Name _____ Class _____ Date _____

CHAPTER 5 Heredity

SECTION 3

Meiosis

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are sex cells?
- How does meiosis help explain Mendel's results?

National Science Education Standards

LS 1c, 1d, 2a, 2b, 2c, 2d

How Do Organisms Reproduce?

When organisms reproduce, their genetic information is passed on to their offspring. There are two kinds of reproduction: asexual and sexual.

STUDY TIP

Summarize Make flashcards that show the steps of meiosis. On the front of the cards, write the steps of meiosis. On the back of the cards, write what happens at each step. Practice arranging the steps in the correct order.

ASEXUAL REPRODUCTION

In asexual reproduction, only one parent is needed to produce offspring. Asexual reproduction produces offspring with exact copies of the parent's genotype.

SEXUAL REPRODUCTION

In sexual reproduction, cells from two parents join to form offspring. Sexual reproduction produces offspring that share traits with both parents. However, the offspring are not exactly like either parent.

What Are Homologous Chromosomes?

Recall that genes are the instructions for inherited traits. Genes are located on chromosomes. Each human body cell has a total of 46 chromosomes, or 23 pairs. A pair of chromosomes that carry the same sets of genes are called **homologous chromosomes**. One chromosome from a pair comes from each parent. ☑

READING CHECK

1. Define What are homologous chromosomes?

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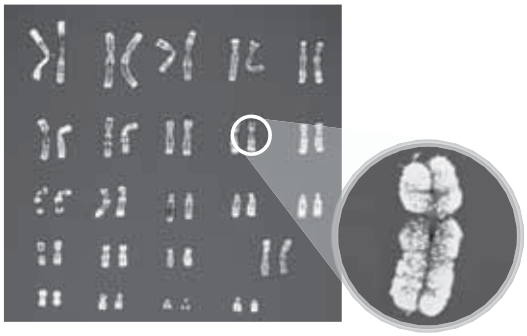

Human body cells have 23 pairs of chromosomes. One member of a pair of homologous chomosomes has been magnified.

TAKE A LOOK

2. Identify How many total chromosomes are in each human body cell?

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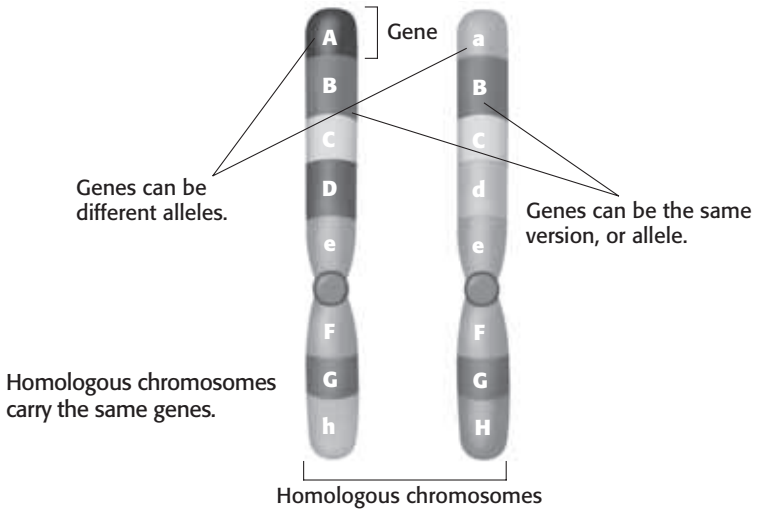

What Are Sex Cells?

In sexual reproduction, cells from two parents join to make offspring. However, only certain cells can join. Cells that can join to make offspring are called *sex cells*. An egg is a female sex cell. A sperm is a male sex cell. Unlike ordinary body cells, sex cells do not have homologous chromosomes. ☑

Imagine a pair of shoes. Each shoe is like a chromosome and the pair represents a homologous pair of chromosomes. Recall that your body cells have a total of 23 pairs of "shoes," or homologous chromosomes. Each sex cell, however, has only one of the chromosomes from each homologous pair. Sex cells have only one "shoe" from each pair. How do sex cells end up with only one chromosome from each pair?

READING CHECK

3. Explain How are sex cells different from ordinary body cells?

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How Are Sex Cells Made?

Sex cells are made during meiosis. **Meiosis** is a copying process that produces cells with half the usual number of chromosomes. Meiosis keeps the total number of chromosomes the same from one generation to the next.

In meiosis, each sex cell that is made gets only one chromosome from each homologous pair. For example, a human egg cell has 23 chromosomes and a sperm cell has 23 chromosomes. When these sex cells later join together during reproduction, they form pairs. The new cell has 46 chromosomes, or 23 pairs. The figure on the next page describes the steps of meiosis. To make the steps easy to see, only four chromosomes are shown.

STANDARDS CHECK

LS 2b In many species, including humans, females produce eggs and males produce sperm...An egg and sperm unite to begin development of a new individual. The individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.

4. Define What is the function of meiosis?

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Steps of Meiosis

First cell division

❶ The chromosomes are copied before meiosis begins. The identical copies, or chromatids, are joined together.

❷ The nuclear membrane disappears. Pairs of homologous chromosomes line up at the equator of the cell.

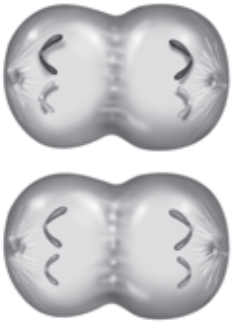
❸ The chromosomes separate from their homologous partners. Then they move to the opposite ends of the cell.

❹ The nuclear membrane re-forms, and the cell divides. The paired chromatids are still joined.

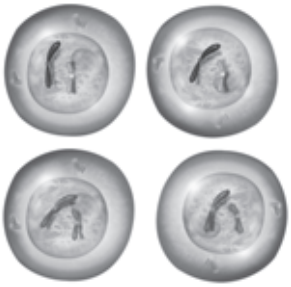
Second cell division

❺ Each cell contains one member of the homologous chromosome pair. The chromosomes are not copied again between the two cell divisions.

❻ The nuclear membrane disappears. The chromosomes line up along the equator of each cell.



❼ The chromatids pull apart and move to opposite ends of the cell. The nuclear membranes re-form, and the cells divide.



❽ Four new cells have formed from the original cell. Each new cell has half the number of chromosomes as the original cell.

Critical Thinking

5. Predict What would happen if meiosis did not occur?

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TAKE A LOOK

6. Identify How many times does the cell nucleus divide during meiosis?

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7. Identify At the end of meiosis, how many sex cells have been produced from one cell?

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How Does Meiosis Explain Mendel's Results?

Mendel knew that eggs and sperm give the same amount of information to offspring. However, he did not know how traits were actually carried in the cell. Many years later, a scientist named Walter Sutton was studying grasshopper sperm cells. He knew about Mendel's work. When he saw chromosomes separating during meiosis, he made an important conclusion: genes are located on chromosomes.

The figure below shows what happens to chromosomes during meiosis and fertilization in pea plants. The cross shown is between two true-breeding plants. One produces round seeds and the other produces wrinkled seeds.

Critical Thinking

8. Identify Relationships How did Sutton's work build on Mendel's work?

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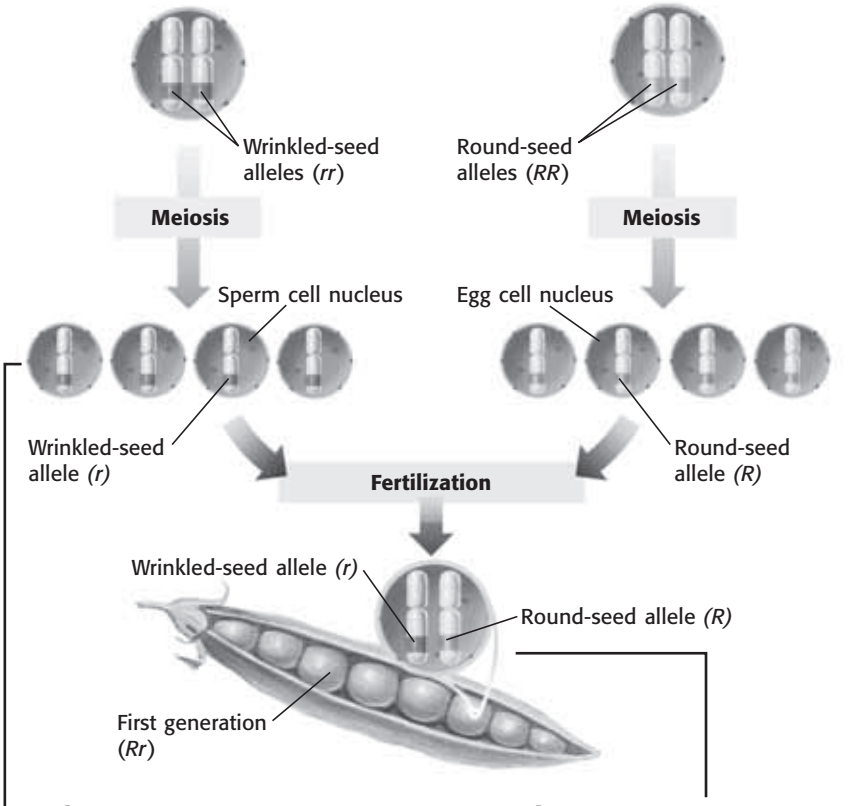
Meiosis and Dominance

Male Parent In the plant cell nucleus below, each homologous chromosome has an allele for seed shape. Each allele carries the same instructions: to make wrinkled seeds.

Female Parent In the plant cell nucleus below, each homologous chromosome has an allele for seed shape. Each allele carries the same instructions: to make round seeds.



a After meiosis, each sperm cell has a recessive allele for wrinkled seeds. Each egg cell has a dominant allele for round seeds.

b Fertilization of any egg by any sperm gives the same genotype (*Rr*) and the same phenotype (round). This result is exactly what Mendel found in his studies.

TAKE A LOOK

9. Explain In this figure, how many genotypes are possible for the offspring? Explain your answer.

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What Are Sex Chromosomes?

Information contained on chromosomes determines many of our traits. **Sex chromosomes** carry genes that determine sex. In humans, females have two X chromosomes. Human males have one X chromosome and one Y chromosome. ☑

During meiosis, one of each of the chromosome pairs ends up in a sex cell. Females have two X chromosomes in each body cell. When meiosis produces egg cells, each egg gets one X chromosome. Males have both an X chromosome and a Y chromosome in each body cell. Meiosis produces sperm with either an X or a Y chromosome.

An egg fertilized by a sperm with an X chromosome will produce a female. If the sperm contains a Y chromosome, the offspring will be male.

READING CHECK

10. Identify What combination of sex chromosomes makes a human male?

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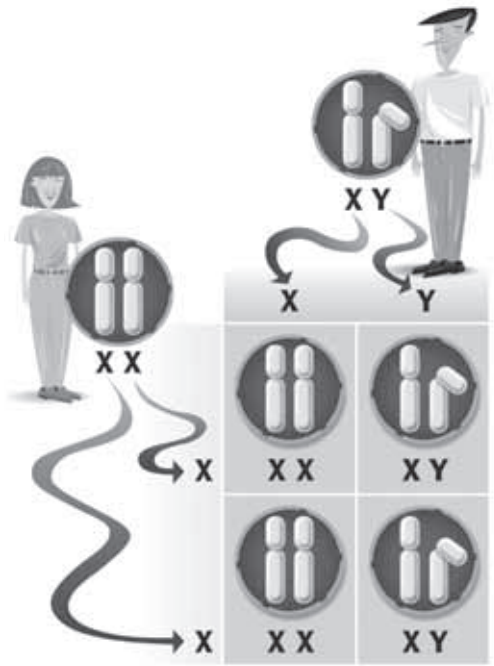

Egg and sperm join to form either the XX or XY combination.

TAKE A LOOK

11. Identify Circle the offspring in the figure that will be female.

SEX-LINKED DISORDERS

Hemophilia is a disorder that prevents blood from clotting. People with hemophilia bleed for a long time after small cuts. This disorder can be fatal. Hemophilia is an example of a sex-linked disorder. The genes for *sex-linked disorders* are carried on the X chromosome. Colorblindness is another example of a sex-linked disorder. Men are more likely than women to have sex-linked disorders. Why is this? ☑

READING CHECK

12. Define What is a sex-linked disorder?

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This stoplight in Canada was made to help the colorblind see signals easily.

The Y chromosome does not carry all of the genes that an X chromosome does. Females have two X chromosomes, so they carry two copies of each gene found on the X chromosome. This makes a backup gene available if one becomes damaged. Males have only one copy of each gene on their one X chromosome. If a male gets an allele for a sex-linked disorder, he will have the disorder, even if the allele is recessive.

TAKE A LOOK

13. Complete A particular sex-linked disorder is recessive. Fill in the Punnett Square to show how the disorder is passed from a carrier to its offspring. The chromosome carrying the trait for the disorder is underlined.

14. Identify Which individual will have the disorder?

_____

	X	***Y***
X		
X		

GENETIC COUNSELING AND PEDIGREES

Genetic disorders can be traced through a family tree. If people are worried that they might pass a disease to their children, they may consult a genetic counselor.

These counselors often use a diagram called a pedigree. A **pedigree** is a tool for tracing a trait through generations of a family. By making a pedigree, a counselor can often predict whether a person is a carrier of a hereditary disease.

The pedigree on the next page traces a disease called *cystic fibrosis*. Cystic fibrosis causes serious lung problems. People with this disease have inherited two recessive alleles. Both parents need to be carriers of the gene for the disease to show up in their children.

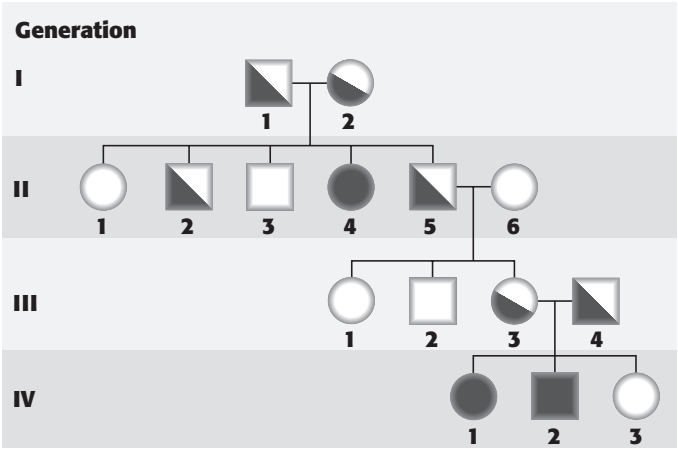
Pedigree for a Recessive Disease

Males Females

Vertical lines connect children to their parents.

or A solid square or circle shows that the person has a certain trait.

or A half-filled square or circle shows that the person is a carrier for the trait.



TAKE A LOOK

15. Identify Circle all of the individuals in the pedigree who have the disorder. Draw a line under the individuals that carry the trait, but do not have the disorder.

You could draw a pedigree to trace almost any trait through a group of people who are biologically related. For example, a pedigree can show how you inherited your hair color. Many different pedigrees could be drawn for related individuals.

What Is Selective Breeding?

For thousands of years, humans have bred plants and animals to produce individuals with traits that they liked. This is known as *selective breeding*. Breeders may choose a plant or animal with traits they would like to see in the offspring. They breed that individual with another that also has those traits. For example, farmers might breed fruit trees that bear larger fruits.

You may see example of selective breeding every day. Different breeds of dogs, such as chihuahuas and German sheperds, were produced by selective breeding. Many flowers, such as roses, have been bred to produce large flowers. Wild roses are usually much smaller than roses you would buy at a flower store or plant nursery.

Say It

Discuss In a small group, come up with other examples of organisms that humans have changed through selective breeding. What traits do you think people wanted the organism to have? How is this trait helpful to humans?

Name _____ Class _____ Date _____

Section 3 Review

NSES LS 1c, 1d, 2a, 2b, 2c, 2d

SECTION VOCABULARY

homologous chromosomes chromosomes that have the same sequence of genes and the same structure **meiosis** a process in cell division during which the number of chromosomes decreases to half the original number by two divisions of the nucleus, which results in the production of sex cells (gametes or spores)	**pedigree** a diagram that shows the occurrence of a genetic trait in several generations of a family **sex chromosomes** one of the pair of chromosomes that determine the sex of an individual

1. **Identify Relationships** Put the following in order from smallest to largest: chromosome, gene, cell.

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2. **Explain** Does meiosis happen in all cells? Explain your answer.

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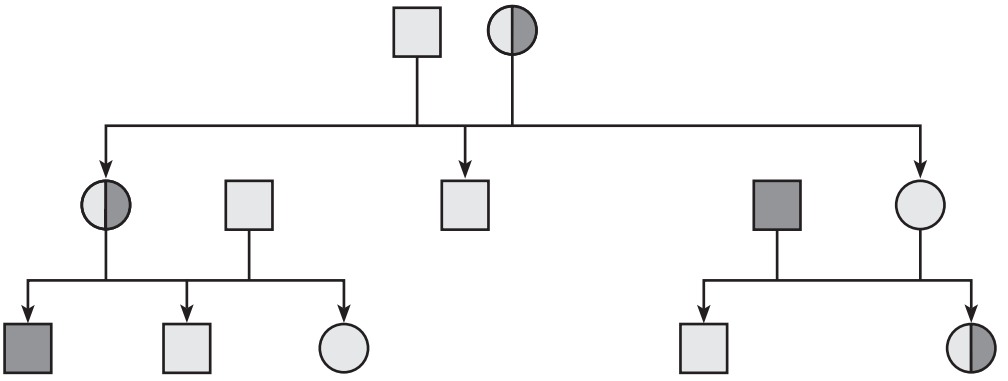
The pedigree below shows a recessive trait that causes a disorder. Use the pedigree to answer the questions that follow.



3. **Identify** Circle all individuals on the pedigree that are heterozygous for the trait. Are these individuals male or female?

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4. **Identify** Put a square around all individuals that have the disorder. Are these individuals male or female?

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5. **Interpret** Is the trait sex-linked? Explain your answer.

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