Name Date Class

Section 10.2

Meiosis

North Carolina Objectives **Objective 3.02** Compare and contrast the characteristics of asexual and sexual reproduction.

Before You Read

In this section you will read about a particular type of cell division, meiosis, that creates many gene combinations. Genes determine the individual traits of all living things. On the lines below, list three different traits or characteristics that you can see in a rose.

Read to Learn

STUDY COACH

Mark the Text **Identify Facts**
Use one color to highlight each fact about diploid cells. Use another color to highlight each fact about haploid cells.

Reading Check

1. What do you call a cell with two of each kind of chromosome?

Reading Check

2. What do you call a cell with one of each kind of chromosome?

Genes, Chromosomes, and Numbers

All living things have thousands of genes. Genes determine individual traits. The genes do not just float around in a cell. They are lined up on chromosomes. A typical chromosome can have thousands of genes.

If you took a cell from one of Mendel's pea plants, you would see that it has 14 chromosomes, or seven pairs. In the body cells of most living things, chromosomes come in pairs. One of the chromosomes in each pair comes from the male parent. The other chromosome comes from the female parent. A cell that has two of each kind of chromosome is called a **diploid** cell. Using microscopes, scientists can now see the paired chromosomes and know that an allele for each trait is located on each paired chromosome.

How are diploid cells different from haploid cells?

A diploid cell is a body cell. Organisms also produce a different kind of cell called a **haploid** cell. This cell contains only one of each kind of chromosome. A gamete, or sex cell, is a haploid cell. Remember, Mendel concluded that parents give one allele of each trait to their offspring. That happens because the gamete is a haploid cell containing half the number of chromosomes as a body cell.

Every living thing has a set number of chromosomes. For example, every dog has 78 chromosomes, every human has 46 chromosomes, and every tomato plant has 24 chromosomes. As you can see, the number of chromosomes is not related to how complex an organism is. When the organism reproduces, it only

passes on half the number of chromosomes. Earlier in this section you learned that genes are lined up on a chromosome. In a diploid cell the two chromosomes of each pair are called **homologous** (hoh MAH luh gus) **chromosomes.** Each chromosome of the pair has genes for the same traits in the same order.

Because there are different alleles for the same gene, it is possible that two chromosomes of a homologous pair will not be identical to each other. For example, garden peas have 14 chromosomes, or seven pairs. The pairs are numbered 1 through 7. Chromosome 4 has genes for three of the traits Mendel studied. Every pea plant has two copies of chromosome 4, one from each parent. Chromosome 4 contains the allele for height. As you know from the previous section, it is possible for one chromosome to contain *T* (tall), and the other chromosome to contain *t* (short). The two chromosomes in a homologous pair might not be identical.

How does a diploid cell become a haploid cell?

How can an organism pass on half its chromosomes? It does so in a process of cell division called meiosis. **Meiosis** (mi OH sus) produces gametes containing half the number of chromosomes as the parent's body cell.

Meiosis is actually two separate divisions. The first division is meiosis I, and the second is meiosis II. The whole process begins with one diploid cell and ends with four haploid cells. The haploid cells are gametes, or sex cells. Male gametes are called **sperm.** Female gametes are called **eggs.** When a sperm unites with, or fertilizes an egg, the resulting zygote has a diploid number of chromosomes. Then, using mitosis, which you studied earlier, the zygote becomes a multicellular organism. This way of reproducing, which involves producing and then uniting haploid sex cells, is called **sexual reproduction.**

Reading Check

3. What does meiosis produce?

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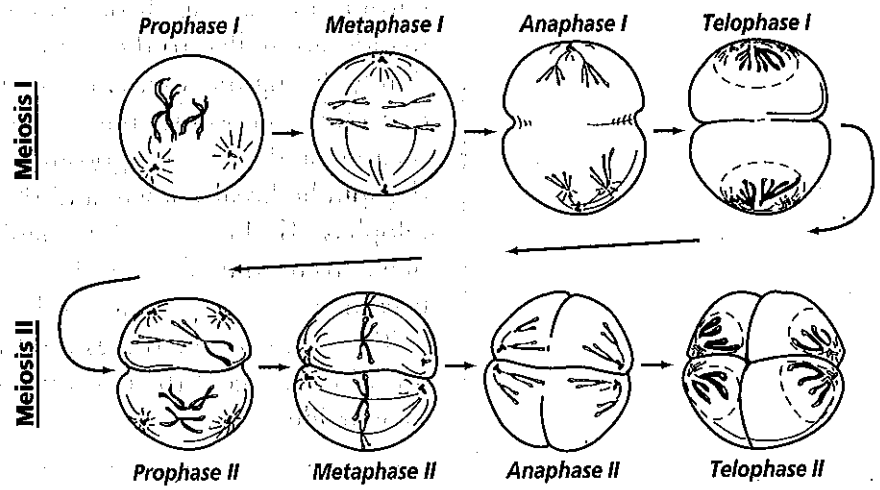
_____

_____

The Phases of Meiosis

Before meiosis begins, the chromosomes in a cell are replicated, or copied. Each chromosome consists of two sister chromatids connected by a centromere. A cell in prophase I of meiosis acts similarly to a cell in prophase of mitosis. The DNA of the



Reading Check

4. What happens during crossing over?

chromosomes coils up and a spindle forms. The chromosomes pair up with their homologous chromosomes near the middle of the cell. This pairing brings the two chromatids of each chromosome close together, making what is called a tetrad. The homologous chromosomes pair so tightly that sometimes a piece of a chromatid can break off. The piece changes places with a piece of the chromatid from the other homologous chromosome of the tetrad. This exchange is called **crossing over.** Crossing over can occur at several places at the same time.

During metaphase I of meiosis, the centromere of each chromosome becomes attached to the spindle fiber. The spindle fibers pull the chromosomes into the center of the cell. The spindle lines up the tetrads. If the cell were a globe, it would be as if one pair of sister chromatids were lying horizontally above the equator, and the other set of sister chromatids were lying horizontally below the equator. Let's stick with our globe illustration. During anaphase I the chromosomes begin to move apart from each other. It is as if the chromosomes above the equator move to the North Pole, and the chromosomes below the equator move to the South Pole. During telophase I of meiosis, the spindle is broken down and the chromosomes uncoil. The cytoplasm divides into two new cells.

How are haploid cells formed?

Each cell has half the genetic information that the original cell had because it has only one chromosome from each homologous pair. But remember that the chromosomes copied themselves at the beginning of the process. The new cells are going to have to divide in order to create haploid cells. This second division is called meiosis II. During prophase II, a spindle forms in each of the new cells. The spindle fibers attach to the centromeres of the chromosomes. The chromosomes, still made up of sister chromatids, are pulled to the center of the cell where they line up randomly during metaphase II. Anaphase II begins as the centromere of each chromosome splits. This allows the sister chromatids to separate and move to opposite poles of the cell. Nuclei re-form, the spindle breaks down, and the cytoplasm divides during telophase II. There are four haploid cells, each cell containing one chromosome from each homologous pair. These haploid cells become gametes, passing on the genes they contain to offspring.

The events of meiosis II are the same as those you studied for mitosis, except the chromosomes do not replicate before they divide.

Section 10.2 **Meiosis,** *continued*

Meiosis Provides for Genetic Variation

As you can see, the cell division that happens during meiosis creates many possible gene combinations. When crossing over occurs, even more variations are possible. The reassortment of genetic information that occurs during meiosis is called **genetic recombination.** It is a major source of variation among organisms. Meiosis also provides the physical basis for explaining Mendel's results. Mendel's laws and meiosis provide the foundation for heredity.

Reading Check

5. How does meiosis provide for genetic variation?

Nondisjunction

Meiosis usually happens without any problems, but sometimes chromosomes do not separate correctly. When this happens, the gametes that form will either have too many chromosomes or not enough chromosomes. The failure of chromosomes to separate correctly is called **nondisjunction.**

An organism with extra chromosomes may survive, but an organism that is missing one or more chromosomes does not usually develop. Surprisingly, in plants, extra chromosomes can actually be helpful. Often the flowers and fruits are larger, and the plant is healthier. Because of this, plant breeders have learned to cause nondisjunction by using chemicals.

Reading Check

6. What is nondisjunction?

Gene Linkage and Maps

Genes on the same chromosome are usually linked and inherited together instead of independently. It is the chromosomes that follow Mendel's law of independent assortment, not the genes. Linked genes can separate as a result of crossing over. Scientists have found that genes that are farther apart on a chromosome tend to cross over more often than genes that are close together. Using this information, scientists can make chromosome maps that show the sequence of genes on a chromosome.

After You Read

Mini Glossary

crossing over: pieces of homologous chromosomes change places during prophase I of meiosis; results in new allele combinations on a chromosome

diploid: cell with two of each kind of chromosome

egg: haploid female sex cell produced by meiosis

genetic recombination: reassortment of genetic information during meiosis that creates many possible gene combinations

haploid: cell with one of each kind of chromosome

homologous (hoh MAH luh gus) chromosome: each chromosome pair contains genes for the same traits arranged in the same order

meiosis (mi OH sus): type of cell division where one specialized body cell produces four gametes, each containing half the number of chromosomes as a parent's body cell

nondisjunction: failure of homologous chromosomes to separate correctly during meiosis; results in gametes with too many or too few chromosomes

sexual reproduction: pattern of reproduction that involves producing and subsequent uniting of haploid sex cells

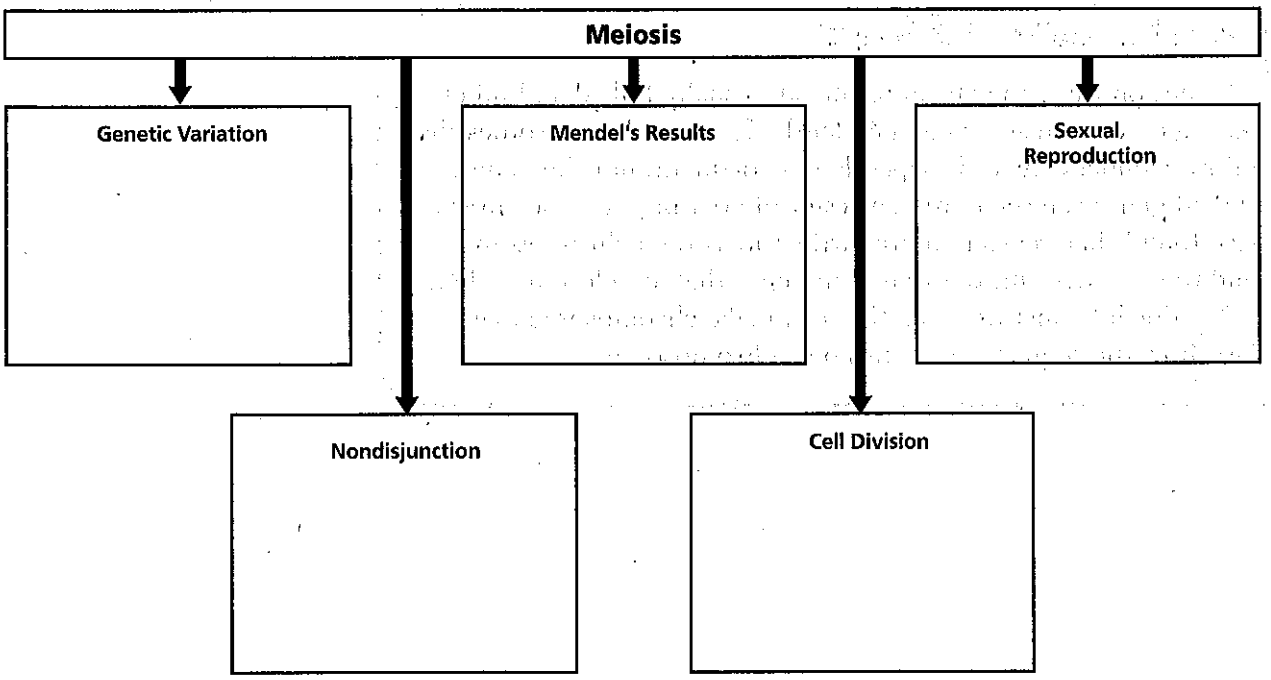
sperm: haploid male sex cell produced by meiosis

1. Review the terms and their definitions in the Mini Glossary above. Then list the four terms that have to do with genetic variation on the lines below.

_____

_____

2. Fill in the boxes below explaining how each of the topics relates to meiosis.



Section 10.2 **Meiosis,** *continued*

3. In column 1 are some new concepts you learned about in this section. Column 2 gives one example of each concept. Put the letter of the example on the line next to the concept that it matches.

New Concept	Example
_____ 1. meiosis	a. explained by the distribution of chromosomes during meiosis
_____ 2. nondisjunction	b. exchange of genetic material
_____ 3. crossing over	c. one diploid cell produces four haploid cells
_____ 4. Mendel's results	d. the failure of chromosomes to separate properly during meiosis

Visit the Glencoe Science Web site at **science.glencoe.com** to find your biology book and learn more about meiosis.