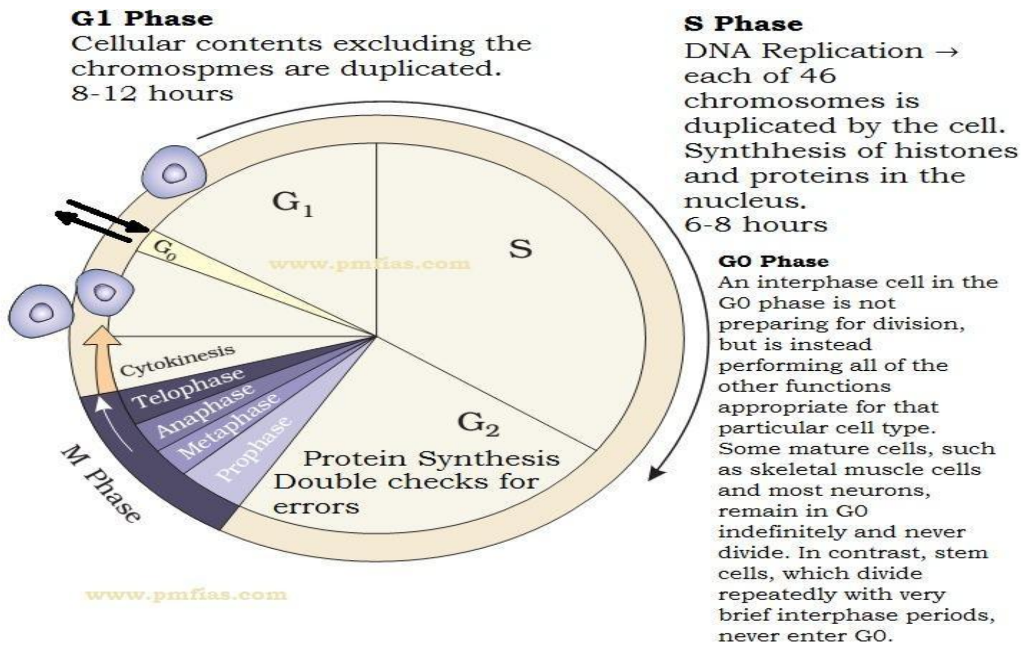
CELL CYCLE AND CELL DIVISION

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

Phases of cell cycle



State	Phase	Abbreviation	Description
Resting	Gap 0	**G_0**	A phase where the cell has left the cycle and has stopped dividing.
Interphase	Gap 1	**G_1**	Cells increase in size in Gap 1. The *G_1 checkpoint* control mechanism ensures that everything is ready for DNA synthesis.

	Synthesis	**S**	DNA replication occurs during this phase.
	Gap 2	**G_2**	During the gap between DNA synthesis and mitosis, the cell will continue to grow. The *G_2 checkpoint* control mechanism ensures that everything is ready to enter the M (mitosis) phase and divide.
Cell division	Mitosis	**M**	Cell growth stops at this stage and cellular energy is focused on the orderly division into two daughter cells. A checkpoint in the middle of mitosis (*Metaphase Checkpoint*) ensures that the cell is ready to complete cell division.

Mitosis

The relatively brief *M phase* consists of nuclear division (karyokinesis). It is a relatively short period of the cell cycle. M phase is complex and highly regulated. The sequence of events is divided into phases, corresponding to the completion of one set of activities and the start of the next. These phases are sequentially known as:

- prophase,
- metaphase,
- anaphase,
- telophase

Mitosis is the process by which a eukaryotic cell separates the chromosomes in its cell nucleus into two identical sets in two nuclei. During the process of mitosis the pairs of chromosomes condense and attach to fibers that pull the sister chromatids to opposite sides of the cell.

Prophase

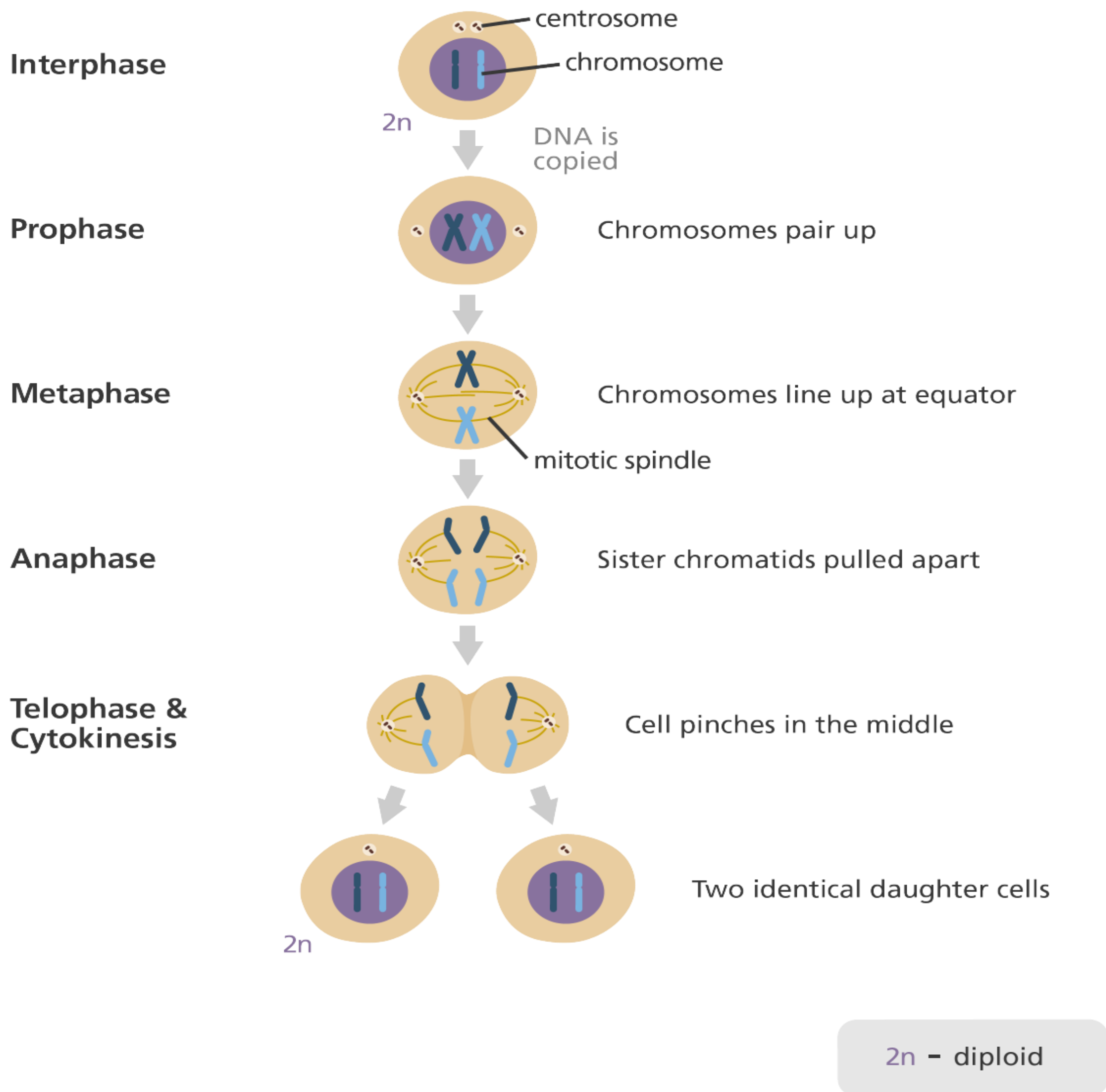
During **prophase**, the complex of DNA and proteins contained in the nucleus, known as chromatin, condenses.

Metaphase

Metaphase is a stage of mitosis in the eukaryotic cell cycle in which chromosomes are at their second-most condensed and coiled stage (they are at their most condensed in anaphase). These chromosomes, carrying genetic information, align in the equator of the cell before being separated into each of the two daughter cells. Metaphase accounts for approximately 4% of the cell cycle's duration.

Anaphase

Anaphase is the phase of mitosis, the process that separates the duplicated genetic material carried in the nucleus of a parent cell into two identical daughter cells. Before anaphase begins, the replicated chromosomes, called sister chromatids, are aligned at along the equator of the cell on the equatorial plane. The sister chromatids are pairs of identical copies of DNA joined at a point called the centromere.



Telophase

Telophase is technically the final stage of mitosis. Its name derives from the latin word telos which means end. During this phase, the sister chromatids reach opposite poles. The small nuclear vesicles in the cell begin to re-form around the group of chromosomes at each end.

Cytokinesis

It is the last stage of cell division wherein the nucleus has divided and division of cytoplasm takes place which leads to the formation of two different daughter cells.

Meiosis

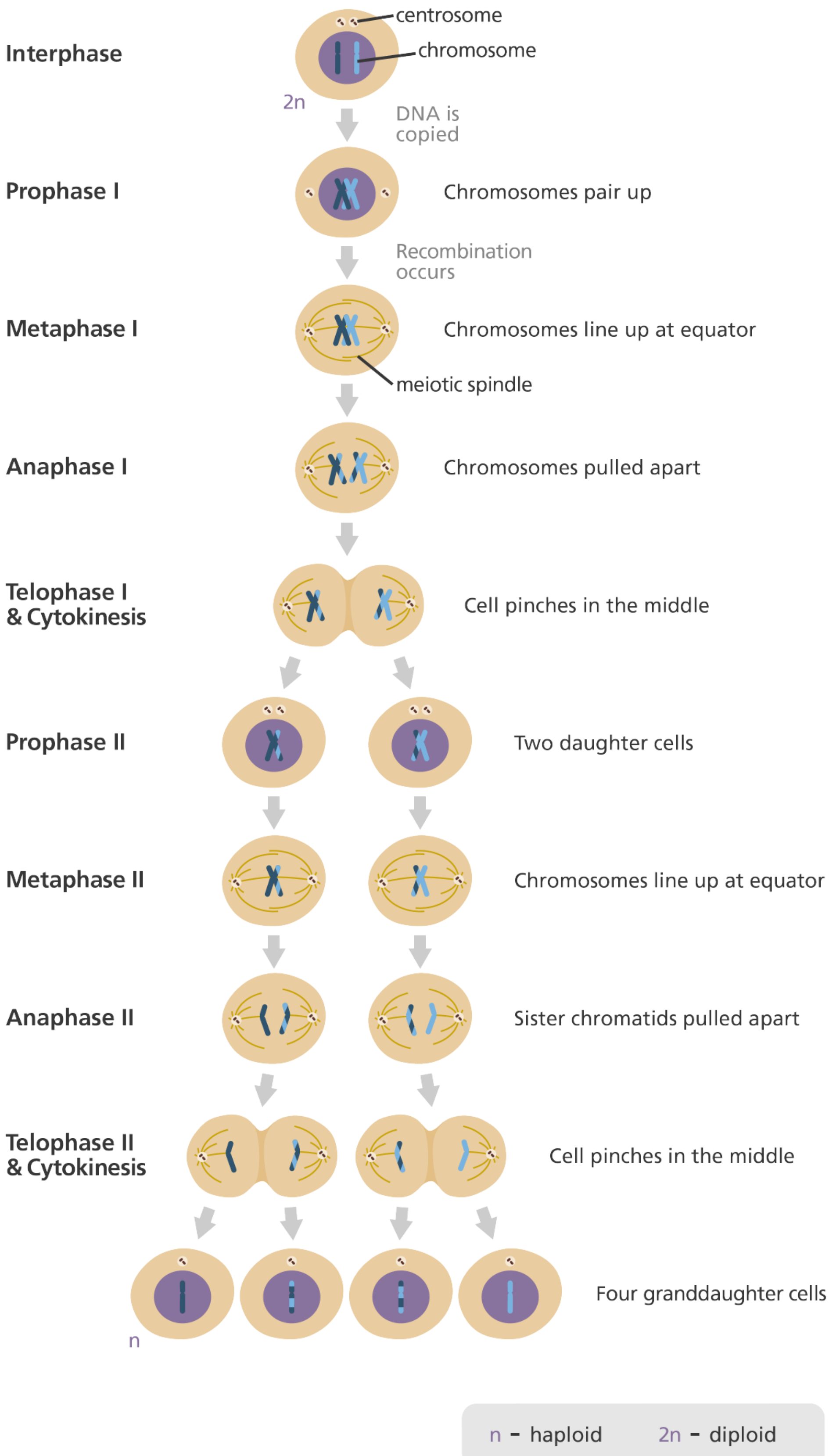
Meiosis,is used for just one purpose in the human body: the production of **gametes**—sex cells, or sperm and eggs. Its goal is to make daughter cells with exactly half as many chromosomes as the starting cell.

Phases of meiosis

In many ways, meiosis is a lot like mitosis. The cell goes through similar stages and uses similar strategies to organize and separate chromosomes. In meiosis, however, the cell has a more complex task. It still needs to separate sister chromatids (the two halves of a duplicated chromosome), as in mitosis. But it must also separate homologous chromosomes, the similar but nonidentical chromosome pairs an organism receives from its two parents.

These goals are accomplished in meiosis using a two-step division process. Homologue pairs separate during a first round of cell division, called meiosis I. Sister chromatids separate during a second round, called meiosis II.

Since cell division occurs twice during meiosis, one starting cell can produce four gametes (eggs or sperm). In each round of division, cells go through four stages: prophase, metaphase, anaphase, and telophase.


Interphase
centrosome
chromosome
2n
DNA is copied
Prophase I
Chromosomes pair up
Recombination occurs
Metaphase I
Chromosomes line up at equator
meiotic spindle
Anaphase I
Chromosomes pulled apart
Telophase I & Cytokinesis
Cell pinches in the middle
Prophase II
Two daughter cells
Metaphase II
Chromosomes line up at equator
Anaphase II
Sister chromatids pulled apart
Telophase II & Cytokinesis
Cell pinches in the middle
Four granddaughter cells
n
n - haploid
2n - diploid

Meiosis I

Before entering meiosis I, a cell must first go through interphase. As in mitosis, the cell grows during G_1 phase, copies all of its chromosomes during S phase, and prepares for division during G_2phase.

During prophase I, differences from mitosis begin to appear. As in mitosis, the chromosomes begin to condense, but in meiosis I, they also pair up. Each chromosome carefully aligns with its homologue partner so that the two match up at corresponding positions along their full length.

This process, in which homologous chromosomes trade parts, is called **crossing over**. It's helped along by a protein structure called the **synaptonemal complex** that holds the homologues together. The chromosomes would actually be positioned one on top of the other throughout crossing over; they're only shown side-by-side in the image above so that it's easier to see the exchange of genetic material.

You can see crossovers under a microscope as **chiasmata**, cross-shaped structures where homologues are linked together. Chiasmata keep the homologues connected to each other after the synaptonemal complex breaks down, so each homologous pair needs at least one. It's common for multiple crossovers (up to 252525!) to take place for each homologue pair.

The spots where crossovers happen are more or less random, leading to the formation of new, "remixed" chromosomes with unique combinations of alleles.

After crossing over, the spindle begins to capture chromosomes and move them towards the center of the cell (metaphase plate). This may seem familiar from mitosis, but there is a twist. Each chromosome attaches to microtubules from just one pole of the spindle, and the two homologues of a pair bind to microtubules from opposite poles. So, during **metaphase I**, homologue pairs—not individual chromosomes—line up at the metaphase plate for separation.

When the homologous pairs line up at the metaphase plate, the orientation of each pair is random. This allows for the formation of gametes with different sets of homologues.

In **anaphase I**, the homologues are pulled apart and move apart to opposite ends of the cell. The sister chromatids of each chromosome, however, remain attached to one another and don't come apart.

Finally, in **telophase I**, the chromosomes arrive at opposite poles of the cell. In some organisms, the nuclear membrane re-forms and the chromosomes decondense, although in others, this step is skipped—since cells will soon go through another round of division, meiosis II. Cytokinesis usually occurs at the same time as telophase I, forming two haploid daughter cells.

Meiosis II

Cells move from meiosis I to meiosis II without copying their DNA. Meiosis II is a shorter and simpler process than meiosis I, and you may find it helpful to think of meiosis II as "mitosis for haploid cells."

The cells that enter meiosis II are the ones made in meiosis I. These cells are haploid—have just one chromosome from each homologue pair—but their chromosomes still consist of two sister chromatids. In meiosis II, the sister chromatids separate, making haploid cells with non-duplicated chromosomes.

During **prophase II**, chromosomes condense and the nuclear envelope breaks down, if needed. The centrosomes move apart, the spindle forms between them, and the spindle microtubules begin to capture chromosomes.

The two sister chromatids of each chromosome are captured by microtubules from opposite spindle poles. In **metaphase II**, the chromosomes line up individually along the metaphase plate. In **anaphase II**, the sister chromatids separate and are pulled towards opposite poles of the cell.

In **telophase II**, nuclear membranes form around each set of chromosomes, and the chromosomes decondense. Cytokinesis splits the chromosome sets into new cells, forming the final products of meiosis: four haploid cells in which each chromosome has just one chromatid. In humans, the products of meiosis are sperm or egg cells.