Question 1:

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

Answer

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

Question 2:

Distinguish cytokinesis from karyokinesis.

Answer

Cytokinesis		**Karyokinesis**	
(i)	Cytokinesis is the biological process involving the division of a cell's cytoplasm during mitosis or meiosis.	**(i)**	Karyokinesis is the biological process involving the division of a cell's nucleus during mitosis or meiosis.
(ii)	It is divided into four stages – prophase, metaphase, anaphase, and telophase.	**(ii)**	Stages such as prophase, metaphase, anaphase, and telophase are not present in karyokinesis.

Question 3:

Describe the events taking place during interphase.

Answer

Interphase involves a series of changes that prepare a cell for division. It is the period during which the cell experiences growth and DNA replication in an orderly manner. Interphase is divided into three phases.

(i) G_1 phase

(ii) S phase

(iii) G_2 phase

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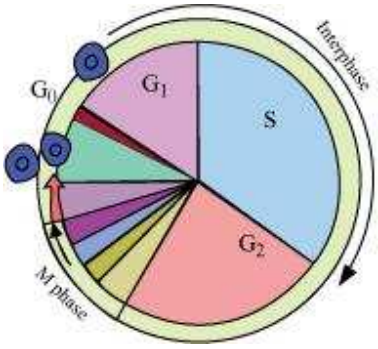
G_1 phase – It is the stage during which the cell grows and prepares its DNA for replication. In this phase, the cell is metabolically active.

S phase – It is the stage during which DNA synthesis occurs. In this phase, the amount of DNA (per cell) doubles, but the chromosome number remains the same.

G_2 phase – In this phase, the cell continues to grow and prepares itself for division. The proteins and RNA required for mitosis are synthesised during this stage.



Question 4:

What is G_0 (quiescent phase) of cell cycle?

Answer

G_0 or quiescent phase is the stage wherein cells remain metabolically active, but do not proliferate unless called to do so. Such cells are used for replacing the cells lost during injury.

Question 5:

Why is mitosis called equational division?

Answer

Mitosis is the process of cell division wherein the chromosomes replicate and get equally distributed into two daughter cells. The chromosome number in each daughter cell is equal to that in the parent cell, i.e., diploid. Hence, mitosis is known as equational division.

Question 6:

Name the stage of cell cycle at which one of the following events occur:

(i) Chromosomes are moved to spindle equator

(ii) Centromere splits and chromatids separate

(iii) Pairing between homologous chromosomes takes place

(iv) Crossing over between homologous chromosomes takes place

Answer

(i) Metaphase

(ii) Anaphase

(iii) Zygotene of meiosis **I**

(iv) Pachytene of meiosis **I**

Question 7:

Describe the following:

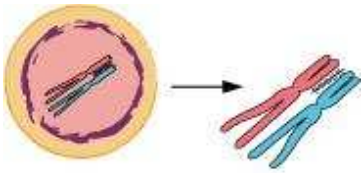
(a) synapsis (b) bivalent (c) chiasmata

Draw a diagram to illustrate your answer.

Answer

(a) Synapsis

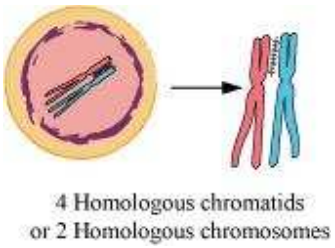
The pairing of homologous chromosomes is called synapsis. This occurs during the second stage of prophase **I** or zygotene.



Synapsis: pairing of homologous chromosomes

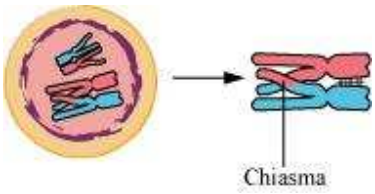
(b) Bivalent

Bivalent or tetrad is a pair of synapsed homologous chromosomes. They are formed during the zygotene stage of prophase **I** of meiosis.



(c) Chiasmata

Chiasmata is the site where two sister chromatids have crossed over. It represents the site of cross-over. It is formed during the diplotene stage of prophase **I** of meiosis.



Question 8:

How does cytokinesis in plant cells differ from that in animal cells?

Answer

Cytokinesis in plant cells		Cytokinesis is animal cells	
(i)	The division of the cytoplasm takes place by cell plate formation.	**(i)**	The division of the cytoplasm takes place by cleavage.
(ii)	Cell plate formation starts at the centre of the cell and grows outward, toward the lateral walls.	**(ii)**	Cleavage starts at the periphery and then moves inward, dividing the cell into two parts.

Question 9:

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

Answer

(a) Spermatogenesis or the formation of sperms in human beings occurs by the process of meiosis. It results in the formation of four equal-sized daughter cells.

(b) Oogenesis or the formation of ovum in human beings occurs by the process of meiosis. It results in the formation of four daughter cells which are unequal in size.

Question 10:

Distinguish anaphase of mitosis from anaphase **I** of meiosis.

Answer

Anaphase of mitosis	**Anaphase I of meiosis**
Anaphase is the stage during which the centromere splits and the chromatids separate. The chromosomes move apart, toward the opposite poles. These chromosomes are genetically identical.	During anaphase **I**, the homologous chromosomes separate, while the chromatids remain attached at their centromeres. Hence, in anaphase **I**, the chromosomes of each bivalent pair separate, while the sister chromatids remain together.

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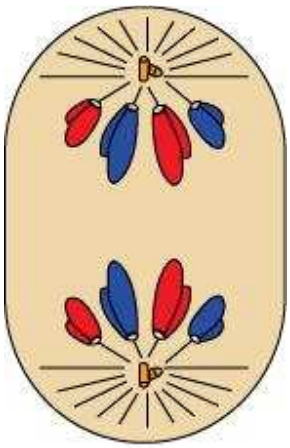
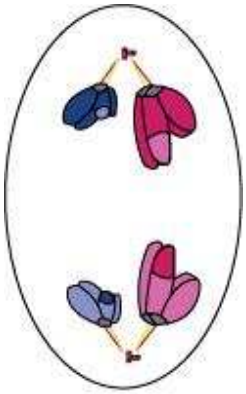
 Anaphase	 Anaphase

Question 11:

List the main differences between mitosis and meiosis.

Answer

Mitosis		**Meiosis**	
1.	In mitotic division, a single division results in two daughter cells.	**1.**	Meiotic division involves two successive divisions – meiosis **I** and meiosis **II**. These divisions result in four daughter cells.
2.	Mitosis is known as equational division. This is because the daughter cells have the same diploid number of chromosomes as the parent.	**2.**	Meiosis **I** is known as reductional division. This is because the chromosome number is reduced to half. Meiosis **II** is known as equational division. This is because the sister chromatids separate and the chromosome number remains the

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			same.
3.	Prophase is short and does not comprise any phase.	**3.**	Prophase **I** is very long and comprises 5 phases –leptotene, zygotene, pachytene, diplotene, and diakinesis.
4.	There is no pairing of chromosomes, crossing-over, or chiasmata-formation during prophase.	**4.**	In the zygotene stage of prophase, the pairing of chromosomes occurs. During pachytene, the crossing-over occurs. The chiasmata are formed in the diplotene stage.
5.	Synaptonemal complex is not formed.	**5.**	Synaptonemal complex is formed during the zygotene stage of prophase **I**.
6.	Anaphase involves the separation of the chromatids of each chromosome.	**6.**	During anaphase **I**, the homologous chromosomes separate, while the chromatids remain attached at their centromeres. During anaphase **II**, the chromatids separate as a result of the splitting of the centromere.
7.	Mitosis plays a significant role in the healing, repair, and growth of a cell.	**7.**	Meiosis brings about variation and maintains the chromosome number from generation to generation.

Question 12:

What is the significance of meiosis?

Answer

Meiosis is the process involving the reduction in the amount of genetic material. It comprises two successive nuclear and cell divisions, with a single cycle of DNA replication. As a result, at the end of meiosis **II**, four haploid cells are formed.

Significance of meiosis

1. Meiosis maintains the chromosome number from generation to generation. It reduces the chromosome number to half so that the process of fertilisation restores the original number in the zygote.

2. Variations are caused by the cross-over and the random distribution of homologous chromosomes between daughter cells. Variations play an important role in evolution.

3. Chromosomal mutations are brought about by the introduction of certain abnormalities. These chromosomal mutations may be advantageous for an individual.

Question 13:

Discuss with your teacher about

(i) haploid insects and lower plants where cell-division occurs, and

(ii) some haploid cells in higher plants where cell-division does not occur.

Answer

(i) In some insects and lower plants, fertilization is immediately followed by zygotic meiosis, which leads to the production of haploid organisms. This type of life cycle is known as haplontic life cycle.

(ii) The phenomenon of polyploidy can be observed in some haploid cells in higher plants in which cell division does not occur. Polyploidy is a state in which cells contain multiple pairs of chromosomes than the basic set. Polyploidy can be artificially induced in plants by applying colichine to cell culture.

Question 14:

Can there be mitosis without DNA replication in S phase?

Answer

Mitotic cell division cannot take place without DNA replication in S phase. Two important events take place during S phase – one is the synthesis or duplication of DNA and the other is the duplication of the centriole. DNA duplication is important as it maintains the chromosome number in the daughter cells. Mitosis is an equational division. Therefore, the duplication of DNA is an important step.

Question 15:

Can there be DNA replication without cell division?

Answer

There can be DNA replication without cell division. During cell division, the parent cell gets divided into two daughter cells. However, if there is a repeated replication of DNA without any cell division, then this DNA will keep accumulating inside the cell. This would increase the volume of the cell nucleus, thereby causing cell expansion. An example of DNA duplication without cell division is commonly observed in the salivary glands of *Drosophila*. The chromosome undergoing repeated DNA duplication is known as polytene chromosome.

Question 16:

Analyse the events during every stage of cell cycle and notice how the following two parameters change

(i) Number of chromosomes (N) per cell

(ii) Amount of DNA content (C) per cell

Answer

During meiosis, the number of chromosomes and the amount of DNA in a cell change.

(i) Number of chromosomes (N) per cell

During anaphase **I** of the meiotic cycle, the homologous chromosomes separate and start moving toward their respective poles. As a result, the bivalents get divided into

two sister chromatids and receive half the chromosomes present in the parent cell. Therefore, the number of chromosomes reduces in anaphase **I**.

(ii) Amount of DNA content (C) per cell

During anaphase **II** of the meiotic cycle, the chromatids separate as a result of the splitting of the centromere. It is the centromere that holds together the sister chromatids of each chromosome. As a result, the chromatids move toward their respective poles. Therefore, at each pole, a haploid number of chromosomes and a haploid amount of DNA are present.

During mitosis, the number of chromosomes remains the same. The DNA duplicated in the S phase gets separated in the two daughter cells during anaphase. As a result, the DNA content (C) of the two newly-formed daughter cells remains the same.

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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 constitutents of the cell and eventually divides into two daughter cells.

Phases of cell cycle : < Interphase / M Phase (Mitosis phase)

Interphase :

- **G_1 Phase :** Cell metabolically active and grows continuously.
- **S Phase :** DNA synthesis occurs, DNA content increases from 2C to 4C. but the number of chromosomes remains same (2N).
- **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) : 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.

MITOSIS

Prophase : (i) Replicated chromosomes, each consisting of 2 chromatids, condense and become visible.

(ii) Microtubules are assembled into mitotic spindle.

(iii) Nucleolus and nuclear envelope disappear.

(iv) Centriole moves to opposite poles.

Metaphase : (i) Spindle fibres attached to kinetochores (small disc-shaped structures at the surface of centromers) of chromosomes.

(ii) Chromosomes line up at the equator of the spindle to form metaphase plate.

Anaphase : (i) Centromeres split and chromatids separate.

(ii) Chromatids move to opposite poles.

Telophase : (i) Chromosomes cluster at opposite poles.

(ii) Nuclear envelope assembles around chromosome cluster.

(iii) Nucleolus, golgi complex, ER reform.

Cytokinesis : Is the divison 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.

Significance of Mitosis :

1. Growth – addition of cells.
2. Maintenance of surface/volume ratio. Maintain Nucleo - cytoplasmic ratio
3. Maintenance of chromosome number.
4. Regeneration.
5. Reproduction in unicellular organisms.
6. Repair and wound healing.

Meiosis :

- Specialised kind of cell division that reduces the chromosome number by half, resulting in formation of 4 haploid daughter cells.
- Occurs during gametogenesis in plants and animals.
- Involves two sequential cycles of nuclear and cell division called Meiosis I and Meiosis II.
- Interphase occurs prior to meiosis which is similar to interphase of mitosis except the S phase is prolonged.
- 4 haploid daughter cells are formed.

Meiosis I

Prophase I : Subdivided into 5 phases.

Leptotene :

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

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.

Pachytene : Crossing over occurs between non-sister chromatids of homologous chromosomes.

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 **chaismata.**

Diakinesis : • Terminalisation of chaismata.

- 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 nucleolus reappear.
- Cytokinesis follows (diad of cells).

Interkinesis : Stage between two meiotic divisions. (meiosis I and meiosis II)

Meiosis II

Prophase II

- Nuclear membrane disappears.
- Chromosomes become compact.

Metaphase 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.

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

3. Maintenance of chromosomal number : By reducing the chromosome number in gametes. Chromosomal number is restored by fertilisation of gametes.

QUESTIONS

Very Short Answer Questions (1 mark each)

1. What are kinetochores ?

2. What is interkinesis ?

3. Why is mitosis called equational division ?

4. Name the stage of meiosis during which synaptonemal complex is formed.

5. What is G_0 phase of cell cycle ?

6. Where does mitosis take place in plants and animals?

Short Answer Questions-II (2 marks each)

7. Differentiate between cytokinesis of plant and animal cell.

8. What is chaismata ? 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-I (3 marks each)

14. Differentiate between mitosis and meiosis.

15. List the significance of mitosis.

16. Describe the following :

(a) Synapase

(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

18. What is cell cycle ? Explain the events occuring in this cycle.

ANSWERS

Very Short Answers (1 mark each)

1. Small disc-shaped structure at the surface of the centromeres.

2. The stage between two meiotic divisions.

3. The chromosome number in daughter cells is equal to that of the parent cell.

4. Zygotene.

5. Cells which enter a stage where they are metabolically active but no

longer proliferate.

6. Plants – Meristematic tissue; Animals - somatic cells.

Short Answers-II (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'.

Metaphase	**Metaphase I**
(a) Chromosome align along the equator of the cell. (b) Figure 10.2 (b) page 165, Text Book of Biology for Class XI.	a) Bivalent chromosomes arrange along the equatorial plane b) Figure 10.3, meta phase I page 169, NCERT Text Book of Biology for Class XI.

Short Answers-I (3 marks each)

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

14. Refer 'Points to Remember'.

15. Refer 'Points to Remember'.

16. Refer 'Points to Remember'.

Long Answers (5 marks each)

17. Refer 'Points to Remember'.

18. Refer 'Points to Remember'.