

## 11.4 Meiosis

### Lesson Objectives

- ▶ Contrast the number of chromosomes in body cells and in gametes.
- ▶ Summarize the events of meiosis.
- ▶ Contrast meiosis and mitosis.
- ▶ Describe how alleles from different genes can be inherited together.

### Lesson Summary

**Chromosome Number** **Homologous** chromosomes are pairs of chromosomes that correspond in body cells. One chromosome from each pair comes from each parent.

- ▶ A cell that contains both sets of homologous chromosomes has a **diploid** number of chromosomes (meaning “two sets”).
- ▶ **Haploid** cells contain only one set of chromosomes. Gametes are haploid.

**Phases of Meiosis** **Meiosis** is the process that separates homologous pairs of chromosomes in a diploid cell, forming a haploid gamete. The phases are as follows:

- ▶ Meiosis I, which is preceded by a replication of chromosomes. Its stages are
  - Prophase I: Each replicated chromosome pairs with its corresponding homologous chromosome forming a **tetrad**. During tetrad formation, alleles can be exchanged between chromatids, a process called **crossing-over**.
  - Metaphase I: Paired homologous chromosomes line up across the center of the cell.
  - Anaphase I: Spindle fibers pull each homologous pair toward opposite ends of the cell.
  - Telophase I: A nuclear membrane forms around each cluster of chromosomes. Cytokinesis then occurs, resulting in two new cells. The resulting daughter cells contain chromosome sets that are different from each other and the parent cell.
- ▶ Meiosis II: Chromosomes do not replicate.
  - Prophase II: Chromosomes, each consisting of two chromatids, become visible.
  - Metaphase II, Anaphase II, Telophase II, and Cytokinesis: These phases are similar to meiosis I. Four haploid cells form. They are the gametes. During fertilization, two gametes unite forming a **zygote**.

### Comparing Meiosis and Mitosis

- ▶ Mitosis is one cell division that results in two genetically identical diploid cells.
- ▶ Meiosis is two cell divisions that result in four genetically different haploid cells.

### Gene Linkage and Gene Maps

- ▶ Alleles tend to be inherited together if they are located on the same chromosome.
- ▶ Chromosomes, not genes, segregate independently.
- ▶ The farther apart genes are on a chromosome, the more likely is cross over.
- ▶ Information on linkage and the frequency of crossing-over lets geneticists construct maps of the locations of genes on chromosomes.

## Chromosome Number

For Questions 1–8, write True if the statement is true. If the statement is false, change the underlined word to make the statement true.

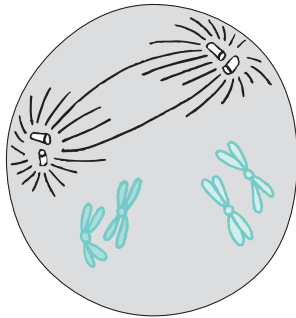
- |                    |  |
|--------------------|--|
| <u>True</u>        | 1. The offspring of two parents obtains a single copy of every <u>gene</u> from each parent. |
| <u>True</u>        | 2. A <u>gamete</u> must contain one complete set of genes.                                   |
| <u>chromosomes</u> | 3. Genes are located at specific positions on <u>spindles</u> .                              |
| <u>homologous</u>  | 4. A pair of corresponding chromosomes is <u>homozygous</u> .                                |
| <u>parent</u>      | 5. One member of each homologous chromosome pair comes from each <u>gene</u> .               |
| <u>diploid</u>     | 6. A cell that contains both sets of homologous chromosomes is <u>haploid</u> .              |
| <u>True</u>        | 7. The gametes of sexually reproducing organisms are <u>haploid</u> .                        |
| <u>12</u>          | 8. If an organism's haploid number is 6, its diploid number is <u>3</u> .                    |

## Phases of Meiosis

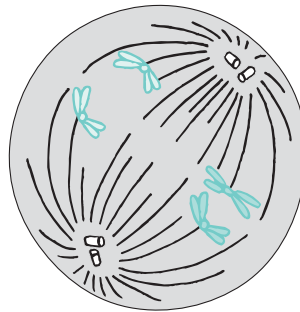
On the lines provided, identify the stage of meiosis I or meiosis II in which the event described occurs.

- |                     |  |
|---------------------|--|
| <u>Prophase I</u>   | 9. Each replicated chromosome pairs with its corresponding homologous chromosome.                                |
| <u>Prophase I</u>   | 10. Crossing-over occurs between tetrads.  |
| <u>Metaphase I</u>  | 11. Paired homologous chromosomes line up across the center of the cell.   |
| <u>Anaphase I</u>   | 12. Spindle fibers pull each homologous chromosome pair toward an opposite end of the cell.                      |
| <u>Telophase I</u>  | 13. A nuclear membrane forms around each cluster of chromosomes and cytokinesis follows, forming two new cells.  |
| <u>Prophase II</u>  | 14. Chromosomes consist of two chromatids, but they do not pair to form tetrads.                                 |
| <u>Telophase II</u> | 15. A nuclear membrane forms around each cluster of chromosomes and cytokinesis follows, forming four new cells. |

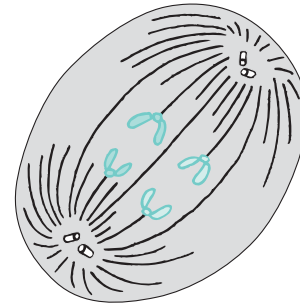
16. **THINK VISUALLY** Draw two homologous pairs of chromosomes (in different colors if you have them) in these diagrams to illustrate what happens during these three phases of meiosis.



Prophase I

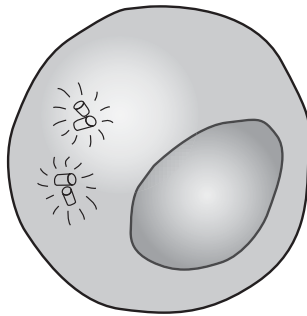


Metaphase I

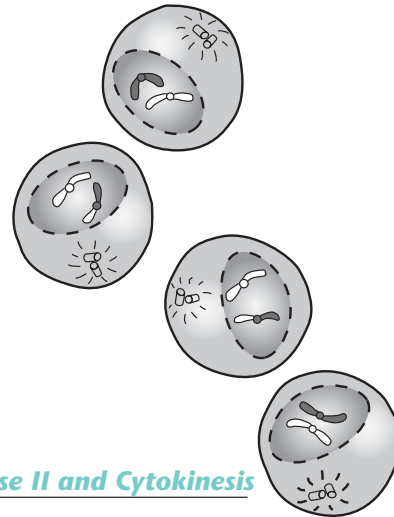


Anaphase II

17. Identify which phase of meiosis is shown in the diagrams below.



Interphase I



Telophase II and Cytokinesis

Use this diagram to answer Questions 18–20.

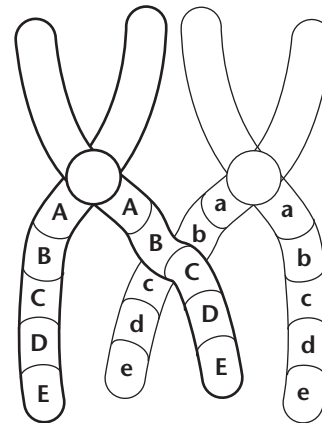
18. What does the diagram show?  
*It shows crossing-over of genes between a pair of homologous chromosomes.*

19. During what phase of meiosis does this process occur?

*It occurs during prophase I of meiosis.*

20. What is the result of this process?

*The result is a new combination of alleles.*



## Comparing Meiosis and Mitosis

21. Complete the table to compare meiosis and mitosis.

	Mitosis	Meiosis
Form of reproduction	<i>Asexual</i>	<i>First stage in sexual</i>
Number of daughter cells	<b>2</b>	<b>4</b>
Change in chromosome number	<i>No change; stays diploid</i>	<i>Cut in half to haploid</i>
Number of cell divisions	<b>1</b>	<b>2</b>
Difference in alleles between parent cell and daughter cells	<i>None</i>	<i>Each of the four daughter cells is genetically different from the parent.</i>

For Questions 22–27, complete each statement by writing the correct word or words.

22. A diploid cell that enters mitosis with 16 chromosomes will divide to produce **2** daughter cells. Each of these daughter cells will have **16** chromosomes.
23. If the diploid number of chromosomes for an organism is 16, each daughter cell after mitosis will contain **16** chromosomes.
24. A diploid cell that enters meiosis with 16 chromosomes will pass through **2** cell divisions, producing **4** daughter cells, each with **8** chromosomes.
25. Gametes have a **haploid** number of chromosomes.
26. If an organism's haploid number is 5, its diploid number is **10**.
27. While a haploid number of chromosomes may be even or odd, a diploid number is always **even**.

## Gene Linkage and Gene Maps

28. What did Thomas Hunt Morgan discover that seemed to violate Mendel's principles?

*Some genes appeared to be linked; they seemed to violate the principle of independent assortment.*

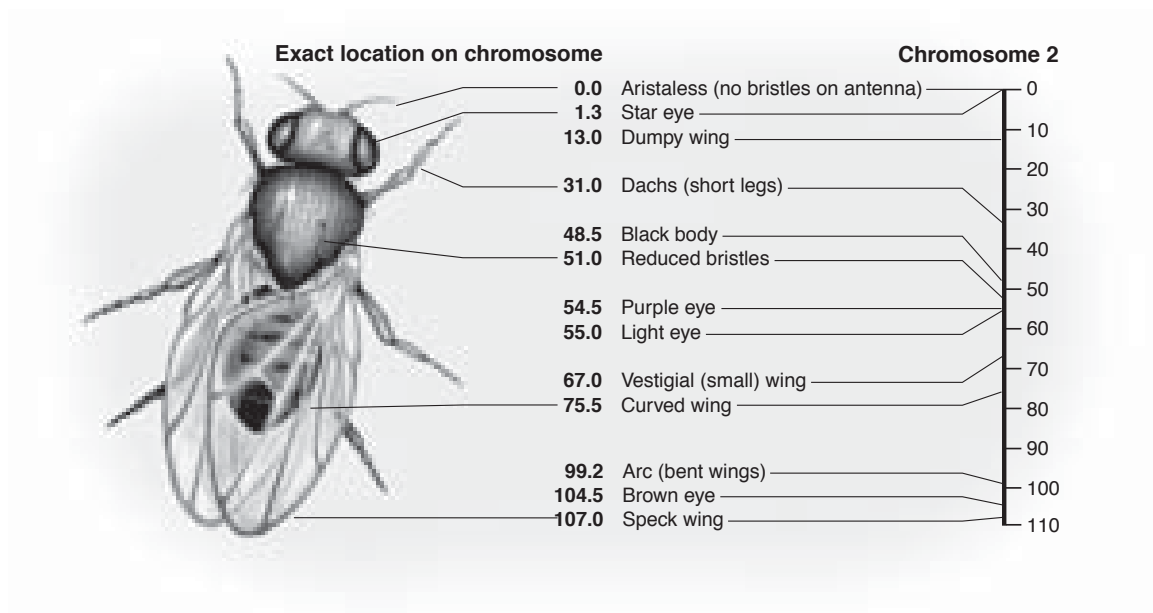
29. How did Morgan explain his finding?

*Linked genes were inherited together because they were close to each other on the same chromosome.*

30. How did Alfred Sturtevant use gene linkage to create gene maps?

*He reasoned that alleles that frequently cross over must be farther apart than those that hardly ever cross over.*

Use this diagram to answer Questions 31–34.



31. What does the diagram show?

*It shows a gene map.*

32. How was the information in this diagram gathered?

*It was gathered from studies of the frequency of crossing-over.*

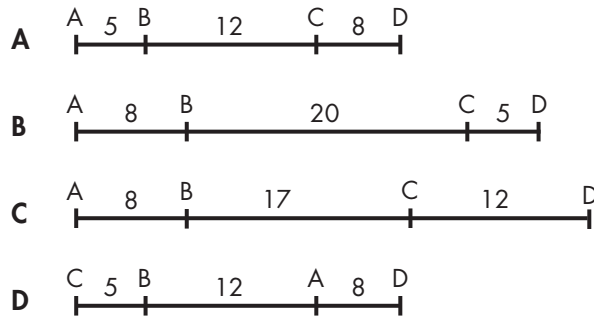
33. Which pairs of characteristics are more likely to cross over: curved wing and dumpy wing; or curved wing and vestigial (small) wing? Why?

*Curved wing and dumpy wing are more likely to cross over because they are farther apart on the chromosome.*

34. Which pair of genes shown is least likely to cross over? How do you know?

*Purple eye and light eye are least likely to cross over because they are only 0.5 units apart. The distance between all the other adjacent genes is greater.*

Use this diagram to answer Questions 35–38.



35. In which gene map is the probability of crossing-over between A and D greatest?  
    C
36. In which gene map is the probability of crossing-over between A and D the least?  
    D
37. In which map are genes C and D most closely linked?     B
38. In map D, which genes are least likely to cross over?     C and B

### Apply the Big idea

39. Some housecats have orange fur with darker orange stripes. The traits of these *tabby* cats are usually seen in male cats. *Tortoiseshell* cats have patches of many different colors. “Torties,” as they are called, are almost always female. What does this tell you about the way cellular information about color and sex are passed on in cats?

***It tells me that the genes for color and sex are linked. The genes for these two traits must be located on the same chromosome.***

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## Chapter Vocabulary Review

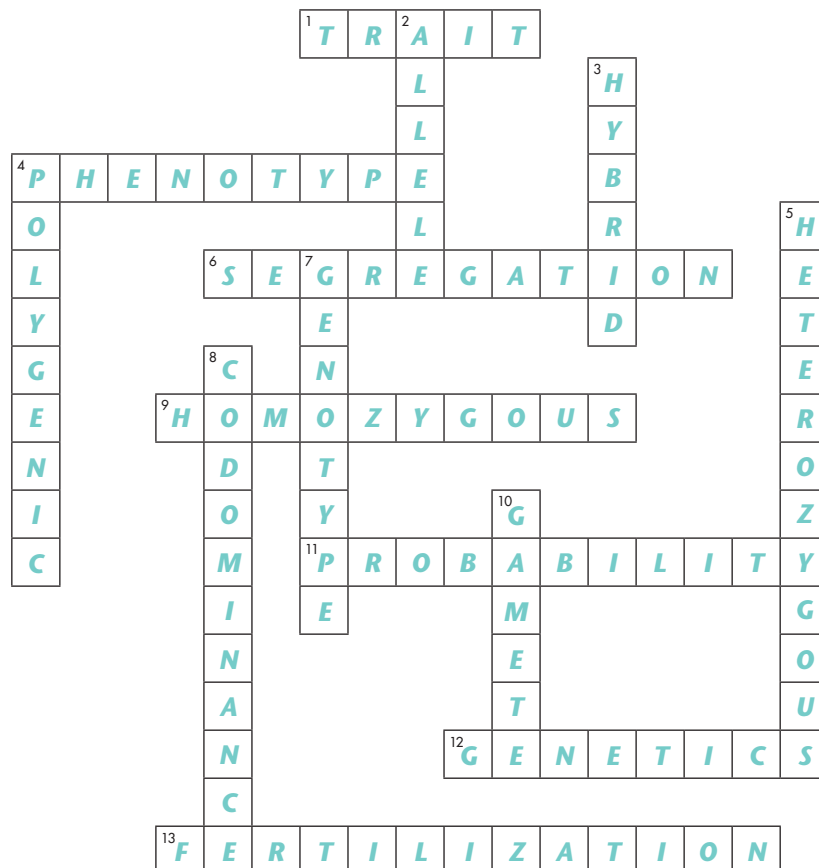
**Crossword Puzzle** Complete the puzzle by entering the term that matches each numbered description.

### Across

1. a specific characteristic
4. physical traits
6. the separation of alleles during formation of sex cells
9. containing two identical alleles for a trait
11. the likelihood of an event occurring
12. scientific study of heredity
13. the union of male and female sex cells

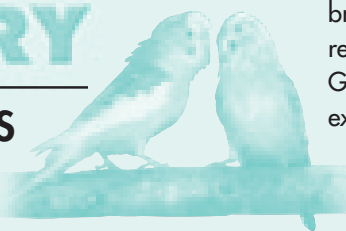
### Down

2. one form of a gene
3. the offspring of a cross between parents with different, true-breeding traits
4. word that describes a trait controlled by two or more genes
5. containing two different alleles for a trait
7. genetic makeup
8. a phenotype in which both alleles are expressed
10. reproductive cell, egg or sperm



# CHAPTER MYSTERY

## GREEN PARAKEETS



In the Chapter Mystery, you read about a brood of parakeets that gave the owners results they didn't expect. Do you think Gregor Mendel ever got results he didn't expect?

21st Century Learning

## Can Results Be Too Good?

As odd as it sounds, if you perform a lot of experiments, you should expect to get results you don't expect. Random chance will cause some of the experiments to have different outcomes from the rest of the experiments. Scientists have a mathematical formula to express an experiment's deviation, or how much the actual results varied from the expected results. If an experiment has a deviation of 0, that means the results were exactly as was expected. If it has a deviation of 2 or  $-2$ , that means the results were quite different from what was expected. A negative deviation indicates that the actual observations were smaller than average. A positive deviation indicates that the actual observations were larger than average.

The table below was created for the number and type of experiments Mendel performed. Each number in the second column represents the number of experiments we would expect Mendel to have had with the deviation in the first column. For example, we would expect Mendel to have had 13 experiments in which the deviation was between 0 and 0.5, and two experiments with deviations between  $-2.0$  and  $-2.5$ . Each number in the third column represents the actual number of experiments with the deviation in the first column. For example, Mendel recorded 16 experiments in which the deviation was between 0 and 0.5.

Deviation	Expected Number of Experiments with This Deviation	Actual Number of Experiments with This Deviation
-2 to -2.5	2	0
-1.5 to -2	3	0
-1 to -1.5	6	4
-0.5 to -1	10	12
-0 to -0.5	13	14
0 to 0.5	13	16
0.5 to 1	10	20
1 to 1.5	6	2
1.5 to 2	3	1
2 to 2.5	2	0

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## 21st Century Themes Science Literacy

- How many experiments with deviations between 1.5 and 2.0 would you expect Mendel to have had? How many did he have? *3; 1*
- Look at the deviations between -1.0 and 1.0. Did Mendel have more or fewer experiments with deviations in this range than expected? *More*
- Look at the deviations beyond -1.0 and 1.0. Did Mendel have more or fewer experiments with deviations in this range than expected? *Fewer*
- Do you think scientists ever throw out results that were quite different from expected? Why might a scientist be tempted to do this? *SAMPLE ANSWER: A scientist might do this to make his or her hypothesis appear to be more valid than it really was.*
- Mendel worked with an assistant, a gardener, and two other monks, all of whom helped count and record the results, and none of whom were scientists. These nonscientists spent years counting tens of thousands of peas. It wouldn't take them long to figure out what the usual results were. How might one or more of Mendel's helpers have caused the low number of high-deviation results?  
*SAMPLE ANSWER: Mendel's helpers may not have reported results that were very different from the results they were usually getting.*
- Do you think that what you described in your answer to Question 4 is excusable? Is what you described in Question 5 excusable? Why or why not? *Students' answers should be based on logical premises and indicate respect for scientific methodology.*
- Would your answer to Question 6 be changed if you were considering a case in which a scientist altered data collected while testing a new medicine? Explain your answer.  
*Students' answers should indicate that they understand the greater ethical implications of altering data in an experiment that affects people's lives, such as testing a new medicine or the strength of a new bridge design.*

## 21st Century Skills A Gardening Play

The skills used in this activity include **creativity and intellectual curiosity, self-direction, and accountability and adaptability.**

You described what one or more of Mendel's helpers might have done to skew the results of the experiments and how you felt about those actions. Now it's time to get creative. Write a one-act play about Mendel's gardener and what he may or may not have done. The gardener may be the main character, or one or more main characters may affect what the gardener does. The play may be a comedy, a drama, or a tragedy.

*When the play is finished, assign each of the roles to one of your classmates and have a play reading, either in class or after school. Evaluate students' plays based on how well the script addresses the topic of tampering with the results of a scientific experiment.*