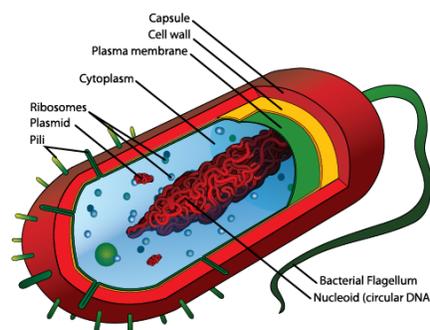


- All cells contain
  - plasma membrane
    - outer covering that separates the cell's interior from its surrounding environment
  - cytoplasm
    - jelly-like region within the cell in which other cellular components are found
  - DNA
    - the genetic material of the cell
  - ribosomes
    - particles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

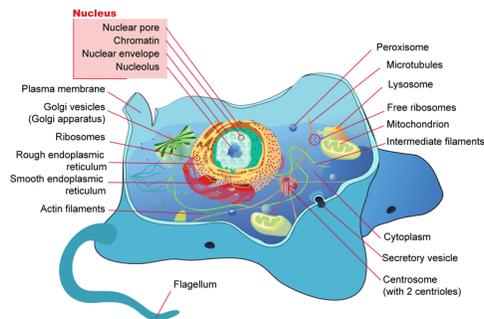


A diagram of a typical prokaryotic cell – Mariana Ruiz Villarreal, LadyofHats (public domain)

- 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>

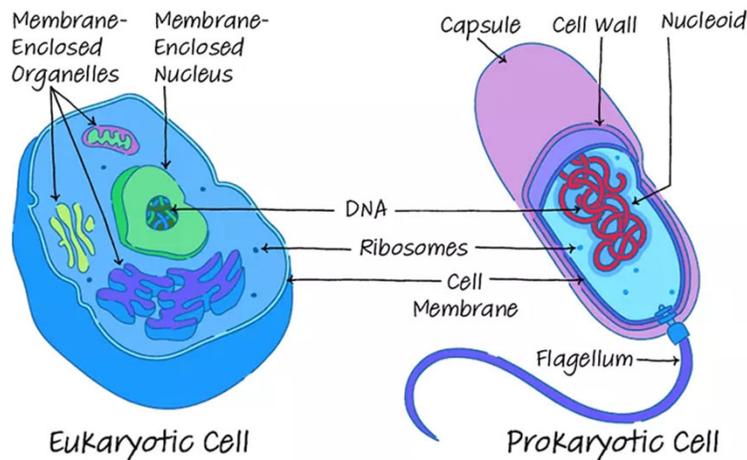


Image: Chen, Dana. "Prokaryotic vs Eukaryotic Cells: Similarities & Differences" sciencing.com,  
<https://sciencing.com/prokaryotic-vs-eukaryotic-cells-similarities-differences-13717689.html>. 16 March 2021.

## Genomic DNA

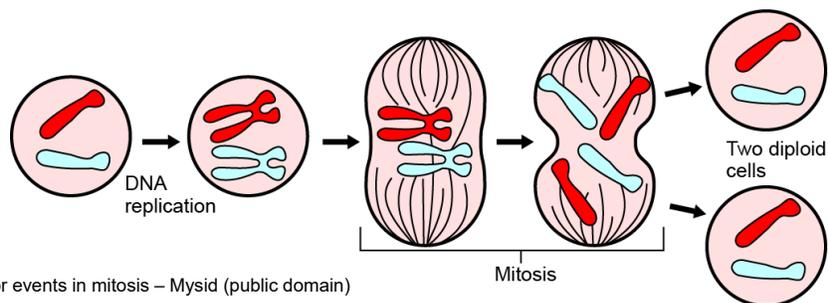
- A cell's complete complement of DNA is called its **genome**.
  - In prokaryotes the genome is composed of a single, double-stranded DNA molecule in the form of a loop or circle.
  - In eukaryotes, the genome comprises several double-stranded, linear DNA molecules bound with proteins to form complexes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

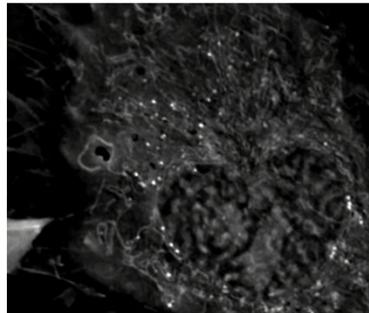
- The cell cycle has two major phases:
  - interphase and the mitotic phase
  - Interphase
    - the cell grows and DNA is replicated
  - Mitotic phase
    - the replicated DNA and cytoplasmic contents are separated and the cell divides



<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](https://creativecommons.org/licenses/by-sa/4.0/))

# Interphase

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

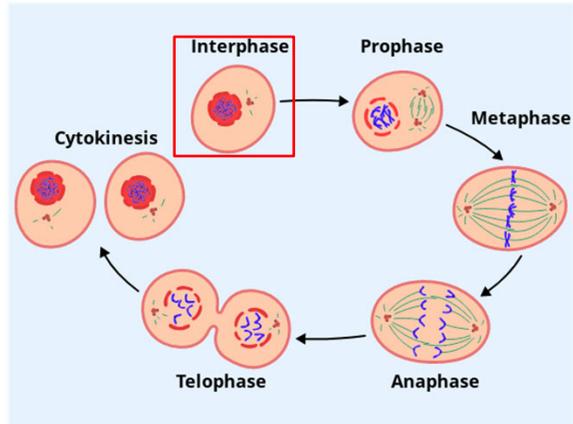


Image credit: CK-12 ([CC BY-NC 3.0](https://creativecommons.org/licenses/by-nc/3.0/))

# Prophase

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

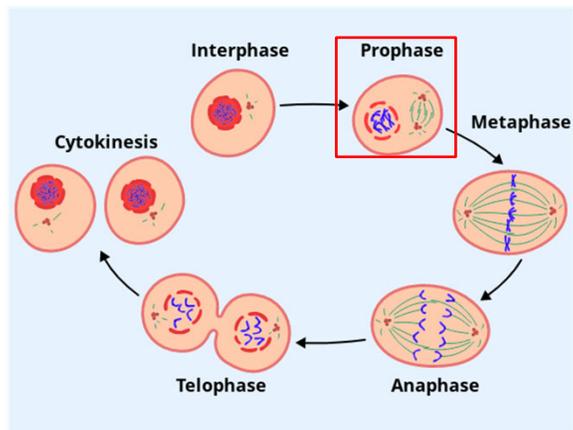


Image credit: CK-12 ([CC BY-NC 3.0](https://creativecommons.org/licenses/by-nc/3.0/))

# Metaphase

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

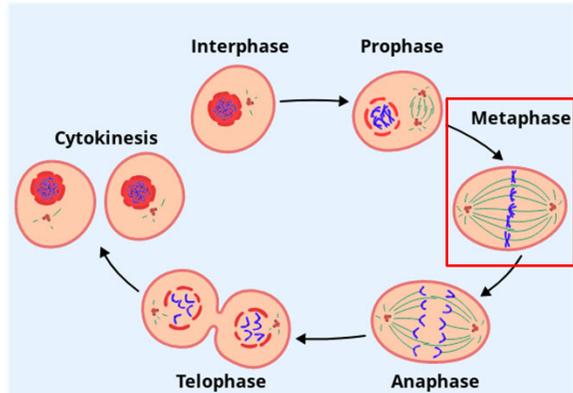


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# Anaphase

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

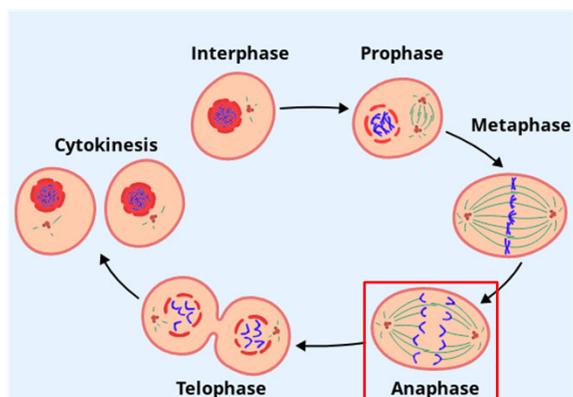


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# Telophase

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

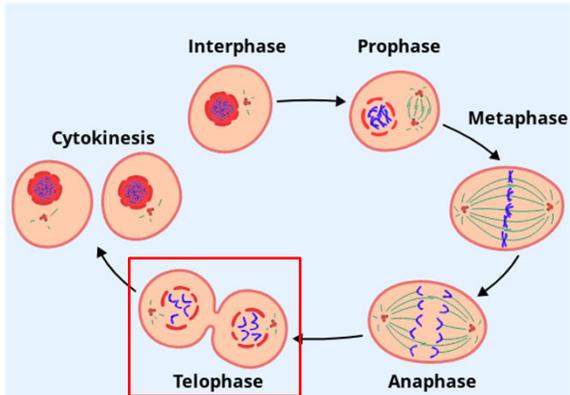


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# Cytokinesis

- Cytoplasm splits into two and the cell divides.

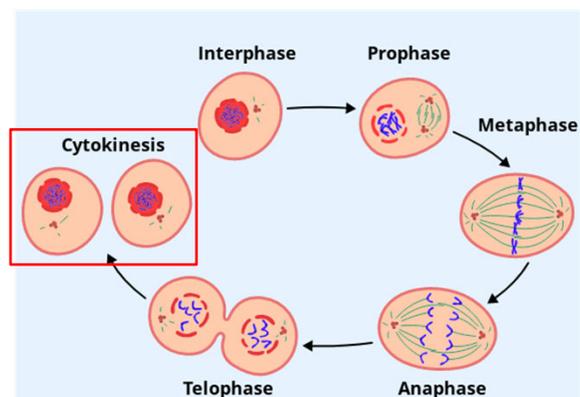
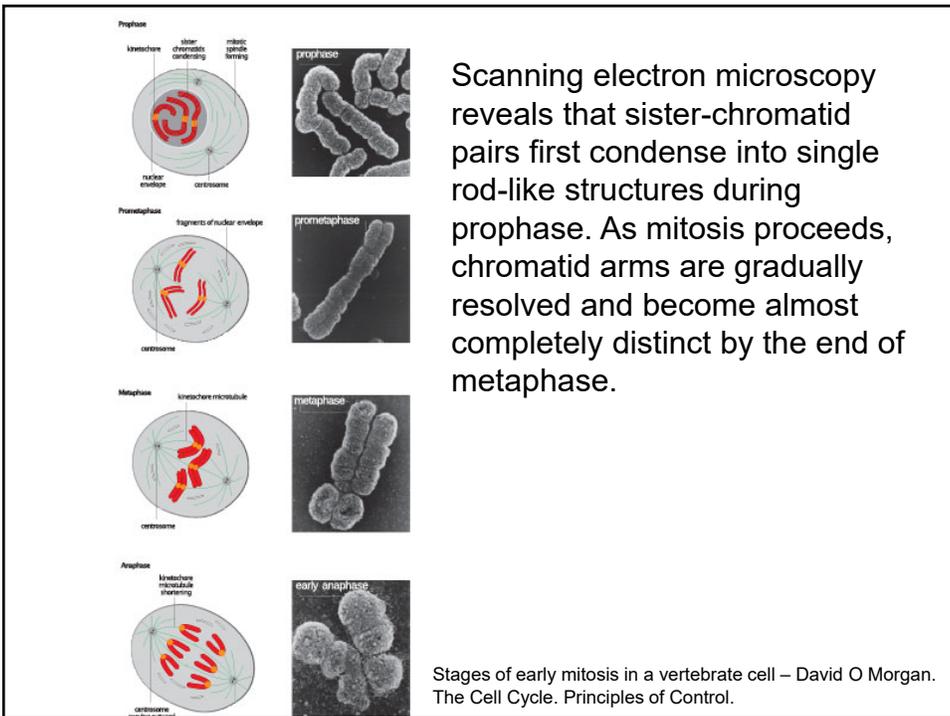
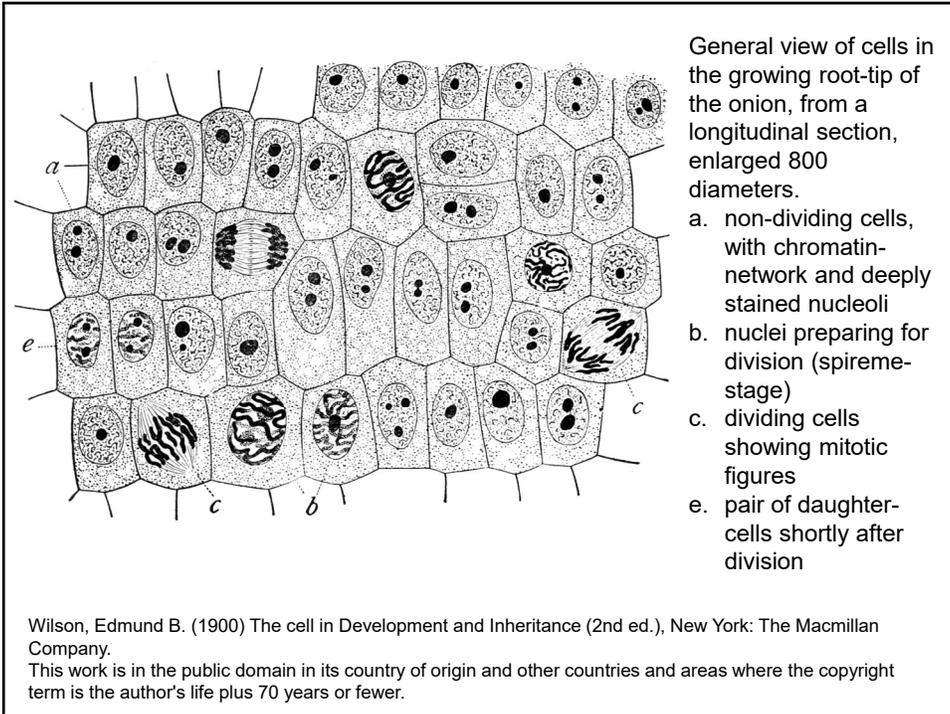


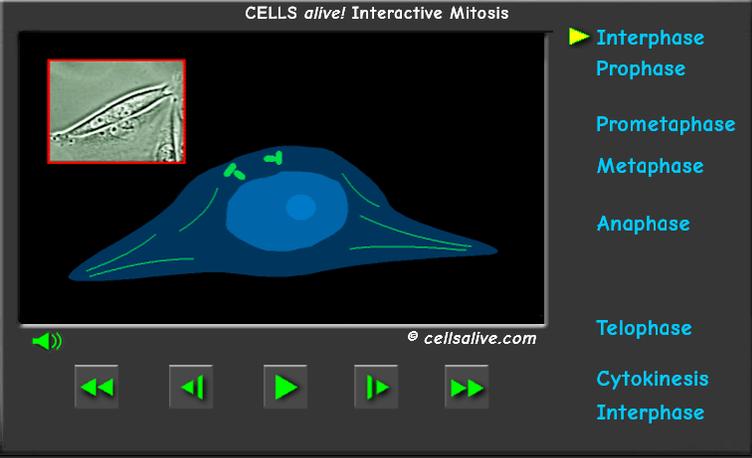
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HOME

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

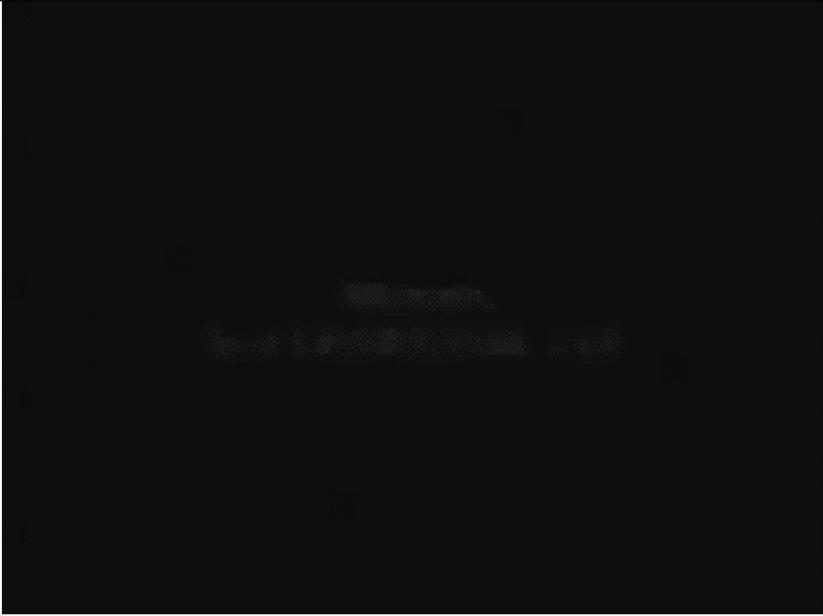
CELLS *alive!* Interactive Mitosis



The interface features a central video player showing a blue cell with internal structures. To the right is a vertical list of stages: Interphase, Prophase, Prometaphase, Metaphase, Anaphase, Telophase, Cytokinesis, and Interphase. Below the video are navigation controls: a volume icon, a play button, and four arrow buttons (left, left, right, right). A small inset image in the top left shows a microscope view of a cell. The text '© cellsalive.com' is visible at the bottom of the video player.

Source: [https://www.cellsalive.com/mitosis\\_js.htm](https://www.cellsalive.com/mitosis_js.htm) Web Viewer Terms | Privacy & Cookies Edit

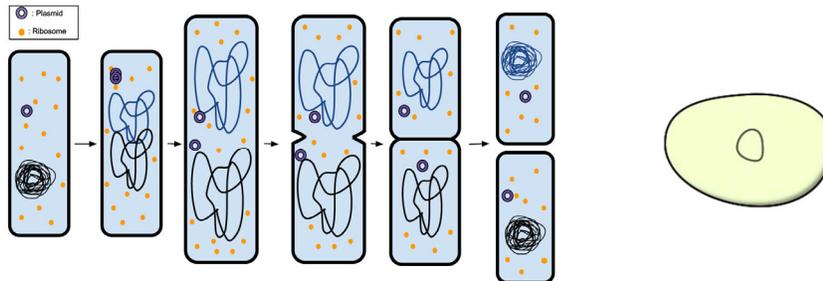
[https://www.cellsalive.com/mitosis\\_js.htm](https://www.cellsalive.com/mitosis_js.htm)



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](https://creativecommons.org/licenses/by-sa/3.0/))  
Binary fission animation – ZabMilenko ([CC BY-SA 3.0](https://creativecommons.org/licenses/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

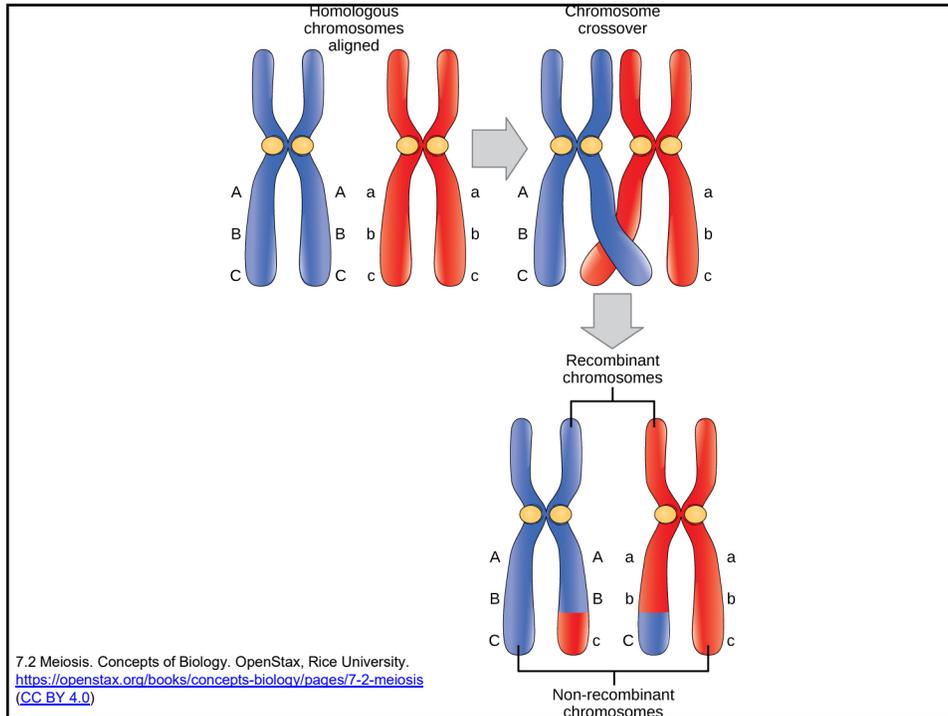


- Two cell divisions occur during meiosis, meiosis I and meiosis II.

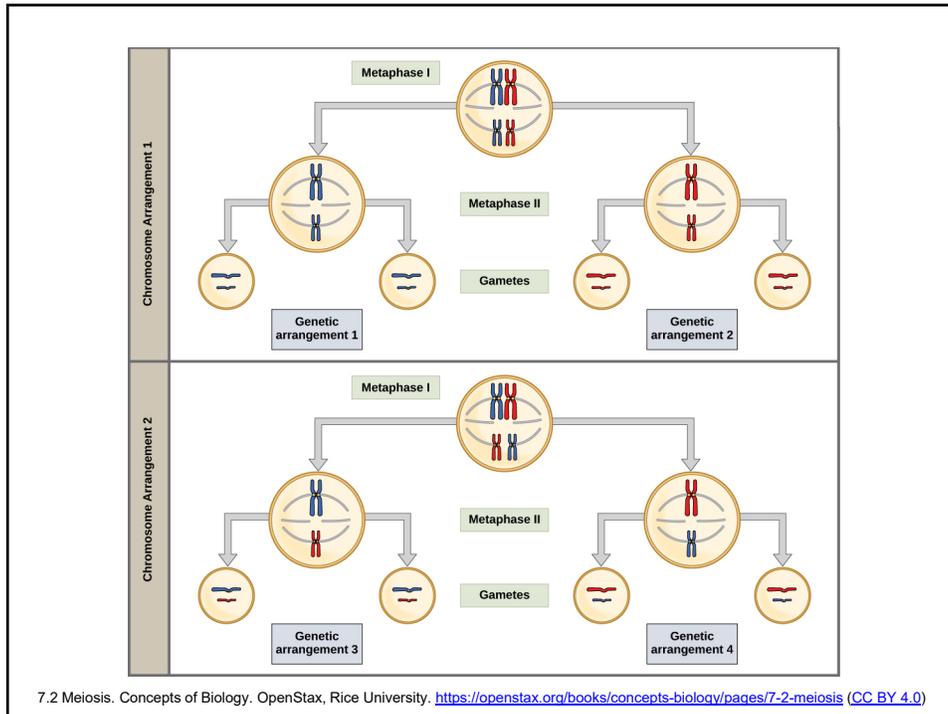
Fabian L, Troscianczuk J, Forer A (2007). "[Calyculin A, an enhancer of myosin, speeds up anaphase chromosome movement](#)". *Cell & Chromosome*. DOI:10.1186/1475-9268-6-1. PMID 17381845. PMC: 1847834. (CC BY 2.0)

## Meiosis I

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

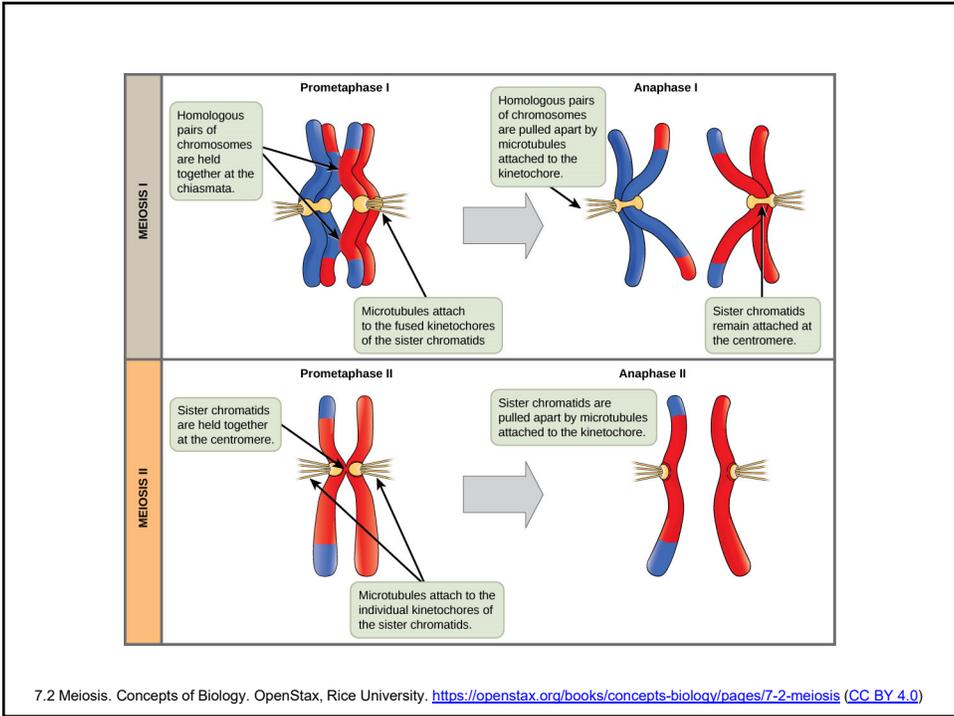


- During metaphase I, homologous chromosomes are randomly arranged in the center of the cell
  - produces a unique combination of maternal and paternal chromosomes that will make their way into the gametes
  - for humans there are  $2^{23} = 8\,388\,608$  different possible combinations



## 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



HOME

< Cell Cycle < Mitosis ^ Meiosis Overview Meiosis

CELLS alive! Interactive Meiosis

Diploid Cell (2N) ?

**Meiosis I**

- Prophase I ?
- Metaphase I ?
- Anaphase I ?
- Telophase I ?

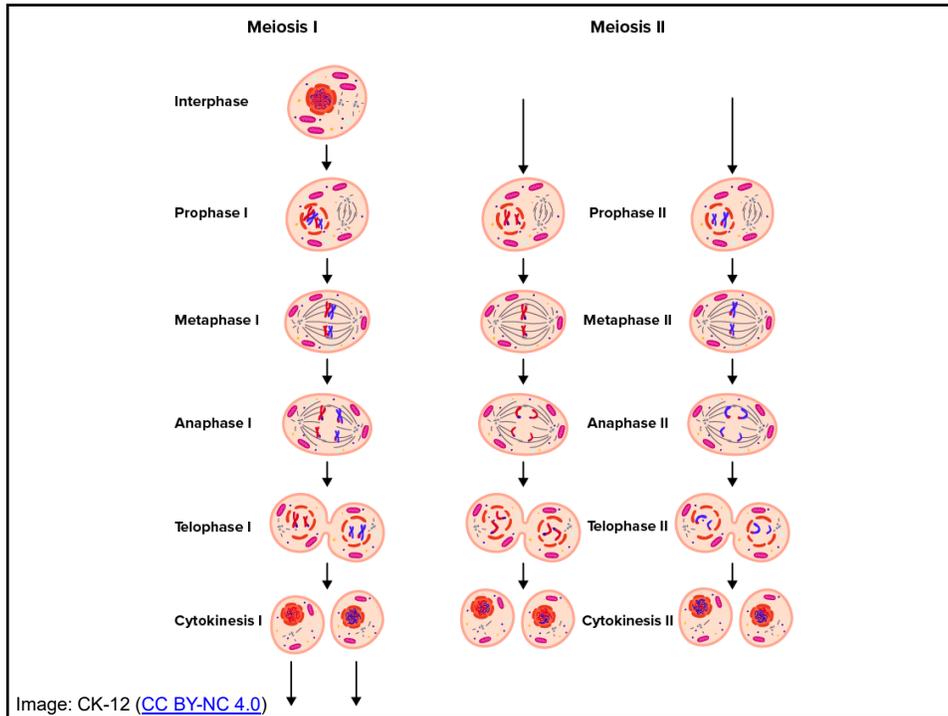
**Meiosis II**

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

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[https://www.cellsalive.com/meiosis\\_js.htm](https://www.cellsalive.com/meiosis_js.htm)

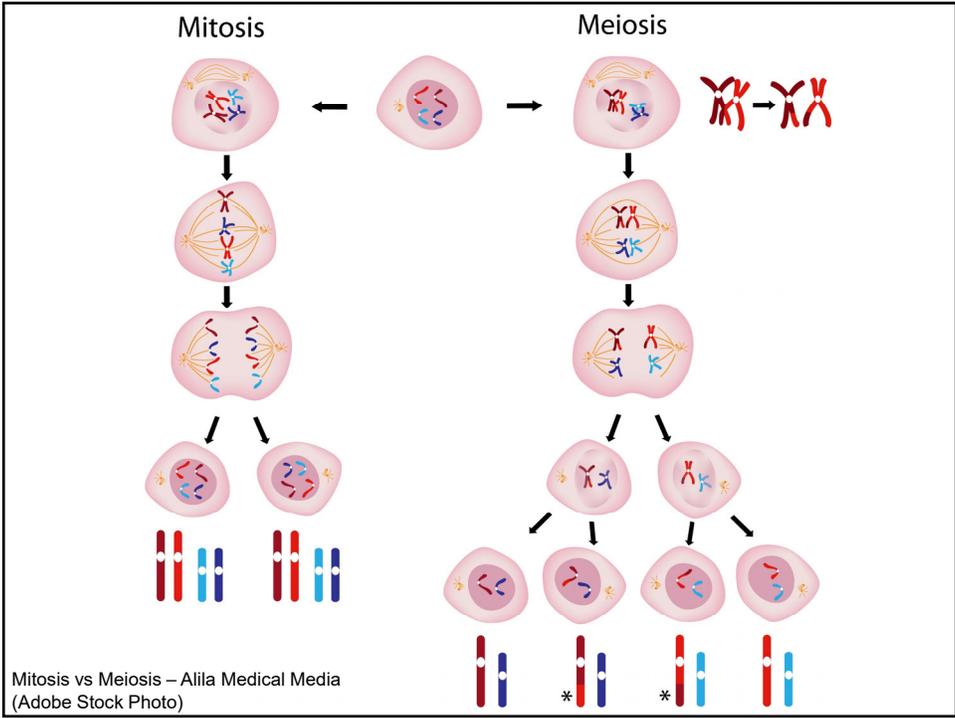


## Mitosis

vs

## Meiosis

- 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
- 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>