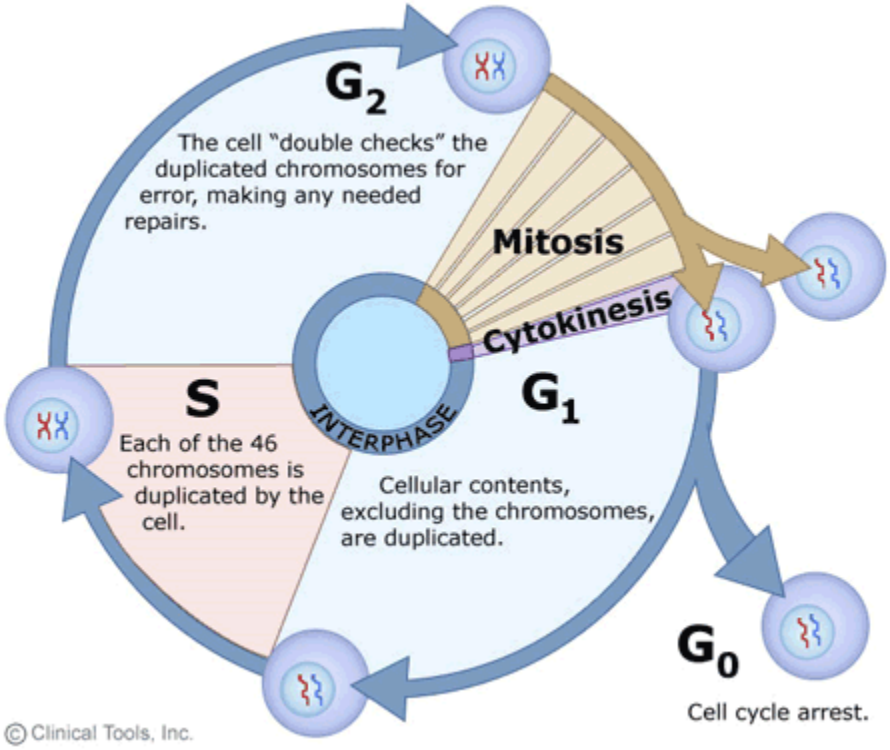
The Cell Cycle, Mitosis and Meiosis

Actively dividing eukaryote cells pass through a series of stages known collectively as the **cell cycle**: two gap phases (G1 and G2); an S (for synthesis) phase, in which the genetic material is duplicated; and an M phase, in which mitosis partitions the genetic material and the cell divides.

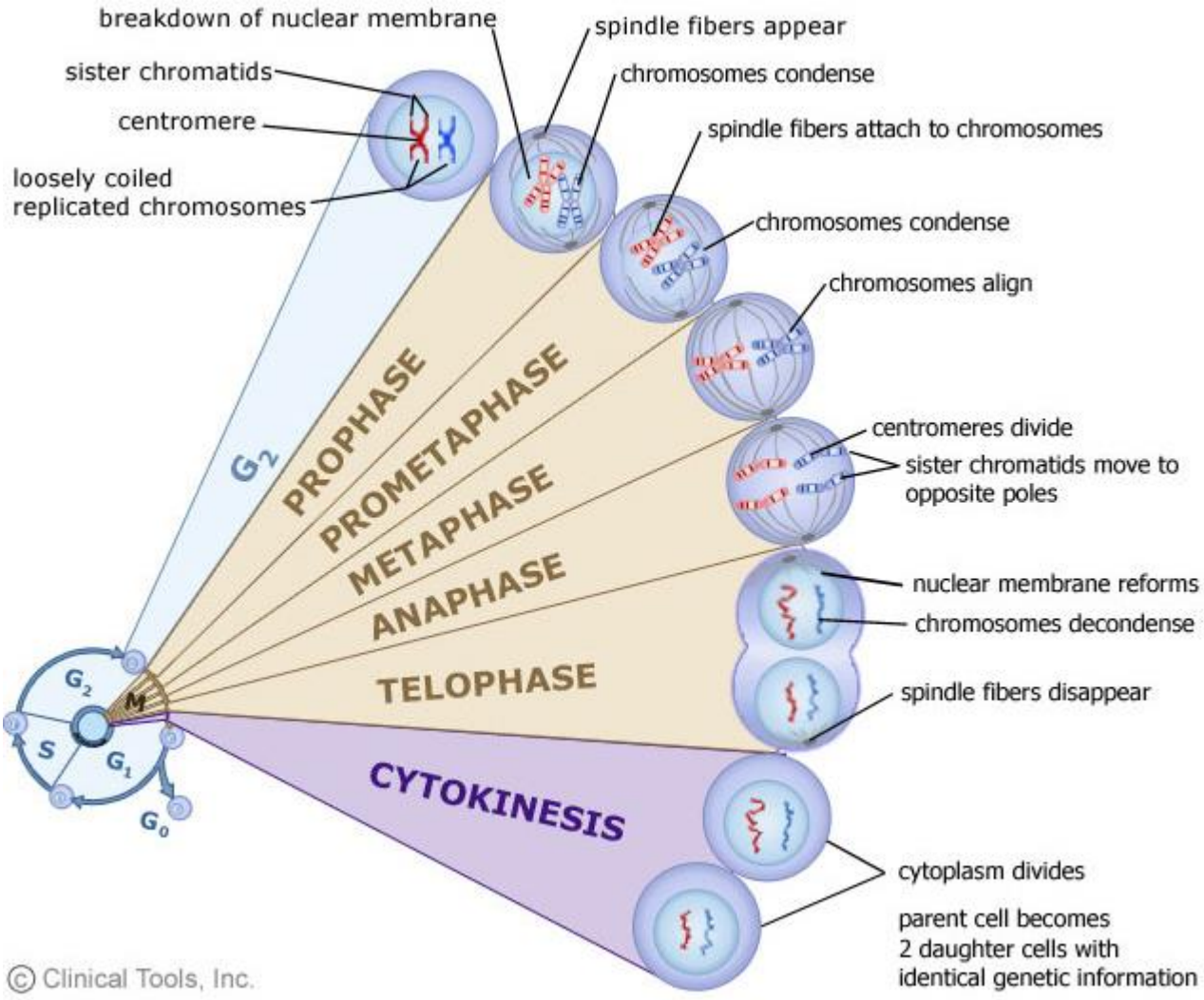


- **G1 phase.** Metabolic changes prepare the cell for division. At a certain point - the restriction point - the cell is committed to division and moves into the S phase.
- **S phase**. DNA synthesis replicates the genetic material. Each chromosome now consists of two sister chromatids.
- **G2 phase.** Metabolic changes assemble the cytoplasmic materials necessary for mitosis and cytokinesis.
- **M phase.** A nuclear division (mitosis) followed by a cell division (cytokinesis).

Mitosis

Mitosis is a form of eukaryotic cell division that produces two daughter cells with the same genetic component as the parent cell. Chromosomes replicated during the S phase are divided in such a way as to ensure that each daughter cell receives a copy of every chromosome. In actively dividing animal cells, the whole process takes about one hour

Mitosis, **although a continuous process, is conventionally divided into five stages: prophase, prometaphase, metaphase, anaphase and telophase**.



1- Prophase

Prophase occupies over half of mitosis. The nuclear membrane breaks down to form a number of small vesicles and the nucleolus disintegrates. A structure known as the **centrosome** duplicates itself to form two daughter centrosomes that migrate to opposite ends of the cell. The centrosomes organise the production of microtubules that form the spindle fibres that constitute the **mitotic spindle**. The chromosomes condense into compact structures. Each replicated chromosome can now be seen to consist of two identical **chromatids** (or **sister chromatids**) held together by a structure known as the **centromere**.

2- Prometaphase

The chromosomes, led by their centromeres, migrate to the equatorial plane in the mid-line of the cell - at right-angles to the axis formed by the centrosomes. This region of the mitotic spindle is known as the **metaphase plate**. The spindle fibres bind to a structure associated with the centromere of each chromosome called a kinetochore. Individual spindle fibres bind to a **kinetochore** structure on each side of the centromere. The chromosomes continue to condense.

3- Metaphase

The chromosomes align themselves along the metaphase plate of the spindle apparatus.

4- Anaphase

The shortest stage of mitosis. The centromeres divide, and the sister chromatids of each chromosome are pulled apart - or 'disjoin' - and move to the opposite ends of the cell, pulled by spindle fibres attached to the kinetochore regions. The separated sister chromatids are now referred to as **daughter chromosomes**. (It is the alignment and separation in metaphase and anaphase that is important in ensuring that each daughter cell receives a copy of every chromosome.)

5-Telophase

The final stage of mitosis, and a reversal of many of the processes observed during prophase. The nuclear membrane reforms around the chromosomes grouped at either

pole of the cell, the chromosomes uncoil and become diffuse, and the spindle fibres disappear.

Cytokinesis

The final cellular division to form two new cells. In plants a cell plate forms along the line of the metaphase plate; in animals there is a constriction of the cytoplasm. The cell then enters interphase - the interval between mitotic divisions.

Meiosis is the form of eukaryotic cell division that produces **haploid** sex cells or gametes (which contain a single copy of each chromosome) from **diploid** cells (which contain two copies of each chromosome). The process takes the form of one DNA replication followed by two successive nuclear and cellular divisions (Meiosis I and Meiosis II). As in mitosis, meiosis is preceded by a process of DNA replication that converts each chromosome into two sister chromatids.

Meiosis I

The first meiotic division is a reduction division (diploid → haploid) in which homologous chromosomes are separated

- **P-I:** Chromosomes condense, nuclear membrane dissolves, homologous chromosomes form bivalents, crossing over occurs
- **M-I:** Spindle fibres from opposing centrosomes connect to bivalents (at centromeres) and align them along the middle of the cell
- **A-I:** Spindle fibres contract and split the bivalent, homologous chromosomes move to opposite poles of the cell
- **T-I:** Chromosomes decondense, nuclear membrane *may* reform, cell divides (cytokinesis) to form two haploid daughter cells

Meiosis II

The second division separates sister chromatids (these chromatids may not be identical due to crossing over in prophase I)

- **P-II:** Chromosomes condense, nuclear membrane dissolves, centrosomes move to opposite poles (perpendicular to before)
- **M-II:** Spindle fibres from opposing centrosomes attach to chromosomes (at centromere) and align them along the cell equator
- **A-II:** Spindle fibres contract and separate the sister chromatids, chromatids (now called chromosomes) move to opposite poles
- **T-II:** Chromosomes decondense, nuclear membrane reforms, cells divide (cytokinesis) to form four haploid daughter cells

The final outcome of meiosis is the production of four haploid daughter cells

- **These cells may all be genetically distinct if crossing over occurs in prophase I (causes recombination of sister chromatids)**