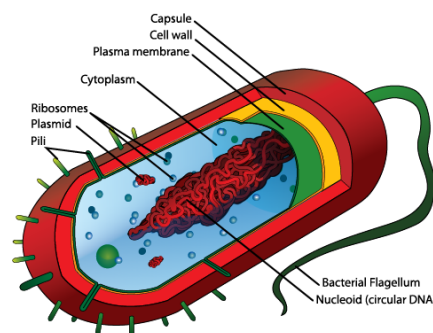


- All cells contain
 - plasma membrane
 - outer covering that separates the cell's interior from its surrounding environment
 - cytoplasm
 - jelly-like region within the cell in which other cellular components are found
 - DNA
 - the genetic material of the cell
 - ribosomes
 - particles that synthesize proteins

Type of Cells

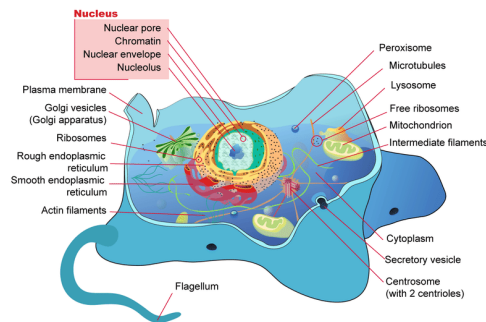
- Prokaryotic Cell
 - simple, single-celled (unicellular) organism that lacks a nucleus, or any other membrane-bound organelle
 - bacteria, archaea



A diagram of a typical prokaryotic cell – Mariana Ruiz Villarreal, LadyofHats (public domain)

- Eukaryotic Cell

- has a membrane-bound nucleus and other membrane-bound compartments or sacs, called organelles, which have specialized functions
- fungi, plants, animals



Prokaryotic and Eukaryotic Cells - CK-12: Biology Concepts, LibreTexts ([CC BY-NC 4.0](https://chem.libretexts.org/@go/page/6439)).
<https://chem.libretexts.org/@go/page/6439>

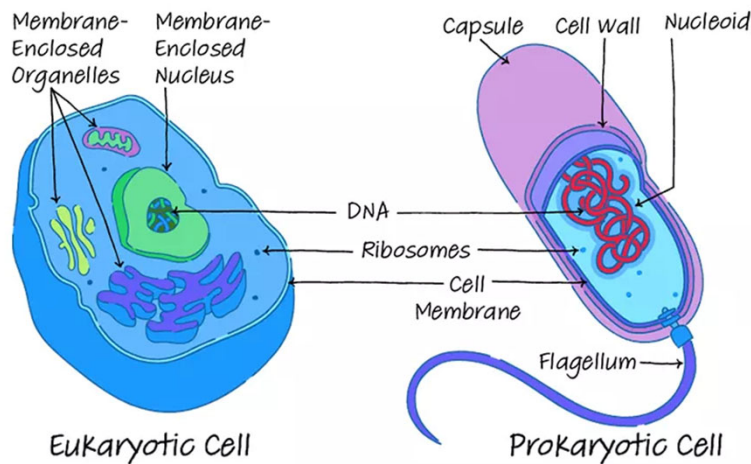


Image: Chen, Dana. "Prokaryotic vs Eukaryotic Cells: Similarities & Differences" sciencing.com,
<https://sciencing.com/prokaryotic-vs-eukaryotic-cells-similarities-differences-13717689.html>. 16 March 2021.

Genomic DNA

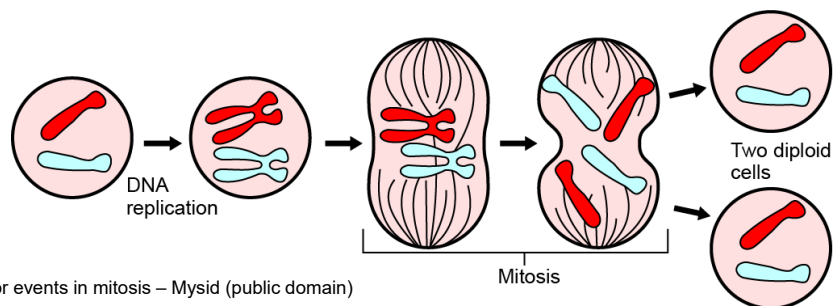
- A cell's complete complement of DNA is called its **genome**.
 - In prokaryotes the genome is composed of a single, double-stranded DNA molecule in the form of a loop or circle.
 - In eukaryotes, the genome comprises several double-stranded, linear DNA molecules bound with proteins to form complexes called **chromosomes**.

- Each species of eukaryote has a characteristic number of chromosomes in the nuclei of its cells.
 - Human body cells (**somatic cells**) have 46 chromosomes
 - two matched sets of 23 chromosomes (**diploid**)
 - the matched set is called a **homologous pair** or **homologous chromosomes**
 - Human sex cells (**gametes** or **germ cells**) have 23 chromosomes
 - one set of 23 chromosomes (**haploid**)

The Cell Cycle

- The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.
- Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth, DNA replication, and division that produce two genetically identical cells.

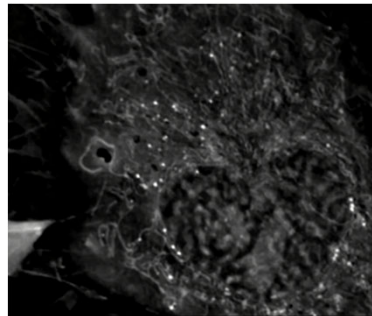
- The cell cycle has two major phases:
 - interphase and the mitotic phase
- Interphase
 - the cell grows and DNA is replicated
- Mitotic phase
 - the replicated DNA and cytoplasmic contents are separated and the cell divides



<https://youtu.be/f-ldPgEfAHI>

Mitosis

- Mitosis is divided into a series of phases
 - interphase
 - prophase
 - metaphase
 - anaphase
 - Telophase
 - cytokinesis
- The result is two identical cells



Live cell imaging of Mesenchymal Stem Cells undergoing mitosis – Evilonan ([CC BY-SA 4.0](#))

Interphase

- The cell grows, performs routine life processes, and prepares to divide.

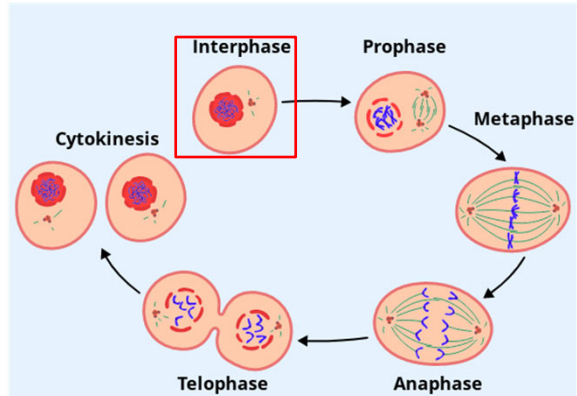


Image credit: CK-12 ([CC BY-NC 3.0](https://creativecommons.org/licenses/by-nc/3.0/))

Prophase

- Chromosomes are visible, nuclear membrane breaks down, and spindle fibers begin to form.

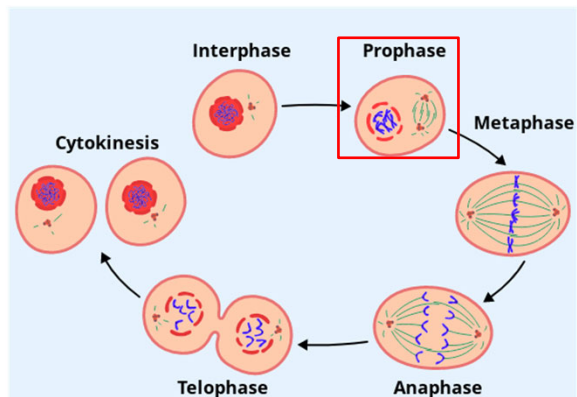


Image credit: CK-12 ([CC BY-NC 3.0](https://creativecommons.org/licenses/by-nc/3.0/))

Metaphase

- Sister chromatids line up at the center of the cell.

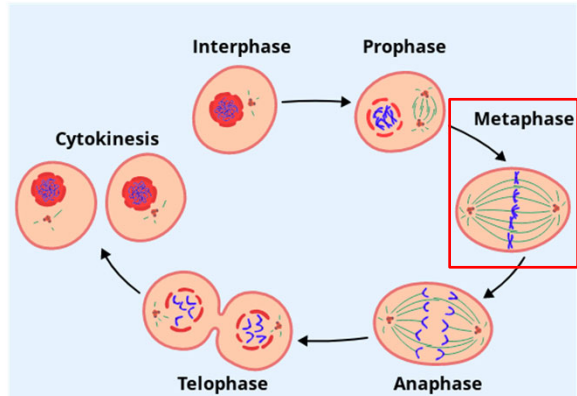


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Anaphase

- Sister chromatids are pulled apart and move to opposite poles of the cell.

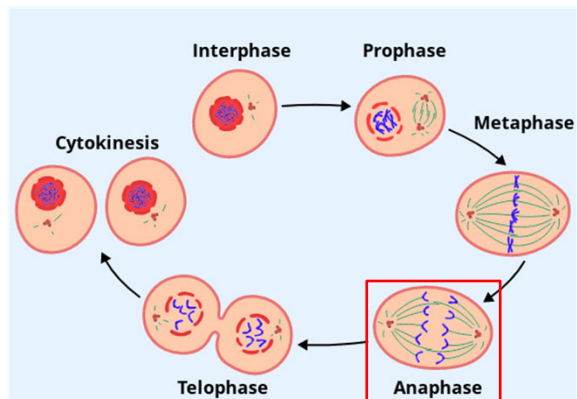


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Telophase

- Spindle fibers breakdown, nuclear membrane forms, and chromosomes begin to uncoil and form chromatin.

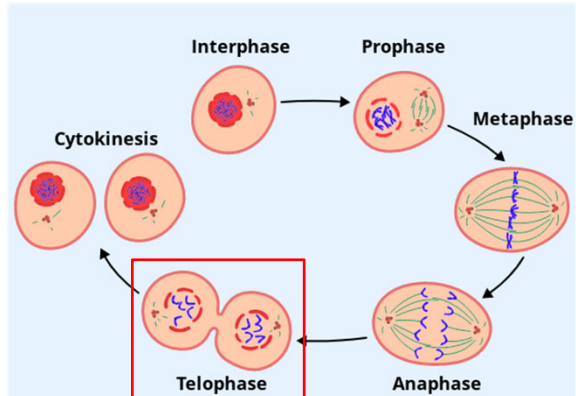


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Cytokinesis

- Cytoplasm splits into two and the cell divides.

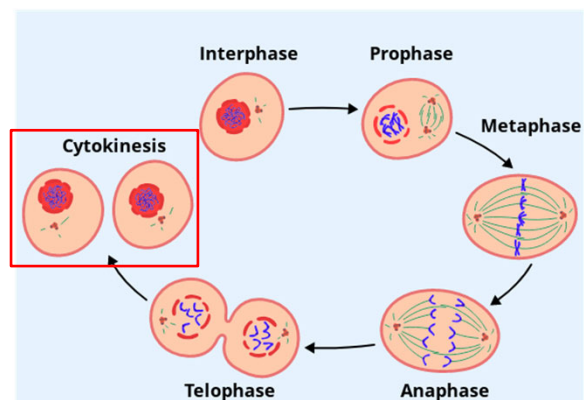
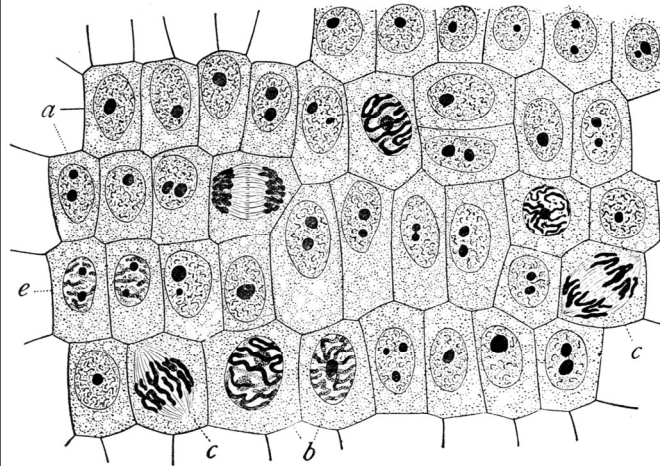


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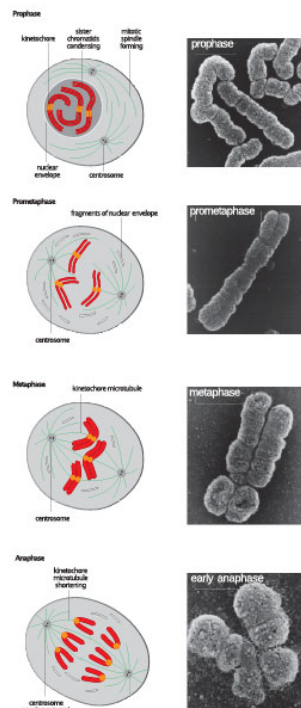


General view of cells in the growing root-tip of the onion, from a longitudinal section, enlarged 800 diameters.

- a. non-dividing cells, with chromatin-network and deeply stained nucleoli
- b. nuclei preparing for division (spireme-stage)
- c. dividing cells showing mitotic figures
- e. pair of daughter-cells shortly after division

Wilson, Edmund B. (1900) *The cell in Development and Inheritance* (2nd ed.), New York: The Macmillan Company.

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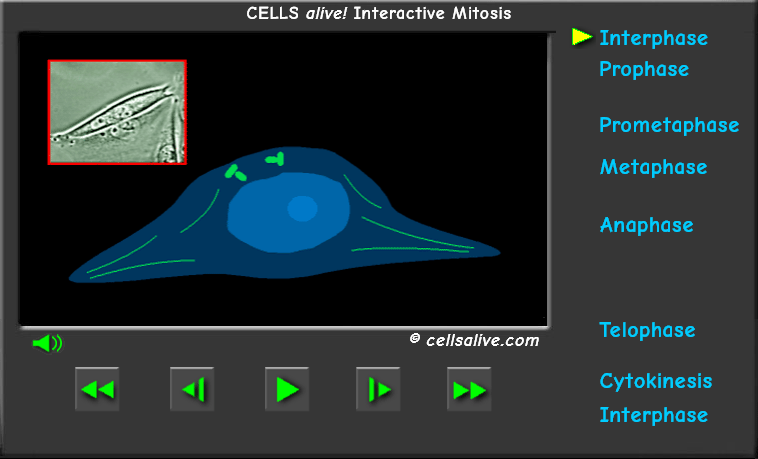
Scanning electron microscopy reveals that sister-chromatid pairs first condense into single rod-like structures during prophase. As mitosis proceeds, chromatid arms are gradually resolved and become almost completely distinct by the end of metaphase.

Stages of early mitosis in a vertebrate cell – David O Morgan. *The Cell Cycle. Principles of Control.*

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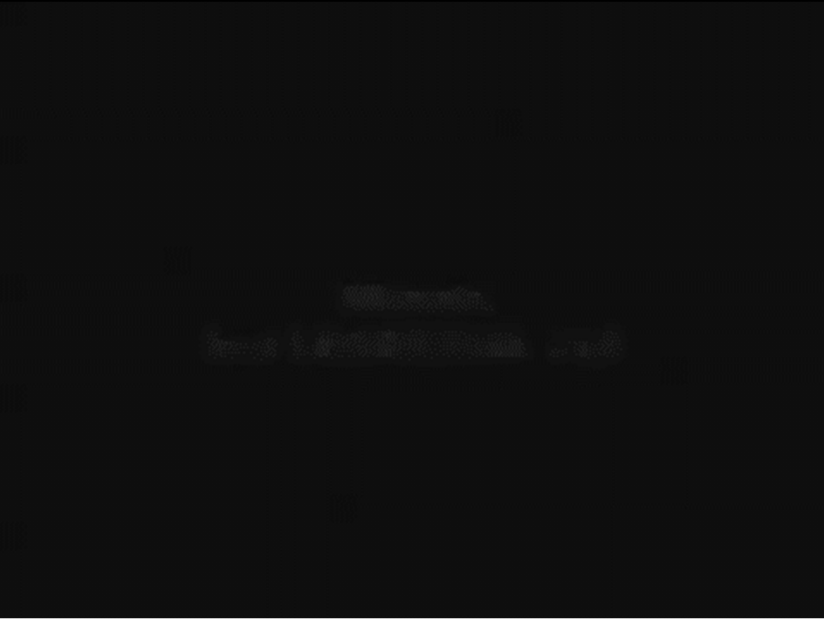
CELLS *alive!* Interactive Mitosis



Interphase
Prophase
Prometaphase
Metaphase
Anaphase
Telophase
Cytokinesis
Interphase

Source: https://www.cellsalive.com/mitosis_js.htm Web Viewer Terms | Privacy & Cookies Edit

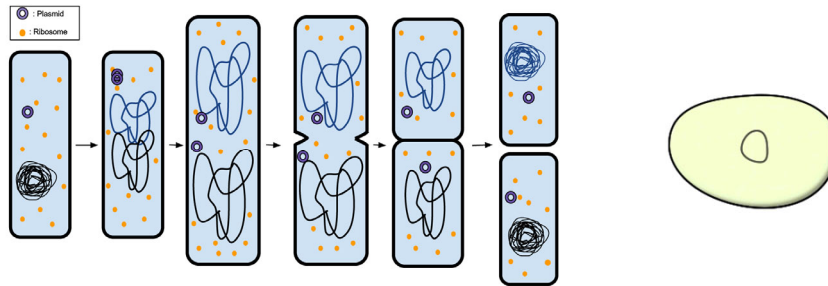
https://www.cellsalive.com/mitosis_js.htm



LEGO Animation of Mitosis (with descriptive titles). Edgerton Outreach.
(<https://techtv.mit.edu/collections/dfc67375a20247f481582347b8581be7/>)
<https://techtv.mit.edu/videos/8d0d428eecdd4d9d97ab561bb9ab740f/>

Binary Fission

- Occurs in prokaryotic cells
- Simpler and faster due to a single, circular DNA chromosome and no nucleus



Binary fission 2 – Ecoddington14 ([CC BY-SA 3.0](#))
Binary fission animation – ZabMilenko ([CC BY-SA 3.0](#))

- **Straightening Out the DNA**
 - The circular strand uncoils and straightens so it can be copied.
- **DNA Replication**
 - The DNA duplicates and the two copies attach themselves to the cell membrane.
- **Cell Elongation**
 - Cell lengthens by adding cell wall and membrane material around the middle
- **Cell Splitting**
 - The cell splits into two daughter cells of equal size

Sexual Reproduction

- Although many unicellular organisms and a few multicellular organisms can produce genetically identical clones of themselves through asexual reproduction, many single-celled organisms and most multicellular organisms reproduce regularly using another method—sexual reproduction.

- Sexual reproduction involves two parents
- Parents produce reproductive cells (**gametes** or **germ cells**) that unite (**fertilization**) to form an offspring
- Gametes are **haploid** cells
 - Contain half the number of chromosomes found in other cells of the organism
- Gametes are produced by a type of cell division called **meiosis**

<https://youtu.be/VzDMG7ke69g>

Meiosis

- A type of cell division in which the number of chromosomes is reduced by half
 - Specific to gamete producing cells in the gonads
- Begins with a diploid cell and ends with four haploid cells
 - These cells eventually differentiate into mature sperm or egg cells

- During meiosis, homologous chromosomes separate, and haploid cells form that have only one chromosome from each pair

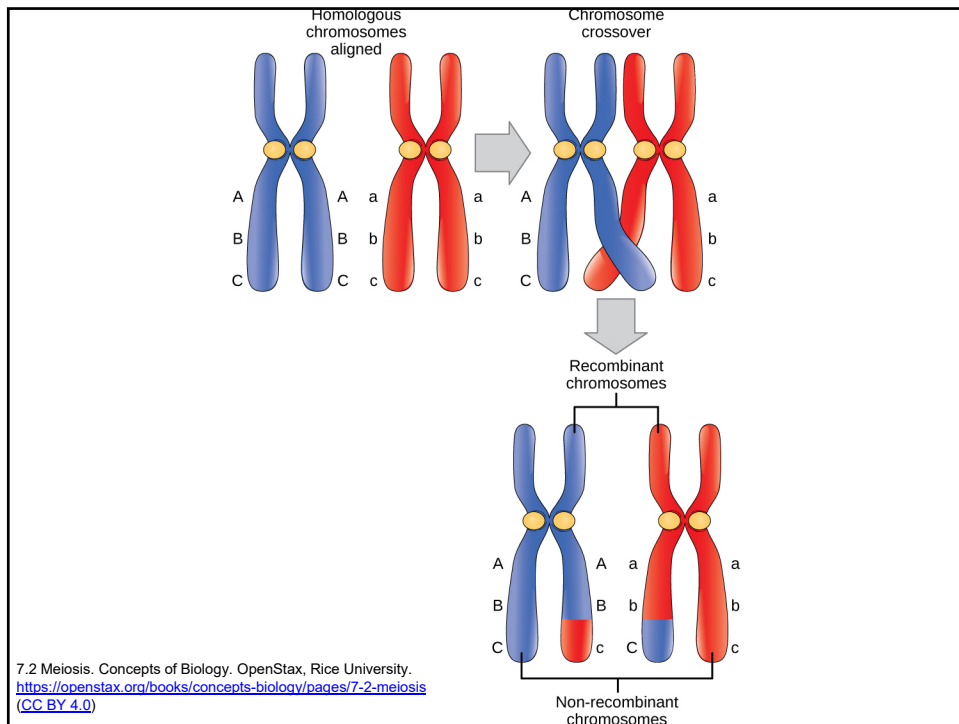


- Two cell divisions occur during meiosis, meiosis I and meiosis II.

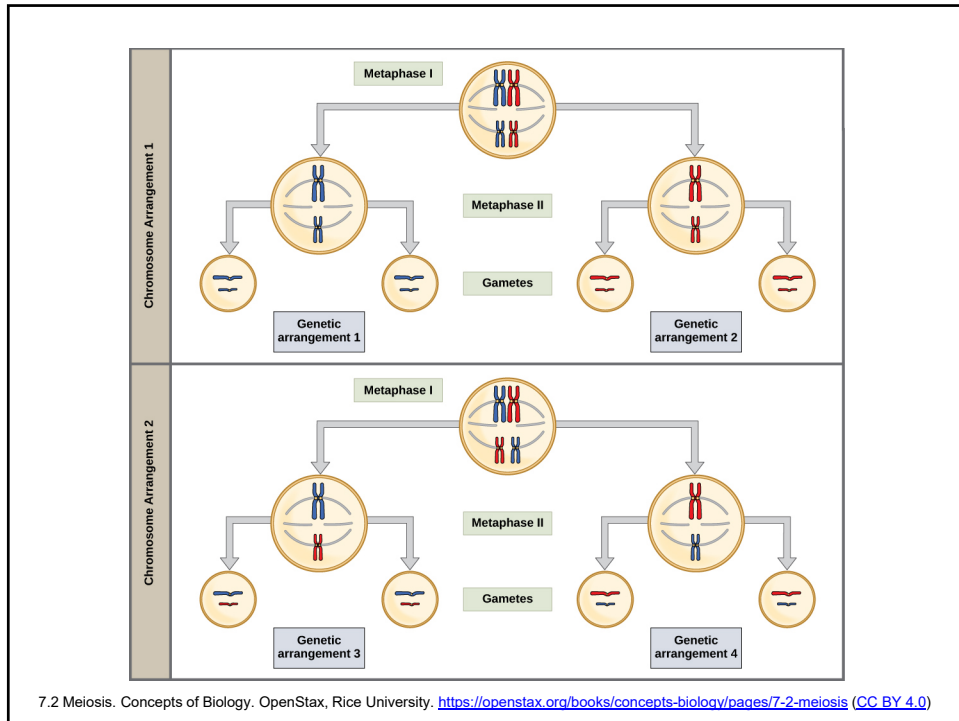
Fabian L, Troszianczuk J, Forer A (2007). "[Calyculin A, an enhancer of myosin, speeds up anaphase chromosome movement](#)". *Cell & Chromosome*. DOI:10.1186/1475-9268-6-1. PMID 17381845. PMC: 1847834. (CC BY 2.0)

Meiosis I

- During prophase I, the maternal and paternal genes are recombined by crossover events occurring on each homologous pair

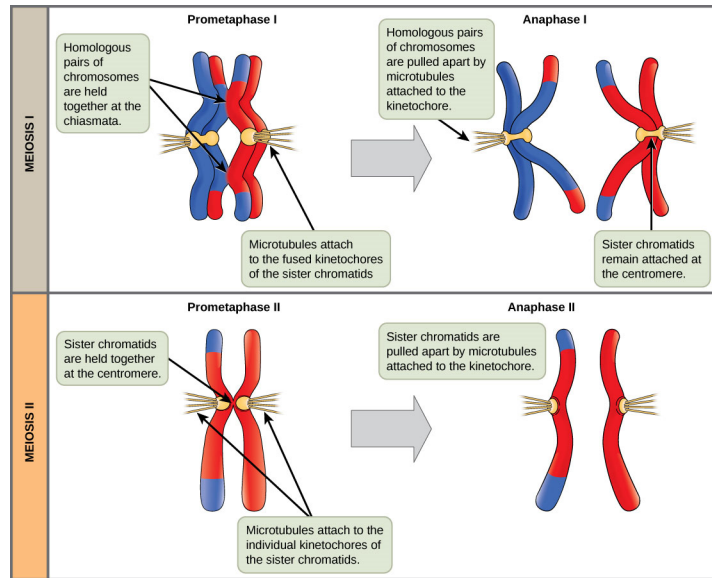


- During metaphase I, homologous chromosomes are randomly arranged in the center of the cell
 - produces a unique combination of maternal and paternal chromosomes that will make their way into the gametes
 - for humans there are $2^{23} = 8\,388\,608$ different possible combinations



Meiosis II

- The connected sister chromatids in the haploid cells from meiosis I will be split to form four haploid cells
- The two cells produced in meiosis I go through the events of meiosis II at the same time



7.2 Meiosis. Concepts of Biology. OpenStax, Rice University. <https://openstax.org/books/concepts-biology/pages/7-2-meiosis> (CC BY 4.0)

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[< Cell Cycle](#) [< Mitosis](#) [^ Meiosis Overview](#) **Meiosis**

CELLS alive! Interactive Meiosis

Diploid Cell (2N) ⓘ

Meiosis I

- Prophase I ⓘ
- Metaphase I ⓘ
- Anaphase I ⓘ
- Telophase I ⓘ

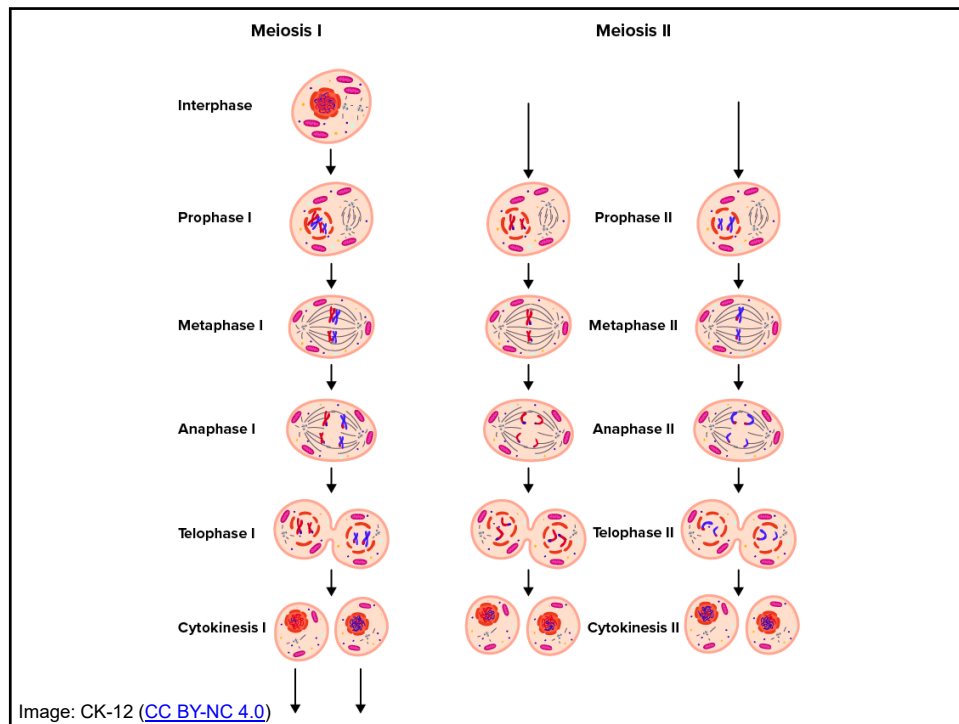
Meiosis II

- Prophase II ⓘ
- Metaphase II ⓘ
- Anaphase II ⓘ
- Telophase II ⓘ
- Gamete (1N) ⓘ

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https://www.cellsalive.com/meiosis_js.htm

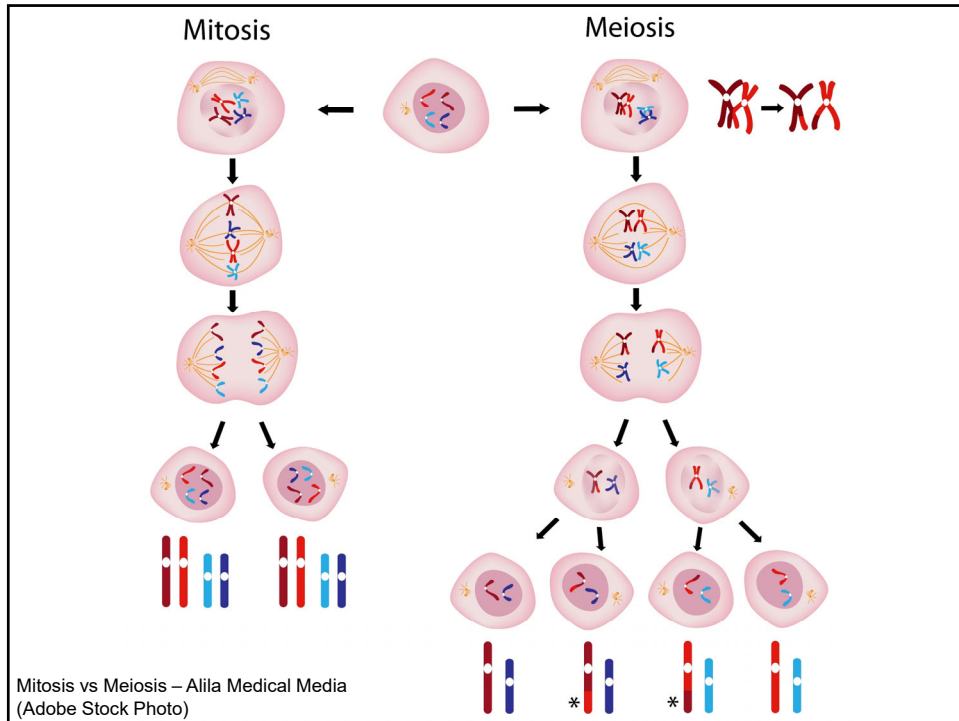


Mitosis

vs

Meiosis

- | | |
|--|---|
| <ul style="list-style-type: none"> • one nuclear division that results in two new cells • nuclei are genetically identical to the original • nuclei contain the same number of sets of chromosomes as the original | <ul style="list-style-type: none"> • two nuclear divisions that result in four new cells • nuclei are never genetically identical to the original • nuclei contain one chromosome set only (half the number of the original cell) |
|--|---|



<https://youtu.be/zrKdz93WIVk>