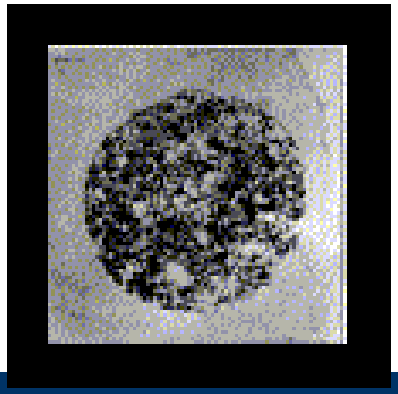
Meiosis
(The complete story)

Biology

Objectives

- Students will know what happens during the stages of meiosis (both meiosis I and II)
- Students will understand what crossing over is and how it contributes to genetic diversity
- Students will be able to describe and explain the similarities and differences between mitosis, meiosis, and each stage of meiosis

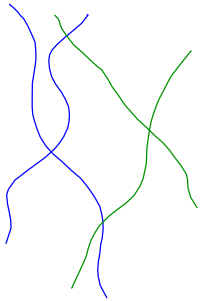
Overview



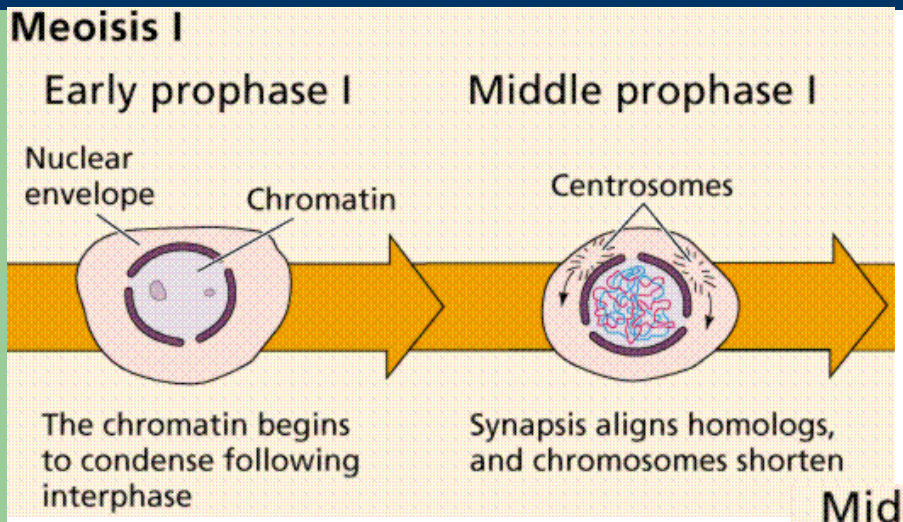
- Meiosis is a type of cell division that occurs in sexually reproducing organisms
- Meiosis happens in 2 stages: Meiosis 1, and Meiosis 2.
- Stage 1 separates homologous chromosomes, creating haploid daughter cells with replicated chromosomes
- Stage 2 separates sister chromatids, creating daughter cells with unreplicated chromosomes
- New cells created by meiotic division are **gametes** (egg and sperm cells in animals).
- Mutations that occur in cells that perform meiosis are heritable (can be passed on from parent to offspring).

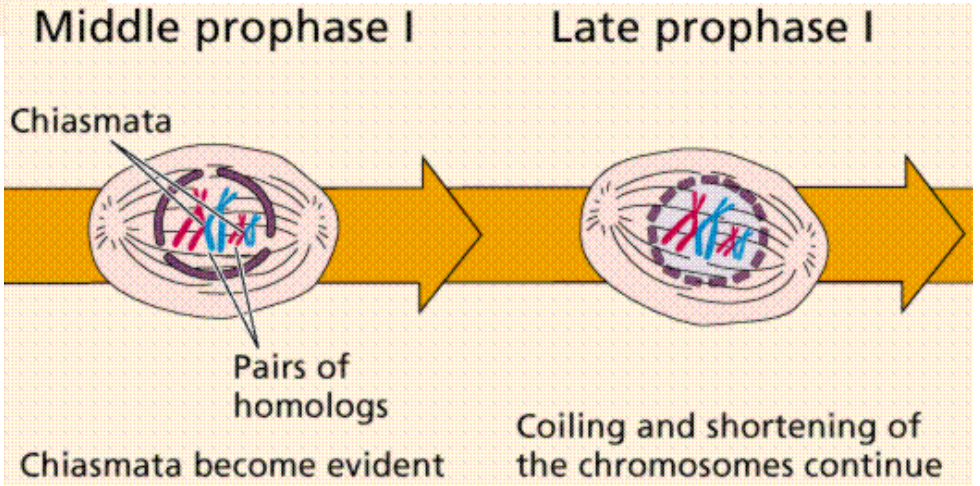
Meiosis 1: Prophase 1

- Begins with replicated DNA
  - Each member of a homologous chromosome pair has copied itself (sister chromatids joined by a centromere)
- Parent cells are diploid (2N)
  - Each cell has two copies of each chromosome (one from mom and one from pop)
- Homologous chromosomes “find each other” in the cell to from tetrads: pairs of homologous chromosomes linked together



Prophase 1


Meoisis I
Early prophase I
Middle prophase I
Nuclear envelope
Chromatin
Centrosomes
The chromatin begins to condense following interphase
Synapsis aligns homologs, and chromosomes shorten

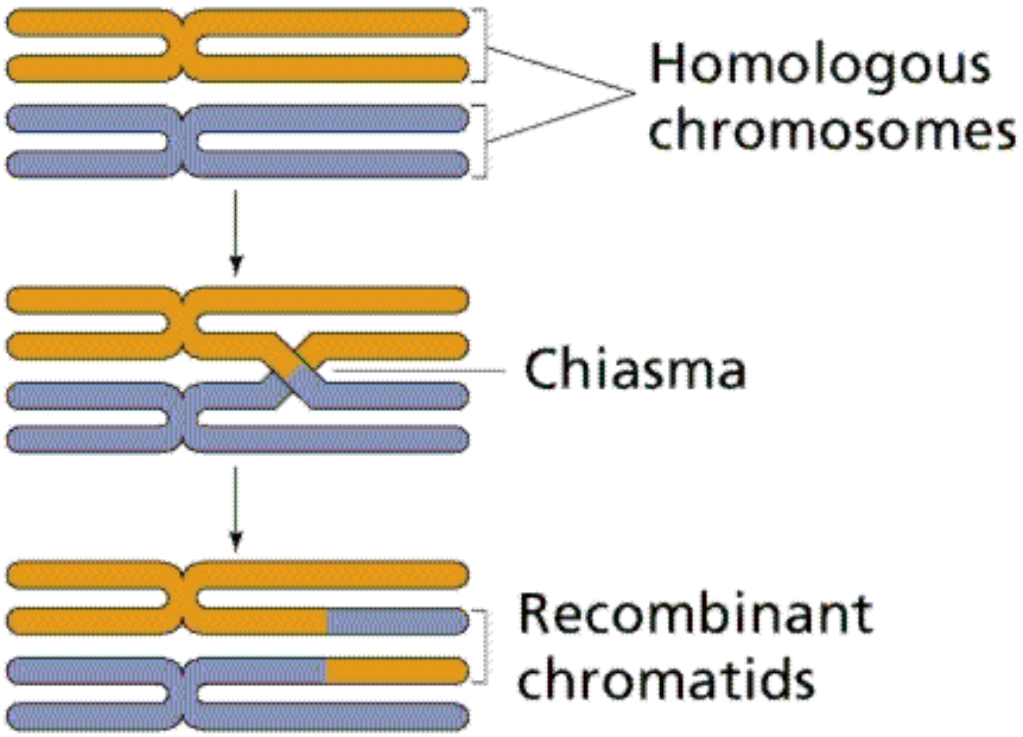

Middle prophase I
Late prophase I
Chiasmata
Pairs of homologs
Chiasmata become evident
Coiling and shortening of the chromosomes continue

Meiosis 1: Metaphase 1

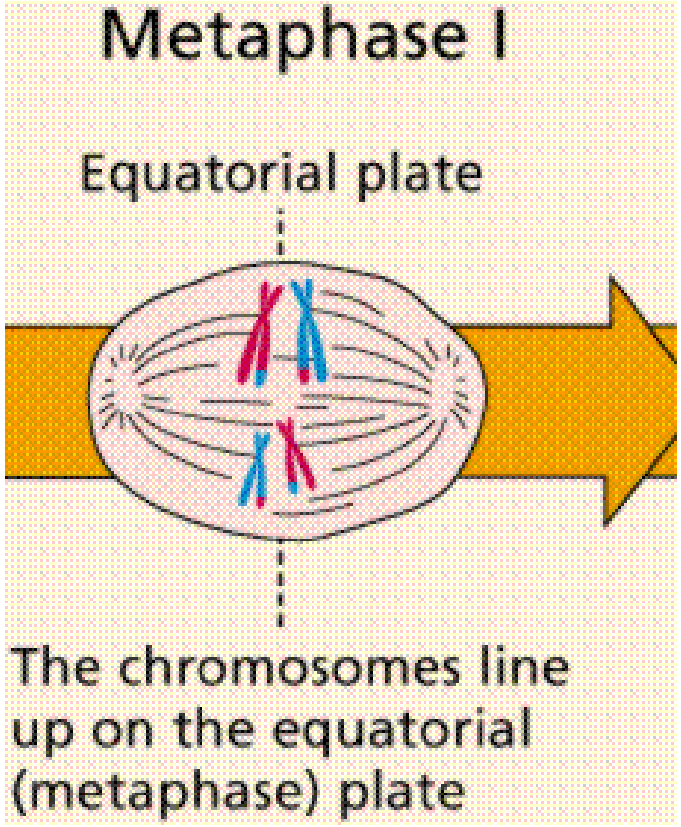
- Tetrads line up in the center of the cell and prepare to divide.
- The initial pairing of the tetrads are so close that the chromosome arms can temporarily tangle and swap genetic material.
  - This is called **crossing over** (or “synapsis”)
  - The result is new combinations of genetic material – the sister chromatids are no longer genetically identical to the original chromosomes

Metaphase 1 - Crossing Over

- Results in new combinations of genetic material



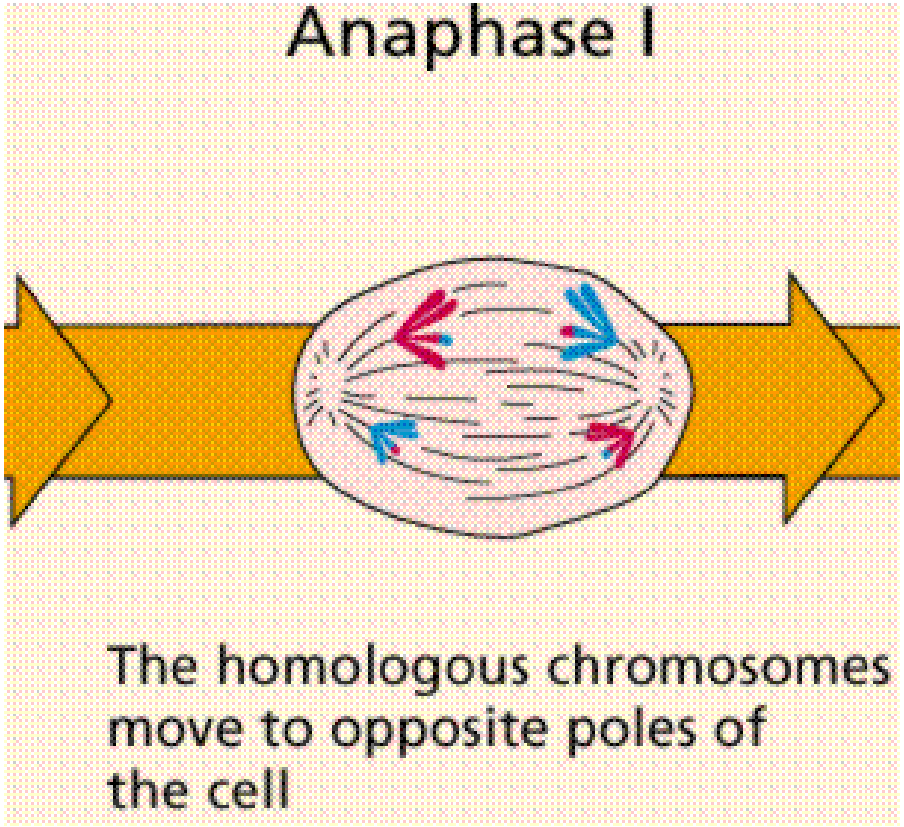
Meiosis 1 - Metaphase 1



Meiosis 1: Anaphase 1

- Tetrads (of homologous chromosomes) separate
- Half the chromosomes move to one end, ½ to the other end of the cell
- The spindle apparatus is what pulls the homologous chromosomes apart

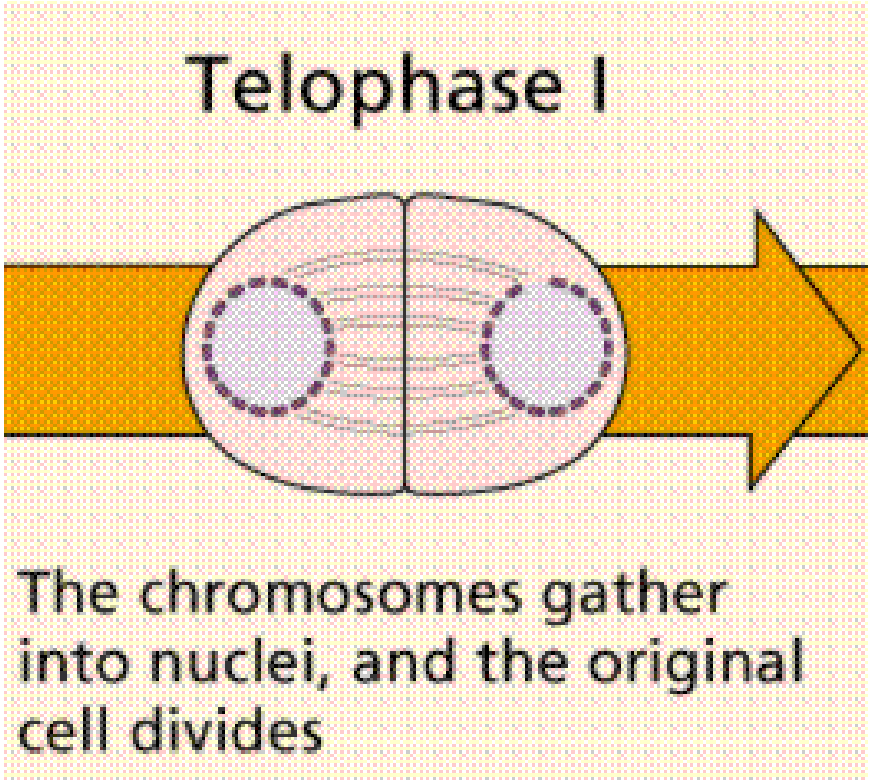
Meiosis 1 - Anaphase 1



Meiosis 1: Telophase 1

- A cell wall or membrane forms, splitting the parent cell in half
- The end result is two haploid (N) cells
  - Each cell has only one chromosome from the original chromosome pair
  - Each chromosome is replicated (there are two sister chromatids)

Meiosis 1 - Telophase 1

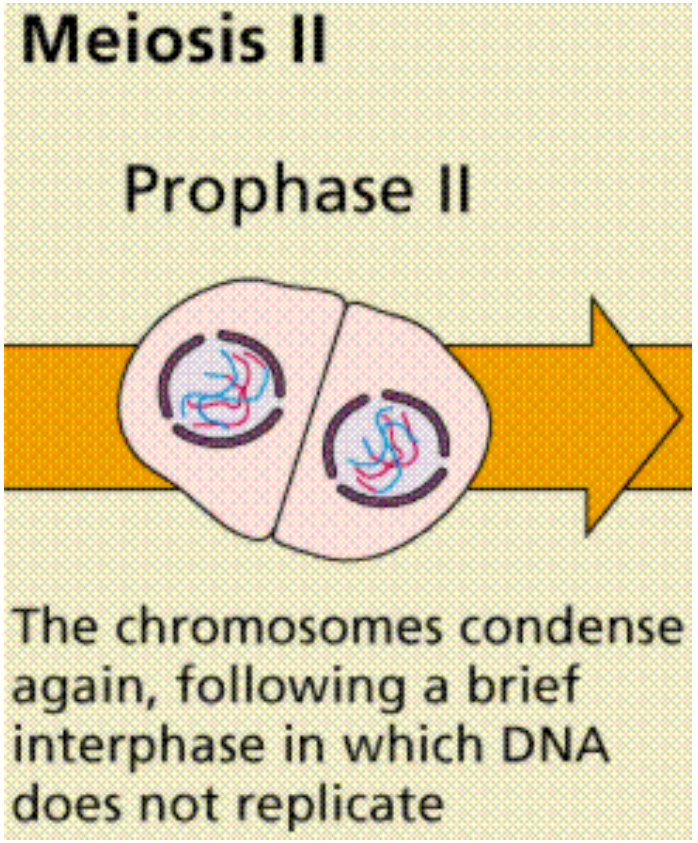


Meiosis 2 (Second stage of meiosis)

- The cells created in Meiosis 1 separate their sister chromatids and create two new cells each (four total)
- At the start of Meiosis 1, the two cells haploid (N); all four daughter cells are haploid as well
- Meiosis 2 is very similar to mitosis: sister chromatids are separated
- Differences between mitosis and Meiosis 2:
  - Daughter cells are not genetically identical due to the process of meiosis 1 and crossing over
  - Both the parent and daughter cells are haploid
  - Meiosis 2 includes cytokinesis

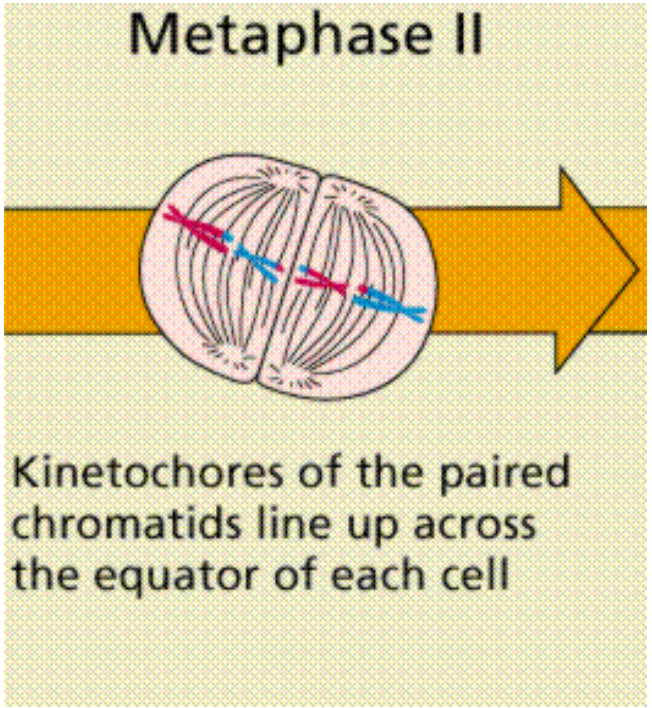
Meiosis 2 - Prophase 2

- Chromosomes condense
- Nuclear envelope begins to dissolve
- Spindle starts to form



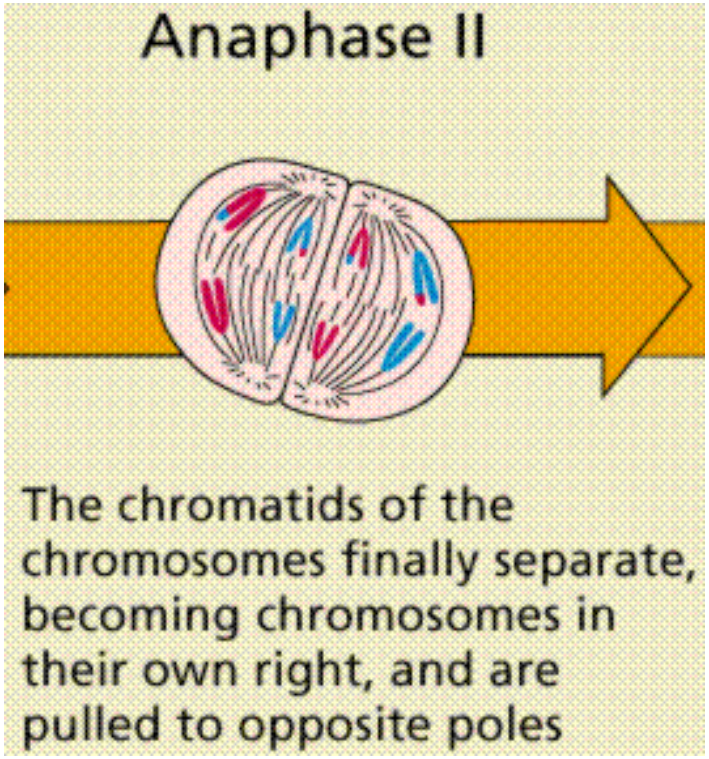
Meiosis 2: Metaphase 2

- Replicated chromosomes line up along the middle of the cell
- Sister chromatids are on opposite sides of midline
- Spindle is attached at the centromere



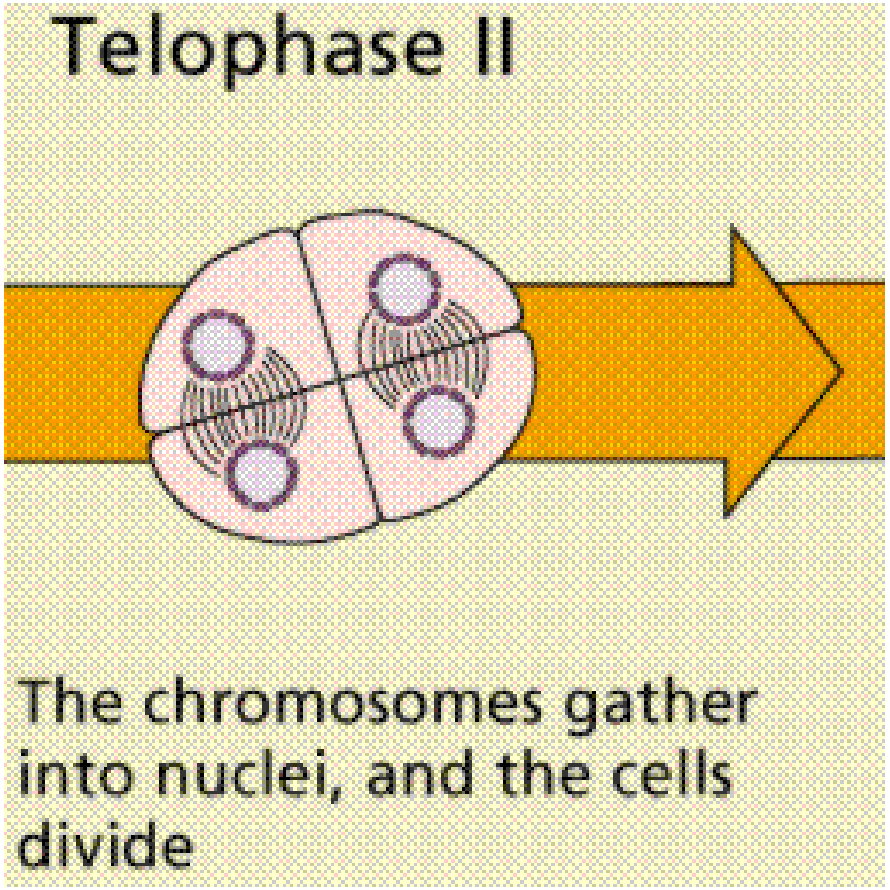
Meiosis 2: Anaphase 2

- Spindle apparatus pulls sister chromatids apart
- Sister chromatids move towards opposite ends of the cell



Meiosis 2: Telophase 2

- Nuclear envelope reforms
- Membrane starts to develop between new cells
- Cytokinesis takes place immediately afterward



End Result of Meiosis:

- Original cell was diploid (2N)
- Four new cells are all haploid (N)
- Daughter cells are genetically unique:
  - Chromosomes from mom and pop are randomly separated so each cell has some of both
  - Crossing-over creates new genetic combinations that are different from original chromosomes from mom and pop
- New cells are **gametes** – they can fuse during sexual reproduction to form a new 2N cell