CHAPTER 10

# Cell Cycle and Cell Division

NCERT FOCUS

## ANSWERS

### Topic 1

**1.** Average cell cycle span of mammalian cell is 24 hours.

**2.** Differences between cytokinesis and karyokinesis are as follows:

| S.No. | 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. |
| (iii) | There is no such elaborate mechanism of equitable distribution of cell organelles. | There is disorganisation of nuclear envelope, appearance of already replicated chromosomes, their splitting and equitable distribution. |

**3.** 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 :

(i) $G_1$ (Gap 1) phase

(ii) S (Synthesis) phase

(iii) $G_2$ (Gap 2) phase

(i) $G_1$ phase corresponds to the interval between mitosis of previous cell cycle and initiation of DNA replication. During $G_1$ phase, the cell is metabolically active and grows continuously but does not replicate its DNA.

(ii) 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.

(iii) During the $G_2$ phase, synthesis of DNA stops while cell growth continues with synthesis of protein and RNA in preparation for mitosis.

**4.** $G_0$ 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 upon to do so depending on the requirement of the organism. *E.g.*, nerve and heart cells of chordates are in permanent $G_0$ phase.

**5.** 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 equational division.

**6.** Plant cytokinesis and animal cytokinesis differ in following aspects :

| S.No. | Plant cytokinesis | Animal cytokinesis |
|---|---|---|
| (i) | It usually occurs by cell plate method. | It takes place by cleavage furrow. |
| (ii) | The spindle usually persists during cytokinesis. | The spindle begins to degenerate soon after anaphase. |
| (iii) | Central part of spindle grows in size and forms an interdigited complex called phragmoplast. | A mid body of dense fibrous and vesicular material is formed in the middle. |
| (iv) | Vesicles derived from Golgi apparatus reach the equator of the phragmoplast and fuse to form cell plate and new cell membranes. | The event is absent in animal cytokinesis. |
| (v) | Cell plate grows centrifugally. | Cleavage progresses centripetally. |
| (vi) | The new cell membrane is derived from vesicles of Golgi apparatus. | The new cell membrane is usually derived from endoplasmic reticulum. |

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

**8.** Yes, endomitosis is the multiplication of chromosomes present 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* 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, and so on...). 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.

## Topic 2

**1.** (i) Metaphase
(ii) Anaphase
(iii) Zygotene of prophase-I of meiosis-I
(iv) Pachytene of prophase-I of meiosis-I

**2.** (a) Synapsis : During zygotene of prophase-I stage, 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.

(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.

(c) Chiasmata : The beginning of diplotene is recognised 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 point of attachment (X-shaped structures) between the homologous chromosomes are called chiasmata.

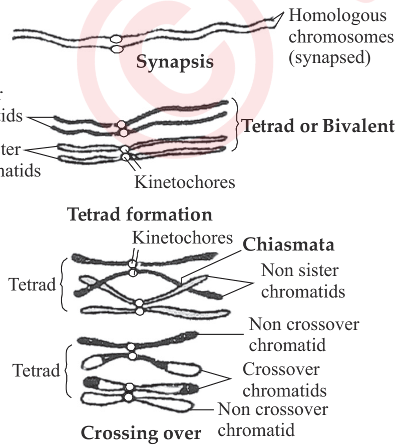


**Fig.:** Diagram showing synapsis, bivalent and chiasmat a

**3.** 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.

**4.** Anaphase of mitosis : It is the phase of shortest duration. APC (anaphase promoting complex) develops. It degenerates proteins-binding 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 poleward 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.

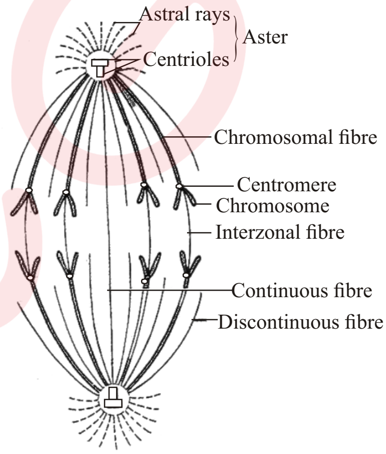


**Fig.:** Mitotic anaphase

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.

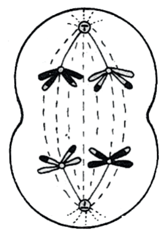

**Fig.:** Meiotic anaphase I

**5.** The differences between mitosis and meiosis are as follows:

| S.No. | Mitosis | Meiosis |
|---|---|---|
| (i) | It occurs in all somatic cells and may continue throughout life. | It occurs in reproductive cells and 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. |
| (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 forms. | 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. |

**6.** The significance of meiosis is as follows:
(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.

**7.** (i) Cell division occurs in haploid insects, such as drones of honeybee and lower plants 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.

**8.** 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 $G_1$, 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-I, number of chromosomes are reduced to half, *i.e.*, from 2N to 1N 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 remains same.