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CELL CYCLE

AND

CELL DIVISION

CELL CYCLE

The sequence of events by which a cell duplicates its genome, synthesises the other constituents of the cell and eventually divides into two daughter cells is termed cell cycle.

cell growth is a continuous process, DNA synthesis occurs only during one specific stage in the cell cycle.

The replicated chromosomes (DNA) are then distributed to daughter nuclei by a complex series of events during cell division.

Phases of Cell Cycle

The cell cycle is divided into two basic phases:

Interphase

M Phase (Mitosis phase

The M Phase represents the phase when the actual cell division or mitosis occurs and the interphase represents the phase between two successive M phases

The M Phase starts with the nuclear division, corresponding to the separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm (cytokinesis). The interphase, though called the resting phase.

The interphase is divided into three further phases:

1 G_1 phase (Gap 1)

2 S phase (Synthesis)

3 G_2 phase (Gap 2)

G_1 phase corresponds to the interval between mitosis and initiation of DNA replication. During G_1 phase the cell is metabolically active and continuously grows but does not replicate its DNA.

S or synthesis phase marks the period during which DNA synthesis or replication takes place. 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.

G_2 phase, proteins are synthesised in preparation for mitosis while cell growth continues.

Quiescent stage

Some cells in the adult animals do not appear to exhibit division. These cells that do not divide further exit G_1 phase to enter an inactive stage called quiescent stage (G_0) of the cell cycle.

M PHASE

The number of chromosomes in the parent and progeny cells is the same, it is also called as equational division.

Mitosis has been divided into four stages of nuclear division (karyokinesis).

Karyokinesis involves following four stages:

1 Prophase

2 Metaphase

3 Anaphase

4 Telophase

Prophase

Prophase is the first stage of karyokinesis of mitosis. Prophase is marked by the initiation of condensation of chromosomal material.

Chromosomal material condenses to form compact mitotic chromosomes. Chromosomes are seen to be composed of two chromatids attached together at the centromere.

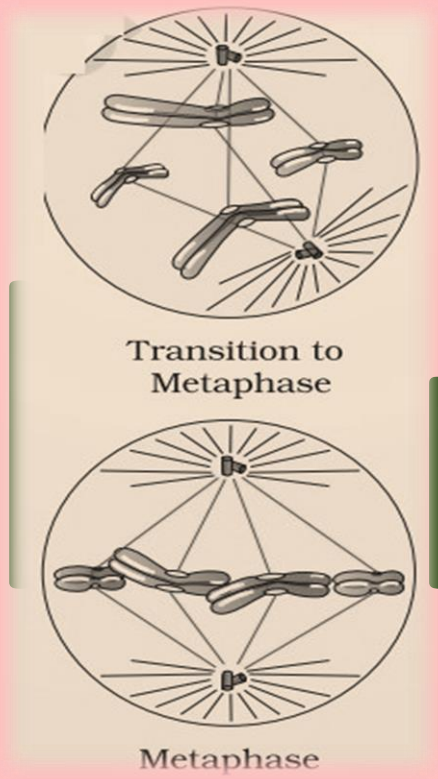
Centrosome which had undergone duplication during interphase, begins to move towards opposite poles of the cell.

Each centrosome radiates out microtubules called asters. The two asters together with spindle fibres forms mitotic apparatus.

Metaphase

the metaphase is characterised by all the chromosomes coming to lie at the equator with one chromatid of each chromosome connected by its kinetochore to spindle fibres from one pole and its sister chromatid connected by its kinetochore to spindle fibres from the opposite pole.

The plane of alignment of the chromosomes at metaphase is referred to as the metaphase plate.



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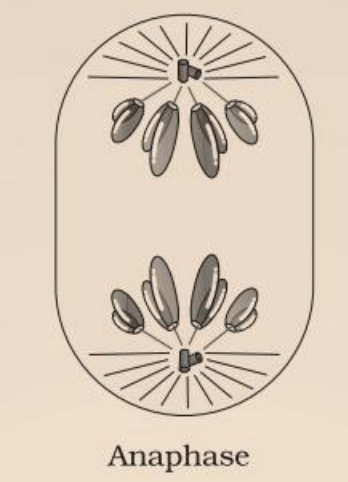
<u>Anaphase</u>

Each chromosome arranged at the metaphase plate is split simultaneously and the two daughter chromatids, now referred to as daughter chromosomes of the future daughter nuclei, begin their migration towards the two opposite poles.

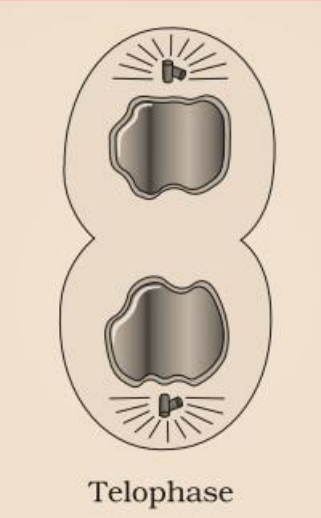
As each chromosome moves away from the equatorial plate, the centromere of each chromosome remains

directed towards the pole and hence at the leading edge, with the arms of the chromosome trailing behind.



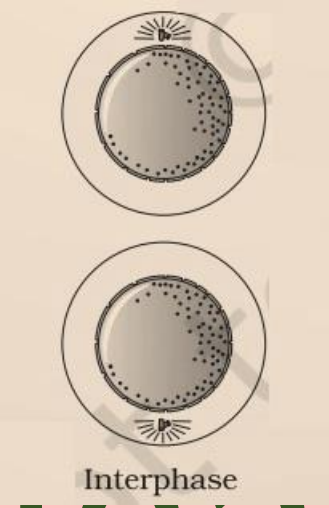
Telophase

In telophase, the chromosomes that have reached their respective poles decondense and lose their individuality. The individual chromosomes can no longer be seen and each set of chromatin material tends to collect at each of the two poles.



Cytokinesis

Mitosis accomplishes not only the segregation of duplicated chromosomes into daughter nuclei (karyokinesis), but the cell itself is divided into two daughter cells by the separation of cytoplasm called cytokinesis at the end of which cell division gets completed.



MEIOSIS

The production of offspring by sexual reproduction includes the fusion of two gametes, each with a complete haploid set of chromosomes. Gametes are formed from specialised diploid cells.

This specialised kind of cell division that reduces the chromosome number by half results in the production of haploid daughter cells. This kind of division is called meiosis.

Meiosis involves two sequential cycles of nuclear and cell division called meiosis I and meiosis II but only a single cycle of DNA replication.

Meiosis I

Prophase I

Prophase of the first meiotic division is typically longer and more complex when compared to prophase of mitosis. It has been further subdivided into the following five phases based on chromosomal behaviour, i.e., Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

Leptotene stage the chromosomes become gradually visible under the light microscope. The compaction of chromosomes continues throughout leptotene.

Zygotene stage chromosomes start pairing together and this process of association is called synapsis. Such paired chromosomes are called homologous chromosomes. chromosome synapsis is accompanied by the formation of complex structure called synaptonemal complex. The complex formed by a pair of synapsed homologous chromosomes is called a bivalent or a tetrad.

Pachytene stage, the four chromatids of each bivalent chromosomes becomes distinct and clearly appears as tetrads. This stage is characterised by the appearance of recombination nodules, the sites at which crossing over occurs between non-sister chromatids of the homologous chromosomes.

Diplotene is recognised by the dissolution of the synaptonemal complex and the tendency of the recombined homologous chromosomes of the bivalents to separate from each other except at the sites of crossovers. These X-shaped structures, are called chiasmata.

Diakinesis phase the chromosomes are fully condensed and the meiotic spindle is assembled to prepare the homologous chromosomes for separation. By the end of diakinesis, the nucleolus disappears and the nuclear envelope also breaks down. Diakinesis represents transition to metaphase

Metaphase I

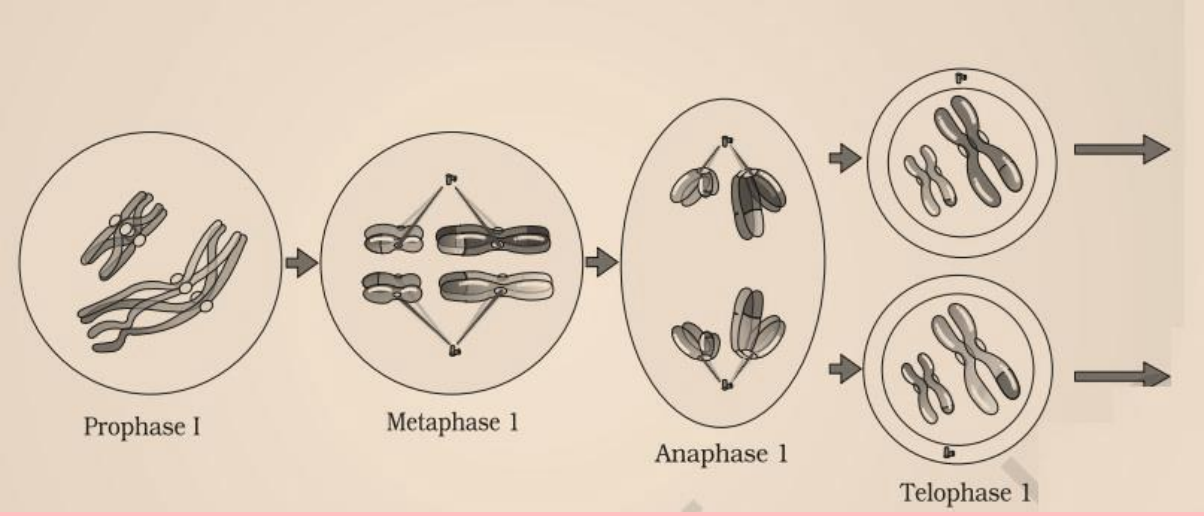
The bivalent chromosomes align on the equatorial plate. The microtubules from the opposite poles of the spindle attach to the kinetochore of homologous chromosomes.

Anaphase I

The homologous chromosomes separate, while sister chromatids remain associated at their centromeres.

Telophase I

The nuclear membrane and nucleolus reappear, cytokinesis follows and this is called as dyad of cells



Meiosis II

Prophase II

Meiosis II is initiated immediately after cytokinesis, usually before the chromosomes have fully elongated. The nuclear membrane disappears by the end of prophase II. The chromosomes again become compact.

Metaphase II

At this stage the chromosomes align at the equator and the microtubules from opposite poles of the spindle get attached to the kinetochores of sister chromatids.

Anaphase II

It begins with the simultaneous splitting of the centromere of each chromosome, allowing them to move toward opposite poles of the cell by shortening of microtubules attached to kinetochores.

Telophase II

Meiosis ends with telophase II, in which the two groups of chromosomes once again get enclosed by a nuclear envelope; cytokinesis follows resulting in the formation of tetrad of cells i.e., four haploid daughter cells.