

THE CELLULAR CYCLE

The life of cells takes place in a cyclical manner characterized by the alternation of mitoses, phases during which they divide to give two daughter cells, and intermitotic phases called interphases.

THE INTERPHASE

The G1 phase: there is no nuclear DNA synthesis, however the synthesis of RNA in the nucleus and proteins in the cytoplasm are very active. This phase determines the final size of the daughter cells resulting from mitosis.

The S phase: it corresponds to the synthesis or replication of nuclear DNA, the quantity of which is exactly doubled at the end of this phase.

The G2 phase: The quantity of nuclear DNA remains equal to that obtained at the end of the previous phase and the synthesis of RNA and proteins continues.

MITOSIS

a-Prophase: diffuse chromatin condenses into chromosomes which appear in the form of fine filaments. This process is accompanied by a slight swelling of the nucleus. At the end of this stage, the chromosomes are well individualized and are made up of two sister chromatids associated by the centromere.

The nuclear envelope and the nucleolus (or nucleoli) begin to disappear. The centrosomes, duplicated during the G1 and G2 stages, move away from each other and become mitotic centers at the origin of microtubules allowing the establishment of the mitotic spindle or achromatic spindle. At the end of prophase, kinetochores, protein plates, develop and attach to either side of the centromere.

Prometaphase: The major event of prometaphase is the disintegration of the nuclear envelope. Polar microtubules penetrate the nuclear space and attach to kinetochores, modified for this purpose. They are then called kinetochore microtubules. They exert tension on the chromosomes to which they are attached.

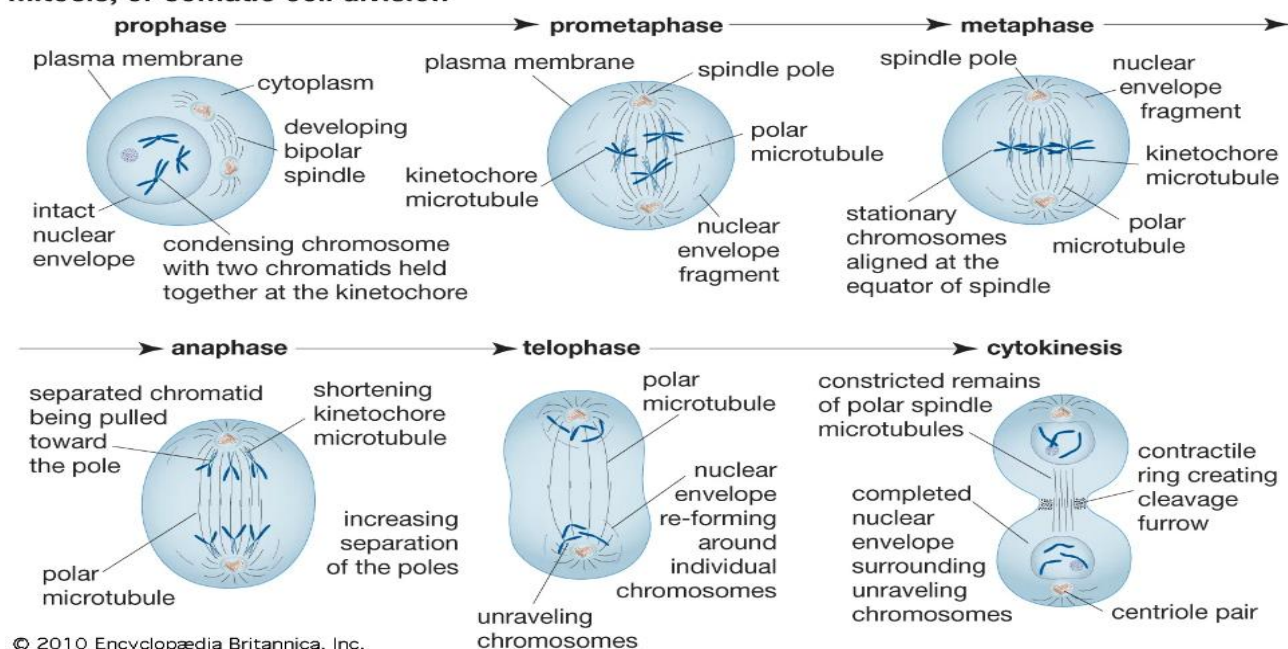
b-The metaphase: it is the second phase after the prophase. During metaphase, the chromosomes, which have reached their maximum degree of condensation, align themselves on the equatorial plate, a position equidistant from the two poles.

c-Anaphase: is marked by the separation of the two sister chromatids, following rupture of the centromere. Each chromatid migrates towards each pole, driven by the shortening of kinetochore microtubules. The polar microtubules elongate, which pushes the spindle poles apart.

d-Telophase: the nuclear vesicles associate with the chromosomes, distributed in two groups at each pole of the cell, and form the new nuclear envelope. The microtubules gradually disappear. The elements of the endomembrane system and the mitochondria separate in equal quantities towards the two future daughter cells. Mitosis is completed with the end of telophase.

Cytokinesis: the division furrow forms in a plane perpendicular to the axis of the mitotic spindle and separates the cell in two. The division furrow tightens until it forms an intermediate body, forming a narrow passage between the two daughter cells and which contains the rest of the mitotic spindle. This will eventually disappear entirely and the two daughter cells will separate completely.

Mitosis, or somatic cell division



THE CELLULAR CYCLE

MEIOSIS

Meiosis is a process that takes place during gametogenesis. It allows the production of haploid cells from diploid cells. It is a series of events divided into two successive divisions, only the first of which is preceded by DNA replication.

FIRST DIVISION OR REDUCTION DIVISION

The first division of meiosis, called meiosis I or reductional meiosis, allows the transition from one diploid cell ($2n$) to two haploid cells (n). It is divided into four successive stages.

Prophase I: goes through 5 stages:

Leptotene during which the nucleus increases in volume, characterized by the beginning of condensation of the chromosomes.

Zygotene beginning of pairing of homologous (bivalent) chromosomes.

Pachytene is the longest stage, during which there is strict pairing of homologous chromosomes and the appearance of nodules allowing crossing over.

Diplotene -separation of homologous chromosomes while remaining attached at multiple points.

-decondensation of chromosomes.

Diakinesis characterized by recondensation of chromatin and disappearance of the nuclear envelope

-Metaphase I: characterized by the positioning of pairs of chromosomes (bivalent) on the equatorial plate. The bivalents, held by the chiasmata, are oriented so that the kinetochores of the chromosomes are directed towards each of the spindle poles. The positioning of the bivalents occurs randomly, leading to a variable distribution of chromosomes of paternal or maternal origin on either side of the equatorial plate.

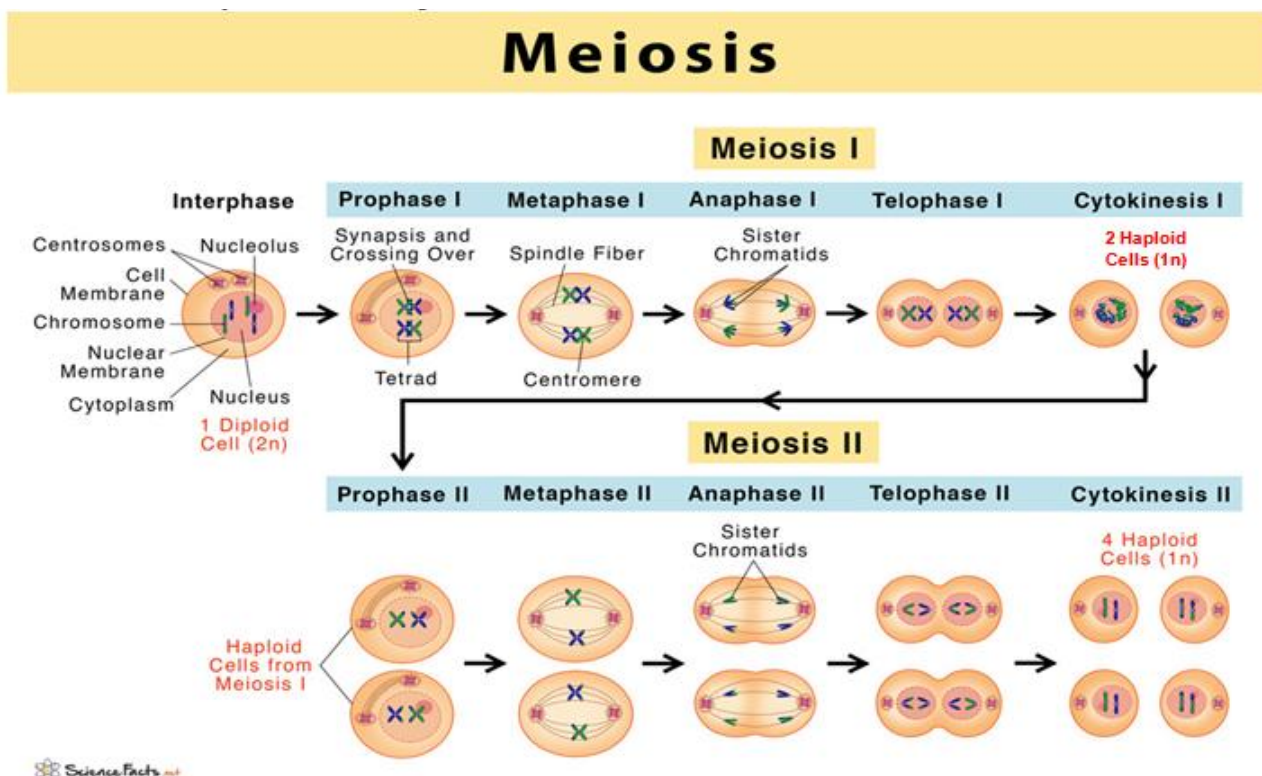
-Anaphase I: each chromosome moves away from its homolog and migrates towards a different pole at random thanks to kinetochore microtubules.

-Telophase I followed by Cytokinesis: characterized by the reconstitution of the nuclear envelopes around the bivalents meeting at each pole of the cell. They form two haploid nuclei, each containing n chromosomes with two chromatids. There was a reduction in the number of chromosomes.

SECOND DIVISION OR EQUATIONAL DIVISION

During the interphase preceding the second division, there is no DNA duplication, because the chromosomes have already duplicated before the reductional division.

This division is very similar to a simple mitosis.



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Mitosis vs Meiosis

Prophase

Duplicated chromosomes are two sister chromatids

Chromosome duplication $2n=4$

Prophase I

Meiosis I

Tetrads are two pairs of sister chromatids

Metaphase

Duplicated chromosomes align

Metaphase I

Tetrads align
Crossing-over

Anaphase

Telophase

Sister chromatids separate

Anaphase I

Telophase I

Homologous chromosomes separate

$2n$

$2n$

2 diploid daughter cells

Sister chromatids separate in anaphase II

n

n

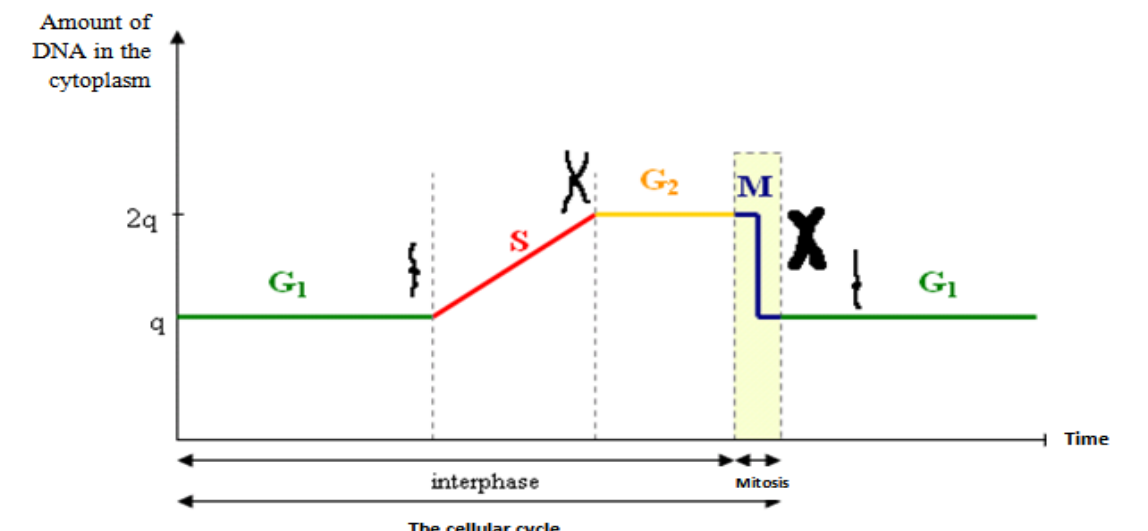
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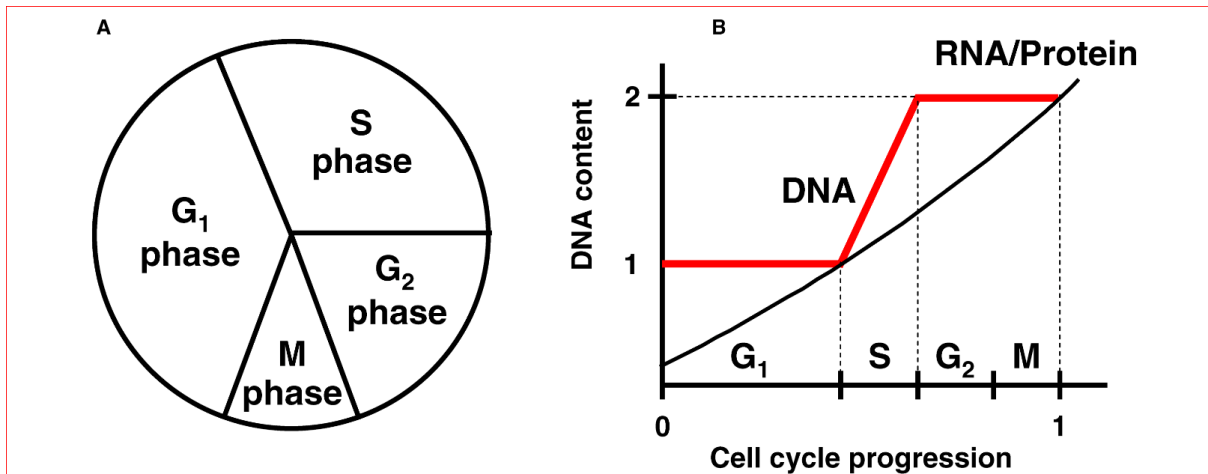
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Meiosis 2

4 haploid daughter cells

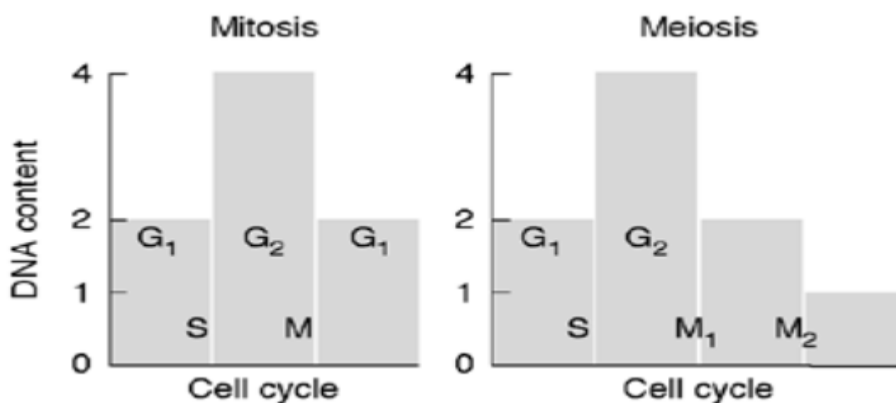
Mitosis vs. Meiosis





(A) General representation of the cell cycle showing the discontinuous events that have to take place only once per cell cycle, namely the S phase and the M phase, spaced with G₁ and G₂ phases that allow increase of the cell size before DNA replication and cell division, respectively.

(B) During the dynamics of the cell cycle, RNA and proteins increase exponentially, while the DNA content show a typical doubling amount until the cell divides to generate a newborn daughter. From G₁ to M phases, the cell increases continuously in mass.



Changes in nuclear DNA content with mitosis and meiosis. G, growth phase; S, DNA synthesis phase; M, mitotic phase.

Enjambment = Crossing-over is a reciprocal recombination between two homologous chromosomes during meiosis. It allows the exchange of alleles between chromosomes and thus participates in genetic diversity