CHAPTER – 10

CELL CYCLE AND CELL DIVISION

EXERCISES

2 Mark Questions

Q1: What is G0 (quiescent phase) of cell cycle?

Answer: G0 phase is the phase of inactivation of cell cycle due to non-availability of mitogens and energy rich compounds. Cells in this stage remain metabolically active but no longer proliferate i.e., do not grow or differentiate unless called on to do so depending on the requirement of the organism. E.g., Nerve and heart cells of chordates are in permanent G0 phase.

Q2: Why is mitosis called equational division?

Answer: Mitosis is a type of cell division in which chromosomes replicate and become equally distributed in two daughter nuclei so that the daughter cells come to have the same number and type of chromosomes as present in parent cell. So mitosis is called as equational division.

Q3: 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) Cell division occurs in haploid insect, such as drones of honey bee and lower plant like gametophyte of algae, bryophytes, and pteridophytes.
(ii) Synergids and antipodals in embryo sac of ovule are haploid cells where cell division does not occur.

Q4: Can there be mitosis without DNA replication in S-phase?

Answer: No there cannot be any mitotic division without-DNA replication in 'S' phase.

4 Mark Questions

Q1: Distinguish cytokinesis from karyokinesis.

Answer: Differences between cytokinesis and karyokinesis are:

	Cytokinesis	Karyokinesis
(i)	Cytokinesis is the division of the cytoplasm of a cell.	Karyokinesis is the division of the nucleus of a cell.
(ii)	It occurs at the end of M-phase, after the nuclear division is over.	It occurs during M-phase of cell cycle before the cytokinesis begins to proceed.

Q2:Find examples where the four daughter cells from meiosis are equal in size and where they are found unequal in size.

Answer: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.

Q3:Analyse the events during every stage of ceil 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: Number of chromosomes and amount of DNA change during S-phase and anaphase of cell cycle. S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time the amount of DNA per cell doubles. If the initial amount of DNA is denoted as 2C then it increases to 4C. However, there is no increase in the chromosome number; if the cell had diploid or 2N number of chromosomes at G,, even after S phase the number of chromosomes remains the same, i.e., 2N.
In mitotic anaphase, number of chromosomes remains the same. It is only sister

chromatids which move towards their respective poles. DNA content remains unchanged. In anaphase I of meiosis, number of chromosomes are reduced to half, i.e., from 2N to IN and also DNA content decrease to one half i.e., from 4C to 2C. In anaphase II of meiosis II DNA content decreases to one half from 2C to 1C but chromosome number remain same.

Q4:Name the stage of cell cycle at which each 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 prophase I of meiosis 1
(iv) Pachytene of prophase I of meiosis I

Q5: State differences between the events of meiosis and mitosis.

Answer: Following are the differences

Attributes	**Mitosis**	**Meiosis**
Place of occurrence	Somatic cells	Germ cells
Nature of Organisms	A sexually and sexually reproducing organisms	Sexually reproducing organisms
Nuclear and cell division	One cycle	Two sequential cycles – Meiosis I & II
DNA replication	Once for each cell division	Once for two cell divisions
Duration of prophase	Short	Long
Nature of prophase	Simple	The first meiotic division is in

		comparison to prophase of mitosis
Cell division and chromosome division	Both divide once each	Two cell divisions, but one chromosome division
End product	Two cells	Four haploid cells

7 Mark Questions

Q1: Describe the following:
(a) Synapsis
(b) Bivalent
(c) Chiasmata
Draw a diagram to illustrate your answer.

Answer:

(a) Synapsis: During zygotene of prophase I stage homologou s chromosomes start pairing together and this process of association is called synapsis. Electron micrographs of this stage indicate that chromosome synapsis is accompanied by the formation of complex structure called synaptonemal complex.

(b) Bivalent: The complex formed by a pair of synapsed homologous chromosomes is called a bivalent or a tetrad i.e., 4 chromatids or a pair of chromosomes.

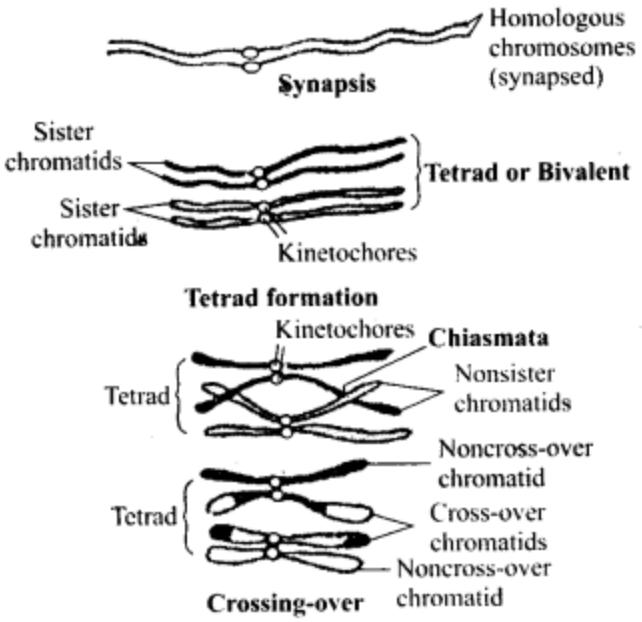


Fig.: Diagram showing synapsis, bivalent and chiasmata

(c) Chiasmata: The beginning of diplotene is recognized by the dissolution of the synaptonemal complex and the tendency of the synapsed homologous chromosomes of the bivalents to separate from each other except at the sites of crossovers. These points of attachment (X-shaped structures) between the homologous chromosomes are called chiasmata.

Q2: Can there be DNA replication without cell division?

Answer: Yes. Endomitosis is the multiplication of chromosomes present in a set in nucleus without karyokinesis and cytokinesis result-ing in numerous copies within each cell. It is of 2 types.

Polyteny: Here chromosomes divide and redivide without separation of chromatids so that such chromosomes become multistranded with many copies of DNA. Such polytene (many stranded) chromosomes remain in permanent prophase stage and do not undergo cell cycle e.g., polytene (salivary glands) chromosome of Drosophila has 512- 1024 chromatids. Here number of sets of chromosomes does not change.

Polyploidy (endoduplication) : Here all chromosomes in a set divide and its chromatids separate but nucleus does not divide. This results in an increase in number of sets of chromosomes in the nucleus (4x, 8x….). This increase in sets of

chromosomes is called polyploidy. It can be induced by colchicine and granosan. These chromosomes are normal and undergo cell cycle.

Q3: List the main differences between mitosis and meiosis.

Answer: The differences are as follows:

Mitosis	**Meiosis**
Occurs in somatic cells	Occurs in germ cells
The number of chromosomes stays the same as the parent cell	The number of chromosomes gets halved in comparison to parent cells.
Two daughter cells are formed	Four daughter cells are formed
Chromosomes replicate before each mitotic division	Chromosomes do not replicate before each meiotic division

Q4: Distinguish anaphase of mitosis from anaphase I of meiosis.

Answer: Anaphase of mitosis : It is the phase of shortest duration. APC (anaphase promoting complex) develops. It degenerates proteins -binding the two chromatids in the region of centromere. As a result, the centromere of each chromosome divides. This converts the two chromatids into daughter chromosomes each being attached to the spindle pole of its side by independent chromosomal fibre. The chromosomes move towards the spindle poles with the centromeres projecting towards the poles and the limbs trailing behind. There is corresponding shortening of chromosome fibres. The two pole-ward moving chromosomes of each type remain attached to each other by interzonal fibres. Ultimately, two groups of chromosomes come to lie at the spindle poles.

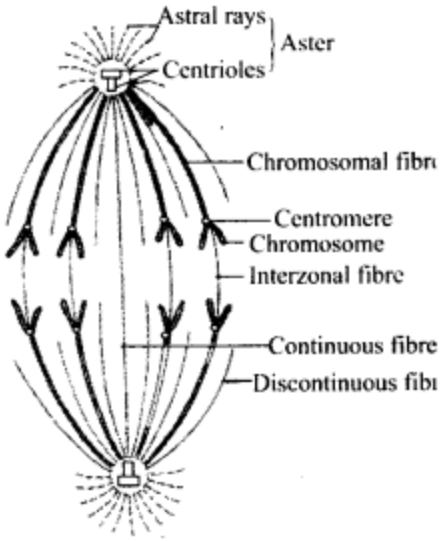


Fig.: Mitotic anaphase.

Anaphase I of meiosis : Chiasmata disappear completely and the homologous chromosomes separate. The process is called disjunction. The separated chromosomes (univalents) show divergent chromatids and are called dyads. They move towards the spindle poles and ultimately form two groups of haploid chromosomes.

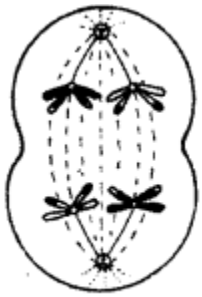


Fig.: Meiotic anaphase I

Q5: What is the significance of meiosis?

Answer:The significance of meiosis is given below:

(i) Formation of gametes – Meiosis forms gametes that are essential for sexual reproduction.

(ii) Genetic information – It switches on the genetic information for the development of gametes or gametophytes and switches off the sporophytic information. ‘

(iii) Maintenance of chromosome number – Meiosis maintains the fixed number of chromosomes in sexually reproducing organisms by halving the same. It is essential since the chromosome number becomes double after fertilisation.

(iv) Assortment of chromosomes – In meiosis paternal and maternal chromosomes assort independently. It causes reshuffling of chromosomes and the traits controlled by them. The variations help the breeders in improving the races of useful plants and animals.
(v) Crossing over – It introduces new combination of traits or variations.
(vi) Mutations – Chromosomal and genomic mutations can take place by irregularities of meiotic divisions. Some of these mutations are useful to the organism and are perpetuated by natural selection.
(vii) Evidence of basic relationship of organisms – Details of meiosis are essentially similar in the majority of organisms showing their basic similarity and relationship.

Q6:Describe the events taking place during the interphase.

Answer: The interphase, though called the resting phase, is metabolically quite active. It is the time during which the cell prepares itself for division by undergoing both cell growth and DNA replication in an orderly manner. The interphase is further divided into three phases:
• G1 (Gap 1) phase
• S (Synthesis) phase
• G2 (Gap 2) phase
G1 phase corresponds to the interval between mitosis of previous cell cycle and initiation of DNA replication. During G1 phase the cell is metabolically active and grows continuously but does not replicate its DNA S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time the amount of DNA doubles per cell. In animal cells, during the S phase, DNA replication occurs in the nucleus, and the centriole duplicates in the cytoplasm. During the G2 phase synthesis of DNA stops while cell growth continues with synthesis of protein and RNA in preparation for mitosis.

Multiple Choice Questions

1.**Meiosis occurs in organisms during**

a. Sexual reproduction

b. Vegetative reproduction

c. Both sexual and vegetative reproduction

d. None of the above

Answer: Sexual reproduction

4. Mitosis is characterised by

a. Reduction division

b. Equal division

c. Both reduction and equal division

d. Pairing of homologous chromosomes

Answer: Equal division

6. A bivalent of meiosis-I consists of

a. Two chromatids and one centromere

b. Two chromatids and two centromere

c. Four chromatids and two centromere

d. Four chromatids and four centromere

Answer: Four chromatids and two centromere

7. Cells which are not dividing are likely to be at

a. G1

b. G2

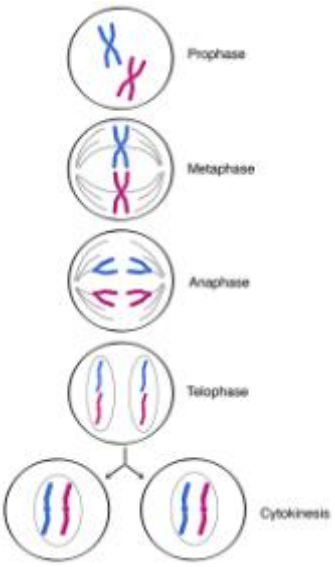
c. Go

d. S phase

Answer: Go

DIAGRAM

metosis



SUMMARY

According to the cell theory, cells arise from preexisting cells. The process by which this occurs is called cell division. Any sexually reproducing organism starts its life cycle from a single-celled zygote. Cell division does not stop with the formation of the mature organism but continues throughout its life cycle.

The stages through which a cell passes from one division to the next is called the cell cycle. Cell cycle is divided into two phases called (i) Interphase – a period of preparation for cell division, and (ii) Mitosis (M phase) – the actual period of cell division. Interphase is further subdivided into G1, S and G2. G1 phase is the period when the cell grows and carries out normal metabolism. Most of the organelle duplication also occurs during this phase. S phase marks the phase of DNA replication and chromosome duplication. G2 phase is the period of cytoplasmic growth. Mitosis is also divided into four stages namely prophase, metaphase, anaphase and telophase. Chromosome condensation occurs during prophase. Simultaneously, the centrioles move to the opposite poles. The nuclear envelope and the nucleolus disappear and the spindle fibres start appearing. Metaphase is marked by the alignment of chromosomes at the equatorial plate. During anaphase the centromeres divide and the chromatids start moving towards the two opposite poles. Once the chromatids reach the two poles, the chromosomal elongation starts, nucleolus and the nuclear membrane reappear. This stage is called the telophase. Nuclear division is then followed by the cytoplasmic division and is called cytokinesis. Mitosis thus, is the equational division in which the chromosome number of the parent is conserved in the daughter cell. In contrast to mitosis, meiosis occurs in the diploid cells, which are destined to form gametes. It is called the reduction division since it reduces the chromosome number by half while making the gametes. In sexual reproduction when the two gametes fuse the chromosome number is restored to the value in the parent. Meiosis is divided into two phases – meiosis I and meiosis II. In the first meiotic division the homologous chromosomes pair to form bivalents, and undergo crossing over. Meiosis I has a long prophase, which is divided further into five phases. These are leptotene, zygotene, pachytene, diplotene and diakinesis. During metaphase I the bivalents arrange on the equatorial plate. This is followed by anaphase I in which homologous chromosomes move to the opposite poles with both their chromatids.

Each pole receives half the chromosome number of the parent cell. In telophase I, the nuclear membrane and nucleolus reappear. Meiosis II is similar to mitosis. During anaphase II the sister chromatids separate. Thus at the end of meiosis four haploid cells are formed.