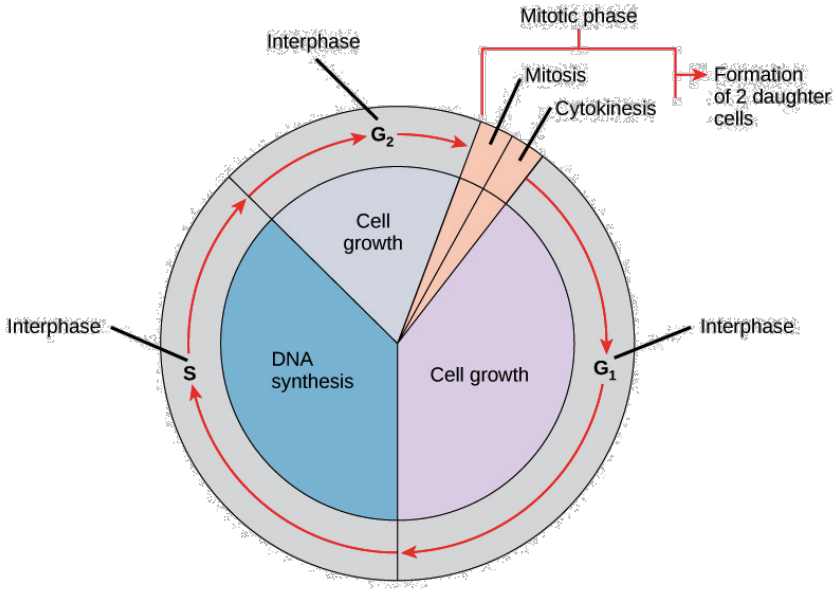
Cell Cycle

Student Guide

Supplemental reading for cat# M3023

Version 091325



The Cell Cycle and Its Stages

The cell cycle is the process by which cells grow, duplicate their DNA, and divide to produce new cells. This cycle ensures that new cells are created for growth, repair, and reproduction. The duration of the cell cycle varies depending on the type of cell and the organism. In rapidly dividing human cells, such as skin cells or the cells lining the intestine, the cell cycle can take about 24 hours. In other types of cells, like liver cells, the cell cycle can take much longer, sometimes up to a year. The cell cycle is divided into two main stages; interphase and the mitotic phase.

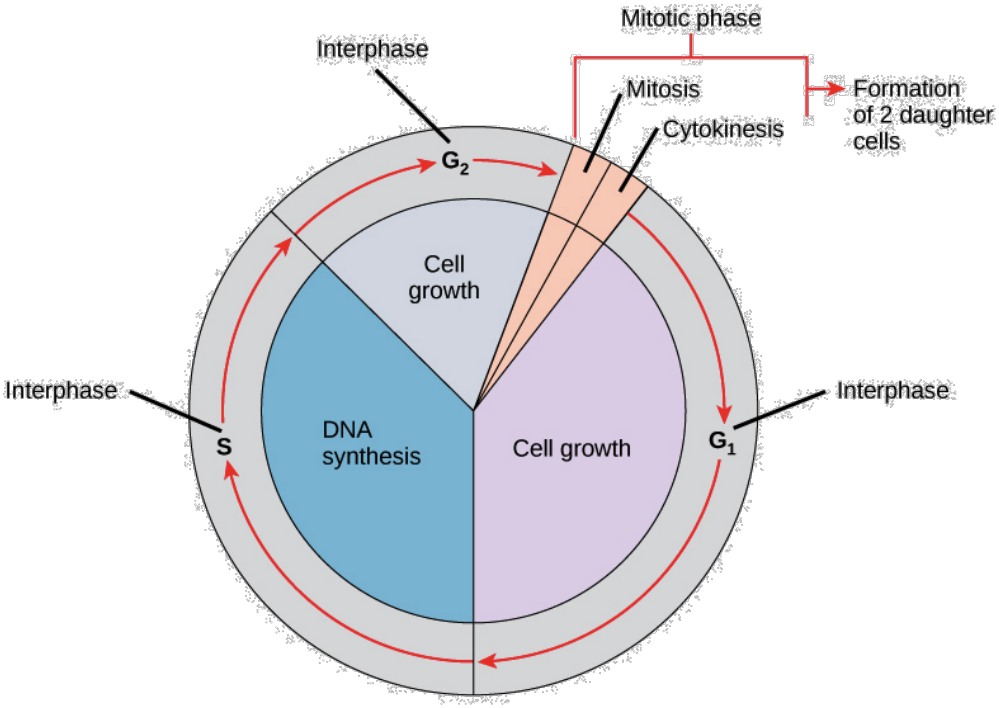


Image credit: **"The cell cycle: Figure 1" by OpenStax College, Biology (CC BY 3.0)**

Interphase is the longest part of the cell cycle, during which the cell prepares for division. It is further divided into four phases: G0 Phase, G1 Phase (Gap 1), S Phase (Synthesis), and G2 Phase (Gap 2).

In the G0 Phase, also known as the quiescent or resting phase in the cell cycle, cells are not actively dividing or preparing to divide, but are maintaining normal metabolic functions, such as producing proteins, generating energy, and performing specialized roles. Some cells that are fully differentiated and no longer dividing stay in G0 permanently, like neurons, while others, like liver cells, can re-enter the cycle when needed, and are stimulated to do so by external signals (e.g., during tissue repair). The G0 Phase is important because it prevents unnecessary cell division and uncontrolled proliferation, as well as supports tissue repair and regeneration.

During the G1 Phase, the cell grows in size by producing new organelles, proteins, and membranes. This is essential in ensuring that the daughter cells are large enough to function after cell division. During this phase, the cell is metabolically active, making essential molecules like enzymes and ribosomes needed for DNA replication. The G1 phase is important because it prevents errors in DNA replication by ensuring that the cell has the necessary resources and undamaged DNA before continuing on to the S Phase. If a cell doesn't need to divide, it can pause in G1 or enter G0 Phase.

In the S Phase, the cell replicates its DNA so that each new cell will have a complete set of chromosomes. Each chromosome is copied to produce two sister chromatids,which are held together by a specialized DNA sequence on the chromosome called the centromere (See Figure below). The centromere is the constricted region of the chromosome (not always in the center of the chromosome) which acts as an attachment point for spindle fibers during cell division.

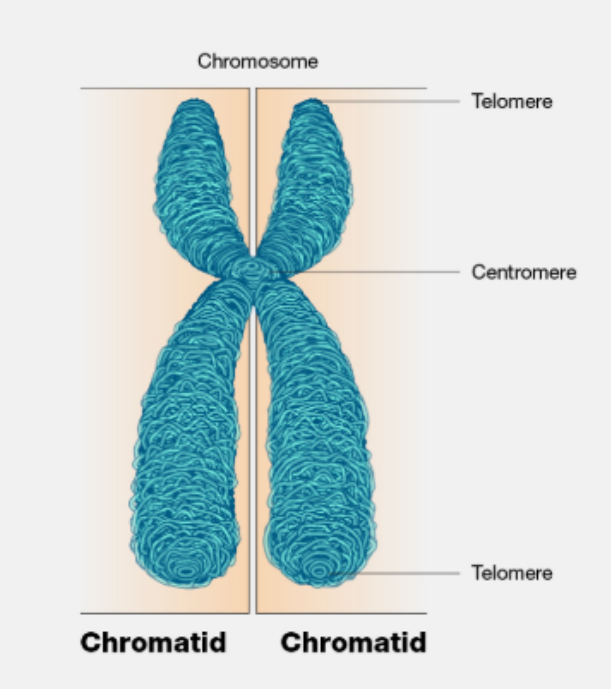
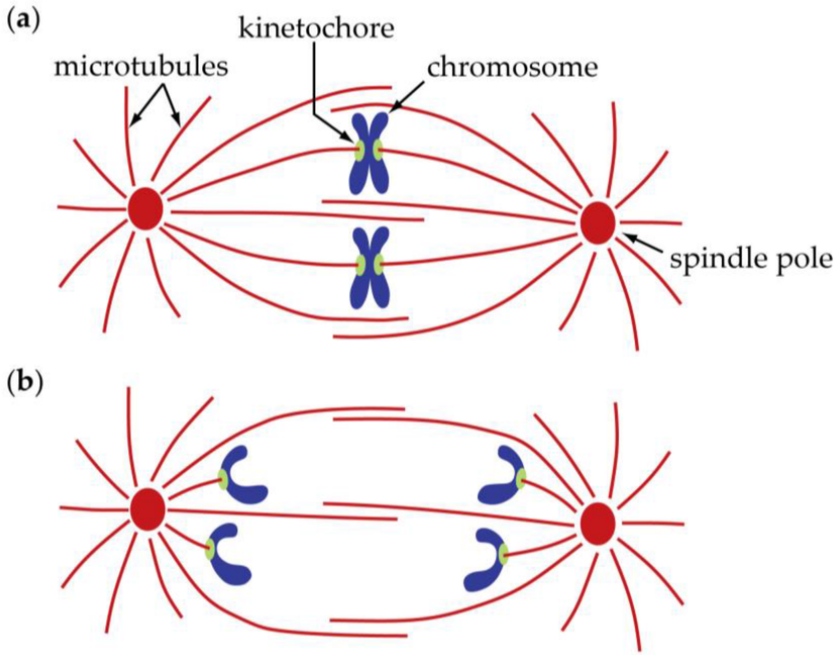


Image credit: https://www.genome.gov/genetics-glossary/Chromatid

A protein structure called the kinetochore assembles on the centromere during mitosis and serves as the attachment point for spindle fibers. The spindle fibers are made up of long protein strands called microtubules. (See Figure below) These fibers separate the sister chromatids by pulling them towards opposite poles of the dividing cell. The centromere, the kinetochore, and the spindle fibers are all essential for proper separation of sister chromatids during cell division, ensuring that proper distribution of genetic material takes place during cell division and prevents scenarios where cells end up with too many or too few chromosomes, known as aneuploidy. The S Phase is important because it ensures that each daughter cell has an identical and complete genome, preventing mutations or missing parts of chromosomes.



Schematic diagram of a spindle in metaphase (a) and anaphase (b). (Asbury, 2017)

In the G2 Phase, the cell continues to grow in size to ensure that both daughter cells will have enough cytoplasm after mitosis. Additionally, organelles, such as mitochondria, endoplasmic reticulum, and Golgi apparatus, duplicate and expand so they can be evenly distributed between daughter cells. The cell proofreads the replicated DNA from S phase, checking for any errors or mutations. If DNA damage is detected, repair mechanisms are activated to correct mistakes. If the damage is too severe, the cell may undergo programmed cell death, or apoptosis to prevent the spread of mutations.

The mitotic phase is when the cell actually divides. It includes two main processes, mitosis and cytokinesis. Mitosis is the process of dividing the cell's nucleus and its genetic material. It consists of four stages: Prophase, Metaphase, Anaphase, and Telophase. During prophase, the chromosomes condense and become visible under a microscope. The nuclear membrane begins to break down and the mitotic spindle, made of microtubules, starts to form. During metaphase, the chromosomes line up in the middle of the cell, along an imaginary line called the metaphase plate. The spindle fibers attach to the centromeres of the chromosomes. The sister chromatids are then pulled apart by the spindle fibers during anaphase, towards opposite ends of the cell. Each chromatid is now considered an individual chromosome. Finally, during telophase, the separated chromosomes reach the opposite poles of the cell, and a new nuclear membrane forms around each set of chromosomes, creating two identical nuclei. The chromosomes begin to decondense and return to their less visible state. After the mitotic phase, cells undergo cytokinesis, where the cytoplasm is divided, resulting in two separated daughter cells.

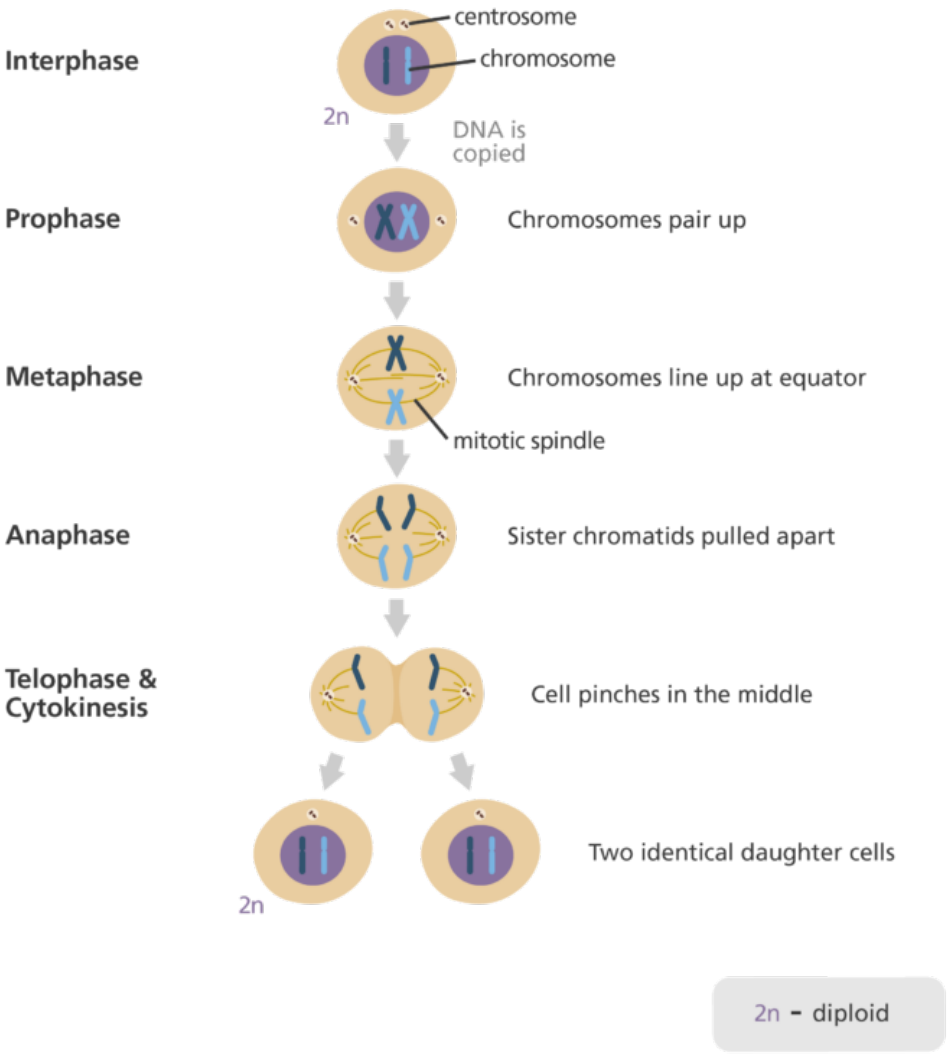


Image credit: https://www.yourgenome.org/theme/what-is-mitosis/

Pre-Lab Question

1. Complete the graphic organizer below by **explaining** what happens during each stage of the cell cycle.

Interphase	G1	
	S	
	G2	
Mitosis	Prophase	
	Metaphase	
	Anaphase	
	Telophase	
Cytokinesis		

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