

The Cell Cycle

During development from stem to fully differentiated, cells in the body alternately divide (mitosis) and "appear" to be resting (interphase). This sequence of activities exhibited by cells is called the cell cycle.

Interphase, which appears to the eye to be a resting stage between cell divisions, is actually a period of diverse activities. Those interphase activities are indispensable in making the next mitosis possible.

Interphase: Interphase generally lasts at least 12 to 24 hours in mammalian tissue. During this period, the cell is constantly synthesizing RNA, producing protein and growing in size. By studying molecular events in cells, scientists have determined that interphase can be divided into 4 steps: Gap 0 (G₀), Gap 1 (G₁), S (synthesis) phase, Gap 2 (G₂).

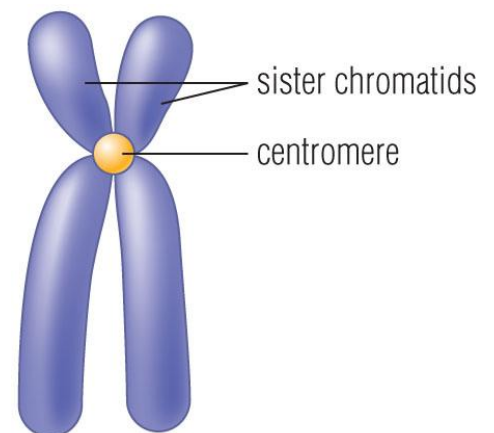
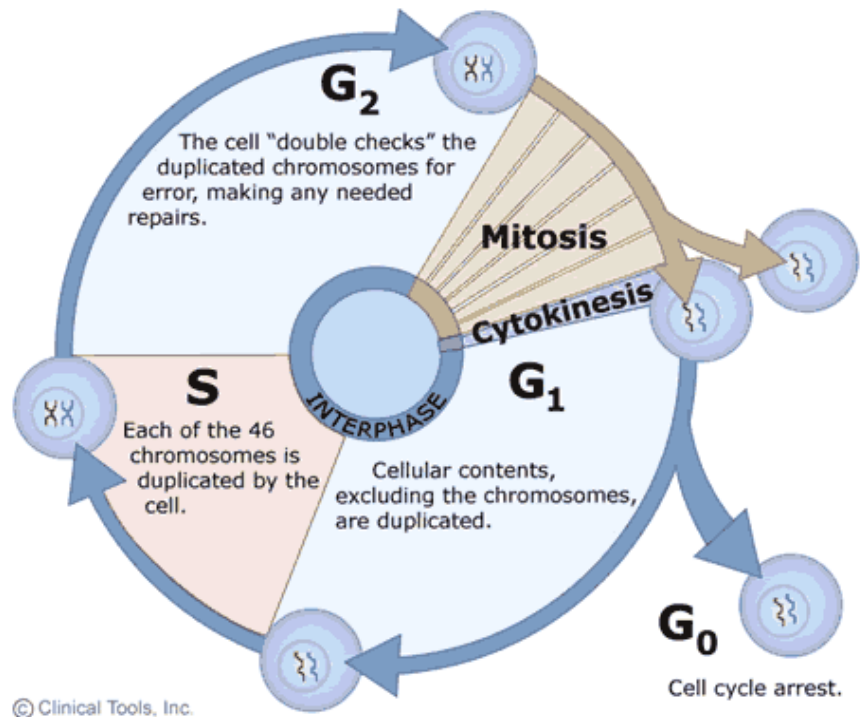
Gap 0 (G₀): There are times when a cell will leave the cycle and quit dividing. This may be a temporary resting period or more permanent. An example of the latter is a cell that has reached an end stage of development and will no longer divide (e.g. neuron).

Gap 1 (G₁): Cells increase in size in Gap 1, produce RNA and synthesize protein. An important cell cycle control mechanism activated during this period (G₁ Checkpoint) ensures that everything is ready for DNA synthesis.

S Phase: To produce two similar daughter cells, the complete DNA instructions in the cell must be duplicated. DNA replication occurs during this S (synthesis) phase. Synthesis produces sister chromatids or two identical chromosomes attached together.

Gap 2 (G₂): During the gap between DNA synthesis and mitosis, the cell will continue to grow and produce new proteins. At the end of this gap is another control checkpoint (G₂ Checkpoint) to determine if the cell can now proceed to enter M (mitosis) and divide.

Mitosis or M Phase: Cell growth and protein production stop at this stage in the cell cycle. All of the cell's energy is focused on the complex and orderly division into two identical daughter cells. Mitosis is much shorter than interphase, lasting perhaps only one to two hours. As in both G₁ and G₂, there is a Checkpoint in the middle of mitosis (Metaphase Checkpoint) that ensures the cell is ready to complete cell division. Actual stages of mitosis can be viewed at [Animal Cell Mitosis](#).



Mitosis

Cells can divide by mitosis, and in **unicellular** organisms, the outcome is new organisms without sex (asexual reproduction). In **multicellular** organisms, cell division is used for growth, development, and repair of the organism. Cell division is controlled by **DNA**, but exact copies of the DNA must be given to the daughter cells (note use of “mother” and “daughter”). Eukaryotes do **mitosis**. In mitosis, each daughter cell gets about half of the cytoplasm from the mother cell and one set or copy of the DNA.

Before cell division occurs, the cell first has to replicate the **chromosomes** so each daughter cell can have a set. When the chromosomes are replicated and getting ready to divide, they consist of two, identical halves called **sister chromatids** which are joined by a central region, the **centromere**. Each chromosome is one long molecule of DNA and special proteins. DNA makes up the **genes**, and we say that genes are “on” chromosomes, or chromosomes “contain” or are made of genes. Some of the proteins in the chromosomes “turn off” the genes that are not needed in that cell. For example, while every cell in your body contains exactly the same genes, you don’t need your eye-color gene operational in cells in your big toe, nor toenail-shape genes active in cells in your stomach.

Two basic types of cells occur in the bodies of eukaryotes. **Somatic cells** are general body cells. These have the same number of chromosomes as each other within the body of an organism. The number of chromosomes in somatic cells is consistent among organisms of the same species, but varies from species to species. These chromosomes come in pairs, where one chromosome in each pair is from the mother and one is from the father. Actually, since most organisms have more than one pair of chromosomes, it would also be correct to say that the organism received one set of chromosomes from its mother and one matching set from its father, and that these sets match in pairs. The other type of cells found in eukaryotes is **gametes** or sex cells, consisting of eggs in females and sperm in males. These special reproductive cells have only one set (half as many) of chromosomes consisting of one chromosome from each pair. In humans *ONLY*, the somatic cells have 46 chromosomes arranged in 23 pairs (= two sets of 23 each), while gametes have 23 individual chromosomes (= one set). In fruit flies, somatic cells have 8 chromosomes (= 4 pairs or 2 sets) and gametes have 4 chromosomes (= 1 set). Geneticists use the term “**-ploid**” to refer to one set of chromosomes in an organism, and that term is typically combined with another wordstem that describes the number of sets of chromosomes present. For example, a cell with one set of chromosomes is called **haploid**, a cell with two sets of chromosomes is **diploid**, and a cell with four sets of chromosomes (not usually a “normal” condition, but sometimes possible) is **tetraploid**.

Technically, **mitosis** is specifically the process of division of the chromosomes, while **cytokinesis** is officially the process of division of the cytoplasm to form two cells. In most cells, cytokinesis follows or occurs along with the last part of mitosis.

Each animal cell has a pair of centrioles located just outside the nucleus. The two centrioles in the pair are oriented at right angles to each other. Just before mitosis, the centrioles replicate, so the cell now has four (two sets of two) as it starts mitosis.

The stages in mitosis include (interphase), prophase, metaphase, anaphase, and telophase. Strictly speaking, interphase is the stage in which a cell spends most of its life and is not part of the process of mitosis, *per se*, but is usually discussed along with the other stages.

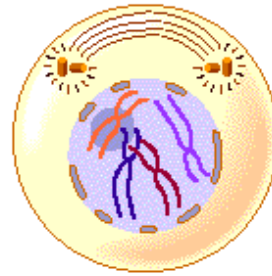
Interphase may appear to be a “resting” stage, but cell growth, replication of the chromosomes, and many other activities are taking place during this time. Near the end of interphase just before the cell starts into the other stages of mitosis, if the cell is an animal cell, the centrioles replicate so there are two pairs. At this time, the strands of DNA that make up the chromosomes are unwound within the nucleus and do not appear as distinct chromosomes. Thus, at this stage, the genetic material is often referred to as **chromatin**. From here, the cell goes through all other stages of mitosis.

In **prophase**, the chromosomes start to coil, shorten, and become distinct. In animals, the centrioles begin to migrate to the poles of the cell. The **mitotic spindle** or **polar fibers** begin to form from the poles of the cell towards the equator. In animals, this starts as **asters** around the centrioles. Eventually, the spindle mechanism finishes growing toward the equator and interacts with the centromeres to line up and, later, move the chromosomes. Also at this time, the nuclear envelope starts to disintegrate.

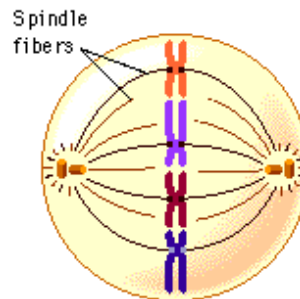
Metaphase is characterized by the lining up of the chromosomes along the equator of the cell or what is called the **metaphase plate**. The nuclear envelope has totally disintegrated and the polar fibers have reached the centromeres of the chromosomes and have begun interacting with them.

In **anaphase**, the sister chromatids separate at the centromeres, thus can now be called chromosomes. These are pulled to the poles of the cell by the mitotic spindle.

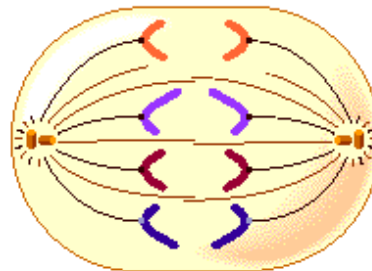
In **telophase**, the new daughter nuclei and nuclear envelopes start to reform and the chromosomes uncoil. Telophase frequently includes the start of cytokinesis. In animal cells, cytokinesis starts with a **cleavage furrow** or indentation around the middle that eventually pinches in, dividing the cell in two. In plants, cytokinesis begins with a series of vesicles that form at the equator of the cell, which subsequently join until the cell is divided in two.



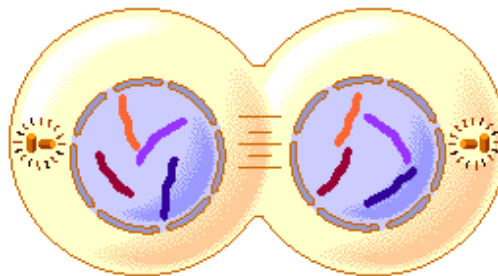
Prophase



Metaphase



Anaphase



Telophase