Visualizing Meiosis Poster
Illustrated Teacher's Guide

#35-1140 PAPER
#35-1141 LAMINATED

Background

Meiosis Basics

Organisms with cells that contain a **nucleus** are called **eukaryotes**. The nucleus contains DNA, the genetic material of the cell. During cell reproduction the **DNA** coils to form **chromosomes**.

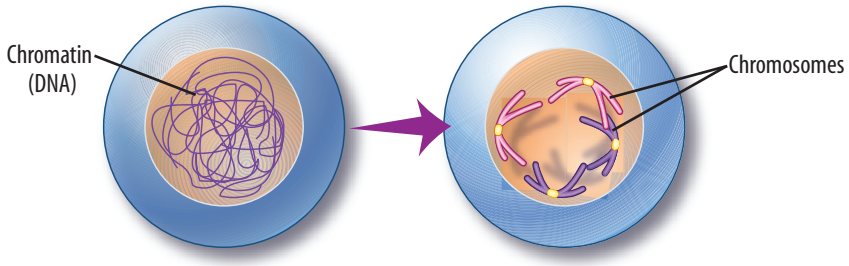


Figure 1. Diagram of a cell showing the nucleus and chromosomes

Only eukaryotic organisms reproduce through the process of **sexual reproduction**. Sexual reproduction occurs when specialized sex cells called **gametes** (sperm, egg) combine to form the first cell of a new individual through the process called **fertilization**. The fertilized egg is called a **zygote**. This first cell undergoes a series of stages of growth and division as it develops into a mature individual. The gametes formed by **male** and **female** organisms differ. Although they have essentially the same role in sexual reproduction, the names of the gametes produced by plants and animals also differ. In plants, the male gametes are called **pollen** and the female gametes are called **ova** (singular: **ovum**) or **eggs**. In animals, the male gametes are called **sperm** and the female gametes are called **eggs**.

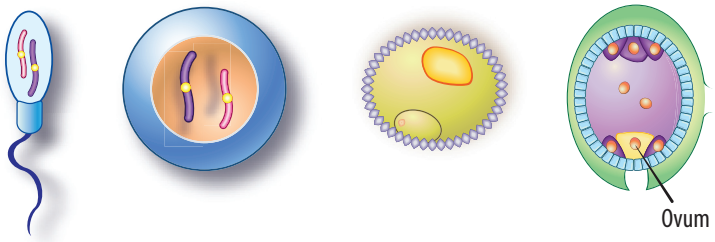


Figure 2. (Left to right) Animal sperm and egg, pollen grain and plant ovule with ovum (not to scale)

The chromosomes in the gametes contain the instructions for all the cell processes necessary for life. Any errors in passing the appropriate number of chromosomes from one generation to the next could harm or even kill the new individual. If each gamete contained a full set of chromosomes, then the fertilized egg would have twice as many chromosomes as a **parent cell**. Each gamete must contain one-half the number of chromosomes so that the zygote has one complete set of chromosomes.

Meiosis

Meiosis occurs in both plant and animal cells. It is commonly called **reduction division**. The process of meiosis reduces the number of chromosomes in gametes to one-half the number contained in the parent cell. Most regular cells typically contain two copies of each chromosome and are described as **diploid (2n)**. Meiosis produces cells with only a single copy of each chromosome and they are described as **haploid (n)** or **monoploid**. A plant undergoes **alternation of generations** in its life cycle as it switches back and forth between diploid and haploid structures. The process of meiosis requires two divisions, called **Meiosis I** and **Meiosis II**. Each is subdivided into stages for reference.

Stages of Meiosis

The order of stages of Meiosis I is **Prophase I**, **Metaphase I**, **Anaphase I**, **Telophase I**, and **Cytokinesis I**. The **daughter cells** are formed and then proceed through a second meiotic division. The names and order of stages of Meiosis II is the same as Meiosis I except that the suffix **II** is used. The process is similar in plants and animals.

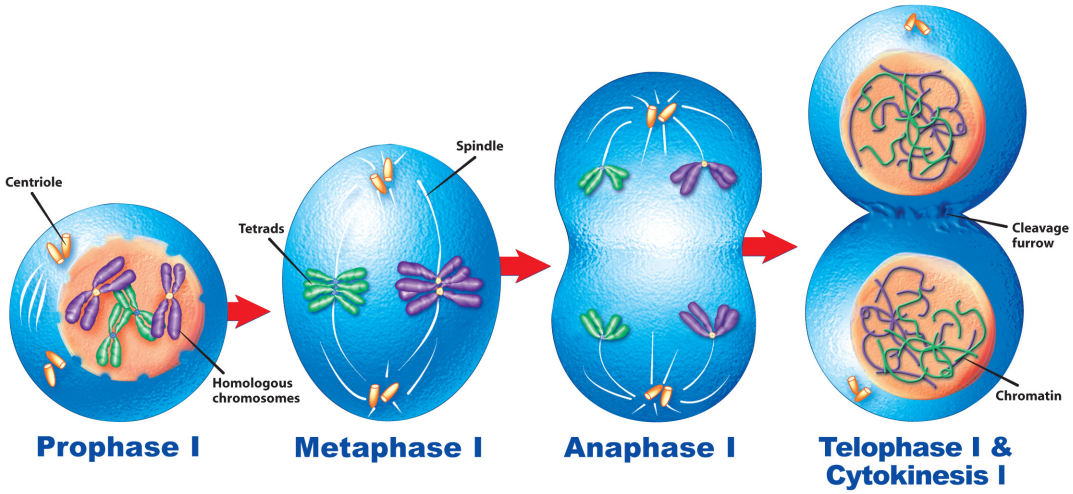


Figure 3. Stages of Meiosis I (Animal cells shown)

Prophase I

During the time before Prophase I, the diploid (2n) cell has already doubled its DNA to become **tetraploid (4n)**. The cell prepares for division by coiling its DNA into chromosomes, pairing **homologous chromosomes** (matched pairs) to form **tetrads**, and dissolving the nuclear membrane during Prophase I (as shown in Figure 3). Parts of chromosomes may be exchanged through **crossing over**.

Metaphase I

Figure 3 shows the formation of the **spindle**. It also shows how the tetrads align at the equator of the cell. Each pair of homologous chromosomes attaches to the spindle.

Anaphase I

Homologous chromosomes separate during Anaphase I, but the **sister chromatids** stay together as they move toward opposite ends of the cell.

Telophase I & Cytokinesis I

During Telophase I the chromosomes gather at the poles and uncoil to become the thin, threadlike form called **chromatin**. The nuclear membrane also reforms. The physical division of the parent cell in Cytokinesis I occurs differently for animals and plants. In animal cells, a cleavage furrow pinches inward near the equator of the cell to form two daughter cells. In plants, a cell plate forms near the center of the cell and spreads outward to separate the two daughter cells. The diploid (2n) daughter cells then begin Prophase II of the second division.

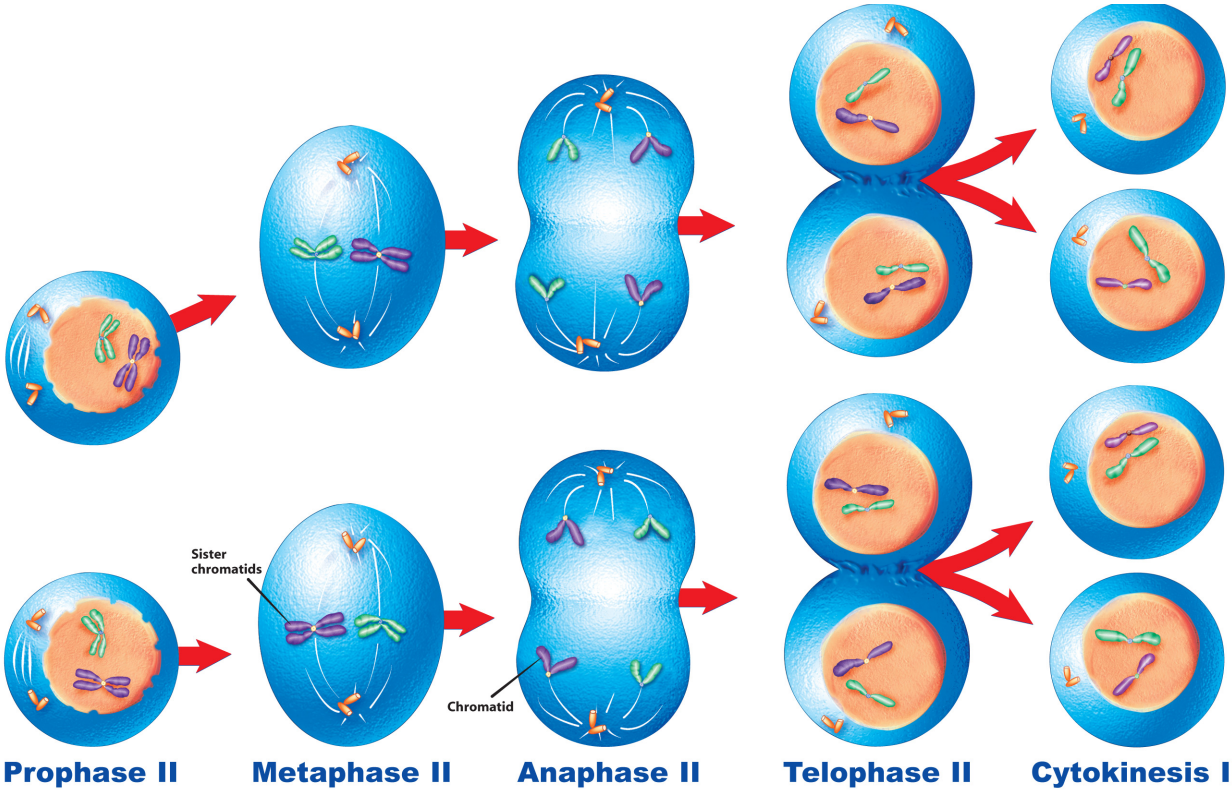


Figure 4. Stages of Meiosis II in animal cells

Prophase II

During Prophase II, the chromosome coil and the nuclear membrane disappears as each daughter cell prepares for division. See Figure 4.

Metaphase II

The spindle forms and the pairs of sister chromatids align at the equator of the cell.

Anaphase II

Figure 4 shows sister chromatids separating during Anaphase II.

Telophase II & Cytokinesis II

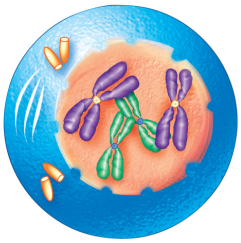
The chromatids reach the poles and uncoil into the thin, threadlike chromatin in Telophase II. The nuclear membrane also reforms. In Cytokinesis II each of the two diploid (2n) daughter cells formed in the first division are physically divided into two haploid (n) daughter cells.

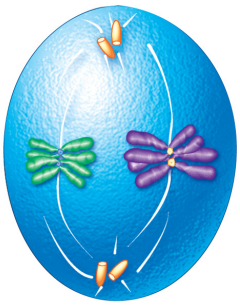
Summary

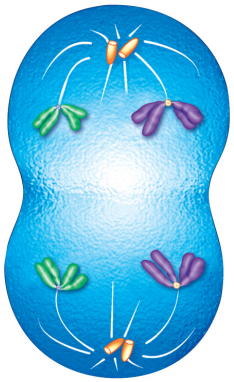
Let's review the process. The original diploid (2n) cell doubles its DNA to become 4n and divides into two diploid (2n) cells which then each divide into two haploid (n) cells. A male animal produces four haploid sperm from each diploid (2n) **primary spermatocyte** that enables the male to produce many sperm. This increases the chance of successfully fertilizing a female's egg. The division of the cell is unequal as a female produces eggs,. Each **primary oocyte** divides twice to reduce the number of chromosomes from diploid to haploid; however, the unequal division yields only one egg and up to three smaller remnants called **polar bodies**. The sperm must live only long enough to reach an egg and fertilize it. The egg must have more energy resources than the sperm to support all the vital life processes for the new individual until it can secure nourishment from the mother. The relatively large egg with the additional resources produced by the unequal divisions increases the chances of survival. The process of gamete formation in plants follows a similar pattern as in animals, but the names of the cells are different.

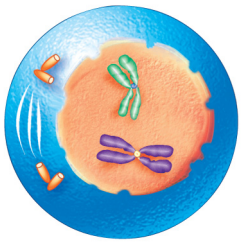
Worksheet # 1 – Stages of Meiosis

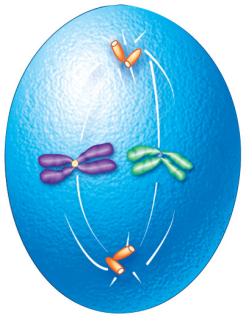
Label each of the stages of Meiosis I & II in the diagram below.

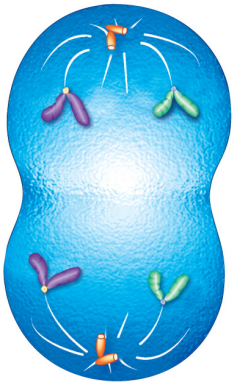


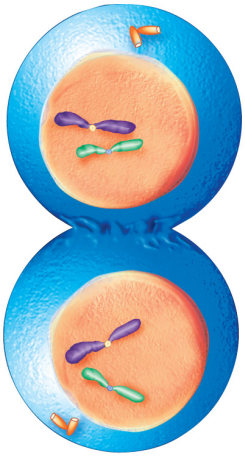


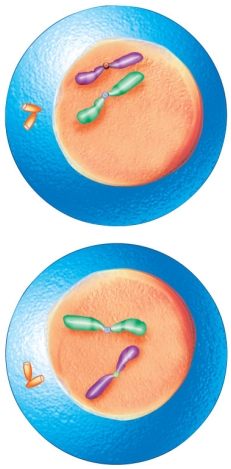












Worksheet # 2 – Meiosis

Answer the questions in the spaces provided.

1. Define diploid and haploid and list their symbols.

2. What are gametes? Be certain to include the names of the male and female gametes produced by plants and animals.

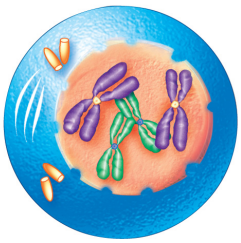
3. Explain why meiosis is sometimes called reduction division.

4. Why is meiosis important in sexual reproduction?

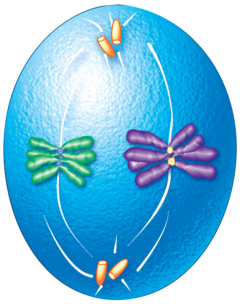
Worksheet # 1 – Stages of Meiosis

(Expected Results)

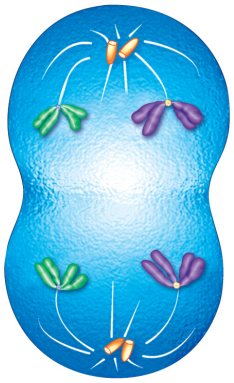
Label each of the stages of Meiosis I & II in the diagram below.



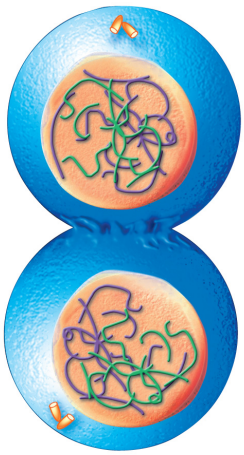
Prophase I



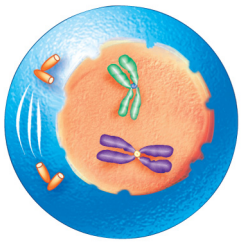
Metaphase I



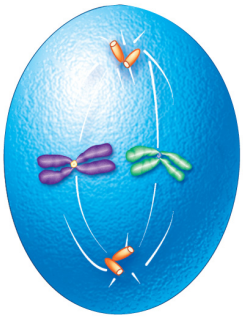
Anaphase I



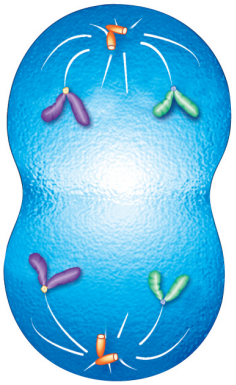
Telophase I & Cytokinesis I



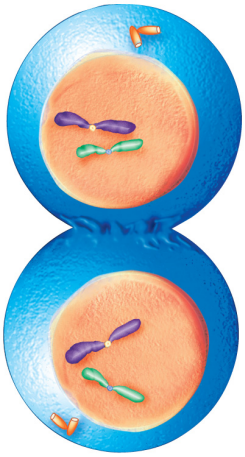
Prophase II



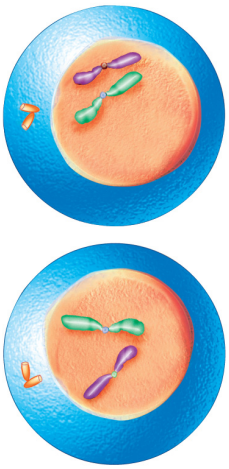
Metaphase II



Anaphase II



Telophase II



Cytokinesis II

Worksheet # 2 – Meiosis

(Expected Results)

Answer the questions in the spaces provided.

1. Define diploid and haploid and list their symbols.

   Diploid means that a cell has two copies of each chromosome and is represented by 2n. Haploid means that a cell has only one copy of each chromosome and is represented by n.

2. What are gametes? Be certain to include the names of the male and female gametes produced by plants and animals.

   Gametes are specialized sex cells. Male plants produce pollen and female plants produce ova or eggs. Male animals produce sperm and female animals produce eggs.

3. Explain why meiosis is sometimes called reduction division.

   The process of meiosis involves two separate divisions (or splitting) of a cell to reduce the number of chromosomes from diploid to haploid, so it is called reduction division.

4. Why is meiosis important in sexual reproduction?

   When the gametes unite or fertilize, their chromosomes combine. Since the gametes are haploid (n), when they unite the zygote formed is diploid (n + n = 2n). If the gametes were diploid (2n), then the zygote would have too many chromosomes (2n + 2n = 4n), which may be harmful.