synapsed homologous chromosomes except at the site of crossovers

(c) formation of X-shaped structures called chiasmata

(d) all of these.

35. G_1 phase of the cell cycle is usually absent in

(a) Hela cells in culture
(b) senescent fibroblast cells
(c) early cleavage stage cells
(d) intestinal epithelial cells.

36. Swollen bead like areas considered to be genes can be observed on chromosomes in _____ subphase of meiosis.

(a) leptotene (b) zygotene
(c) pachytene (d) none of these

37. Interphase is the period in which the cell

(a) has stopped all its metabolic activities
(b) is metabolically inactive but grows in size
(c) has kept up metabolic activities but not dividing
(d) is set to divide by stopping other metabolic activities.

38. In which stage of cell cycle nucleus becomes bigger?

(a) G_1 (b) G_2 (c) S (d) M

39. There are 14 chromosomes in each cell and 2C DNA after M-phase in a plant. Find out the correct match in the following table.

	Stage	Chromosome No.	DNA content
A.	G_1	14	2C
B.	S	28	4C
C.	G_2	14	4C
D	M	14	2C

(a) A and B are correct.
(b) A, B and D are correct.
(c) A, C and D are correct.
(d) B, C and D are correct.

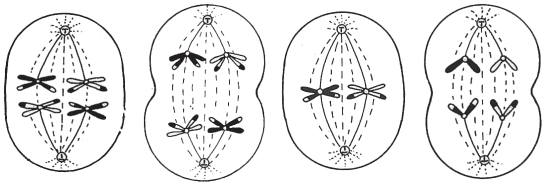
40. Which of the following are essential features of meiosis?

(i) Two successive divisions but no DNA replication prior to second division.
(ii) Crossing over
(iii) Formation of chiasmata

(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iii) (d) (i), (ii) and (iii)

Case Based MCQs

Case I : Study the figures given below and answer the questions from 41 to 45.



41. Identify the labelled figures A and B.

(a) Metaphase and Metaphase I
(b) Metaphase I and Anaphase I
(c) Metaphase II and Anaphase II
(d) Anaphase I and Anaphase II

42. Which type of spindle is shown in the given cell?

(a) Anastral (b) Amphiastral
(c) Both of these (d) None of these

43. Which of the following does not occur in anaphase-I but occurs in anaphase-II?

(a) Condensation of chromosomes
(b) Poleward movement of chromosomes
(c) Contraction of spindle fibres
(d) Splitting of centromere.

44. Identify the meiotic stage in which the homologous chromosomes separate while the sister chromatids remain associated at their centromeres.

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

45. Select the stage that begins with the simultaneous splitting of centromere of each chromosome.

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

Case II : Read the following passage and answer the questions from 46 to 50.

Mitosis is the type of division in which chromosomes replicate and become equally distributed both quantitatively and qualitatively into two daughter nuclei. Thus, it is also called equational division since the chromosome number of the parent is conserved in the daughter cell. On the basis of nuclear division, M-phase is divided into four stages: Prophase, Metaphase, Anaphase and Telophase. Mitosis starts with nuclear division followed by daughter chromosome separation and ends with division of cytoplasm. It is necessary for growth and development of a multicellular organism.

46. Which among the following is the longest and shortest phase in mitosis?
(a) Telophase and Prophase
(b) Metaphase and Anaphase
(c) Prophase and Anaphase
(d) Anaphase and Prophase

47. X phase is characterised by condensation of chromosomal material to form compact mitotic chromosomes X is
(a) prophase (b) anaphase
(c) metaphase (d) telophase.

48. Which of the following is the best stage to study the morphology of chromosomes?
(a) Prophase (b) Metaphase
(c) Anaphase (d) Telophase

49. How many mitotic divisions are required for a cell to make 512 cells?
(a) 8 (b) 6
(c) 7 (d) 9

50. Read the given statements and select which ones are true (T) and which ones are false (F).
I. Germ cells are formed by mitosis.
II. Mitosis is capable to regenerate whole organism.
III. Mitosis involves multiplication of both unicellular and multicellular organisms.
IV. Mitosis increases the nucleocytoplasmic ratio.

	I	II	III	IV
(a)	F	F	T	F
(b)	T	T	T	F
(c)	T	F	F	F
(d)	F	T	T	F

Assertion & Reasoning Based MCQs

For question numbers 51-60, two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

51. Assertion : Meiotic division results in the production of four dissimilar cells.
Reason : Synapsis occurs during zygotene of meiosis.

52. Assertion : Meiosis II is similar to mitosis.
Reason : Meiosis I cannot occur in haploid cells.

53. Assertion : Bivalents are formed during pachynema.
Reason : Bivalent and tetrad conditions of chromosomes are two different conditions.

54. Assertion : Sexual reproduction always needs meiosis.
Reason : Gametes involved in sexual reproduction are always haploid.

55. Assertion : Mitosis occurs in both unicellular and multicellular organisms.
Reason : Mitosis is a method of sexual reproduction in unicellular organisms.

56. Assertion : Interphase occurs between two dividing M-phase.
Reason : Interphase cell is metabolically quite active.

57. Assertion : Plants can show mitotic division only in diploid somatic cells.
Reason : Cells in G_0 stage is metabolically active but no longer proliferate.

58. Assertion : Meiosis increases genetic variability in the population.
Reason : Chromosomal and genomic mutations can take place by irregularities of meiotic divisions.

59. Assertion : Interkinesis is metabolic stage between telophase of meiosis I and prophase of meiosis II.
Reason : During interkinesis, chromatin reticulum is formed.

60. Assertion : Meiosis introduces new combination of traits in the progeny.
Reason : Meiosis involves crossing over.

SUBJECTIVE TYPE QUESTIONS

Very Short Answer Type Questions (VSA)

1. Write the name of the phase that occurs between the two successive mitotic divisions.

2. Distinguish cytokinesis from karyokinesis?

3. What is the average cell cycle span for a mammalian cell?

4. If a tissue has 1024 cell at a given time, how many cycles of mitosis had the original parental single cell undergone?

5. Can there be DNA replication without cell division?

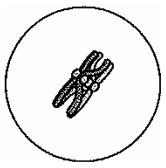
6. What happens during anaphase-I of meiosis?

7. Can there be mitosis without DNA replication in S-phase?

8. Name the sub-stages of prophase of meiosis.

9. What does a bivalent of meiosis-I consists of?

10. The diagram shows a bivalent at prophase-I of meiosis. Which of the four chromatids can cross over?



Short Answer Type Questions (SA-I)

11. A cell having 32 chromosomes, undergoes mitotic divisions. What will be the chromosome number (n) during metaphase? What would be the DNA content (C) during anaphase?

12. Why do the chromosomes become short and thick in prophase?

13. Give a specific scientific term for each of the following.
(i) The period between meiosis I and meiosis II.
(ii) Point at which two sister chromatids are held together.
(iii) Phase in the cell cycle when protein and RNA are synthesised.
(iv) Mitotic poison that does not allow the formation of spindle.

14. Why is mitosis called equational division?

15. There occurs a process in which division of nucleus takes place. Identify the process and also write about its different phases.

16. 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?

17. Mention about the synaptonemal complex.

18. Complete the following sentences with suitable words.
(i) Chromosome condensation occurs during _____
(ii) _____ is marked by the alignment of chromosomes at the equatorial plate.
(iii) _____ is the equational division in which the chromosome number of the parent is conserved in the daughter cell.
(iv) Each parent cell has a pair of _____ chromosomes.

19. Discuss about the attributes does a chromatid require to be classified as a chromosome.

20. Mention the significance of meiosis.

Short Answer Type Questions (SA-II)

21. Give examples where the four daughter cells from meiosis are equal in size and where they are found unequal in size.

22. Both unicellular and multicellular organisms undergo mitosis. What are the differences, if any, observed in the process between the two?

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

24. Describe cell division. List various types of cell division. Also mention about the need of cell division.

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

26. In which phase of meiosis are the following formed?
(i) Synaptonemal complex.
(ii) Recombination nodules.
(iii) Appearence/activation of enzyme recombinase.
(iv) Terminalisation of chiasmata.
(vi) Formation of dyad of cell.

27. Distinguish anaphase of mitosis from anaphase-I of meiosis.

28. Analyse the events during every stage of cell cycle and briefly explain in relation with chromosome number and DNA content.

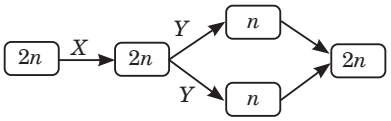
29. While examining the mitotic stage in a tissue, one finds some cells with 16 chromosomes and some with 32 chromosomes. What possible reasons could you assign to this difference in chromosome number. Do you think that cell with 16 chromosomes number could have arisen from cell with 32 chrmosomes or vice-versa?

30. Differentiate between S-phase and G_2-phase.

31. Name the stage of cell cycle at which one of the following events occur?
(i) Chromosomes move to spindle equator.
(ii) Centromere splits and chromatids separate.
(iii) Pairing between homologous chromosomes take place.
(iv) Crossing over between homologous chromosomes take place.

32. Comment on the statement – Meiosis enables the conservation of specific chromosome number of each species even though the process per se, results in reduction of chromosome number.

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



(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*.

34. 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.

Long Answer Type Questions (LA)

35. Briefly describe the significance of cell division.

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

37. Describe the following words
(i) Synapsis (ii) Bivalent (ii) Chiasmata

ANSWERS

OBJECTIVE TYPE QUESTIONS

1. (b) : Synthesis or replication of DNA in interphase takes place in S phase. Amount of DNA per cell doubles *i.e.*, 1C to 2C for haploid cells and 2C to 4C for diploid cells.

2. (b) : Replication of DNA takes place in S phase. DNA content of the chromosomes gets doubled. In somatic cell cycle, cell divides into two identical daughter cells.

3. (b) : Histone proteins are synthesised during S phase of interphase.

4. (b) : Mitosis (cell division into two identical daughter cells) is divided into four stages - (1) Prophase, (2) Metaphase (3) Anaphase and (4) Telophase.

5. (c) : Mitosis is the process used for rapid multiplication of eukaryotic cell.

6. (c) : Colchicine acts as a mitotic poison by inhibiting formation of mitotic spindle because it prevents assembly of microtubules. Chromosomes gets doubled in colchicine-treated cells.

7. (d)

8. (d) : Nucleolus degenerate completely in late prophase and nuclear envelope degenerates at the beginning of prometaphase of mitosis.

9. (c) : Enzyme responsible for fixing crossed over parts of non-sister chromatids is R-protein which is a part of recombinase enzyme.

10. (a) : Anaphase II of meiosis II is characterised by splitting of centromere of each chromosomes and sister chromatids move toward opposite poles of the cell.

11. (c) : Terminalisation is the process of shifting chiasmata towards the ends of chromosomes, which takes place during diakinesis of meiosis I.

12. (b) : Lampbrush chromosomes are decondensed diplotene chromosomes which get engaged in RNA synthesis.

13. (d)

14. (c) : Homologous pair of chromosomes are approximately of same length, number of genes but alleles on them may be different resulting in different phenotypes of same genes.

15. (d) : When cells are not to divide after G_1 phase and may start undergoing differentiation into specific types of cells such cells are said to be in G_0 phase/ G_0 state.

16. (c)

17. (a) : Mitosis is initiated after the G_2 phase of cell cycle of interphase. Mitosis produce two daughter cells from a parent cell. Chromosome number of parent cell (2n) and daughter cells (2n) are same.

18. (a)

19. (b) : Chromosomes are most condensed during the metaphase stage of cell division. Metaphase is the best time to count the number and study the morphology of chromosomes.

20. (b) : Chromosomes are arranged at the equatorial region of a cell during metaphase. Spindle fibres from both the poles get attached to the kinetochore in centromeric region of each chromosome. At late metaphase to early anaphase, centromere divides, each part with a chromatid get separated and start moving towards the opposite pole.

21. (b) : Mitosis produces two identical daughter cells by the equatorial division. Chromosome number of parent (2n) and daughter cells (2n) are same. The size, cellular components and genetic characters remain same in the daughter cells as in the parent cell.

22. (c) **23. (d)**

24. (d) : During anaphase, spindle fibres attached to the centromeres of the chromosomes, shorten and pull the chromosomes to the opposite poles.

25. (c) : Centromere is a specialised constricted region of a chromosome to which spindle fibres attach during cell division and two sister chromatids (the two exact copies of each chromosome that are formed after replication) are joined. Spindle fibre are microtubular apparatus and is responsible for the ordered separation of chromosomes.

26. (a) : Zygotene is characterised by pairing of homologous chromosomes which is called synapsis. In pachytene, crossing over of homologous chromosomes takes place. Crossing-over is responsible for inducing variability in parents and offsprings. 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. The point where crossing-over takes place giving rise to cross-shaped figures, are called chiasmata. They are seen in diplotene of prophase-I. Only two of the four chromatids take part in crossing over. The other two are called non crossovers.

27. (a) : The cell cycle is the series of events that takes place in a cell leading to its division and duplication. A cell cycle is divided into two periods : interphase and mitotic phase. Interphase, is further of three stages, G_1, S and G_2. During interphase, cell grows accumulating nutrients needed for cell division. The most significant event of interphase is the replication of genetic material (DNA) in S phase. Cell may escape interphase and enter into G_0 phase for differentiation.

28. (c) : DNA duplication occurs in S-phase of cell cycle. Chromosome number remains same, DNA amount is doubled. Duplication of centrioles and histone synthesis also occur in S-phase.

29. (d) : DNA duplication occurs in S-phase of cell cycle. Chromosome number remains same, DNA amount is doubled.

30. (b) : In many animal cells, the chromosomes show a peculiar arrangement during leptotene sub-phase of prophase - I, called bouquet stage. Meiosis occurs in diploid cells giving rise to four haploid cells.

31. (b) : The homologous chromosomes separate out causing disjunction. They move towards the spindle poles along the path of their tractile fibrils in anaphase I.

32. (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.

33. (b) : Chromosomes are moved to spindle equator and get aligned through spindle fibres to both poles in metaphase of mitotic cell division. Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements in telophase of mitotic cell division.

34. (d) **35. (c)**

36. (a) : Swollen bead like areas called chromomeres which are considered to be genes can be observed on chromosomes during leptotene stage of prophase I of meiosis I.

37. (c) : Interphase is a long non-dividing growing phase which is metabolically active.

38. (c) : In S phase of cell cycle, DNA replication takes place, hence duplicate sets of genes are formed. Thus, nucleus become bigger.

39. (c) : In S-phase, number of chromosomes is 14, DNA is 4C.

40. (d) : Crossing over and formation of chiasmata are features of meiosis. In meiosis, two successive divisions take place but DNA replication does not occur before the second division.

41. (b) : A - Metaphase I, B - Anaphase I

42. (b) : As there are two asters, the spindle is called amphiastral.

43. (d) : The splitting of centromere does not occur in anaphase I but occurs in anaphase II.

44. (c) : During anaphase I, the homologous chromosomes separate, while sister chromatids remain associated at their centromeres.

45. (a) : Anaphase II begins with the simultaneous splitting of centromere of each chromosome.

46. (c)

47. (a) : During prophase, chromosomal material condenses to form compact mitotic chromosomes. Chromosomes are seen to be composed of two chromatids attached together at the centromere.

48. (b) : Metaphase is the best time to count the number and study the morphology of chromosomes.

49. (d) : 9 mitotic divisions are required for a single cell to make 512 cells.

50. (d)

51. (b) : Meiosis is a double division which occurs in a diploid cell (or nucleus) and gives rise to four haploid cells (or nuclei), each having half the number of chromosomes as compared to the parent cell. Synapsis occurs during zygotene of meiosis-I. The two homologous chromosomes get paired to each other, and the process of pairing is known as synapsis. It produces a complex known as synaptonemal complex.

52. (b) : Meiosis consists of two divisions, meiosis I and meiosis II. The first division of meiosis is called heterotypic or reduction division. During this division the number of chromosomes is reduced to half. The two chromatids of a chromosome become genetically different due to crossing over. These chromatids are separated in the second division of meiosis. The second meiotic division is known as homotypic or equational division, because the chromosome number remains the same as produced after the end of the first division. Though meiosis II 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.

53. (c) : Pairing of the homologous chromosomes occurs during pachynema. Each bivalent or tetrad chromosome pair is made up of actually four chromatids, two of each chromosome.

54. (a)

55. (c) : Mitosis is the method of multiplication of unicellular organisms.

56. (b)

57. (d) : Plants can show mitotic divisions in both haploid and diploid cells.

58. (b)

59. (c) : Interkinesis is metabolic stage between telophase of meiosis I and prophase of meiosis II. Chromosomes are elongated but chromatin reticulum is not formed. Protein and RNA synthesis may occur.

60. (a)

SUBJECTIVE TYPE QUESTIONS

1. Interphase is the period between the two successive mitotic cell divisions.

2. Cytokinesis is the division of cytoplasm whereas karyokinesis is the division of nucleus of the cell.

3. The average cell cycle span for a mammalian cell is 24 hours.

4. 10 (2^n, where $n = 10$ generations).

5. Yes, DNA replication takes place during the synthetic stage of interphase in the cell cycle. It is totally independent of cell division. After G_2-phase a cell may or may not enter into the M-phase.

6. During anaphase-I, homologous chromosomes separates from each other.

7. Mitosis cannot occurs 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.

8. The various sub-stages of prophase occurs in meiosis are leptotene, zygotene, pachytene, diplotene and diakinesis.

9. Bivalent of meiosis-I consists of four chromatids and two centromeres.

10. The non-sister chromatids of homologous pair of chromosomes undergo crossing over.

11. The number of chromosome during metaphase will be 32. Also, the DNA content during anaphase will be same as in the parent cell.

12. The chromosomes become short and thick in prophase because it is physically easier for short and compact chromosomes to move through the cytoplasm than the very long and twisted interphase chromosomes.

13. (i) Interkinesis

(ii) Centromere

(iii) G_1-phase

(iv) Colchicine

14. Mitosis is called an equational division because it divides the mother cell into two daughter cells, which are identical to each other and also to the original mother cell in every respect. In mitosis, the chromosomes of the mother cell are duplicated and distributed equally to the two daughter cells.

15. Karyokinesis is a series of uninterrupted changes before forming two daughters nucleus. Though karyokinesis is a continuous process, it has been divided into four phases. They are prophase, metaphase, anaphase and telophase.

16. Though meiosis II 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.

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

18. (i) prophase

(ii) metaphase

(iii) mitosis

(iv) homologous

19. 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 second meiotic division. Hence, crossing over is an attribute, which classify chromatids as chromosomes.

20. Meiosis is the mechanism by which conservation of specific chromosome number of each species is achieved across generations in sexually reproducing organisms.

It also increases the genetic variability in the population of organism from one generation to the next. Variations are very important for the process of evolution.

21. During formation of male gametes (*i.e.*, spermatozoa) in a typical mammal (*i.e.*, human being), the four daughter cells formed from meiosis are equal in size. On the other hand, during formation of female gamete (*i.e.*, ovum) in a typical mammal (*i.e.*, human being), the four daughter cells are unequal in size.

22. In unicellular organisms, mitosis is a method of asexual reproduction. *E.g.*, in bacteria, mitosis results in formation of identical daughter cells. However in multicellular organisms, mitosis helps in growth and repair of cells and tissues. *E.g*, Repair of damaged skin through production of new skin cells.

23. Three phases of interphase are G_1-phase (post-mitotic or pre-synthetic phase), S-phase (synthesising phase) and G_2-phase (post-synthetic or pre-mitotic phase).

Major event of each phase is as follows :

(i) G_1-phase is the longest phase during which synthesis of RNA and DNA takes place.

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

(iii) G_2-phase is the phase in which synthesis of DNA gets stopped. However, formation of RNA takes place.

24. Cell division, or cell multiplication is the process of formation of new daughter cell from the pre-existing cell or parent cell. It is of three types :

(i) Amitosis

(ii) Mitosis

(iii) Meiosis.

Cell division maintains continuity of living matter generation after generation.

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

(i) Crossing over is exchange 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.

26. (i) Zygotene

(ii) Pachytene

(iii) Pachytene

(iv) Diakinesis

(v) Anaphase-I

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

	Anaphase of Mitosis	Anaphase-I of Meiosis
(i)	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.
(ii)	The centromere of each chromosome is towards the pole with arms of chromosome trailing behind.	The centromere is not divided, so half of the chromosomes of parent nucleus go to one pole and the remaining half in the opposite pole.
(iii)	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.

28. (i) During the complete cell cycle, the number of chromosomes (*n*) per cell remains same. It does not show any changes if the division is of mitosis type.

(ii) The overall DNA content will remains same however it becomes doubles during the S-phase and afterwards become half during the dividing phase.

29. Difference in chromosome number during mitotic division might be due to polyploidy, *i.e.,* having more than two sets of chromosomes. It occurs due to failure of chromosomes to separate during anaphase or due to non-disjunction. This change in chromosome number can be due to mutations. Cells with 32 chromosomes might have arisen from cells with 16 chromosomes.

30. Differences between S-phase and G_2-phase are :

	S-phase	G_2-phase
(i)	It is called synthetic phase.	It is called pre-mitotic phase.
(ii)	Replication of DNA occurs.	RNA of all three types and proteins for asters and spindle are synthesised in it.
(iii)	It lasts for 6-8 hours.	It lasts for 2-5 hours.

31. (i) Metaphase

(ii) Anaphase

(ii) Zygotene stage of meiosis-I

(iv) Pachytene stage

32. Meiosis is reductional division which ensures production of haploid phase in life cycle of sexually reproducing organisms, but fertilisation restores the diploid phase, thus, enables conservation of specific chromosome number, *e.g.,* gametes produced by 2*n* parents are haploid (*n*), but the zygote is diploid.

33. (i) *X*-Mitosis
Y-Meiosis

(ii) (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.

34. III (prophase) $\rightarrow$ II (metaphse) $\rightarrow$ IV (anaphase) $\rightarrow$ I (telophase)

35. Cell division is significant in the following ways :

(i) Cell multiplication : Cell division is a means 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 organs.

(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 cell in an individual despite being different structurally and functionally.

36. A pair of homologous chromosomes are genetically different because in a set of homologous chromosomes, one of the chromosome belongs to the male parent and the other come 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 are 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.

37. (i) Synapsis : During meiosis-I, the process of pairing of two homologous chromosomes is known as synapsis. It is so exact that pairing is not merely between corresponding chromosomes but between corresponding individual units.

(ii) Bivalent : The complex formed by a pair of synapsed homologous chromosomes is called a bivalent or a tetrad. It consists of four chromatids.

(iii) Chiasmata : The chiasmata formation is the indication of completion of crossing over and beginning of separation of chromosomes. The chiasma is formed when the chromosomal parts begin to repel each other except in the region where these are in contact. Thus, chiasmata formation is necessary for the separation of homologous chromosomes.