Revision Notes on Cell Cycle and Cell Division

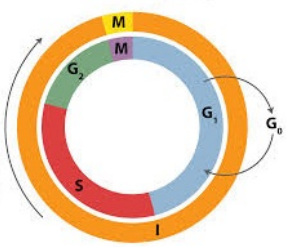
1. **Introduction:** It is the process by which a mature cell divides and forms two nearly equal daughter cells which resemble the parental cell in a number of characters.
2. **Discovery:** Prevost and Dumas (1824) first to study cell division during the cleavage of zygote of frog.
3. Nagelli (1846) was the first to propose that new cells are formed by the division of pre-existing cells.
4. Rudolf virchow (1859) proposed "omnis cellula e cellula" and "cell lineage theory".
5. A cell divides when it has grown to a certain maximum size which disturb the karyoplasmic index (KI)/Nucleoplasmic ratio (NP)/Kernplasm connection.
6. Two processes take place during cell reproduction.

- **Cell growth:** (Period of synthesis and duplication of various components of cell).
- **Cell division:** (Mature cell divides into two cells).

7. **Cell cycle:** Howard and Pelc (1953) first time described it. The sequence of events which occur during cell growth and cell division are collectively called cell cycle. Cell cycle completes in two steps:

- Interphase
- M-phase/Dividing phase

(i) Interphase : It is the period between the end of one cell division to the beginning of next cell division. It is also called resting phase or not dividing phase. But, it is actually highly metabolic active phase, in which cell prepares itself for next cell division. In case of human beings it will take approx 25 hours. Interphase is completed in to three successive stages.



(a) G_1 phase/Post mitotic/Pre-DNA synthetic phase/Gap I^{st}

(b) S-phase/Synthetic phase

(c) G_2-phase/Pre mitotic/Post synthetic phase/gap-II^{nd}

(ii) M-phase/Dividing phase/Mitotic phase

(a) Nuclear division i.e. karyokinesis occurs in 4 phases – prophase, metaphase, anaphase and telophase. It takes 5-10% (shortest phase) time of whole division.

(b) Cytokinesis : Division of cytoplasm into 2 equal parts. In animal cell, it takes place by cell furrow method and in plant cells by cell plate method.

8. **Duration of cell cycle:** It depends on the type of cell and external factors such as temperature, food and oxygen. Time period for G_1, S, G_2 and M-phase is species specific under specific environmental conditions. e.g. 20 minutes for bacterial cell, 8-10 hours for intestional epithelial

cell, and onion root tip cells may take 20 hours.

9. **Regulation of cell cycle:** Stage of regulation of cell cycle is G_1 phase during which a cell may follow one of the three options.

- It may start a new cycle, enter the S-phase and finally divide.
- It may be arrested at a specific point of G_1 phase.
- It may stop division and enter G_0 quiscent stage. But when conditions change, cell in G_0 phase can resume the growth and reenter the G_1 phase.

10. Cell division is of three types, Amitosis, Mitosis and Meiosis.

11. Difference between cell Mitosis and Meiosis

S.No	Characters	Mitosis	Meiosis
I. General			
(1)	Site of occurrence	Somatic cells and during the multiplicative phase of gametogenesis in germ cells.	Reproductive germ cells of gonads.
(2)	Period of occurrence	Throughout life.	During sexual reproduction.
(3)	Nature of cells	Haploid or diploid.	Always diploid.
(4)	Number of divisions	Parental cell divides once.	Parent cell divides twice.
(5)	Number of daughter cells	Two.	Four.
(6)	Nature of daughter cells	Genetically similar to parental cell. Amount of DNA and chromosome number is same as in parental cell.	Genetically different from parental cell. Amount of DNA and chromosome number is half to that of parent cell.
II. Prophase			
(7)	Duration	Shorter (of a few hours) and simple.	Prophase-I is very long (may be in days or months or years) and complex.
(8)	Subphases	Formed of 3 subphases : early-prophase, mid-prophase and late-prophase.	Prophase-I is formed of 5 subphases: leptotene, zygotene, pachytene, diplotene and diakinesis.
(9)	Bouquet stage	Absent.	Present in leptotene stage.
(10)	Synapsis	Absent.	Pairing of homologous chromosomes

	Synapsis	Absent.	Pairing of homologous chromosomes in zygotene stage.
(11)	Chiasma formation and crossing over.	Absent.	Occurs during pachytene stage of prophase-I.
(12)	Disappearance of nucleolus and nuclear membrane	Comparatively in earlier part.	Comparatively in later part of prophase-I.
(13)	Nature of coiling	Plectonemic.	Paranemic.
III. Metaphase			
(14)	Metaphase plates	Only one equatorial plate	Two plates in metaphase-I but one plate in metaphase-II.
(15)	Position of centromeres	Lie at the equator. Arms are generally directed towards the poles.	Lie equidistant from equator and towards poles in metaphase-I while lie at the equator in metaphase-II.
(16)	Number of chromosomal fibres	Two chromosomal fibre join at centromere.	Single in metaphase-I while two in metaphase-II.
IV. Anaphase			
(17)	Nature of separating chromosomes	Daughter chromosomes (chromatids with independent centromeres) separate.	Homologous chromosomes separate in anaphase-I while chromatids separate in anaphase in anaphase-II.
(18)	Splitting of centromeres and development of inter-zonal fibres	Occurs in anaphase.	No splitting of centromeres. Inter-zonal fibres are developed in metaphase-I.
V. Telophase			
(19)	Occurrence	Always occurs	Telophase-I may be absent but telophase-II is always present.
VI. Cytokinesis			
(20)	Occurrence	Always occurs	Cytokinesis-I may be absent but cytokinesis-II is always present.
(21)	Nature of daughter cells	2N amount of DNA than 4N amount of DNA in parental cell.	1 N amount of DNA than 4 N amount of DNA in parental cell.
(22)	Fate of daughter cells	Divide again after interphase.	Do not divide and act as gametes.
VII. Significance			

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(23)	Functions	Helps in growth, healing, repair and multiplication of somatic cells. Occurs in both asexually and sexually reproducing organisms.	Produces gametes which help in sexual reproduction.
(24)	Variations	Variations are not produced as it keeps quality and quantity of genes same.	Produces variations due to crossing over and chance arrangement of bivalents at metaphase-I.
(25)	In evolution	No role in evolution.	It plays an important role in speciation and evolution.

12. **Types of Mitosis**

- **Anastral mitosis:** It is found in plants in which spindle has no aster.
- **Amphiastral mitosis:** It is found in animals in which spindle has two asters, one at each pole of the spindle. Spindle is barrel-like.
- **Intranuclear or Promitosis:** In this nuclear membrane is not lost and spindle is formed inside the nuclear membrane e.g. Protozoans (Amoeba) and yeast. It is so as centriole is present within the nucleus.
- **Extranuclear or Eumitosis:** In this nuclear membrane is lost and spindle is formed outside nuclear membrane e.g. in plants and animals.
- **Endomitosis:** Chromosomes and their DNA duplicate but fail to separate which lead to polyploidy e.g. in liver of man, both diploid (2N) and polyploid cells (4N) have been reported. It is also called endoduplication and endopolyploidy.
- **Dinomitosis:** In which nuclear envelope persists and microtubular spindle is not formed. During movement the chromosomes are attached with nuclear membrane.

13. **Types of meiosis:** On the basis of time and place, meiosis is of three types

- **Gametic/Terminal meiosis:** In many protozoans, all animals and some lower plants; meiosis takes place before fertilization during the formation of gametes. Such meiosis is described as gametic or terminal.
- **Zygotic or Initial Meiosis:** In fungi, certain protozoan groups, and some algae fertilization is immediately followed by meiosis in the zygote, and the resulting adult organisms are haploid. Such a meiosis is said to be zygotic or initial. This type of life cycle with haploid adult and zygotic meiosis is termed the haplontic cycle.
- **Sporogenetic Meiosis**

(a) Diploid sporocytes or spore mother cells of sporophytic plant, undergo meiosis to form the haploid spores in the sporangia.

(b) Haploid spore germinates to form haploid gametophyte which produces the haploid gametes by mitosis.

(c) Haploid gametes fuse to form diploid zygote which develops into diploid sporophyte by mitotic

divisions. e.g. in higher plants like pteridophytes, gymnosperms and angiosperms.