Cell Cycle and Cell Division Biology

10 Chapter

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

Ans. The average cell cycle span for a mammalian cell is 24 Hours.

2. Distinguish between cytokinesis and karyokinesis.

Ans. The differences between cytokinesis and karyokinesis are—

Cytokinesis	Karyokinesis
'Cyto'stands for the cytoplasm and kinesis for division. So, Cytokinesis is the physical method of cell division, where the cytoplasm of a parental cell is divided into two daughter cells.	Karyon denotes nucleus and kinesis denotes division. So karyokinesis is the physical method of the nucleus division. Karyokinesis precedes cytokinesis.
It occurs at the end of the M-phase after the nuclear division is over.	It takes place during the M-phase of the cell cycle.

3. Explain the events that take place throughout the inter-phase.

Ans.

- The interphase is also known as the preparatory phase of the cell cycle.
- During this period although the cell is said to be in a resting phase, it is metabolically quite active.
- It is the time during which the cell prepares itself for division by enduring both DNA replication and cell growth in a sequential and orderly manner and it is completed in three steps.

i. G_1 (Gap 1) phase- It involves RNA and protein synthesis.

ii. S (Synthesis) phase – It involves DNA replication. Throughout this time the amount of DNA double per cell. In animal cells, during the S phase DNA replication takes place in the nucleus, and the centriole replicates in the cytoplasm.

iii. G_2 (Gap 2) phase – It also involves RNA and protein synthesis.

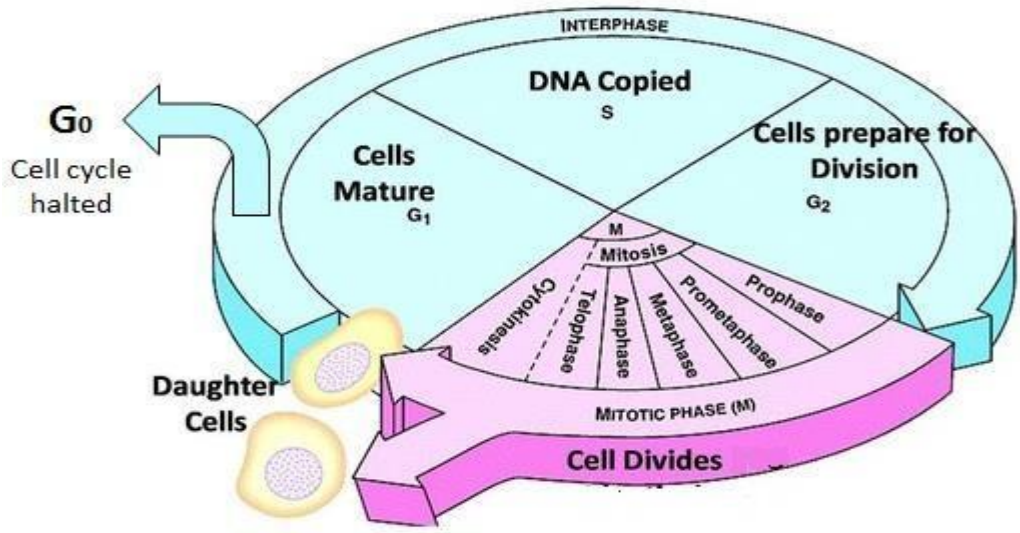


Diagram showing Interphase of the cell cycle

4. What is the Go (quiescent phase) of the cell cycle?

Ans.

- The go phase is the phase of inactivation of the cell cycle because of the non-availability of mitogens as well as energy-rich compounds.
- Cells in this phase remain metabolically active but no longer proliferate. i.e., do not split unless called on to do so dependent on the requirement of the organism.
- E.g., the Nerve and heart cells of chordates are in the permanent Go phase.

5. Why is mitosis called equational division?

Ans.

- 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 the mother cell.
- So, mitosis is called equational division.

6. Name the phase of the cell cycle at which each one of the following events takes place:

i. When chromosomes are transferred to the spindle equator.

Ans. Metaphase

ii. When centromere splits and chromatids separate.

Ans. Anaphase

iii. When a pairing between homologous chromosomes takes place.

Ans. Zygotene of prophase-I of meiosis

iv. When a crossing over among homologous chromosomes occurs.

Ans. Pachytene of prophase-I of meiosis

7. Describe the following.

(a) Synapsis

Ans.

- During zygotene of prophase-I of meiosis homologous chromosomes start pairing together and this process of association is called synapsis.
- Electron micrographs of this phase reveal that chromosome synapsis is accompanied by the formation of a complex structure known as synaptonemal complex among the synapsed chromosomes.
- Pairing is taking place in a zipper-like fashion.

(b) Bivalent

Ans.

- The complex established by a pair of synapsed homologous chromosomes

is known as a tetrad or a bivalent i.e., a pair of chromosomes or four chromatids.

- A bivalent contains two centromeres and four chromatids.

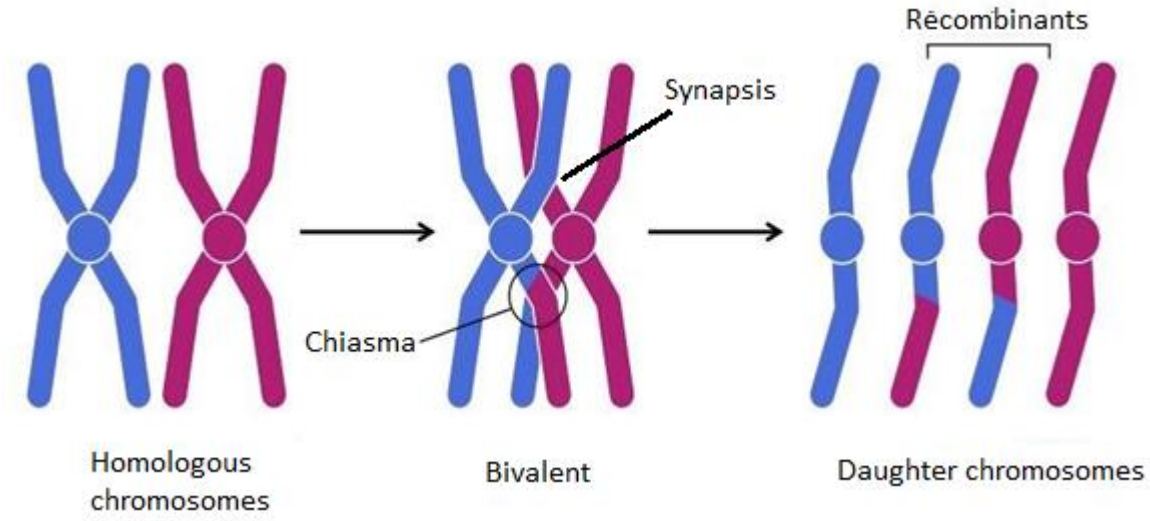
(c) Chiasmata

Ans.

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

Draw a diagram to illustrate your answer.

Ans. Following diagram shows the synapsis, bivalent and chiasma formation.



8. In what way does cytokinesis in animal cells vary from that in plant cells?

Ans.

- 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 cell wall development begins in the middle of the cell and develops outward to connect the existing lateral

walls.

- This involves the laying of a cell plate which characterises the middle lamella among the cell walls of adjacent cells.
- Cell plate develops centrifugally. Animal cells lack a cell wall. Hence cytokinesis involves the development of a furrow in the cell membrane. This grows centripetally and connects ultimately in the center of the cell and the cytoplasm is split into two.

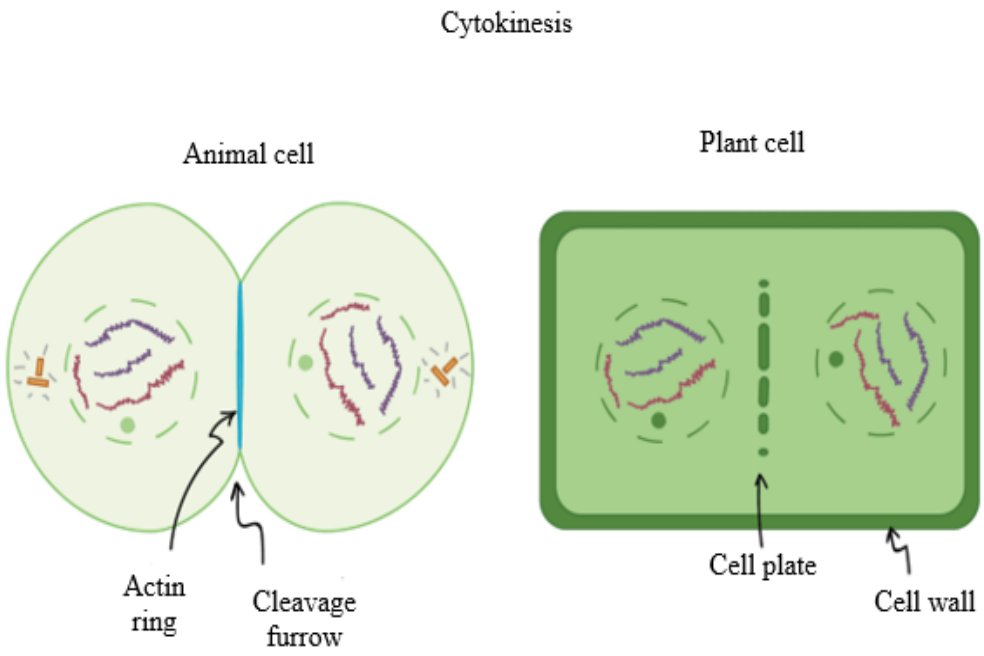


Diagram showing differences between animal and plant cell cytokinesis

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

Ans. During the formation of male gametes (i.e., spermatozoa) in a human being, the four daughter cells formed from meiosis are equal in size. Then, during the creation of a female gamete (i.e., ovum), in a human being, the four daughter cells are unequal in size.

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

Ans.

Anaphase of mitosis	Anaphase I of meiosis
1. The centromere of every chromosome divides.	1. The centromere do not divide.
2. Separation of sister chromatids takes place.	2. Homologous chromosomes are separated.
3. Only one chromatid of every chromosome moves to the pole.	3. Each homologous pair of chromosomes moves to the pole with both the chromatids.
4. The chromatids moving to one pole are genetically identical to those moving to the opposite pole.	4. The chromosomes moving to one pole are not genetically identical to those moving to the opposite pole.

11. List the main differences between mitosis and meiosis.

Ans.

Mitosis	**Meiosis**
It occurs in all somatic cells and may persist all over life.	It occurs in reproductive cells at specific times.
It involves a single division, which leads to two daughter cells only.	It involves two successive divisions, which leads to four daughter cells.
Consequent mitotic divisions are similar to the previous ones.	Two meiotic divisions are dissimilar, the first is reductional while the

	second is equational.
Prophase is relatively short and simple.	Prophase I is very long and elaborate, which comprises five subphases like leptotene, pachytene, zygotene, diplotene, and diakinesis.
There is no pairing of homologous chromosomes.	Homologous chromosomes pair and often undergo crossing over in prophase I.
Chromatids are genetically similar to the chromosomes they arise from.	Chromatids may vary genetically from the chromosomes they emerge from because of crossing over.
No synaptonemal complex formed.	Synaptonemal complex forms among synapsed homologous chromosomes.
Chromosomes do not unfold, and no protein synthesis and transcription take place in prophase.	Chromosomes unfold, n and protein synthesis and transcription may take place in diplotene of prophase I (oocytes of specific animals).
Daughter cells have a diploid number (2N) of chromosomes like the parent cell.	Daughter cells have a haploid number (N) of chromosomes, unlike the parent cell.

12. What is the significance of meiosis?

Ans. The significance of meiosis is given below:

- **Formation of gametes:** Meiosis forms gametes that are essential for sexual reproduction.
- **Genetic information:** It switches on the genetic information, for the development of gametophytes or gametes and switches off the saprophytic information.

- **Maintenance of chromosome number:** Meiosis maintains the fixed number of chromosomes in sexually reproducing organisms by producing gametes that have half of the chromosomes as compared to the mother cell. It is vital since the chromosome number develops into a double after fertilization
- **Assortment of chromosomes:** In meiosis maternal and paternal chromosomes separate independently. It leads to the reordering of chromosomes and the characteristics controlled by them. The variations help the breeders in enhancing the races of domesticated animals and plants.
- **Crossing over:** It leads to the recombination of genes that brings about variations.
- **Mutations:** Chromosomal and genomic mutations can occur by irregularities of meiotic divisions. Some of these mutations are useful to the organism and are propagated by natural selection.
- **Evidence of basic relationship of organisms:** Details of meiosis are basically similar in the vast majority of organisms indicating their basic resemblance and relationship.

13. Discuss with your teacher about:

i. Haploid insects and lower plants where cell division occurs, and

Ans. Cell division occurs in haploid insects, such as drones of the honey bee and lower plant-like gametophytes of algae, bryophytes, and pteridophytes.

ii. Some haploid cells in higher plants where cell division does not occur.

Ans. Synergids and antipodals in the embryo sac of the ovule are haploid cells where cell division does not occur.

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

Ans. 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.

15. Can there be DNA replication without cell division?

Ans. Yes, there can be DNA replication without involvement of cell division in a cell and one such condition existential is called as 'Polyteny'.
Polyteny basically occurs because of failure of separation of replicated strands of DNA repeatedly.
This failure results in formation of 'Giant Chromosomes' which can contain up to 1000 parallel attached chromatids in conspicuous pattern.
Polyteny can be easily observed in Order Diptera of Class Insecta of Phylum Arthropoda (eg- Drosophila Salivary glands).

16. Analyze events that took place during each phase of the cell cycle and observe in what way the following two parameters change.

i. Number of chromosomes (N) per cell.

Ans.

- In mitotic division, the number of chromosomes remains the same as the parent cell at prophase and metaphase. At the anaphase stage of mitosis when the sister chromatids separate and form two nucleus in telophase, each of them contains the same number of chromosomes as the parent cell.
- In meiotic division, the homologous chromosomes get separated into two different poles during anaphase-I. Thus, during prophase-I, metaphase-I and anaphase-I the cell contains the same chromosome number as the parent cell. As two separate nuclei are formed in telophase, each contains half the number of chromosomes compared to the parent cell.
- During meiosis-II, the sister chromatids are separated in anaphase-II. Thus the daughter cells retain their chromosome number the same as cells after meiosis I. So, the daughter cells contain N number of chromosome if the parent cell has ^{2}N chromosomes.

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

Ans.

- S or synthesis phase indicates the period during which DNA replication or synthesis takes place. Throughout this time the amount of DNA per cell becomes double.
- If the initial amount of DNA is signified as ^{2}C then it rises to ^{4}C. During prophase, metaphase and anaphase of mitosis, the DNA content remain ^{4}C.
- After the telophase, as the sister chromatids are separated into two separate nuclei, each nucleus contains ^{2}C amount of DNA same as the parent cell in G_1 phase.

- In meiosis, the daughter cells after first division contains volume of DNA which gets halved i.e., C after second division. ^{2}C