Chapter 10
Cell Cycle and Cell Division Biology

Question 1:
What is the average cell cycle span for a mammalian cell?

Solution 1:
24 Hours.

Question 2:
Distinguish cytokinesis from karyokinesis.

Solution 2:
Differences between cytokinesis and karyokinesis are

Cytokinesis	Karyokinesis
(i) Cyto stands for cytoplasm and kinesis for division. So cytokinesis is the division of cytoplasm.	Karyon stands for nucleus and kinesis stands for division. So karyokinesis is the division of the nucleus. Karyokinesis precedes cytokinesis.
(ii) It occurs at the end of M-phase, after the nuclear division is over.	It occurs during M-phase of cell cycle.

Question 3:
Describe the events taking place during inter-phase.

Solution 3:
The interphase is also known as the preparatory phase of cell cycle. During this period although the cell is said to be at resting phase, it 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 and sequential manner and it is completed in three steps.

- G1 (Gap 1) phase- It involves RNA and protein synthesis.
- S (Synthesis) phase – It involves DNA replication. During this time the amount DNA double per cell. In animal cells, during the S phase DNA replication occurs in the nucleus, and the centriole duplicates in the cytoplasm.
- G2 (Gap 2) phase – It also involves RNA and protein synthesis.

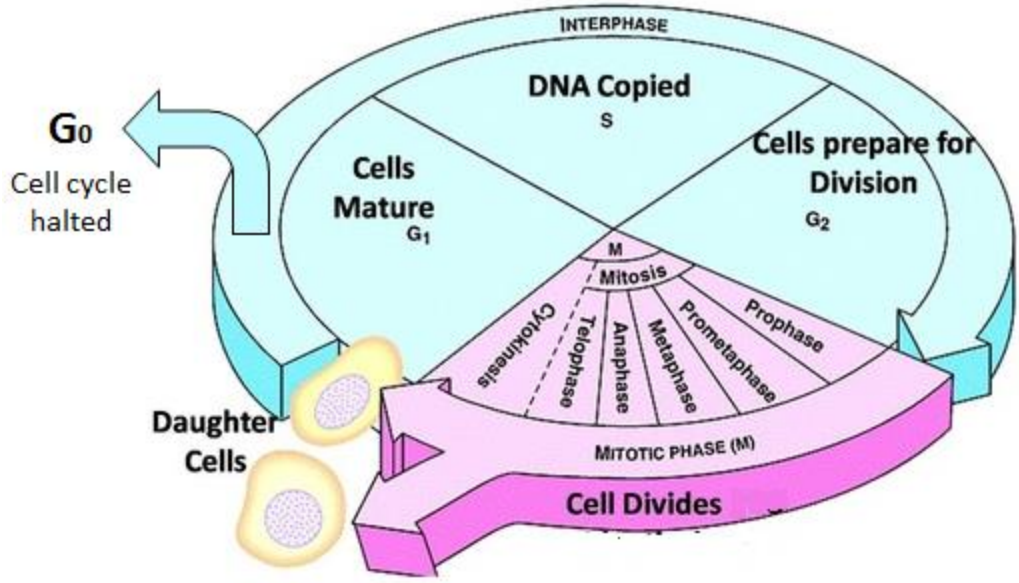


Diagram showing Interphase of cell cycle.

Question 4:

What is Go (quiescent phase) of cell cycle?

Solution 4:

Go 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 divide unless called on to do so depending on the requirement of the organism. E.g., Nerve and heart cells of chordates are in permanent Go phase.

Question 5:

Why is mitosis called equational division?

Solution 5:

Mitosis is 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 mother cell. So mitosis is called as equational division.

Question 6:

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.

Solution 6:

(i) Metaphase
(ii) Anaphase
(iii) Zygotene of prophase | of meiosis
(iv) Pachytene of prophase | of meiosis

Question 7:

Describe the following
(a) Synapsis
(b) Bivalent
(c) Chiasmata

Draw a diagram to illustrate your answer.

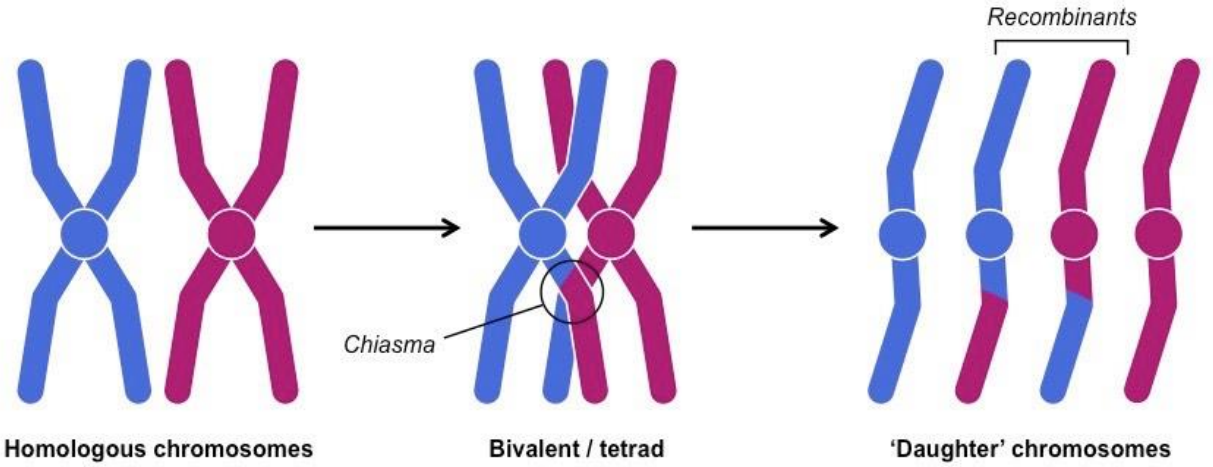
Solution 7:

(a) Synapsis:

During zygotene of prophase I of meiosis homologous 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 between the synapsed chromosomes. Pairing takes place in a zipper like fashion.

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. A bivalent has two centromeres and four chromatids.



(c) Chiasmata

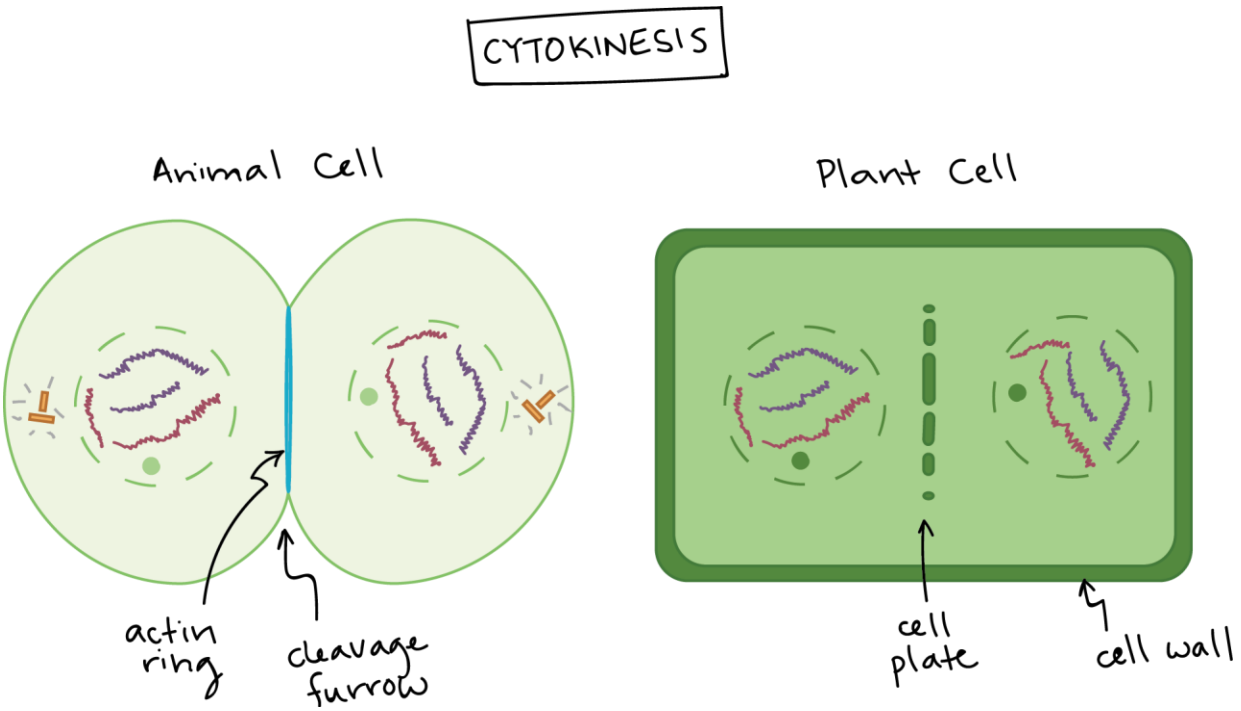
Chiasmata are cross like structures which appear in synapsed chromosomes. They represent sites at which crossing over has taken place. Crossing over is the exchange of gene segments between non sister chromatids of homologous chromosomes. Crossing over takes place at pachtene stage, however chiasmata is visible in diplotene stage of prophase 1 of meiosis.

Question 8:

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

Solution 8:

Cytokinesis in plant cells takes place by cell plate formation whereas in animal cells cytokinesis is accomplished by furrow formation. Plant cells have a rigid cell wall. So. In plant cells wall formation starts in the middle of the cell and grows outward to meet the existing lateral walls. This involves laying of cell plate which represents middle lamella between the cell walls of adjacent cells. Cell plate grows centrifugally. Animal cells lack cell wall. Therefore cytokinesis involves formation of a furrow in the cell membrane. This grows centripetally and joins ultimately in the centre of the cell and cytoplasm is divided into two.



Question 9:
Find examples where the four daughter cells from meiosis are equal in size and where they are found unequal in size.

Solution 9:
During formation of male gametes (i.e., spermatozoa) in a 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 human being, the four daughter cells unequal in size.

Question 10:
Can there be DNA replication without cell division?

Solution 10:
Yes. Endomitosis is the multiplication of chromosomes present in a set in a set in nucleus without karyokinesis and cytokinesis resulting 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. 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 (alkaloid obtained from *Colchicum autumnale* (family –liliaceae). These chromosomes are normal and undergo cell cycle.

Question 11:

List the main differences between mitosis and meiosis.

Solution 11:

	Mitosis	Meiosis
(i)	It occurs in all somatic cells and may continue throughout life.	It occurs in reproductive cells at specific times.
(ii)	It involves a single division, resulting in two daughter cells only.	It involves two successive divisions, resulting in four daughter cells.
(iii)	Subsequent mitotic divisions are similar to the earlier ones	Two meiotic divisions are dissimilar, first is reductional while the second is equational.
(iv)	Prophase is relatively short and simple.	Prophase I is very long and elaborate, comprising 5 subphases ie. Leptotene, zygotene, pachytene, diplotene and diakinesis.
(v)	There is no pairing of homologous chromosomes.	Homologous chromosomes pair and often undergo crossing over in prophase I.
(vi)	Chromatids are genetically similar to chromosomes they arise from.	Chromatids may differ genetically from the chromosomes they arise from due to crossing over.
(vii)	No synaptonemal complex formed.	Synaptonemal complex forms between synapsed homologous chromosomes.

(viii)	Chromosomes do not unfold, and no transcription and protein synthesis occur in prophase.	Chromosomes unfold, and transcription and protein synthesis may occur in diplotene of prophase I (oocytes of certain animals).
(ix)	Daughter cells have diploid number (2N) of chromosomes like the parent cell.	Daughter cells have haploid number (N) of chromosomes unlike the parent cell.

Question 12:

Distinguish anaphase of mitosis from anaphase 1 of meiosis.

Solution 12:

During anaphase of mitosis, chromatids separate from each other, whereas during anaphase I of meiosis the synapsed homologous chromosomes separate from each other.

It is important to recollect here that during metaphase stage of prophase chromosomes lie on the equator with their centromere lying on the metaphase plate. During anaphase the centromere divides and the chromatids move to opposite poles.

In the metaphase I of Meiosis the bivalents arrange themselves on the equator and centromeres of synapsed homologous chromosomes do not lie on the equator. Anaphase I involves separation of paired homologous chromosomes to the opposite poles of the equator.This is known as disjunction of chromosomes.

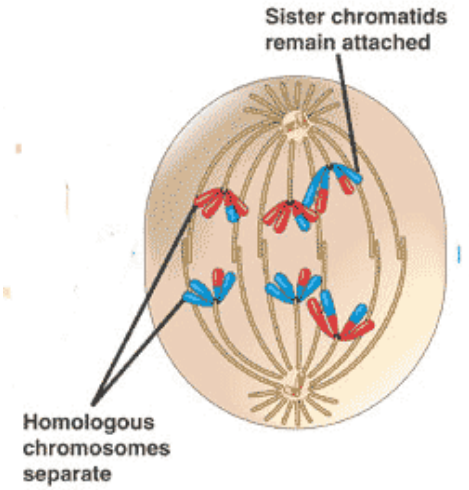


Diagram showing anaphase I of Meiosis

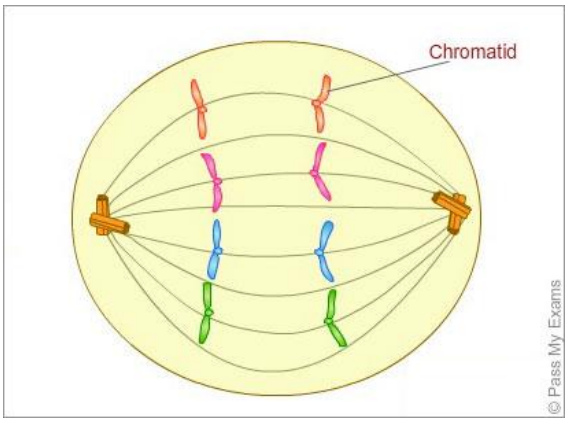


Diagram showing anaphase of Mitosis

Question 13:

What is the significance of meiosis?

Solution 13:

The significance of meiosis is given below:

(i) Formation of gametes – Meiosis forms gamete 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 saprophytic information.
(iii) Maintenance of chromosome number – meiosis maintains the fixed number of chromosomes in sexually reproducing organisms by producing gametes which have half of the chromosomes as compared to the mother cell.. It is essential since the chromosome number becomes double after fertilization
(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 domesticated ‘plants and animals.
(v) Crossing over – It leads to recombination of genes that brings about 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.

Question 14:

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.

Solution 14:

(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 the embryo sac of ovule are haploid cells where cell division does not occur.

Question 15:

Can there be mitosis without DNA replication in 'S' phase?

Solution 15:

No there cannot be any mitotic division without – DNA replication in 'S' phase.

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

Solution 16:

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 N. Also DNA content is decreased to 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.
