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KEY CONCEPT

4.3 Meiosis is a special form of cell division.

BEFORE, you learned

- Mitosis produces two genetically identical cells
- In sexual reproduction, offspring inherit traits from both parents
- Genetic traits are inherited in predictable patterns

NOW, you will learn

- Why meiosis is necessary for sexual reproduction
- How cells and chromosomes divide during meiosis
- How meiosis differs from mitosis

VOCABULARY

gamete p. 118
egg p. 118
sperm p. 118
fertilization p. 118
meiosis p. 119

EXPLORE Meiosis

Why does sexual reproduction need a special form of cell division?

PROCEDURE

1. Suppose the cells that combine during sexual reproduction are produced by mitosis, with the same pairs of chromosomes as most cells. Model this combination with the pipe cleaners; both red pipe cleaners and both blue pipe cleaners end up in the new cell.
2. Now model a way for the new cell to end up with the same number of chromosomes as most other cells.

MATERIALS

- 2 blue pipe cleaners
- 2 red pipe cleaners

WHAT DO YOU THINK?

- What was wrong with the new cell produced at the end of step 1?
- Describe your model of the way a new cell could end up with the correct number of chromosomes.

Meiosis is necessary for sexual reproduction.

In Section 4.1 you learned that two cells combine during the process of sexual reproduction. One of the cells contains genetic information from the mother. The other contains genetic information from the father. The two cells combine into a completely new cell, which becomes the offspring.

CHECK YOUR READING How does the genetic material of offspring produced by sexual reproduction compare with the genetic material of the parents?

Most human cells, which can be referred to as body cells, contain 46 chromosomes—the full number of chromosomes that is normal for a human being. Any cell that contains the full number of chromosomes (two sets) for a species is a $2n$ cell, also called a diploid cell. The $2n$ cells for a fruit fly, for example, contain 8 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 special type of cell, called a gamete, is needed.

VOCABULARY
Be sure to make a word magnet for the term *gamete*.

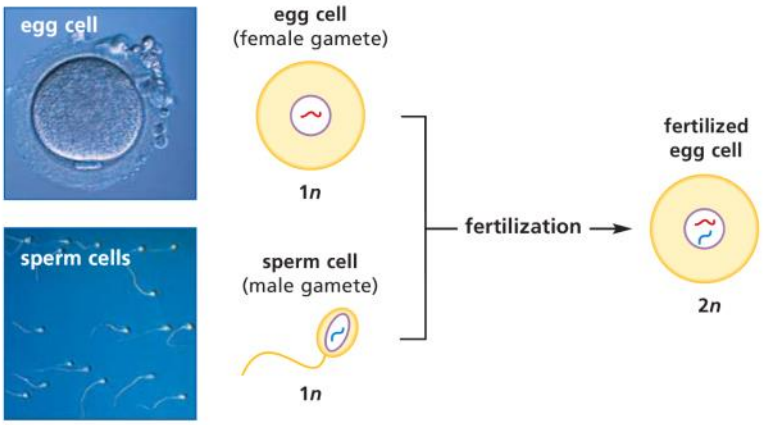
Gametes are cells that contain half the usual number of chromosomes—one chromosome from each pair. Gametes are $1n$ cells, also called haploid cells. Human gametes contain 23 unpaired chromosomes. The gametes of a fruit fly contain 4 unpaired chromosomes. Gametes are found only in the reproductive organs of plants and animals. An **egg** is a gamete that forms in the reproductive organs of a female. A gamete that forms in the reproductive organs of a male is a **sperm**.

CHECK YOUR READING What is a gamete?

During sexual reproduction two gametes combine to become a $2n$ cell that can grow into a new offspring. **Fertilization** is the process that takes place when a sperm and an egg combine to form one new cell. The diagram below shows what happens to the chromosomes in gametes during fertilization. In humans, an egg cell with 23 chromosomes joins a sperm cell with 23 chromosomes to form a new $2n$ cell with 46 chromosomes.

Fertilization

During fertilization, a $1n$ egg cell from a female combines with a $1n$ sperm cell from a male, producing a $2n$ fertilized egg cell, which develops into an offspring.



INVESTIGATE Fertilization

How can you model fertilization?

In fertilization, a sperm and an egg combine to form a new cell. Design a model of fertilization.

DESIGN YOUR OWN EXPERIMENT

SKILL FOCUS
Modeling

MATERIALS
- pipe cleaners
- gallon milk jug
- film canister
- yarn

TIME
25 minutes

PROCEDURE

1. Use the materials provided to make simple models of an egg and a sperm.
2. Use the sperm and egg models to show the fertilization process.

WHAT DO YOU THINK?

- Describe your model of the cell that exists at the end of the fertilization process.
- How is it different from the sperm cell and egg cell?

CHALLENGE Design a model for fertilization in fruit flies.

You know that body cells divide by the process called mitosis. Mitosis produces two daughter cells, each containing exact copies of the chromosomes in the parent cell. Each daughter cell formed by mitosis is a standard diploid ($2n$) cell.

But to produce gametes, which are haploid, a different kind of cell division is necessary. **Meiosis** is a special kind of cell division that produces haploid ($1n$) cells. During meiosis, a single cell goes through two cell divisions—meiosis I and meiosis II. Meiosis takes place only in the reproductive tissues of an organism.

Cells divide twice during meiosis.

NOTETAKING STRATEGY
Use an earlier strategy or one that you think works well to take notes on the division of cells during meiosis.

Before meiosis begins, the chromosomes of the parent cell are copied. A cell that is ready to divide contains two copies of each chromosome pair—twice as many chromosomes as usual. So to end up with cells that have half the usual number of chromosomes, there must be two divisions.

Remember that the two chromosomes in a pair are called homologs. At the beginning of meiosis I, the cell has two copies of each homolog. During meiosis I the homologs divide. The starting cell divides into two cells. One cell contains the two copies of one homolog of each pair, while the other cell contains the two copies of the other homolog of each pair. Then, during meiosis II, each of the two cells is divided, producing four haploid cells. Each haploid cell has one unpaired set of chromosomes.

Meiosis I

As you can see in the diagram on page 121, there are four steps in meiosis I: prophase I, metaphase I, anaphase I, and telophase I. Included in telophase I is a cytokinesis, the division of the cytoplasm. The diagram shows what would happen during meiosis I in a species that has four chromosomes in its $2n$ body cells.

READING TiP

As you read about meiosis I and meiosis II, match the numbers in the text to the numbers in the diagram on page 121.

1. **Prophase I** Chromosomes pair up with their partners. There are two sets of each of the chromosome pairs in the parent cell. The members of each chromosome pair are attached together in sets of doubled homologs.
2. **Metaphase I** Each set of chromosome pairs lines up along the center of the cell.
3. **Anaphase I** The two copies of one homolog are pulled apart from the two copies of the other homolog. This dividing of the homologs is the most significant step of meiosis I.
4. **Telophase I and Cytokinesis** A new cell membrane forms at the center of the cell, dividing the parent cell into two daughter cells.

CHECK YOUR READING What happens to the parent cell during telophase I?

Meiosis II

RESOURCE CENTER CLASSZONE.COM

Learn more about meiosis.

During meiosis I, two daughter cells are formed. The chromosomes of these two cells are not copied before meiosis II begins. Both of these cells divide during meiosis II, to produce a total of four daughter cells. The four steps in meiosis II, shown on page 121, are prophase II, metaphase II, anaphase II, and telophase II (with cytokinesis).

5. **Prophase II** In each daughter cell, there are two copies of each of n chromosomes. The copies are attached together.
6. **Metaphase II** The chromosomes line up along each cell's center.
7. **Anaphase II** The two attached copies of each chromosome separate and are pulled to opposite poles in each cell.
8. **Telophase II and Cytokinesis** A new cell membrane forms in the center of each cell, as each cell divides into two $1n$ daughter cells, producing a total of four $1n$ cells.

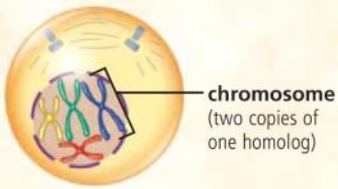
During meiosis, one cell in an organism's reproductive system divides twice to form four $1n$ cells. In male organisms, these gametes become sperm. In female organisms, at least one of these cells becomes an egg. In some species, including humans, only one of the four daughter cells produced by a female during meiosis becomes an egg. The rest dissolve back into the organism or, in some cases, are never produced.

Meiosis

Meiosis reduces the number of chromosomes by half, producing four 1*n* cells.

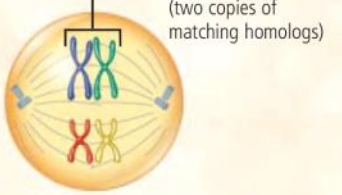
Meiosis I: Paired chromosomes separate

1 Prophase I



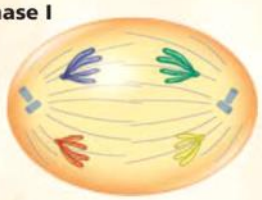
DNA condenses into chromosomes. The nuclear membrane disappears.

2 Metaphase I



Chromosomes arrange as pairs in the middle of the cell.

3 Anaphase I



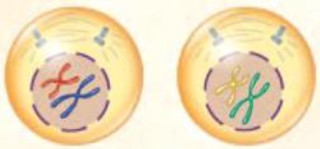
The homologs of each chromosome pair separate and are pulled to opposite ends of the cell.

4 Telophase I and Cytokinesis

The cell divides into two daughter cells.

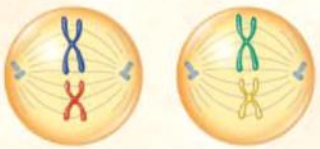
Meiosis II: Chromosomes separate

5 Prophase II



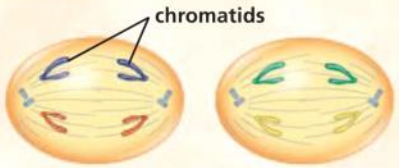
The two copies of each homolog remain attached as chromosomes.

6 Metaphase II



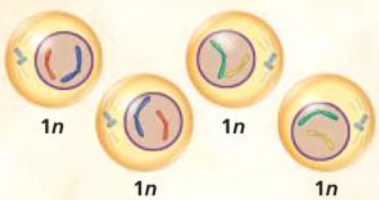
Chromosomes line up in the middle of the cell.

7 Anaphase II



Each chromosome splits into chromatids, so that one copy of each homolog is pulled to the opposite ends of the cells.

8 Telophase II and Cytokinesis



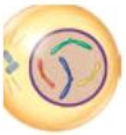
Both cells divide, producing four 1*n* cells.

Meiosis and mitosis differ in some important ways.

READING TiP
As you read about how meiosis and mitosis are different, refer to the diagrams on pages 83 and 121.

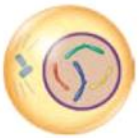
You can see that the processes of meiosis and mitosis are similar in many ways. However, they also have several very important differences.

- Only cells that are to become gametes go through meiosis. All other cells divide by mitosis.
- A cell that divides by meiosis goes through two cell divisions, but the chromosomes are not copied before the second division. In mitosis, the chromosomes are always copied before division.
- Daughter cells produced by meiosis, which are haploid ($1n$), contain only half of the genetic material of the parent cell (one of each chromosome).



Cell produced by meiosis

- Daughter cells produced by mitosis, which are diploid ($2n$), contain exactly the same genetic material as the parent (pairs of chromosomes).



Cell produced by mitosis

CHECK YOUR READING What are four ways in which meiosis differs from mitosis?

4.3 Review

KEY CONCEPTS

1. What kind of cell is produced by meiosis?
2. What is fertilization?
3. In your own words, describe the differences between meiosis and mitosis.

CRITICAL THINKING

4. **Compare** How do prophase I and prophase II differ?
5. **Communicate** Make a Venn diagram to show the similarities and differences between mitosis and meiosis.

CHALLENGE

6. **Synthesize** Why does meiosis II result in four $1n$ cells rather than four $2n$ cells?