CELL CYCLE

M.Sc.-Sem-II
(2023-25)

MBOTCC-10
Unit-II

Introduction:

Cell cycle can be considered as a complex series of phenomena by which the cellular material divides equally between the daughter cells. A growing cell undergoes a cell cycle which comprises two phases: Interphase (the preparatory phase for cell division) and Period of Division (Mitosis/Meiosis). Cells spend most of their life span in interphase which is a period of intense biosynthetic activity. During this interphase cell duplicates its genetic complement (chromosomes and genes) while cell division is only the final and microscopically visible phase in an underlying change that has occurred at the molecular level. Thus, cell division can be considered as the final separation of the already duplicated molecular units (DNA/genes/chromosomes).

Mammalian nerve cells (neurons) do not divide at all after birth. Thus, for a human neuron Interphase lasts for the entire life span of an individual.

Phases of the cell cycle:

(i) Most cells divide one or several times during their life time.

(ii) While doing so, they undergo an ordered sequence of events that collectively forms the cell cycle.

(iii) Duration of the cell cycle varies greatly from one cell to another. The shortest cell cycle occurs in early embryo and can last as little as

...Contd.p.2

eight minutes.

The cell cycle of growing eukaryotic cells lasts from 9b minutes to more than 24 hours, its duration varying considerably within a population of cells.

(iv) Cell cycle of the eukaryotic cell is divided into two fundamental parts: Interphase and Mitosis.

During interphase several changes take place at the molecular level that are not visible microscopically. The cell duplicates precisely its genetic complement (DNA). Interphase thus takes major duration of the cell cycle and mitosis is usually accomplished in a matter of hour.

Periods of the Interphase:

Interphase consists of three successive sub-phases or periods G_1, S and G_2 and it normally comprises 90% or more of the total duration of the cell cycle.

G stands for the Gap and S for synthesis. Thus G_1 represents the first gap between the preceding division and the period of DNA synthesis (S) while G_2 denotes the second gap between the DNA synthesis and the onset of mitosis.

G_1 Period:

(i) This is the period between the end of telophase of the preceding cell division and the onset of DNA synthesis (S) for the next division.

(ii) G_1 is usually longer and varies widely among different organisms.

(iii) Generally S, G_2 and mitosis are relatively constant in the cells of the same organism. But G_1 period is most variable in length. It may constitute 25-50% of the total

...Contd. p.3

interphase duration.

- In some cells, G1 may be very short or absent.

- Depending on the physiological condition, the cell may retain in G1 period for days, months or years.

(iv) Cells which have stopped growing also become arrested at a specific point of G1 (eg., liver cells, lymphocytes). Arrested cells can be induced to divide again.

(v) Intensive cellular synthesis takes place during G1 period.

- Mitochondria, chloroplasts, ER, lysosomes, Golgi apparatus, vacuoles and vesicles are produced at G1.

(vi) In cells preparing for cell division there is a marked synthesis of mRNA, tRNA and proteins during G1.

(vii) Enzymes and substrates necessary for DNA synthesis during S period are also synthesized during G1.

(viii) Nucleolus produces rRNA and ribosomes are synthesized. This is necessary for the entry of cells into mitosis.

- As a whole, cellular metabolism is at a very high rate.

(ix) Commitment to DNA replication in S period takes place in G1.

If the nutritional status of the cell is appropriate, this commitment is fulfilled in S period.

G0 State :

(i) Some cells do not divide at all and are considered to have indefinitely withdrawn from the cell cycle into another state, resembling G1 but distinct from it

... Contd. p. 4

because they are unable to enter S phase.

Thus, cells are arrested to non-cycling state which is called G_0 State. Neurons are the most common examples.

(ii) But certain cell types can be stimulated to leave G_0 and re-enter a cell cycle. For example, liver cells normally neither grow nor divide, but liver damage rapidly induces them to divide. Reactivation into the cell cycle takes place effectively at an early part of G_1.

— Yeast cells starved of nutrients or mammalian cells deprived of growth factors get arrested early in G_1 in the state G_0.

(iii) G_0 cells usually contain fewer ribosomes and less RNA than the corresponding cycling G_1 cells, and they synthesize proteins at rates less than half the rate in G_1 cells.

S Period :

(i) This is the intermediate phase between G_1 and G_2.

(ii) It is a highly specialized period of interphase during which DNA synthesis takes place. Before a cell can divide, it must produce a new copy of DNA in each chromosome and assembly of a new set of chromosomal proteins onto the DNA to form chromatin.

(iii) By the end of S period, each chromosome in a cell has been copied to two complete chromatids which remain joined together at their centromeres until the M phase (Mitosis or Meiosis).

G_2 Period :

(i) This is the period from the end of S phase and onset of mitosis.

(ii) This is usually the shortest period of interphase.

... Contd. p. 5

(iii) Intensive cellular synthesis occurs during this period.

(iv) Mitochondria and chloroplasts divide.

– Energy storage increases and mitotic spindle begins at preliminary stages.

Control Points (= Check Points) during the cell cycle :

(i) There are two control points such as G_1/S and G_2/M at which cell takes a decision on whether to proceed or not to the next step. They are also known as Check points.

– These control points or check points provide an opportunity for the cells to ensure:

- Whether all conditions are favourable for DNA replication or not ?
- Whether the cytoplasmic mass has increased to a level adequate for division or not ?
- Whether DNA replication is completed and DNA is unaltered and undamaged ?

If the check points do not give any green signal, the cells may halt in G_1/S or G_2/M to rectify the anomalies/deficiencies, if any.

(fig. below)

—— X ——

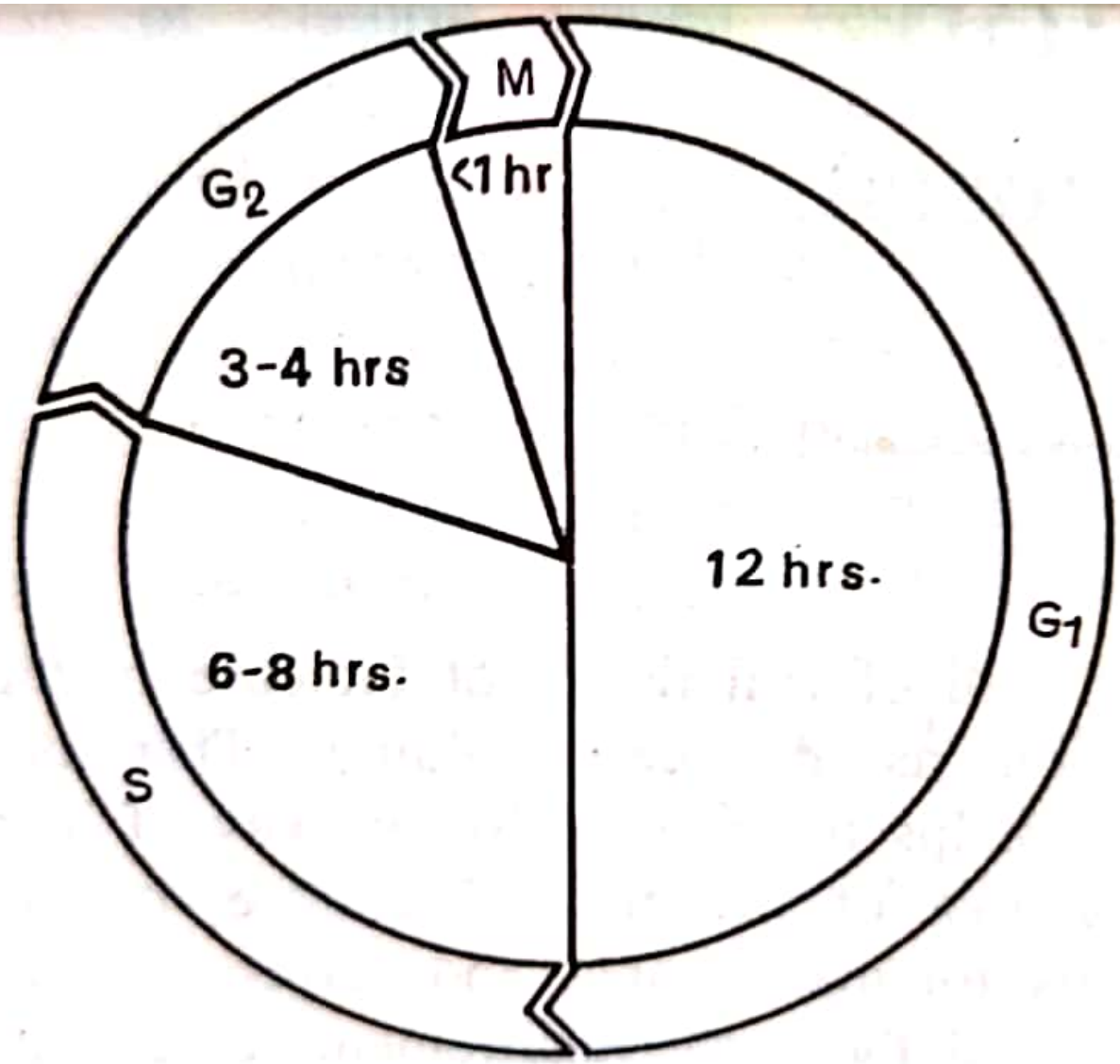

Fig. 17.1. Diagrammatic representation of cell cycle of mouse L cells doubling every 24 hours (redrawn from Lewin's *Gene Expression-2*).