

Reproduction of Organisms

Sexual Reproduction and Meiosis

..... Before You Read

What do you think? Read the three statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	1. Humans produce two types of cells: body cells and sex cells.	
	2. Environmental factors can cause variation among individuals.	
	3. Two parents always produce the best offspring.	

..... Read to Learn

What is sexual reproduction?

Have you ever seen a litter of kittens? One kitten might have orange fur like its mother. A second kitten might have gray fur like its father. A third kitten might look like a combination of both parents. How does this happen?

The kittens look different because of sexual reproduction. **Sexual reproduction** is a type of reproduction in which the genetic materials from two different cells combine, producing an offspring. The cells that combine are called sex cells. Sex cells form in reproductive organs. There are two types of sex cells—eggs and sperm. An **egg** is the female sex cell, which forms in an ovary. A **sperm** is the male sex cell, which forms in a testis. **Fertilization** (fur tuh luh ZAY shun) occurs when an egg cell and a sperm cell join together. When an egg and a sperm join together, a new cell is formed. The new cell that forms from fertilization is called a **zygote**. ✓

Key Concepts

- What is sexual reproduction, and why is it beneficial?
- What is the order of the phases of meiosis, and what happens during each phase?
- Why is meiosis important?

Study Coach

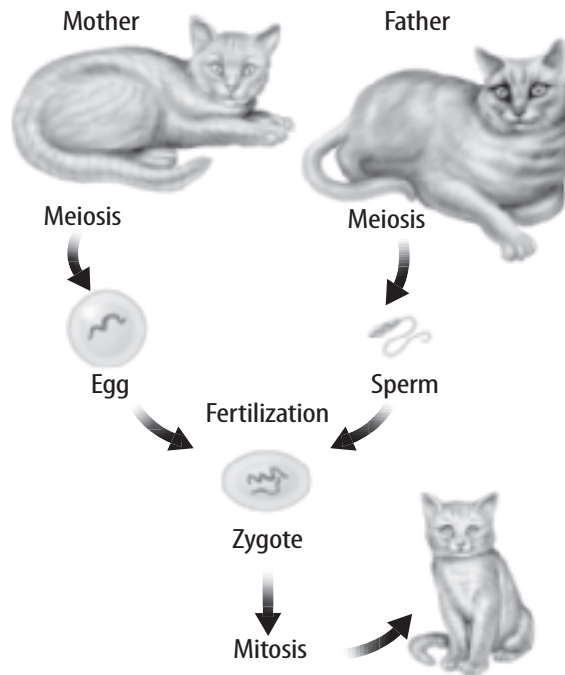
Vocabulary Quiz Write a question about each vocabulary term in this lesson. Exchange questions with another student. Together, discuss the answers to the questions.

Reading Check

1. Describe What is sexual reproduction?

Visual Check

2. Identify Circle the name of the female sex cell. Put a box around the name of the male sex cell.



Diploid Cells

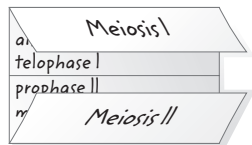
After fertilization, a zygote goes through mitosis and cell division, as shown above. Mitosis and cell division produce nearly all of the cells in a multicellular organism. The kitten in the picture above is a multicellular organism. Organisms that reproduce sexually form two kinds of cells—body cells and sex cells. In the body cells of most organisms, chromosomes occur in pairs. *Cells that have pairs of chromosomes are called **diploid** cells.*

Chromosomes

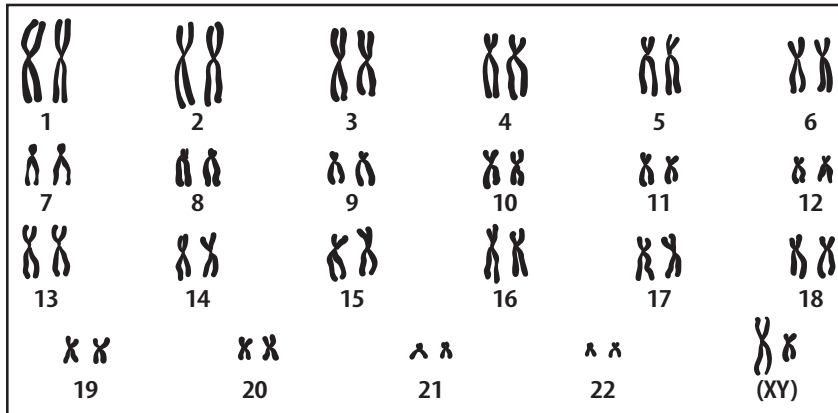
*Pairs of chromosomes that have genes for the same traits arranged in the same order are called **homologous** (huh MAH luh gus) **chromosomes**.* Because one chromosome is inherited from each parent, the chromosomes are not always identical. For example, the kittens you read about earlier inherited a gene for orange fur color from their mother. They also inherited a gene for gray fur color from their father. Some kittens might be orange, and some kittens might be gray. No matter what the color of a kitten's fur, both genes for fur color are found at the same place on homologous chromosomes. In this case, each gene codes for a different color.

FOLDABLES®

Make the following shutter-fold book, then use it to describe and illustrate the phases of meiosis.



Chromosomes of a Human Cell



Different organisms have different numbers of chromosomes. Recall that diploid cells have pairs of chromosomes. Human diploid cells have 23 pairs of chromosomes, as shown in the picture above. This means that human diploid cells have a total of 46 chromosomes.

It is important to have the correct number of chromosomes. If a zygote has too many or too few chromosomes, it will not develop properly. The process of meiosis helps maintain the correct number of chromosomes. ✓

Haploid Cells

Organisms that reproduce sexually also form egg and sperm cells, or sex cells. Sex cells have only one chromosome from each pair of chromosomes. **Haploid cells are cells that have only one chromosome from each pair.**

Organisms produce sex cells using a special type of cell division called meiosis. *In **meiosis**, one diploid cell divides and makes four haploid sex cells.* Meiosis occurs only during the formation of sex cells. ✓

The Phases of Meiosis

Recall that mitosis and cytokinesis involve one division of the nucleus and cytoplasm. Meiosis involves two divisions of the nucleus and the cytoplasm. These two divisions are phases called meiosis I and meiosis II. Meiosis results in four haploid cells, each with half the number of chromosomes as the original cell.

Phases of Meiosis I

A reproductive cell goes through interphase before beginning meiosis I. During interphase, the reproductive cell grows and copies, or duplicates, its chromosomes. Each duplicated chromosome consists of two sister chromatids joined by a centromere.

Visual Check

3. Identify How many chromosomes do human diploid cells have?

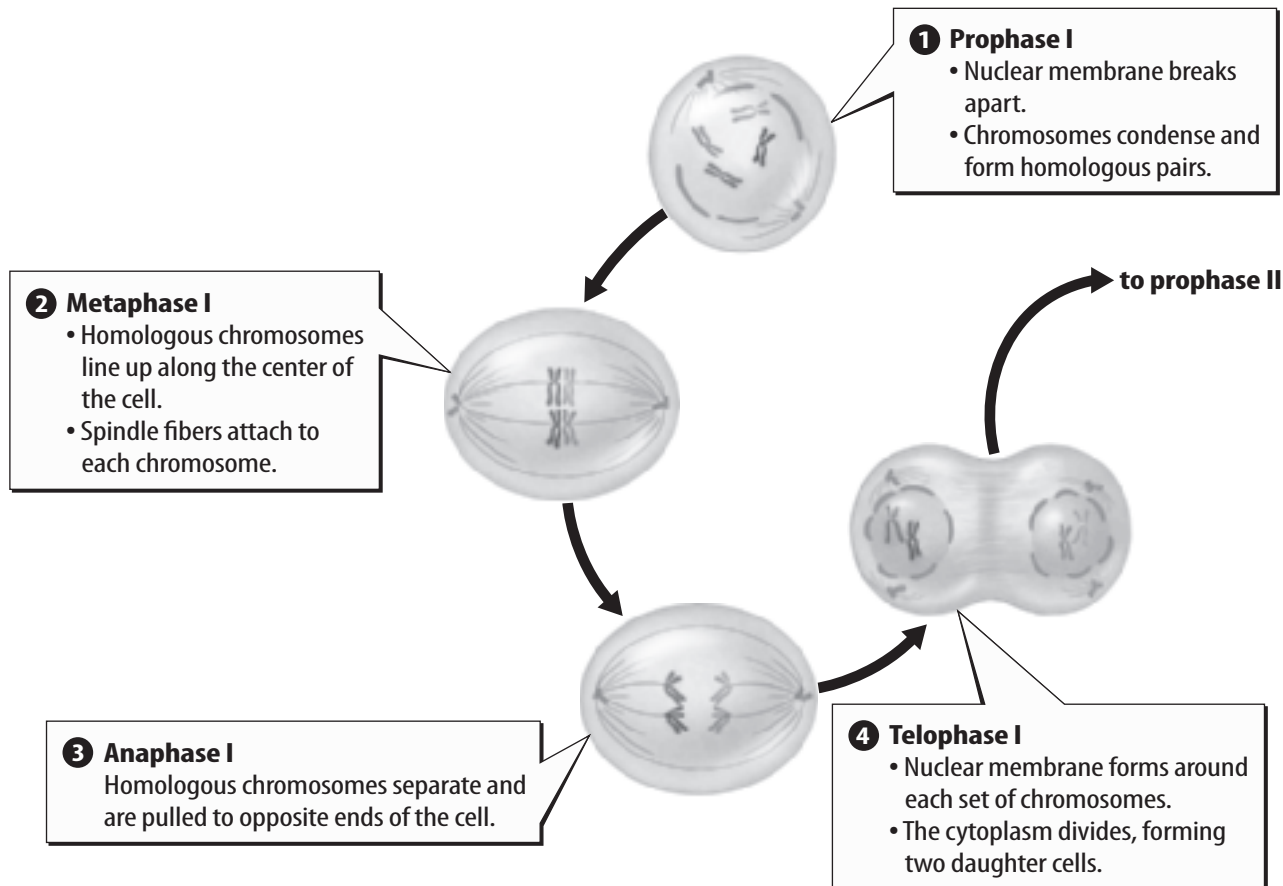
Reading Check

4. Explain Why is it important for an organism to have the correct number of chromosomes?

Reading Check

5. Contrast How do diploid cells differ from haploid cells?

Meiosis I



Visual Check

6. Explain what happens during metaphase I.

Reading Check

7. Describe what happens to the sister chromatids at the end of anaphase I.

As you read about the phases of meiosis I, refer to the figure above. Think about the process that produces cells with a reduced number of chromosomes.

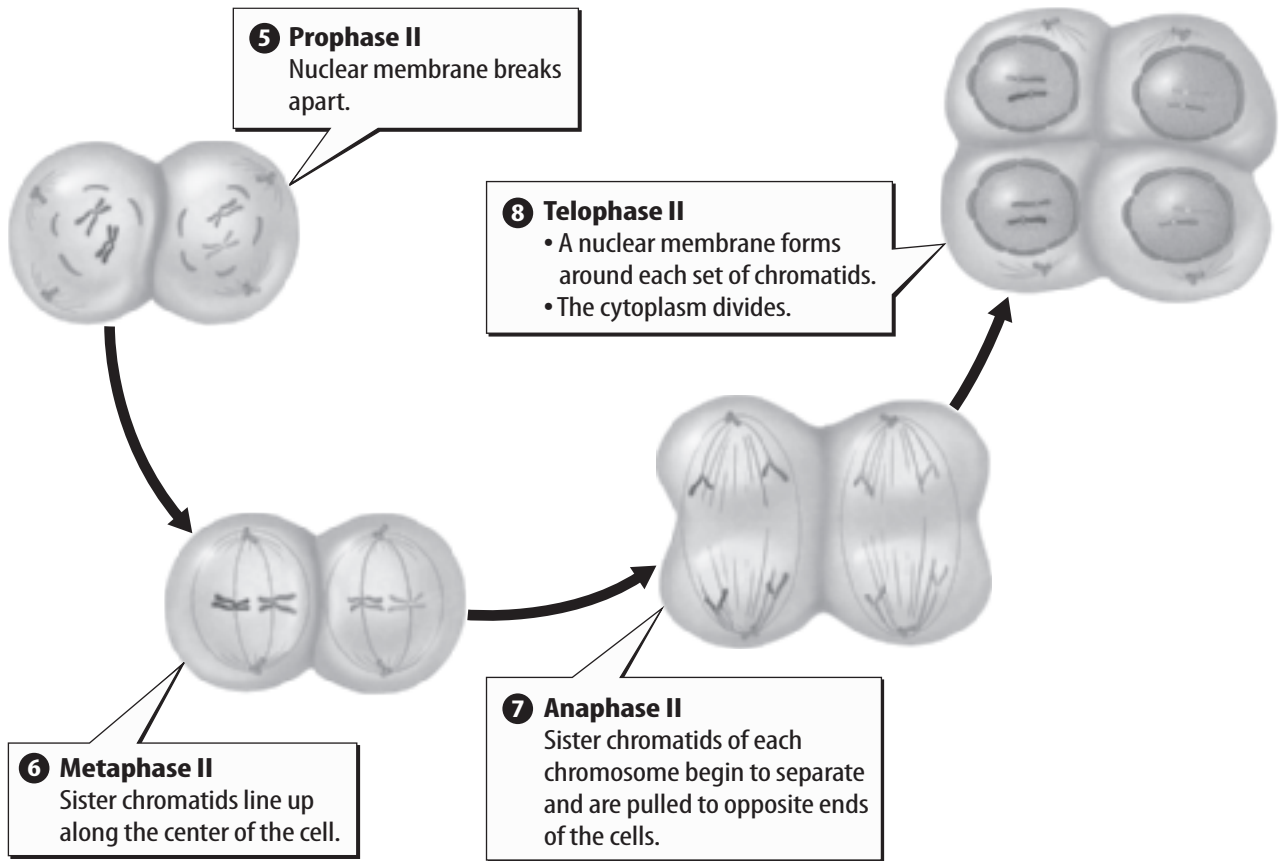
1. Prophase I During prophase I, duplicated chromosomes condense, or shorten, and thicken. Homologous chromosomes come together and form pairs. The membrane around the nucleus breaks apart and the nucleolus disappears.

2. Metaphase I During metaphase I, homologous chromosome pairs line up along the middle of the cell, as shown in the figure above. A spindle fiber attaches to each chromosome.

3. Anaphase I During anaphase I, chromosome pairs separate and are pulled toward opposite ends of the cell. Notice in the figure above that the sister chromatids stay together. ✓


4. Telophase I During telophase I, a membrane forms around each group of duplicated chromosomes. The cytoplasm divides through cytokinesis, and two daughter cells form. Sister chromatids remain together.

Meiosis II



Phases of Meiosis II

After meiosis I, the two cells formed during this stage go through a second division of the nucleus and the cytoplasm. This process is called meiosis II. Meiosis II is shown in the figure above.

- 1. Prophase II** Unlike prophase I, chromosomes are not copied again before prophase II. They remain short and thick sister chromatids. During prophase II, the membrane around the nucleus breaks apart, and the nucleolus disappears in each cell.
- 2. Metaphase II** During metaphase II, the pairs of sister chromatids line up along the middle of the cell in single file.
- 3. Anaphase II** During anaphase II, the sister chromatids of each duplicated chromosome are pulled apart. They then move toward opposite ends of the cells.
- 4. Telophase II** The final phase of meiosis is telophase II. During telophase II, a nuclear membrane forms around each set of chromatids. The chromatids are again called chromosomes. The cytoplasm divides through cytokinesis, and four haploid cells form. 

Visual Check

8. Differentiate How does telophase II differ from telophase I?

Key Concept Check

9. Name the phases of meiosis in order.

Math Skills

A proportion is an equation that shows that two ratios are equivalent. If you know that one cell produces two daughter cells at the end of mitosis, you can use proportions to calculate how many daughter cells will be produced by eight cells undergoing mitosis.

Example:

Set up an equation of the two ratios.

$$\frac{1}{2} = \frac{8}{y}$$

Cross-multiply.

$$1 \times y = 8 \times 2$$
$$1y = 16$$

Divide each side by 1.

$$y = 16$$

10. Use Proportions

You know that one cell produces four daughter cells at the end of meiosis. If 12 sex cells undergo meiosis, how many daughter cells will be produced?

Key Concept Check

11. State why meiosis is important.

Visual Check

12. Compare How many cells are produced during mitosis? During meiosis?


Why is meiosis important?

Meiosis is important to sexual reproduction. It forms the correct haploid number of chromosomes. This maintains the correct diploid number of chromosomes in organisms when sex cells join. Meiosis also leads to genetic variation.

Maintaining Diploid Cells

Meiosis helps maintain diploid cells in offspring by making haploid sex cells. When haploid sex cells join together during fertilization, they make a diploid zygote, or fertilized egg. The zygote divides by mitosis and cell division and creates a diploid organism.

Creating Haploid Cells

The result of meiosis is haploid sex cells. The formation of haploid cells is important because it results in genetic variation. Sex cells can have different sets of chromosomes, depending on how chromosomes line up during metaphase I. The genetic makeup of offspring is a mixture of chromosomes from two sex cells. Variation in the sex cells results in more genetic variation in the next generation. 

How do mitosis and meiosis differ?

The table below lists the differences between mitosis and meiosis.


Characteristic	Meiosis	Mitosis
Number of chromosomes in parent cell	diploid	diploid
Type of parent cell	reproductive	body
Number of divisions of the nucleus	2	1
Number of daughter cells produced	4	2
Chromosome number in daughter cells	haploid	diploid
Function in organism	forms sperm and egg cells	growth, cell repair, some types of reproduction

Advantages of Sexual Reproduction

The main advantage of sexual reproduction is that it results in genetic variation among offspring. Offspring inherit half their DNA from each parent. Inheriting different DNA means that each offspring has a different set of traits.

Genetic Variation


Genetic variation exists among humans. You can look at your friends to see genetic variations. Some people have blue eyes; others have brown eyes. Some people have blonde hair; others have red hair. Genetic variation occurs in all organisms that reproduce sexually.

Because of genetic variation, individuals within a population have slight differences. These differences might be an advantage if the environment changes. Some individuals might have traits that make them able to survive harsh conditions. For example, some plants within a population might be able to survive long periods of dry weather. Sometimes the traits might help keep an organism from getting infected by a disease. 

Selective Breeding

Selective breeding is a process that involves breeding certain individuals within a population because of the traits they have. For example, a farmer might choose plants with the biggest flowers and stems. These plants would be allowed to reproduce and grow. Over time, the offspring of the plants would all have big flowers and stems. Selective breeding has been used to produce many types of plants and animals with certain traits.

Disadvantages of Sexual Reproduction

Sexual reproduction takes time and energy. Organisms have to grow and develop until they are mature enough to produce sex cells. Before they can reproduce, organisms have to find mates. Searching for a mate takes time and energy. The search might also expose individuals to predators, diseases, or harsh environmental conditions. Sexual reproduction can be limited by certain factors. For example, fertilization cannot take place during pregnancy, which can last as long as two years in some mammals. 

REVIEW VOCABULARY

DNA

the genetic information in a cell

Key Concept Check

13. Identify Why is sexual reproduction beneficial?

Reading Check

14. State the disadvantages of sexual reproduction.

..... After You Read

Mini Glossary

diploid: cells that have pairs of chromosomes

egg: the female sex cell, which forms in an ovary

fertilization (fur tuh luh ZAY shun): the process in which an egg cell and a sperm cell join together

haploid: cells that have only one chromosome from each pair

homologous (huh MAH luh gus) chromosomes: pairs of chromosomes that have genes for the same traits arranged in the same order

meiosis: the process in which one diploid cell divides and makes four haploid cells

sexual reproduction: a type of reproduction in which the genetic materials from two different cells combine, producing an offspring

sperm: the male sex cell, which forms in a testis

zygote: the new cell that forms from fertilization

1. Review the terms and their definitions in the Mini Glossary. Use at least two words from the Mini Glossary in a sentence to describe the difference between the female and male sex cells.

2. In the table below, list the advantages and disadvantages of sexual reproduction.

Advantages	Disadvantages

3. How is genetic variation related to meiosis?

What do you think **NOW?**

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?



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