

# Meiosis

## ESSENTIAL QUESTION

### How do cells divide for sexual reproduction?

By the end of this lesson, you should be able to describe the process of meiosis and its role in sexual reproduction.



The sperm cell and egg cell shown here were produced by a special kind of cell division called meiosis.





### Quick Labs

- Meiosis Flipbook
- Crossover and Meiosis

## Engage Your Brain

**1 Predict** Check T or F to show whether you think each statement is true or false.

- |                          |                          |  |
|--------------------------|--------------------------|--|
| <b>T</b>                 | <b>F</b>                 |  |
| <input type="checkbox"/> | <input type="checkbox"/> | The offspring of sexual reproduction have fewer chromosomes than their parents have. |
| <input type="checkbox"/> | <input type="checkbox"/> | During sexual reproduction, two cells combine to form a new organism.                |
| <input type="checkbox"/> | <input type="checkbox"/> | Sex cells are produced by cell division.   |
| <input type="checkbox"/> | <input type="checkbox"/> | Sex cells have half the normal number of chromosomes.                                |

**2 Calculate** Organisms have a set number of chromosomes. For example, humans have 46 chromosomes in body cells and half that number (23) in sex cells. In the table below, fill in the number of chromosomes for different organisms.

Organism	Full set of chromosomes	Half set of chromosomes
Human	46	23
Fruit fly		4
Chicken		39
Salamander	24	
Potato	48	

## Active Reading

**3 Synthesize** You can often define an unknown word if you know the meaning of its word parts. Use the word parts and the sentence below to make an educated guess about the meaning of the term *homologous*.

Word part	Meaning
<i>homo-</i>	same
<i>-logos</i>	word, structure

### Example sentence

Homologous chromosomes are a pair of chromosomes that look similar and have the same genes.

*homologous*:

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## Vocabulary Terms

- homologous chromosomes
- meiosis

**4 Apply** As you learn the definition of each vocabulary term in this lesson, write your own definition or make a sketch to help you remember the meaning of the term.



# Number Off!

## How do sex cells differ from body cells?

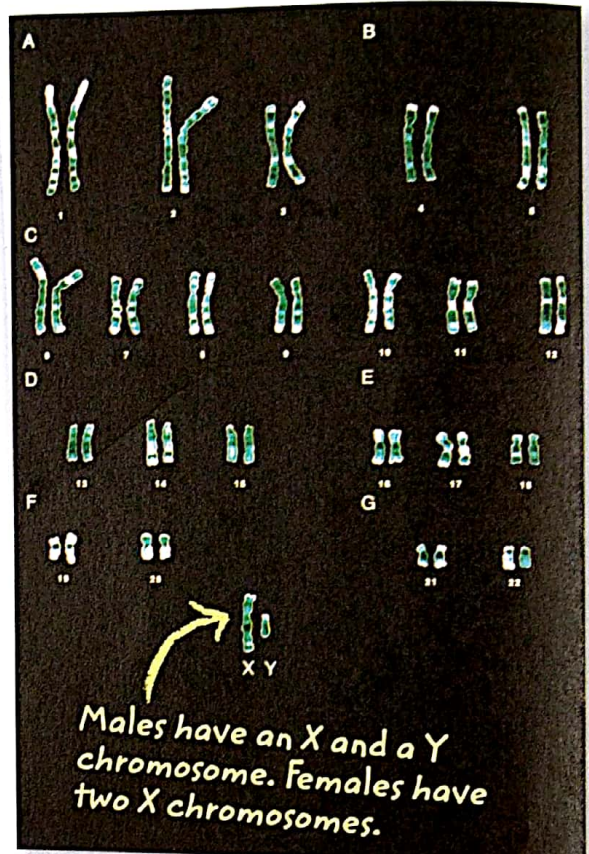
Before sexual reproduction can take place, each parent produces sex cells. *Sex cells* have half of the genetic information that body cells have. Thus, when the genetic information from two parents combines, the offspring have a full set of genetic information. The offspring will have the same total number of chromosomes as each of its parents.

**Active Reading** 5 **Relate** Describe sex cells.

### Chromosome Number

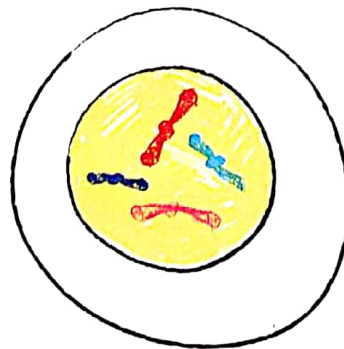
In body cells, most chromosomes are found in pairs that have the same structure and size. These **homologous chromosomes** (huh•MAHL•uh•guhs KROH•muh•sohmz) carry the same genes. A homologous chromosome pair may have different versions of the genes they carry. One chromosome pair is made up of *sex chromosomes*. Sex chromosomes control the development of sexual characteristics. In humans, these chromosomes are called X and Y chromosomes. Cells with a pair of every chromosome are called *diploid* (DIP•loyd). Many organisms, including humans, have diploid body cells.

This photo shows the 23 chromosome pairs in a human male. Body cells contain all of these chromosomes. Sex cells contain one chromosome from each pair.



### Visualize It! Inquiry

**6 Predict** The cell shown is a body cell that has two pairs of homologous chromosomes. Use the space to the right to draw a sex cell for the same organism.



Body cell

Sex cell



## Why do organisms need sex cells?

Most human body cells contain 46 chromosomes. Think about what would happen if two body cells were to combine. The resulting cell would have twice the normal number of chromosomes. A sex cell is needed to keep this from happening.

Sex cells are also known as *gametes* (GAM•eetz). Gametes contain half the usual number of chromosomes—one chromosome from each homologous pair and one sex chromosome. Cells that contain half the usual number of chromosomes are known as *haploid* (HAP•loyd).

Gametes are found in the reproductive organs of plants and animals. An egg is a gamete that forms in female reproductive organs. The gamete that forms in male reproductive organs is called a sperm cell.

## How are sex cells made?

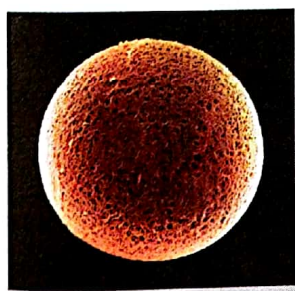
You know that body cells divide by the process of mitosis. Mitosis produces two new cells, each containing exact copies of the chromosomes in the parent cell. Each new cell has a full set of chromosomes. But to produce sex cells, a different kind of cell division is needed.

### Meiosis

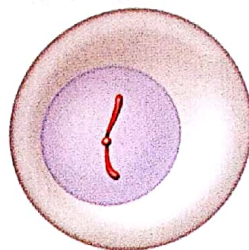
A human egg and a human sperm cell each have 23 chromosomes. When an egg is joined with, or *fertilized* by, a sperm cell, a new diploid cell is formed. This new cell has 46 chromosomes, or 23 pairs of chromosomes. One set is from the mother, and the other set is from the father. The newly formed diploid cell may develop into an offspring. **Meiosis** (my•OH•sis) is the type of cell division that produces haploid sex cells such as eggs and sperm cells.

### Visualize It!

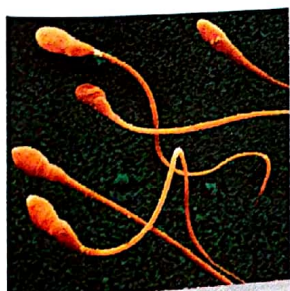
For the example of fertilization shown, the egg and sperm cells each have one chromosome.



Egg cell  
(female gamete)



Haploid



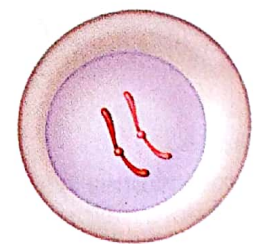
Sperm cell  
(male gamete)



Haploid

Fertilization

Fertilized egg cell  
(zygote)



Diploid

**7 Summarize** Based on the figure, describe the process of fertilization.

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# One Step at a Time

## What are the stages of meiosis?

Meiosis results in the formation of four haploid cells. Each haploid cell has half the number of chromosomes found in the original cell. Meiosis has two parts: meiosis I and meiosis II.

### Meiosis I

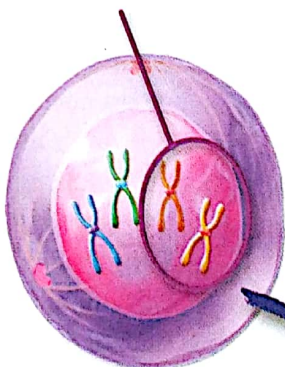
Remember that homologous chromosomes have the same genes, but they are not exact copies of each other. Before meiosis I begins, each chromosome is duplicated, or copied. Each half of a duplicated chromosome is called a *chromatid* (KROH•muh•tid). Chromatids are connected to each other by *centromeres* (SEN•truh•mirz). Duplicated chromosomes are drawn in an X shape. Each side of the X represents a chromatid, and the point where they touch is the centromere.

During meiosis I, pairs of homologous chromosomes and sex chromosomes split apart into two new cells. These cells each have one-half of the chromosome pairs and their duplicate chromatids. The steps of meiosis I are shown below.

#### Active Reading

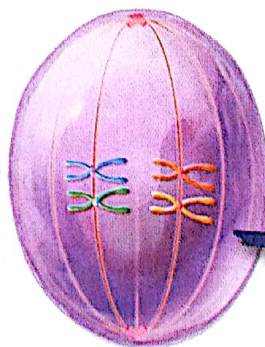
**8 Sequence** As you read, underline what happens to chromosomes during meiosis.

Duplicated homologous chromosomes



#### Prophase I

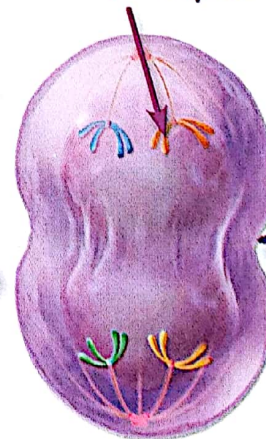
The chromosomes are copied before meiosis begins. The duplicated chromosomes, each made up of two chromatids, pair up.



#### Metaphase I

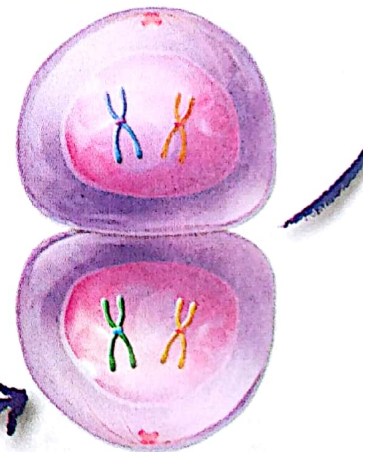
After the nuclear membrane breaks down, the chromosome pairs line up in the middle of the cell.

Half of a homologous chromosome pair



#### Anaphase I

The chromosomes separate from their partners, and then move to opposite ends of the cell.



#### Telophase I and cytokinesis

The nuclear membranes re-form, and the cell divides into two cells. The chromatids are still joined.



## Visualize It!

**9 Contrast** How does meiosis II differ from meiosis I?

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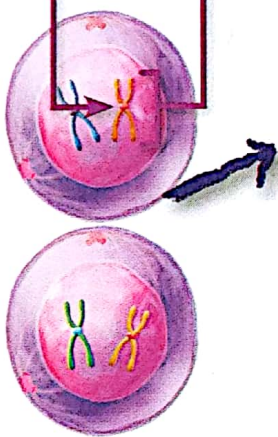


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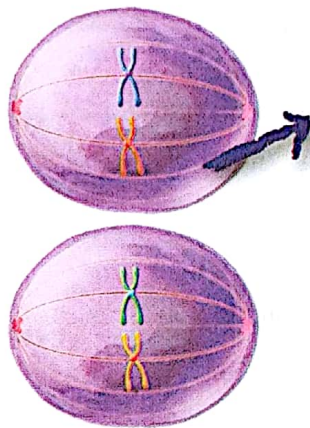
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Centromere  
Chromatid



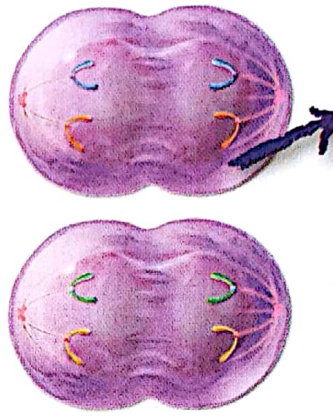
### Prophase II

The chromosomes are not copied again before meiosis II. The nuclear membrane breaks down.



### Metaphase II

The chromosomes line up in the middle of each cell.



### Anaphase II

The chromatids are pulled apart and move to opposite sides of the cell.

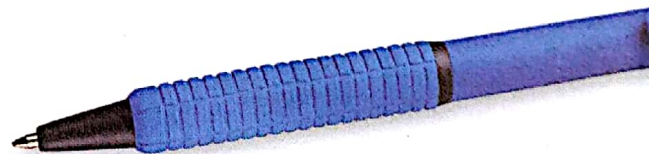


### Telophase II and cytokinesis

The nuclear membranes re-form and the cells divide. Four new haploid cells are formed. Each has half the usual number of chromosomes.

## Think Outside the Book

**10 Summarize** Work with a partner to make a poster that describes all the steps of meiosis.



## Meiosis II

Meiosis II involves both of the new cells formed during meiosis I. The chromosomes of these cells are not copied before meiosis II begins. Both of the cells divide during meiosis II. The steps of meiosis II are shown above.

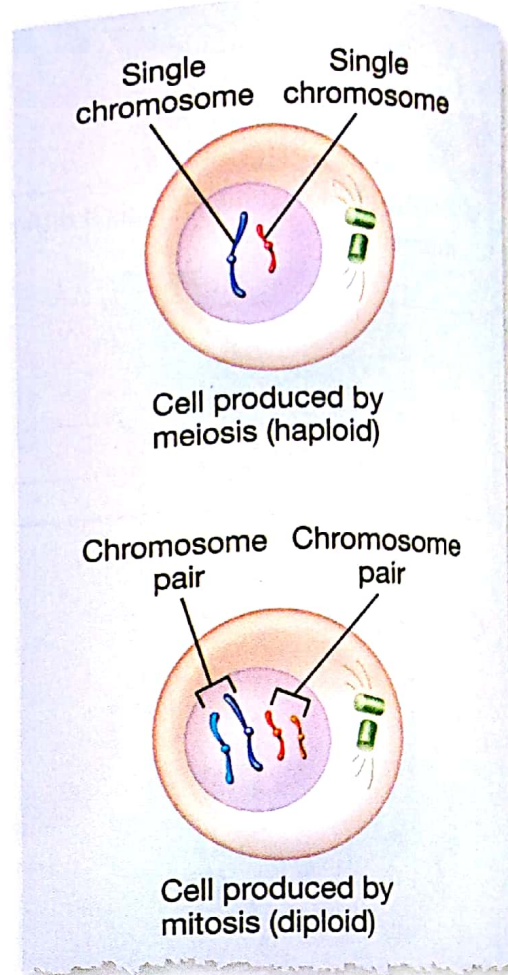
Meiosis II results in four haploid sex cells. In male organisms, these cells develop into sperm cells. In female organisms, these cells become eggs. In females of some species, three of the cells are broken down and only one haploid cell becomes an egg.

**11 Identify** At the end of meiosis II, how many cells have formed?

# How does meiosis compare to mitosis?

The processes of meiosis and mitosis are similar in many ways. However, they also have several very important differences.

- Only cells that will become sex cells go through meiosis. All other cells divide by mitosis.
- During meiosis, chromosomes are copied once, and then the nucleus divides twice. During mitosis, the chromosomes are copied once, and then the nucleus divides once.
- The cells produced by meiosis contain only half of the genetic material of the parent cell—one chromosome from each homologous pair and one sex chromosome. The cells produced by mitosis contain exactly the same genetic material as the parent—a full set of homologous chromosomes and a pair of sex chromosomes.



**12 Summarize** Using the table below, compare meiosis and mitosis.

<i>Characteristic</i>	<i>Meiosis</i>	<i>Mitosis</i>
<i>Number of nuclear divisions</i>		
<i>Number of cells produced</i>		
<i>Number of chromosomes in new cells (diploid or haploid)</i>		
<i>Type of cell produced (body cell or sex cell)</i>		
<i>Steps of the process</i>		

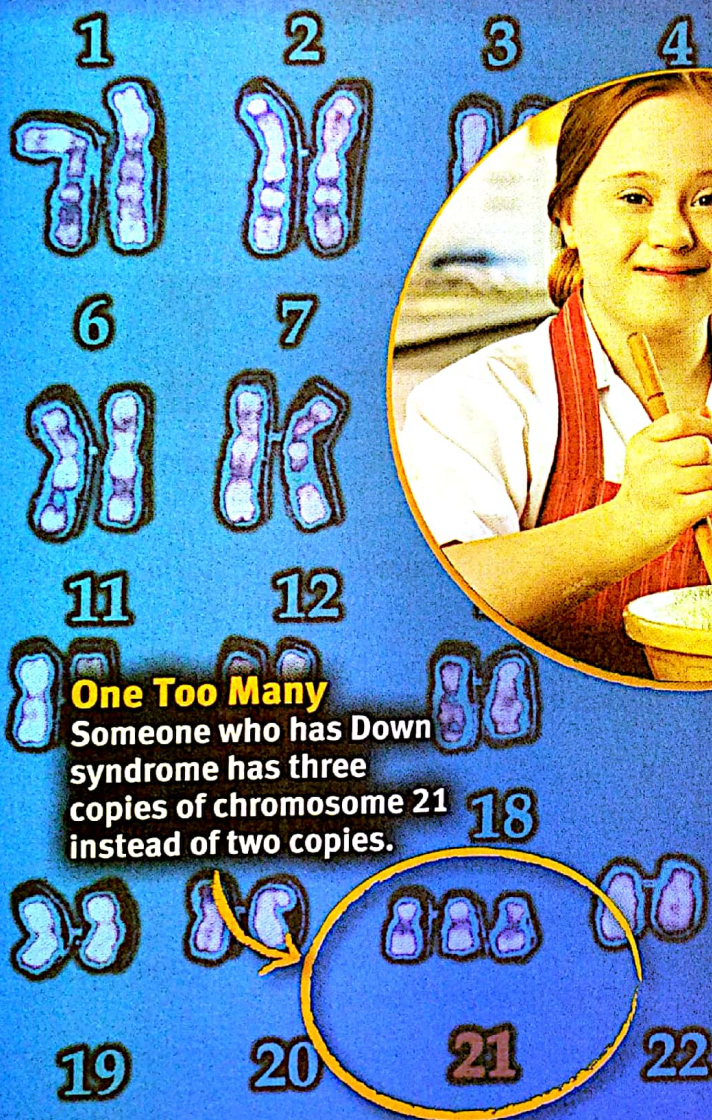


# Down Syndrome

Down syndrome is a genetic disease. It is usually caused by an error during meiosis. During meiosis, the chromatids of chromosome 21 do not separate. So, a sex cell gets two copies of chromosome 21 instead of one copy. When this sex cell joins with a normal egg or sperm, the fertilized egg has three copies of chromosome 21 instead of two copies.

## Beating the Odds

Down syndrome causes a number of health problems and learning difficulties, but many people with Down syndrome have fulfilling lives.



### One Too Many

Someone who has Down syndrome has three copies of chromosome 21 instead of two copies.



## Extend

- 13 Identify** What type of error in meiosis causes Down syndrome?
- 14 Investigate** Research the characteristics of Down syndrome. How can some of the difficulties caused by the disorder be overcome?

## Inquiry

- 15 Recommend** Research the Special Olympics. Then make an informative brochure, poster, or oral presentation that describes how the Special Olympics gives people with Down syndrome and other disabilities the chance to compete in sports.

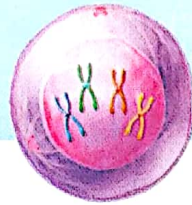


# Visual Summary

To complete this summary, fill in the blanks with the correct word or phrase. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

## Meiosis

Meiosis produces haploid cells that can become sex cells.



16 List the steps of meiosis I.

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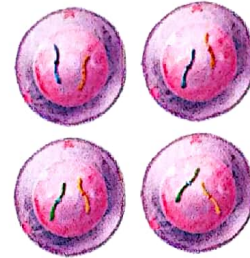
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17 List the steps of meiosis II.

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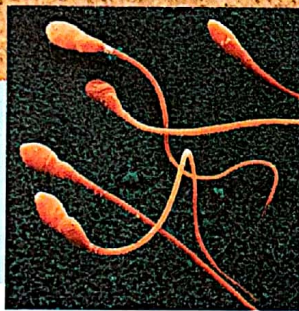


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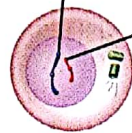
Sex cells have half as many chromosomes as body cells.



18 Sex cells produced by males are called \_\_\_\_\_, and sex cells produced by females are called \_\_\_\_\_

Mitosis and meiosis have similarities and differences.

Single chromosome



Cell produced by meiosis (haploid)

Chromosome pair



Cell produced by mitosis (diploid)

19 During \_\_\_\_\_, chromosomes are copied once and the nucleus divides twice.

20 During \_\_\_\_\_, chromosomes are copied once and the nucleus divides once.

21 **Summarize** Briefly describe what happens during meiosis I and meiosis II.

Answers: 16 prophase I, metaphase I, anaphase I, telophase I, and cytokinesis; 17 prophase II, metaphase II, anaphase II, and cytokinesis; 18 sperm cells; eggs; 19 meiosis; 20 mitosis



# Lesson Review

## Vocabulary

Fill in the blanks with the term that best completes the following sentences.

- 1 \_\_\_\_\_ chromosomes are found in body cells but not sex cells.
- 2 The process of \_\_\_\_\_ produces haploid cells.

## Key Concepts

**3 Compare** How does the number of chromosomes in sex cells compare with the number of chromosomes in body cells?

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**4 Identify** What is the function of meiosis?

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**5 List** Identify the steps of meiosis.

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**6 Compare** How are mitosis and meiosis alike and different?

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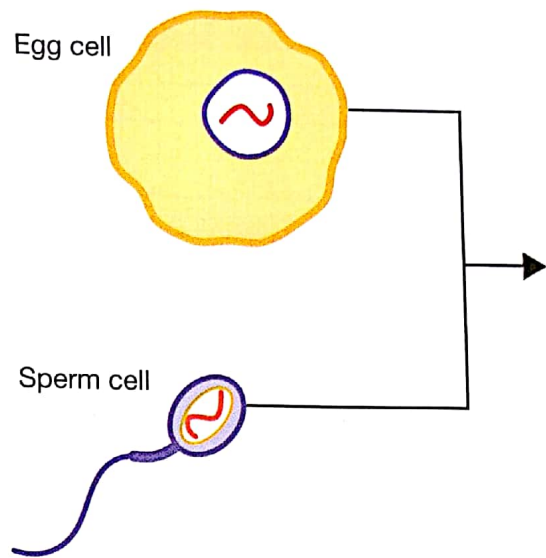
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## Critical Thinking

Use the figure to answer the following questions.



**7 Identify** By what process did these cells form?

**8 Identify** How many chromosomes does a body cell for the organism shown have?

**9 Predict** Draw a picture of the cell that would form if the sperm cell fused with the egg cell. What is this cell called?

**10 Synthesize** What would happen if meiosis did not occur?

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